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Pamukkale J Sport Sci, 16(1), 1-22, 2025 Research Article

Adaptation of Sport Event Image Scale to Turkish Culture: A Validity and Reliability Study

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ABSTRACT

The purpose of this study was to adapt the Turkish version of the "Sport Event Image Scale" (SEIS) developed by Kaplanidou and Vogt (2007) and to test its validity and reliability. 418 voluntary runners aged 18 years and above who agreed to attend the study and who ran in the 5km, 10km, and 21km competition routes in the "Gökova Half Marathon" event were the sample of the study. In the first stage of the adaptation process, the committee approach was utilized for language equivalence. Then, the pilot study was performed with 54 athletes who participated in the same event in the previous year via e-mail to test the comprehensibility of the scale items. In the next stage, to test the construct validity Confirmatory Factor Analysis was used. In addition, reliability was conducted with test-retest and internal consistency analysis. The CFA findings supported the single-factor structure of the scale in line with the original version (cmin/df = 3.441, RMSEA = 0.077, RMR = 0.007, GFI = 0.976, NFI = 0.994, CFI = 0.996, RFI = 0.976). The internal consistency coefficient value was 0.976 and the test-retest result was 0.901. As a result, according to the findings, it is possible to say that the adapted Turkish version of the SEIS preserved the psychometric properties, which can be used as a valid and reliable scale in future research studies that will be conducted on the Turkish population.

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INTRODUCTION

Sports are the most basic physical activity; hundreds of thousands of people around the world participate in different sports activities and events every single day. This shows that sports have been intertwined with human life. Since the development of the media sector, these activities and events have reached millions of people through mass media, and this situation has attracted the attention of many investors to sports activities and events (Dever & Sözen, 2021). Today, this interest contributes to developing sport as an organized commercial activity (Khan et al., 2016).

Sports is a priority area for corporate companies that prefer to sponsor due to its ability to reach and influence society (Walraven et al., 2016). Sponsorship activities have a critical role in the growth and development of companies. As one of the marketing mix elements, the sponsorship serves to create public opinion, improve the brand image, enhance the brand communication, and increase the brand awareness of consumers (Keller, 2003).

In general, a brand can be defined as a name or sign that guarantees the authenticity of a product, an identity embedded in a product that differentiates it, a strong position in the minds of consumers, a trustworthy promise, a power that influences markets, benefits or values offered to consumers, a name that can create a community around these values, a name that creates desire or loyalty and makes you forget the price, a name that drives respect, love or loyalty (Kapferer, 2012). Similar to the definitions mentioned, brand is the distinctive name/symbol used to identify the goods/services of one/group of sellers and to differentiate that goods/services from competitors (Aaker, 2009; Kotler, 2002). It is stated that sport events can be considered as a brand in their own context (Lee & Cho, 2009). In this sense, sports events, just like brands, want to establish a connection with participants by presenting distinctive features specific to the event and using the event name, logo, or slogan for this purpose (Chalip & Costa, 2005). This connection with participants can be an emotional, historical, social, organizational, or physical environment of the event, event type (e.g., adventure sports, extreme sports, individual sports, team sports, etc.), and the satisfaction it creates (Kaplanidou, 2010). The total interpretation of these qualitative meanings or associations attributed to the event by consumers is considered the image of the event (Gwinner, 1997; Gwinner et al., 2009).

Sports event image is the total of cognitive (such as the organization of the event and the characteristics of its physical environment) and emotional (the evaluation of the event by

the participant) images that contribute to the sportive competitions it hosts (Baloğlu & McCleary, 1999). Gwinner (1997) and Gwinner (2013) suggested that event type (sport, music, art, festival, etc.), event characteristics (professional-amateur, size, location, etc.), and individual factors (meanings, historical connections, etc.) may be effective on event image. The type of participants can also influence the event image. Competitive sports participants tend to associate their emotions with the physical settings (such as facilities and equipment) where the competitions will be held and with the quality organisation. In contrast, non-competitive sports participants (spectators) tend to associate their emotions with the physical environment, location, and social aspects of the event (Hallmann et al., 2010). Kaplanidou (2007), found that athletes relate to the image in terms of the organization of the event, its physical setting (such as facilities, and equipments), the type of activity involved, socialization opportunities, satisfaction, and emotional connection, while spectators relate to the physical environment and location (touristic attractions) of the event. This distinction shows that athletes are more likely to attribute emotional and functional meanings to the event (Filo et al., 2008).

Researchers suggest that sport event image is transformed into brand image through sponsorship activities (Dos-Santos et al., 2016; Grohs & Reisinger, 2014; Gwinner, 2005; Gwinner & Eaton, 1999). Big sporting events such as the Olympic Games, World and European Championships, Tour de France, 24H Le Mans have become brands and sponsoring such events affects the sponsors' brand image. Besides, being a sponsor of one of the sport event is an effective way to transfer the messages to different market segments with the help of the special and unique characteristics (e.g. identity, personality, image, sponsor-sponsee fit) of each sports event (Alay, 2008; 2010; Gwinner et al., 2009). Research has shown that consumer loyalty and brand image are positively related to each other (Aicher et al., 2018; Cevallos et al., 2020; Min & Lee, 2022). In particular, participants' previous year's participation and intention to attend the same event for the next year and positive word of mouth to others are related to event image (Koo et al., 2014; Wu & Liu, 2017). Girish and Lee (2019) expressed that brand experience aspects of affective, behavioral, and sensory are positively related to the ultramarathon event image, which can be linked to loyalty. Runners are arguably the most important elements of competitions. The continuity of sports events depends on participation, that is, the presence of runners. The number of runners participating in the sports events affects the recognition, popularity, image, income, and existence of the event in the following years (Ocakoglu, 2020).

Recently, more and more sports events have turned into festivals that encompass cultural and tourism activities (Tiessen-Raaphorst, 2016). Athletes expect a creative atmosphere where they can express themselves more, extra ancillary activities, social interaction and fun. Therefore, the event atmosphere plays a key role in; unique sport experiences, re-participant intent, and positive word-of-mouth (Wang et al., 2018). Consequently, event managers should enrich their ancillary activities and enhance their services with entertainment elements (Karagiorgos et al., 2022). Besides, event organizers and managers are facing an increasingly competitive market and should focus more on differentiating their events from others. Additionally, previous research shows that reducing competition and maintaining and growing the loyal customer base can be achieved by creating events with a positive image (Alexandris, 2016; Koo et al., 2014). Also, it is stated that event personality and image have a positive relationship (Karagorios et al., 2022; Lianopoulos et al., 2021). Considering the increase in the number of sports events worldwide, especially in Türkiye, it has become very important for event organizers to create a satisfied and loyal participant base in order to make the event sustainable in the following years. Knowing the overall image of the sports event will also support event organizers and managers in developing strategies, as it influences many variables such as event personality, distinctiveness, finding the right and appropriate sponsors, creating satisfied and loyal participants through positive word-of-mouth, and intention to participate again.

However, it is seen that sports event image is not sufficiently addressed in Turkish sports literature, and there is no specific measurement tool that can be used in studies to be conducted in this context. When the international literature is examined, very limited research was found regarding sports event image (Girish & Lee, 2019; Huang et al., 2015; Karagiorgos et al., 2022; Kogoya et al., 2022; Koo et al., 2014). It is seen that the only measurement tool is the "Sport Event Image Scale" (SEIS) developed by Kaplanidou and Vogt (2007), which is a 7-point Semantic Differential type and consists of 13 items. This scale assessing event image perceived by athletes, used by the researchers mentioned above, except the original language of English, scale adapted to Chinese, Korean, and Indonesian language.

Considering all these, the purpose of this study is to adapt the SEIS to Turkish culture, which measures the perceived image of a sports event by its participants. In terms of practical value, the adapted scale may help sports organizers and managers assess the image of their events, which can support them in developing strategies to differentiate themselves from the competition by revealing the distinctive features of their events. Besides, the findings of this

adapted scale can also help the likelihood of finding fit-for-purpose sponsors, increasing event awareness, contributing to positive word-of-mouth by building a base of satisfied and loyal participants and sustaining the event in subsequent years.

METHODS

In this study, the validity and reliability of the SEIS for Turkish culture were tested using a survey model based on the quantitative research paradigm. During the scale adaptation process, the steps suggested by Hambleton and Patsula (1999), Brislin (1980) were followed; deciding to develop a new scale or adapt an existing one, obtaining permission from the owner of the scale when the adaptation study is decided, selection of qualified translators, translation of scale items, reviewing the translated version of the scale items and making changes if necessary (translation committee approach for face validity), piloting (testing comprehensibility), conducting validity reliability tests with appropriate statistical methods and reporting of results.

Participant

The population consisted of athletes who participated in the 5km, 10km, and 21km running routes in the "Gökova Half Marathon" event held in the Ula district of Muğla on November 18, 2023. The sample was selected using criterion sampling, which is one of the purposive sampling methods. According to event participation rules, athletes must be over the age of 16 but there were no upper limit of the age. Voluntary runners aged 18 years and above who voluntarily agreed to attend and who completed the "Gökova Half Marathon" event composed the sample of the study. The total registered athletes was 598 for the event; 462 athletes completed the race, and 418 athletes who completed the competition participated (surveyed) in the study (a total of 450 questionnaires were distributed and collected; 418 were fully completed, and the remaining 32 were incomplete/incorrect ones were eliminated from the research).

The study sample is composed of 418 ($\bar{x}_{age}$ = 39.89±19.61) participants, 146 (34.93%) of whom are female ($\bar{x}_{age}$ = 35.68±18.45) and 272 (65.07%) are male ($\bar{x}_{age}$ = 41.13±19.73). Female participants were between 18 and 58 ages, and the male ones between 18 and 67. The mean age of the total participants is 39.89±19.61 (Table 1). Running routes preference of the participants: 5 km represents 99 (23.68%), 10 km represents 187 (44.74%), and 21 km represents 132 (31.58%) as shown in Table 2.

Table 1
Participant Demographics

Gender	N	Age Mean	sd	Age Min	Age Max
Female	146	35.68	18.45	18	58
Male	272	41.13	19.73	18	67
Total	*418*	*39.89*	*19.61*	*18*	*67*

Table 2
Running Route Preference

Running Route Preference	N	%
5 km	99	23.68
10 km	187	44.74
21 km	132	31.58
Total	*418*	*100*

Procedure

Before the scale adaptation process, written permission was obtained from the authors of SEIS. The volunteer participants were informed regarding the purpose of the research, reminded that they had the right to leave from research at any time without giving any reason, and assured of confidentiality.

In psychometric studies conducted by translating a measurement tool prepared for different cultures into other cultures, it is recommended to select experts who are fluent in both the native language of the scale and the language to be translated and to conduct a preliminary application to a group of 50 people who have the power to represent the targeted population (Hambleton & Patsula, 1999). The committee approach to the translation of the scale items aims to reduce the impact of cultural biases inherent to the native language by collaboration and consensus (Martinez et al., 2006; Pan & De La Puente, 2005; Simonsen & Elklit, 2008). Regarding SEIS, items were translated and back the method by the committee suggested by Brislin (1980), who said that the members are experienced in sports sciences and sporting events to test the face validity. To test the comprehensibility of the scale items, the pilot study was performed by reaching 54 athletes who participated in the "Gökova Half Marathon" event in the previous year via e-mail between September 1 and October 30, 2023. There were no misunderstandings or objections regarding translated items after pilot study.

After successful translation, the process continued with testing the construct (Confirmatory Factor Analysis) validity, convergent (CR and AVE) validity, and reliability. Hambleton and Patsula (1999), state that for healthy Confirmatory Factor Analysis (CFA), a sample of 5-10 times of scale items are suitable. Accordingly, the data was collected by face-

to-face survey method on November 18, 2023, during the "Gökova Half Marathon" event. 598 athletes registered for the event, 462 athletes completed the race and 418 athletes who completed the competition participated in the study therefore, it can be said that the required sample size for factor analysis was overreached. Following the completion of data collection, normality tests (skewness-kurtosis) and validity analysis (CFA, CR, AVE) were performed then internal consistency (Cronbach's Alpha) was examined in the same 418 athletes to test reliability. In addition, a test-retest reliability analysis was conducted on 113 participants in the same 418 athletes three weeks after when it was seen that no items were eliminated (at the end of the second round of CFA) and the fit indices were within the required range.

Data Collection Tools

The "Personal Information Form" developed by the researchers, which consists of age, gender, and running route preference, and the "Sport Event Image Scale" (SEIS) developed by Kaplanidou and Vogt (2007) was used to collect the data.

In the development phase of SEIS, according exploratory factor analysis (EFA) performed by researchers, it was found that one single factor with 13 items had a high Cronbach's Alpha reliability coefficient (0.920), and the items that loaded on this single factor captured the qualitative aspects identified by the focus group data analysis (Kaplanidou & Vogt, 2007). This single factor consisted of 13 items model was further tested for discriminant and convergent validity (construct validity dimensions) with the survey data. To test for the discriminant validity of the model by reserachers, confirmatory factor analysis (CFA) was conducted to estimate how the sport event image construct correlates with the rest of the constructs. The results supported the discriminant validity of the scale. Low correlation coefficients were observed between sports event image and past experience with the destination ($r = -0.050$), which are variables that semantically should not correlate highly with the event image (Kaplanidou & Vogt, 2007). Convergent validity of the sports event image construct was evaluated by incorporating into the survey questionnaire a brand personality scale by Aaker (1997) "to determine 1) the extent to which the measure correlates with other measures designed to measure the same thing and 2) whether the measure behaves as expected" (Churchill, 1979). This scale was chosen by researchers because brand personality is considered to be associated with brand image (Aaker, 1997). Another CFA was conducted between the two concepts, and the results revealed a significant correlation between the sports

event image and the brand personality scale ($r = 0.590$, $p<0.05$), which supports the convergent validity of the sports event image construct (Kaplanidou & Vogt, 2007).

Participants wrote their age, marked their gender and running route preferences in the personal information form, and indicated their judgments on a 7 point Semantic Differential scale that includes items such as "Unfulfilling/Fulfilling, Stimulating/Unstimulating (reverse coded item), Poor/Excellent, Sad/Joyful, Healthy/Unhealthy (reverse coded item), Boring/Exciting, Gloomy/Cheerful, Valuable/Worthless (reverse coded item), Ugly/Beautiful, Distressing/Relaxing, Unadventurous/Adventurous, Inspiring/Uninspiring (reverse coded item) and Unsupportive/Supportive".

Data Analysis

Descriptive statistics were used to provide personal information about the participants (demographics), the mean and standard deviation, and to test the normality of the research data. Written permission for the use of the scale was obtained from the authors of the SEIS, and ethics committee permission was obtained for this study from Marmara University Health Sciences Institute Ethics Committee within the scope of the doctoral thesis (Protocol No: 21.06.2023/78).

A structural equation modeling approach with maximum likelihood estimation is used to examine the latent variables within their causal structures after understanding that the research data has normal distribution (Thompson, 2008). The two-step approach was used as the basis for estimating the measurement model (Anderson & Gerbing, 1988). A Confirmatory Factor Analysis (CFA) was conducted on the model to ensure the measurement model's psychometric properties. Thereafter, the structural model was estimated to test the causal relationships. Assessing the fit of the model to the research data based on minimum discrepancy divided by degree of freedom (CMIN/DF), root mean square of approximation (RMSEA), root mean square residual (RMR), standardized root mean square residual (SRMR), goodness-of-fit index (GFI), adjusted goodness-of-fit-index (AGFI), comparative fit index (CFI), relative fit index (RFI), normed fit index (NFI) and non-normed fit index (NNFI; NNFI also known as TLI-TuckerLewis index) (Baumgartner & Homburg, 1996; Hu & Bentler, 1999; Tabachnick & Fidell, 2007).

CR (Composite Reliability; Convergent/Construct Reliability) and AVE (Average Variance Explained) were calculated to determine whether the scale provided convergent validity (Fornell & Larcker, 1981; Hair et al., 2010; Kline, 2011). The internal consistency coefficient Cronbach's Alpha was examined for reliability. Test-retest reliability was

conducted to understand whether the measurements obtained at different times were stable over time. For data analysis, SPSS 26 and AMOS 24 package programs were used.

RESULTS

Descriptives

The SEIS's mean score is 5.698±0.423 on the 7-point semantic differential scale. The distributions of the data were examined, and the skewness and kurtosis values were all within ± 2.0, indicating that the normality assumption was maintained (Table 3) and that it was appropriate to proceed with a factor analysis (Hair et al., 2022).

Table 3
Descriptive Statistics

Scale	N	Mean	sd	Skewness	Kurtosis
SEIS	418	5.698	0.423	1.689	1.756
Total	*418*	*5.698*	*0.423*	*1.689*	*1.756*

Confirmatory Factor Analysis (CFA) and Reliability Findings

In this stage of the data analysis process, CFA was performed to test the accuracy of the structural pattern. The factor loadings of the items between 0.764 and 0.959. This can be shown as evidence that the items in the scale strongly represent the dimension they are in (Marsh & Hocevar, 1985).

After the first round of CFA, CMIN/DF=7.427, RMSEA=0.124, and AGFI=0.805 values have been found out of the acceptable fit range (Tabachnick & Fidell, 2007). RFI=0.949 value has been found to be an acceptable fit (Byrne, 2011; Hu & Bentler, 1999) and RMR=0.006, SRMR=0.005, GFI=0.957, CFI=0.989, NFI=0.987 and NNFI(TLI)=0.956 values have been found excellent fit range (Bentler, 1980; Kline, 2011). The initial round of CFA results revealed insufficient fit indices values for CMIN/DF, RMSEA, and AGFI. In order to see if any improvements occur in the values, the CFA is repeated according to the suitable modification suggestions, which did not contradict with the theoretical frame of the original scale (Kline, 2011; p.210). In line with the suggestion of the analysis program, modification was made between items 6 and 7 in a way that would not disrupt the theoretical structure of the scale. The model diagram of the scale after the second round of CFA is shown in Figure 1.

Figure 1
Model Diagram of the Sport Event Image Scale

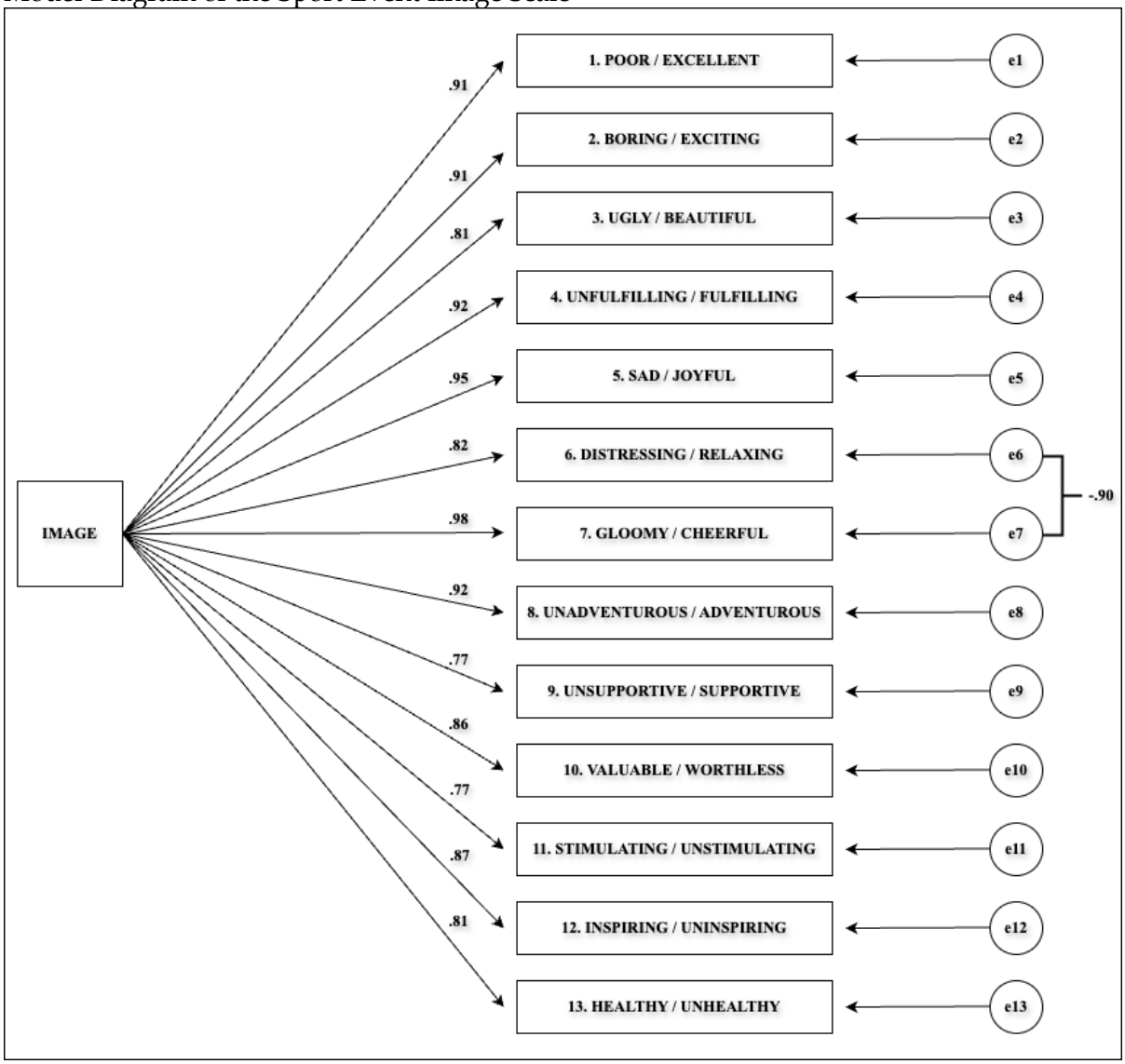

Table 4 shows the goodness of fit values of the scale after modification in the second round of CFA. CMIN/DF, RMSEA and AGFI values have been found acceptable fit (Awang, 2012; Tabachnick & Fidell, 2007). RMR, SRMR, GFI, RFI, CFI, NFI and NNFI (TLI) values have been found excellent fit ranges (Baumgartner & Homburg, 1996; Bentler, 1980; Bentler & Bonet, 1980; Byrne, 2011; Engel et al., 2003; Hu & Bentler, 1999; Marsh & Hocevar, 1985).

Table 4
Goodness of Fit Index

Fit Index	Excellent Treshold	Acceptable Treshold	SEIS
[1]CMIN/DF	0<CMIN/DF<2	2<CMIN/DF<5	3.441
[2]RMSEA	0<RMSEA<0.05	0.05<RMSEA<0.08	0.077
[3]RMR	0<RMR<0.05	0.05<RMR<0.08	0.007
[3]SRMR	0<SRMR<0.05	0.05<SRMR<0.1	0.006
[4]GFI	0.95<GFI<1	0.90<GFI<0.95	0.976
[4]AGFI	0.90<AGFI<1	0.85<AGFI<0.90	0.885
[5]RFI	0.95<RFI<1	0.90<RFI<0.95	0.976
[6]CFI	0.95<CFI<1	0.90<CFI<0.95	0.996
[7]NFI	0.95<NFI<1	0.90<NFI<0.95	0.994
[7]NNFI (TLI)	0.95<NNFI<1	0.90<NNFI<0.95	0.983

Note. [1567] (Bentler & Bonet, 1980), [1457] (Marsh & Hocevar, 1985), [15] (Byrne, 2011), [2] (Hair et al., 2010), [124] (Tabachnick & Fidell, 2007), [2] (Awang, 2012), [3456] (Hu & Bentler, 1999), [34] (Kline, 2011), [47] (Baumgartner & Homburg, 1996), [4] (Engel et al., 2003), [67] (Bentler, 1980).

In addition, CR (Composite Reliability; Convergent/Construct Reliability) and AVE (Average Variance Explained) were calculated to determine whether the scale has convergent validity. Table 5 shows that CR was bigger than 0.700 and AVE was bigger than 0.500. According to these construct validity values, it is understood that the factor and all items met the convergent validity (Fornell & Larcker, 1981; Hair et al., 2010; Kline, 2011).

Two different techniques were used to determine SEIS's reliability. Cronbach's Alpha was 0.976 as the internal consistency coefficient value, and Pearson's R was 0.901 as the test-retest correlation coefficient to test the scale's consistency over time, which was conducted after a three-week interval from CFA (Table 5).

Table 5
CR, AVE, Cronbach's Alpha and Test-Retest Results

Scale	CR	AVE	Cronbach's Alpha	Test-Retest
SEIS	0.979	0.782	0.976	0.901

DISCUSSION

The current study, which purposed to adapt and test the validity and reliability of the "Sport Event Image Scale" for the Turkish population, included several phases such as translation from the original language to Turkish, confirmation of the psychometric structure, and testing the reliability. After translation of SEIS into the target language, normality was checked and to test the compatibility of the Turkish version with the original version's psychometric structure a confirmation analysis was performed via CFA (Anderson & Gerbing, 1988). CFA were conducted using the maximum likelihood estimation method.

Various studies on goodness fitting and lack of fitting are used in CFA. However, more than 30 indices are developed as fit indices and/or lack of fit indices (Marsh et al., 1988). However, these indices are not always consistent, leading to disagreements about the "best-fit index" (Thompson & Daniel, 1996). Steiger (1990), states that there is no such concept as "best fit coefficient". For that reason, Jaccard and Wan (1996) emphasize that at least 3 indices, and Kline (2011) emphasize that at least 4 indices should be reported in studies involving model estimation. Raykov et al. (1991) recommended reporting the CMIN/DF, RMSEA, RMR, NFI, NNFI (TLI), and CFI; Hu and Bentler (1999) suggested reporting the CMIN/DF, RMSEA, SRMR, CFI, and NNFI (TLI) indices. Also, Fornell and Larcker (1980), with Bentler and Bonett (1980) recommendations were to report CMIN/DF, RMSEA, NFI, CFI, and GFI; Hair et al. (2010) CMIN/DF, RMSEA, AGFI, CFI, NFI, and GFI indices. While such indices can be classified into two different categories, such as fit or lack of fit indices, there is a more common classification in the literature. According to the most basic common classification in the literature, fit and lack of fit indices are classified into two categories; (a) absolute fit indices, and (b) incremental or relative fit indices (Widaman & Thompson, 2003; Yuan, 2005). In this study, recommended indices according to the literature mentioned above, CMIN/DF, RMSEA, RMR, SRMR, AGFI, and GFI considered as absolute fit, and RFI, CFI, NFI and NNFI (TLI) are considered as incremental or relative fit indices were used (Gupta & Singh 2014; Mulaik et al., 1989; Yurdugül, 2007).

Chinese adapted version of the SEIS, GFI was 0.960 (excellent fit; Huang et al., 2015) while Korean version of GFI was 0.912 (acceptable fit) and AGFI was 0.907 (acceptable fit) (Girish & Lee, 2019). Baumgartner and Homburg (1996), Engel et al. (2003), Marsh and Hocevar (1985), Tabachnick and Fidell (2007), suggest that 0.900 for GFI and 0.850 and above for AGFI are acceptable fit values. The results showed that the model has similar GFI and AGFI values in previous adaptations of SEIS. Excellent fit index values for GFI (0.976) and acceptable fit index values for AGFI (0.885).

Koo et al. (2014) used the scale (in the original English version) in their research regarding event images and reported the CFI value as 0.923 (acceptable fit). Chinese adapted version of the SEIS CFI was 0.970 (excellent fit; Huang et al., 2015), and the Korean version of the CFI was 0.951 (excellent fit; Girish & Lee, 2019). CFI compares the fit model with the fit null hypothesis model that ignores correlation and covariance between latent variables. It predicts that there is no relationship between variables. Between 0-1 values show that CFI has the goodness of fit and increases as it approaches 1. For CFI to be accepted, it is expected to

exceed 0.900 (Bentler, 1980; Bentler & Bonet, 1980; Hu & Bentler, 1999). Parallel to the previous adaptations of SEIS, the CFI value obtained from this study (0.996) indicates an excellent fit.

Chinese adapted version of the SEIS, NFI was 0.950 (acceptable fit; Huang et al., 2015), and the Korean version of the NFI was 0.927 (acceptable fit; Girish & Lee, 2019). NFI investigates the fit hypothesized model with the null hypothesis model, and the value found is desired to be above 0.900; the closer it is to 1, the better the goodness of fit (Baumgartner & Homburg, 1996; Bentler, 1980; Bentler & Bonet, 1980; Marsh & Hocevar, 1985). While in previous adaptations of the SEIS, the CFI has been found to be an acceptable fit, in this adaptation study, the NFI value, which has an excellent fit, was found to be 0.994.

Koo et al. (2014) reported the NNFI (TLI) value as 0.913 (acceptable fit) in their study using SEIS. The NNFI or TLI attempts to correct for negative bias by considering the null model and the degrees of freedom of the researcher's model. More significant than 0.900 is recommended for an acceptable fit NNFI (TLI; Baumgartner & Homburg, 1996; Bentler, 1980; Bentler & Bonet, 1980; Marsh & Hocevar, 1985). While Koo et al. (2014) have found an acceptable fit, in this adaptation study, the NNFI (TLI) value was found to be 0.994, which is an excellent fit.

RFI includes a factor that represents deviations from a null model and compares the hypothesized model chi-square to one from a “null” or “baseline” model. It takes a value between 0-1 and an acceptable RFI to exceed 0.900 (Bentler & Bonet, 1980; Byrne, 2011; Hu & Bentler, 1999; Marsh & Hocevar, 1985). The RFI value was found to be 0.976, which has an excellent fit. Neither in previous adaptations of the SEIS, nor in the original version, the RFI index, has been reported.

RMR value changes depend on size, number of variables, and values of other fit indices. SRMR is a standardized version of RMR. While the RMR and SRMR values are expected to be below 0.050, it is stated that this value can be stretched up to 0.080 for RMR and 0.1 for SRMR (Hu & Bentler, 1999; Kline, 2011). The RMR value of the scale is at the level of excellent fit with 0.007 and SRMR is also excellent fit with 0.006. Koo et al. (2014) found SRMR value acceptable fit of 0.053 in their study related to event images.

Korean adapted version of the SEIS, RMSEA was 0.031 (excellent fit; Girish & Lee, 2019) while Chinese version of RMSEA was 0.060 (acceptable fit; Huang et al., 2015). Koo et al. (2014) reported the RMSEA value as 0.053 (acceptable fit) in their study using SEIS. RMSEA is an index that evaluates fit as a function of degrees of freedom (DF); according to Tabachnick and Fidell (2007), the expected RMSEA value should be less than 0.050, but it is stated that up to

0.080 is acceptable (Awang, 2012; Hair et al., 2010). The RMSEA value of this adaptation study is at the level of acceptable fit with 0.077, which is a parallel result of previous adaptations of SEIS.

Chinese adapted version of the SEIS, CMIN/DF was 1.880 (excellent fit; Huang et al., 2015), and Korean version was 1.690 (excellent fit; Girish & Lee, 2019). CMIN/DF is the minimum discrepancy divided by the degree of freedom; less than 2 is an excellent fit, whereas between 2 and 5 refers to an acceptable fit (Bentler & Bonet, 1980; Byrne, 2011; Marsh & Hocevar, 1985; Tabachnick & Fidell, 2007). While Huang et al. (2015) with Girish and Lee (2019) report the CMIN/DF values as an excellent fit, Koo et al. (2014) has been found an acceptable fit at 2.405. In this adaptation study, the CMIN/DF value was found to be 3.441, which is an acceptable fit similar to that of Koo et al. (2014).

When the convergent validity of the scale was evaluated as a result of CFA, there were no statements below the lower cut-off point of 0.764 among the 13 items. Fornell and Larcker (1981), show that factor loadings exceed 0.700 as evidence of convergent validity. When all of the scale items are evaluated, it can be said that convergent validity is achieved. In addition that, CR and AVE values were calculated. CR was bigger than 0.700 and AVE was bigger than 0.500. According to these construct validity values, it is understood that all items met the convergent validity (Fornell & Larcker, 1981; Hair et al., 2010). In previous adaptations of the SEIS; Chinese version CR was 0.830 (CR > 0.700) and AVE was 0.660 (AVE > 0.500; Huang et al., 2015), while Korean version CR was 0.940 (CR > 0.700) and AVE was 0.760 (AVE > 0.500) (Girish & Lee, 2019). Also, Koo et al. (2014) reported to CR value as 0.924 (CR > 0.700) and AVE as 0.607 (AVE > 0.500) in their study using SEIS. Convergent validity was evaluated with the help of another scale (a brand personality) developed by Aaker (1997) in the original version of SEIS. Researchers chose this scale because brand personality is considered to be associated with brand image (Aaker, 1997). The results revealed a significant correlation between the sports event image and the brand personality scale ($r = 0.590$, $p < 0.05$), which supports the convergent validity of the sports event image construct (Kaplanidou & Vogt, 2007). The same procedure was made by Kogoya et al. (2022) in the Indonesian version of SEIS ($r = 0.675$, $p < 0.05$).

In the evaluation of the reliability of the SEIS, internal consistency analysis was performed. Cronbach's Alpha coefficient for the total scale is 0.976. According to DeVellis (2017) with Nunnally and Bernstein (1994), when the Cronbach's Alpha coefficient is more significant than 0.900, the scale has a high level of reliability. As can be understood from this,

the adaptation of SEIS in Turkish culture has high internal consistency. In previous adaptations of the SEIS, Korean version of Cronbach's Alpha was 0.837 (Girish & Lee, 2019), while Chinese version of Cronbach's Alpha was 0.870 (Huang et al., 2015). Also, Koo et al. (2014) found the Cronbach's Alpha coefficient value as 0.896 in their study using SEIS. The original version of SEIS internal consistency was found to be 0.920 (Kaplanidou & Vogt, 2007). Test-retest reliability analysis was conducted on 113 participants in the same group three weeks after the fit indices were within the acceptable range. The correlation coefficient (Pearson's R) between the measurements was calculated as 0.901. According to Hair et al. (2010), the Pearson's correlation coefficient, which shows the test-retest result, indicates a high level of relationship as it approaches 1. In other words, it can be said that there is a high consistency among the items in the scale, meaning that there is no problem with the reliability of the scale over time.

Limitations

The study sample, which was composed of runners of the Gökova Half Marathon event, may be the limitation of this study. Therefore, in the following research studies, testing the reliability and validity of the scale through different sports events with different participants (active sport tourists) may contribute to its reliability and validity and strengthen its functionality in different sample groups.

CONCLUSION

Results showed that adapted SEIS maintained the psychometric properties of the original scale. Moreover, it had adequate CFA fit indices and a high level of internal consistency coefficients. This feature of adapted SEIS in Turkish culture is similar to previous adaptations of it in different cultures (Girish & Lee, 2019; Huang et al., 2014; Kogoya et al., 2022). To conclude, the "Sport Event Image Scale" can be considered as a valid and reliable instrument for research studies that will be conducted on the Turkish population to make meaningful interpretations of the general image of sports events organized in Türkiye.

Athletes can be motivated to participate in a sports event for several reasons, including the unique qualities of the event that differentiate it from others in the marketplace or the event's image and reputation (Aicher & Brenner, 2015; Lough et al., 2016). Therefore, it is important to know the overall image of the sports event in order to attract these motivated athletes to the event, to make a satisfied and loyal consumer base, to add distinctive features

to the event, and to have a strategic position in the market. Limited research was found in international literature regarding event image relationship with participant motivation, past experience, satisfaction, loyalty, and behavioral intention (Girish & Lee, 2019; Huang et al., 2015; Kogoya et al., 2022; Koo et al., 2014; Lianopoulos et al., 2021). When the Turkish sports literature is examined, there is no research regarding the effect of sports event image on event participation, motivation, and event loyalty. It is recommended to conduct research on sports event image using this adapted scale.

PRACTICAL IMPLICATIONS

In Türkiye, especially in recent years, there has been an increase in the number of public and private events in many sports disciplines and a corresponding increase in the mobility of domestic sports athletes. This positive situation not only intensifies competition between events but also challenges event organizers and managers in terms of the sustainability of the event in the following years.

To hold a competitive advantage over other athletic events, it is important for event organizers and managers to determine the overall image of their sports event in order to build satisfied and loyal participants. Emphasizing the distinctive qualities of the event, investing in the event in all kinds of emotional, social, organizational, and physical dimensions that will make a difference, or finding the right and appropriate sponsors to invest in, is the biggest task of event organizers and managers in terms of both sustainability and creating a satisfied and loyal participant profiles.

The SEIS, adapted through this study, is very valuable for event organizers and managers in terms of evaluating the related sport event's image from the perspective of active athlete participants. Gathering such information would be fruitful for organizers and managers to determine the event's position in the market, identify the distinctive features of the event, and find the right sponsors suitable for the event's image.

In line with the results obtained from the research, the following recommendations have been developed.

- It is recommended that brands that want to sponsor sports events evaluate the compatibility between their company and the event image using the SEIS before making the sponsorship decision.
- Sponsorship involves image sharing for both parties. Sports marketers who want to strengthen the sport event image are recommended to test the event image using

the scale before planning the sponsorship process and to choose the sponsors using the data obtained.

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Authors' Contributions

The first and second authors contributed to conceptualizing the research, literature review, data collection, research outline, determining the research method, collecting the data, evaluating the data analysis, and critically interpreting the final draft. The first and third authors contributed to performing data analysis, evaluating findings, and critical interpretation of the final draft.

Declaration of Conflict Interest

The authors declared no potential conflicts of interest regarding the research, authorship, and/or publication of this article.

Ethics Statements

The authors of the SEIS gave written permission to use the scale, and the ethics committee of Marmara University Health Sciences Institute gave permission for this study within the scope of the doctoral thesis (Protocol No: 21.06.2023/78).

REFERENCES

Aaker, D. A. (2009). *Managing brand equity: Capitalizing on the value of a brand name.* NY: The Free Press.

Aaker, J. L. (1997). Dimensions of brand personality. Journal of Marketing Research, 34(3), 342-352. https://doi.org/10.2307/3151897

Aicher, T. J. & Brenner, J. (2015). Individuals' motivation to participate in sport tourism: a self-determinationtheory perspective. *International Journal of Sport Management Recreation & Tourism, 18*(1), 56-81. https://doi.org/10.5199/ijsmart-1791-874X-18d

Aicher, T. J., Simmons, J., & Cintron, A. (2018). An analysis of running event consumer behaviors. *Journal of Applied Sport Management, 10*(2), 26-35. https://doi.org/10.18666/JASM-2018-V10-I2-8836

Alay, S. (2008). Female consumers' evaluations of sponsorship and their response to sponsorship. *South African Journal for Research in Sport, Physical Education and Recreation, 30*(2), 15-29. https://doi.org/10.4314/sajrs.v30i2.25976

Alay, S. (2010). Sponsorship evalutation scale (SES): A validity and reliability study. *South African Journal for Research in Sport, Physical Education and Recreation, 32*(2), 1-12. https://doi.org/10.4314/sajrs.v32i2.59291

Alexandris, K. (2016). Testing the role of sport event personality on the development of event involvement and loyalty. *International Journal of Event and Festival Management, 7*(1), 2-20. https://doi.org/10.1108/IJEFM-10-2015-0041

Anderson, J. C. & Gerbing, D. W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin, 103*(3), 411-423. https://doi.org/10.1037/0033-2909.103.3.411

Awang, Z. (2012). *A handbook on structural equation modelling: SEM using AMOS graphic*. Kota Baru: Universiti Teknologi Mara Kelantan.

Baloğlu, S. & McCleary, K. W. (1999). A model of destination image formation. *Annals of Tourism Research, 26*(4), 868-897. https://dx.doi.org/10.1016/S0160-7383(99)00030-4

Baumgartner, H. & Homburg, C. (1996). Applications of structural equation modeling in marketing and consumer research: A review. *International Journal of Research in Marketing, 13*(2), 139-161. https://doi.org/10.1016/0167-8116(95)00038-0

Bentler, P. M. (1980). Multivariate analysis with latent variables: Causal modeling. *Annual Review Of Psychology, 31*(1), 419-456. https://doi.org/10.1146/annurev.ps.31.020180.002223

Bentler, P. M. & Bonett, D. G. (1980). Significance tests and goodness of fit in the analysis of covariance structures. *Psychological Bulletin, 88*(3), 588-606. https://doi.org/10.1037/0033-2909.88.3.588

Brislin, R. W. (1980). Translation and content analysis of oral and written material. *Handbook of Cross-Cultural Psychology, 2*(2), 349-444.

Byrne, B. M. (2011). *Structural equation modeling with Amos basic concepts, applications and programming*. NY: Routledge.

Cevallos, D. M., Alguacil, M., & Moreno, F. C. (2020). Influence of brand image of a sports event on the recommendation of its participants. *Sustainability MDPI, 12*(12), 1-13. https://doi.org/10.3390/su12125040

Chalip, L. & Costa, C. (2005). Sport event tourism and the destination brand: Towards a general theory. *Sport in Society, 8*(2), 218-237. https://doi.org/10.1080/17430430500108579

Churchill, G. A. J. (1979). A paradigm for developing better measures of marketing constructs. *Journal of Marketing Research, 16*(1), 64–73. http://dx.doi.org/10.2307/3150876

DeVellis, R. F. (2017). *Scale development: Theory and applications*. Thousand Oaks, CA: Sage.

Dever, A. & Sözen, (2021). *Sports sociology*. Gazi Publications.

Dos-Santos, M. A., Vveinhardt, J., Calabuig-Moreno, F., & Montoro-Rios, F. J. (2016). Involvement and image transfer in sports sponsorship. *Engineering Economics, 27*(1), 78–89. https://doi.org/10.5755/j01.ee.27.1.8536

Engel, K., Moosbrugger, H., & Müller, H. (2003). Evaluating the fit of structural equation models: Tests of significance and descriptive goodness of fit measures. *Methods of Psychological Research Online, 8*(2), 23-74. https://doi.org/10.23668/psycharchives.12784

Filo, K. R., Funk, D. C., O'Brien, D., Dwyer, L., & Fredline, L. (2008). It's really not about the bike: Exploring attraction and attachment to the events of the Lance Armstrong Foundation. *Journal of Sport Management, 22*(5), 501-525. https://doi.org/10.1123/jsm.22.5.501

Fornell, C. & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research, 18*(1), 39-50, https://doi.org/10.1177/002224378101800104

Girish, V. G. & Lee, C. (2019). The relationships of brand experience, sports event image and loyalty: Case of Jeju International Ultramarathon Race. *International Journal of Sports Marketing and Sponsorship, (20)*4, 567-582. https://doi.org/10.1108/IJSMS-08-2017-0095

Grohs, R. & Reisinger, H. (2014). Sponsorship effects on brand image: The role of exposure and activity involvement. *Journal of Business Research, 67*(5), 1018–1025. http://dx.doi.org/10.1016/j.jbusres.2013.08.008

Gupta, K. & Singh, N. (2014). Fit estimation in SEM: A synthesis of related statistics. *HSB Research Review, 8*(2), 20-27.

Gwinner, K. P. (1997). A model of image creation and image transfer in event sponsorship. *International Marketing Review, 14*(3), 145-158. http://dx.doi.org/10.1108/02651339710170221

Gwinner, K. P. & Eaton, J. (1999). Building brand image through event sponsorship: The role of image transfer. *Journal of Advertising, 28*(4), 47-57. https://doi.org/10.1080/00913367.1999.10673595

Gwinner, K. P. (2005). *Image transfer in global sport sponsorship*. Berg: NY.

Gwinner, K. P., Larson, B. V., & Swanson, S. R. (2009). Image transfer in corporate event sponsorship: Assessing the impact of team identification and event-sponsor fit. *International Journal of Management and Marketing Research, 2*(1), 1-15.

Gwinner, K.P. (2013). *Levaraging brand in sport business*. Routledge.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). *Multivariate data analysis*. NY: Prentice Hall.

Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2022). *A primer on partial least squares structural equation modeling (PLS-SEM)*. CA: Sage Publications.

Hallmann, K., Kaplanidou, K., & Breuer, C. (2010). Event image perceptions among active and passive sport tourists at marathon races. *International Journal of Sports Marketing and Sponsorship, 12*(1), 37-52. https://doi.org/10.1108/IJSMS-12-01-2010-B005

Hambleton, R. K. & Patsula, L. (1999). Increasing the validity of adapted tests: Myths to be avoided and guidelines for improving test adaptation practices. *Journal of Applied Testing Technology, 1*(1), 1-30.

Hu, L. T. & Bentler, P. M. (1999). Cut off criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*(1), 1-55. http://dx.doi.org/10.1080/10705519909540118

Huang, H., Lunhua Mao, L., Wang, J., & Zhang, J. J. (2015). Assessing the relationships between image congruence, tourist satisfaction and intention to revisit in marathon tourism: The Shanghai International Marathon. *International Journal of Sports Marketing and Sponsorship, 16*(4), 46-66. https://doi.org/10.1108/IJSMS-16-04-2015-B005

Jaccard, J. & Wan, C. K. W. (1996). LISREL approaches to interaction effects in multiple regression. Sage Publications.

Kapferer, J. N. (2012). *The new strategic brand management: Advanced insights and strategic thinking*. London: Kogan Page.

Kaplanidou, K. (2007). Affective event and destination image: Their influence on Olympic travelers' behavioral intentions. *Event Management, 10*(2), 159-173. https://doi.org/10.3727/152599507780676706

Kaplanidou, K. & Vogt, C. (2007). The interrelationship between sport event and destination image and sport tourists' behaviours. *Journal of Sport and Tourism, 12*(3), 183-206. https://doi.org/10.1080/14775080701736932

Kaplanidou, K. (2010). Active sport tourists: Sport event image considerations. *Tourism Analysis, 15(*3), 381-386. https://doi.org/10.3727/108354210X12801550666303

Karagiorgos, T., Ntovoli, A., & Alexandris, K. (2022). Developing a brand personality framework in the context of outdoor small-scale sport events. *Journal of Convention & Event Tourism*, *24*(3), 246-268. https://doi.org/10.1080/15470148.2022.2158153

Keller, K. (2003). Undestanding brands, branding and brand equity. Journal of Direct, Data and Digital Practise, 5(1), 7-20. https://doi.org/10.1057/palgrave.im.4340213

Khan, B., Ahmed, A., & Abid, G. (2016). Using the 'big-five' for assessing personality traits of the champions: An insinuation for the sports industry. *Pakistan Journal of Commerce and Social Sciences, 10*(1), 175-191.

Kline, R. B. (2011). *Principles and practice of structural equation modeling*. London: Guilford Publications.

Kogoya, K., Guntoro, T. S., & Putra, M. F. P. (2022). Sports event ımage, satisfaction, motivation, stadium atmosphere, environment, and perception: A study on the biggest multi-sport event in Indonesia during the pandemic. *Social Sciences MDPI, 11*(6), 1-13. https://doi.org/10.3390/socsci11060241

Koo, S. K., Byon, K. K., & Baker, T. A. (2014). Integrating event image, satisfaction, and behavioral intention: Small-scale marathon event. *Sport Marketing Quarterly, 23*(3), 127-137.

Kotler, P. (2002). *Marketing management: Analysis, planning and control.* Englewood Cliffs: Prentice-Hall.

Lee, H. S. & Cho, C. H. (2009). The matching effect of brand and sporting event personality: Sponsorship implications. *Journal of Sport Management, 23*(1), 41-64. https://doi.org/10.1123/jsm.23.1.41

Lianopoulos, Y., Theodorakis, N. D., Alexandris, K., & Papanikolaou, M. (2021). Testing the relationships among event personality, event image and runners' loyalty: A study of an international running event. *Sport, Business and Management: An International Journal 12*(1), 189-207. https://doi.org/10.1108/SBM-12-2020-0135

Lough, N. L., Pharr, J. R., & Geurin, A. (2016). I am bolder: A social cognitive examination of road raceparticipant behavior. *Sport Marketing Quarterly, 25*(2), 90-102.

Marsh, H. W. & Hocevar, D. (1985). Application of confirmatory factor analysis to the study of self-concept: First and higher order factor models and their invariance across groups. *Psychological Bulletin, 97*(1), 562-582. https://doi.org/10.1037/0033-2909.97.3.562

Marsh, H. W., Balla, J. R., & McDonald, R. P. (1988). Goodness-of-fit indexes in confirmatory factor analysis: The effect size. *Psychological Bulletin, 103*(3), 391-410. https://doi.org/10.1037/0033-2909.103.3.391

Martinez, G., Marin. B., & Schoua-Glusberg A. (2006). Translating from English to Spanish: The 2002 national survey of family growth. *Hispanic Journal of Behaviour Science, 28*(1), 531-545. https://doi.org/10.1177/07399863062922

Min, D. & Lee, W. (2022). The relationships between sport spectators' experience, destination image, event image and behavioral intention: The case of the 18th FINA World Aquatics Championships. International Journal of Applied Sports Sciences, 34(2), 183-202. https://doi.org/10.24985/ijass.2022.34.2.183

Mulaik, S. A., James, L. R., Van Alstine, J., Bennett, N., Lind, S., & Stilwell, C. D. (1989). Evaluation of goodness-of-fit indices for structural equation models. *Psychological Bulletin, 105*(3), 430-445. https://doi.org/10.1037/0033-2909.105.3.430

Nunnally, J. C. & Bernstein, I. H. (1994). *Psychometric theory*. New York: McGraw-Hill.

Ocakoğlu, O. (2020). Factors influencing race selection of runners. *Gazi Journal of Physical Education and Sport Sciences, 25*(2), 77-92.

Pan, Y. & De La Puente, M. (2005). *Census bureau guideline for the translation of data collection instruments and supporting materials*. Washington DC: Educational Research Press.

Raykov, T., Tomer, A., & Nesselroade, J. R. (1991). Reporting structural equation modeling results in psychology and aging: Some proposed guidelines. *Psychology and Aging, 6*(1), 499–503. https://doi.org/10.1037/0882-7974.6.4.499

Simonsen, E. & Elklit, A. (2008). *Experiences in translating and validating the MCMI in Denmark*. NewYork: Guilford Press.

Steiger, J.H. (1990). Structural model evaluation and modification: An interval estimation approach. *Multivariate Behavioral Research, 25*(2), 173-80. https://doi.org/10.1207/s15327906mbr2502_4

Tabachnick, B. G. & Fidell, L. S. (2007). *Using multivariate statistics.* Boston: Pearson Education Inc.

Thompson, B. (2008). *Foundations of behavioral statistics: An insight-based approach*. New York: Guilford Press.

Thompson, B. & Daniel, L. G. (1996). Factor analytic evidence for the construct validity of scores: A historical overview and some guidelines. *Educational and Psychological Measurement, 56*(2), 197-208. https://doi.org/10.1177/0013164496056002001

Tiessen-Raaphorst, A. (2016). Running across Europe: The rise and size of the largest sport markets. *European Journal for Sport and Society, 13*(1), 250-251. https://doi.org/10.1080/16138171.2016.1226032

Walraven, M., Bijmolt, T., Koning, R., & Los, B. (2016). Benchmarking sports sponsorship performance: Efficiency assessment with data envelopment analysis. *Journal of Sport Management, 30*(4), 411-426. https://doi.org/10.1123/jsm.2015-0117

Wang, J. J., Wann, D. L., Lu, Z., & Zhang, J. J. (2018). Self-expression through sport participation: Exploring participant desired self-image. *European Sport Management Quarterly, 18*(5), 583-606. https://doi:10.1080/16184742.2018.1446994

Widaman, K. F. & Thompson, J. S. (2003). On specifying the null model for incremental fit indices in structural equation modeling. *Psychological Methods, 8*(1), 16-37. https://doi.org/10.1037/1082-989X.8.1.16

Wu, M. H. & Liu, C. C. (2017). The influences of motivations, past experiences, destination image, event image, satisfaction and intentions on participation in Taiwan road running events. *The Journal of Human Resource and Adult Learning, 13*(1), 26-38.

Yuan, K. (2005). Fit indices versus test statistics. *Multivariate Behavioral Research, 40*(1), 115-148. https://doi.org/10.1207/s15327906mbr4001_5

Yurdugül, H. (2007). The effects of different correlation types on goodness-of-fit indices in first order and second order factor analysis for multiple choice test data. *Elementary Education Online, 6*(1), 154-179.

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Pamukkale J Sport Sci, 16(1), 23-51, 2025 Research Article

"The Water's Very Nice, Come On!": The Mediating Role of Event Satisfaction in the Relationship Between Flow Experience and Personal Well-Being

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ABSTRACT

The study aimed to investigate the mediating role of event satisfaction in the relationship between recreational flow experience and personal well-being in a sample participating in swimming events. A total of 301 volunteers participated in this research, comprising 139 females (46.2%) and 162 males (53.8%). The ages of participants varied from 18-60 years ($Mean_{age}$ = 35.44±7.84). As data collection tools, the Recreational Flow Experience Scale (RFES), Event Satisfaction Scale (ESS), and Personal Well-Being Index-Adult (PWBI-A) were used. In accordance with the basic aim of the study, mediation analysis was performed using the PROCESS macro for data analysis. When the correlation coefficients related to the scales were investigated, statistically moderate and high levels of positive significant correlations were identified between the mean scores for recreational flow experience, event satisfaction, and personal well-being among individuals participating in swimming events ($p < 0.01$). The analysis results indicate that recreational flow experience had a positive and direct significant effect on personal well-being ($\beta = 0.22$; $p < 0.01$). Additionally, event satisfaction was confirmed to play a mediating role in the relationship between recreational flow experience and personal well-being ($\beta = 0.21$; $p < 0.01$). The results show that individuals regularly participating in swimming events will have increased personal well-being mediated by the satisfaction they obtain from the event by experiencing flow. The study emphasizes the potential of flow experiences and event satisfaction to contribute to the well-being of individuals.

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INTRODUCTION

Leisure is time remaining after mandatory work and responsibilities that individuals may use freely (Roberts, 2018). During this time, individuals may relax physically or mentally and participate in activities to help develop themselves (Chick et al., 2016; Koçak & Gürbüz, 2024). Home-based activities, outdoor activities, cultural, artistic, social, and touristic activities, and physical activity-based events offer a variety of choices for individuals to pass their leisure time (Gürbüz, 2017; Kelly, 2019; Stebbins, 1992). Leisure activities, encompassing a broad range of choices such as home-based, outdoor, cultural, and physical pursuits, are crucial in enhancing individuals' overall well-being (Chick et al., 2022; Doğan, 2021). Within this diverse spectrum, physical activity-based options stand out, offering unique opportunities for both health and enjoyment, among which water sports hold a special place.

From this perspective, water sports are among important physical activity-based recreational activities supporting bodily health and ensuring mental relaxation for individuals (Choi & Park, 2021). Water-based activities like swimming, canoeing, and surfing offer the opportunity to spend leisure more productively and satisfyingly. Activities completed in aqueous environments offer a different experience to individuals compared to sporting activities on land due to the unique physical properties of water. For example, swimming improves general fitness by lessening the pressure on joints and supports cardiovascular health (Tanaka, 2009). Cumming (2017) stated that regular swimming improved cardiac and vascular health and lowered blood pressure. Additionally, movements against water resistance increase muscle strength and benefit joint health, and these features make it ideal for individuals with joint disorders (Silva et al., 2020). According to research, swimming does not just offer physical benefits; at the same time, it supports general psychological well-being by improving the mental state of individuals (Overbury et al., 2023; Sheard & Golby, 2006). Research shows that swimming reduces levels of stress, anxiety, and burnout with this psychologically relaxing effect (Sukur et al., 2023). The positive effects of water on mental health become more pronounced for water-based activities like swimming. This effect is largely related to the relaxing feeling created by water on the body, and regular swimming is associated with increasing endorphin production (Carrasco et al., 2007). Endorphins reduce stress, making individuals feel happier and improving general psychological health (Özant, 2024; Sran et al., 2021). Due to water activities like swimming, individuals experience flow, an area of study in positive psychology (Chen & Meggs, 2021). Flow is frequently observed

during repetitive and rhythmic activities like swimming. While swimming, individuals focus on bodily movements, are removed from external stimuli, and only feel within the water, which may trigger flow.

In recent years, recreational flow experience has emerged as a prominent research topic, particularly in terms of the intense focus and satisfaction individuals experience during their leisure activities (Ahn & Song, 2024; Er & Cengiz, 2023; Sevim et al., 2022). However, studies examining the impact of flow experience on event satisfaction remain relatively limited (Armbrecht & Andersson, 2020; Ding et al., 2023). Investigating the relationship between recreational flow experience and event satisfaction, especially in from swimming activities. Activities like swimming, which require intense focus, can uniquely affect individuals' physical and psychological well-being. This study aims to explore the relationship between recreational flow experience and event satisfaction in the context of swimming, thereby addressing gaps in the literature and offering unique contributions to understanding individuals' well-being.

Recreational flow results from positive or negative evaluation of general life satisfaction with personal well-being when an individual focuses on recreational activities, shaped by the feelings and emotions obtained from these activities (Sidorová, 2015). Individuals with high-flow experiences participate intensely in recreational activities and greatly benefit from this process (Akçakese et al., 2024). This contributes to individuals experiencing positive feelings by keeping them from negative feelings (Cheng & Lu, 2015). In this context, the specific features of the flow experience, such as concentration (Marty-Dugas & Smilek, 2019), intrinsic motivation (Mehta & Vyas, 2022), and a sense of control (Wu et al., 2020), may positively influence personal well-being through the mediation of event satisfaction.

Theoretical Framework and Hypotheses

Relationship Between Recreational Flow Experience and Event Satisfaction

Flow is a psychological state characterized by internal motivation when individuals fully concentrate on an activity and feel deep satisfaction (Csikszentmihalyi & Larson, 2014). This concept was first proposed by Mihaly Csikszentmihalyi and was defined as an individual's perception of time being lost during an activity when they focus intensely and achieve enjoyment (Csikszentmihalyi, 2013). Flow ensures individuals are fully caught up in an activity by creating a balance between the capabilities of the individuals and the level of difficulty of the activity. Among the basic features of flow are the individual focusing on the

activity at a high level, feeling time passing quickly, internal satisfaction obtained from the activity, dealing with difficult but doable tasks, and feeling in full control of the activity (Csikszentmihalyi, 2020). Flow may be observed in a variety of areas like sports, art, music, games, and work life, generally (Nakamura & Csikszentmihalyi, 2002). In this context, the flow experienced by individuals during swimming ensures the opportunity to understand the psychological effects of this activity more deeply. Swimming is an activity with features triggering flow because individuals perform continuous repetitive movements and physically adjust to the resistance provided by the water while swimming; they enter a certain rhythm. This situation allows the person the opportunity to fully focus, both physically and mentally, on the swimming activity. Smith (2021) stated that swimming is strongly associated with the flow experience, enabling individuals to connect deeply with water and their surroundings. Swimming in a state of flow enhances individuals' physical performance and increases their ecological awareness and sensitivity. This experience emerges at a point where the individual's capabilities are tested but not overwhelmed, and this situation may ensure that the individual obtains satisfaction from swimming.

Event satisfaction is a psychological concept representing the satisfaction experienced by individuals during a certain event. This concept measures the degree of general satisfaction obtained by individuals from an event and involves the emotional and cognitive responses of the individual to the event (Funk et al., 2011). This concept is related to factors like the enjoyment a person receives from the event generally, the level to which the event meets expectations and general attitudes about the event (Ragheb & Beard, 1982). Event satisfaction may be affected by a variety of factors. For example, the compatibility of the event with the individual's interest and capabilities has a significant effect on the levels of enjoyment and satisfaction obtained from the event (Beard & Ragheb, 1980). Additionally, the balance between the difficulty level of the event and the individual's abilities is another factor affecting event satisfaction. Compatibility between difficulty and ability ensures a high degree of satisfaction is experienced by individuals during the event (Csikszentmihalyi, 2020). Cater et al. (2021) examined the causal relationship between flow experience and satisfaction in diving activities. The study found that flow experience plays a role in increasing satisfaction and that the flow experienced during diving directly impacts participants' satisfaction levels. Recreational flow experience and event satisfaction are closely interconnected (deMatos et al., 2024; Kim, 2022), as the immersive and enjoyable nature of flow not only enhances individuals' engagement with the activity but also significantly contributes to their overall satisfaction with

the event, creating a more meaningful and memorable experience. In light of this knowledge, we propose the following hypothesis.

Hypothesis 1: Recreational flow experience will have a direct positive effect on event satisfaction.

Relationship Between Recreational Flow Experience and Personal Well-Being

Personal well-being is a comprehensive concept related to the long-term life satisfaction of individuals and not just a temporary mood (Diener, 1984). This concept is not limited to the presence of positive emotions and the absence of negative emotions in the life of individuals; it involves cognitive assessments and general satisfaction levels of individuals about their lives (Diener et al., 2018). This broad definition of personal well-being offers an in-depth approach to understanding how individuals assess their own satisfaction by considering all aspects of their lives (Andrews & Robinson, 1991; Angner, 2010). Personal well-being is affected by a variety of factors in the individual's life. Among these are social relationships and activities, physical health, economic status, and personal success (Bortes et al., 2021; Buecker et al., 2021; Cooper et al., 1992; Goswami, 2012; Lamu & Olsen, 2016). Social relationships play a critical role in increasing the personal well-being of individuals because strong bonds formed between individuals and their close surroundings provide psychological and emotional support (Diener et al., 2018). Similarly, protecting physical health increases the satisfaction a person receives from life and positively impacts the general well-being levels of individuals (Cross et al., 2018; Dobewall et al., 2018). Especially when the difficulty level is consistent with the individual's abilities, individuals experience higher personal satisfaction and well-being as they feel competent and successful (Csikszentmihalyi, 2020; Fong et al., 2015). Recreational flow, defined as a process where the individual focuses intensely on an activity and experiences full participation, emerges as a strong factor positively affecting the personal well-being levels of individuals (Shen et al., 2022). Flow does not just affect the enjoyment and satisfaction an individual feels during an activity; at the same time, it leads to positive outcomes for personal development, self-efficacy, and psychological well-being after the activity (Jackson et al., 2004). Zou et al. (2024) revealed that the flow experienced during physical activities increased the personal well-being of students, and this contributed to mental and emotional health. The study emphasized that a supportive exercise atmosphere, especially, assisted in strengthening this relationship by providing the necessary conditions for flow. Individuals experiencing flow in the business world especially were more creative and productive and were more satisfied with their work, and this satisfaction was reflected in

general life happiness (Salanova et al., 2006). A study by Chang (2017) stated that risk-taking skills increased when individuals experienced flow in extreme sports, while contrary to this, well-being was positively impacted. Flow, improving individuals' general quality of life by increasing productivity in work life and work satisfaction, is associated with high performance, satisfaction and well-being during recreational activities. In line with this information, we propose the following hypothesis.

Hypothesis 2: Recreational flow experience will have direct positive effect on personal well-being.

Relationship Between Event Satisfaction and Personal Well-Being

In the literature, though a direct correlation was not identified between event satisfaction and personal well-being, there is information that personal well-being is closely associated with leisure satisfaction (Argan et al., 2018; Liu, 2014). Hribernik and Mussap (2010) stated that individuals' satisfaction from leisure activities significantly increases their general life satisfaction and subjective well-being levels. Individuals spending their leisure time doing enjoyable, meaningful, and valuable activities were observed to have higher levels of psychological health. The results of another study identified that when students developed positive attitudes toward leisure activities, they obtained higher levels of satisfaction from these activities, and this satisfaction significantly impacted their psychological well-being levels (Kim et al., 2015). In this context, the relationship between event satisfaction and personal well-being highlights the significant impact that individuals' event experiences have on their emotional, psychological, and physical states of well-being (Theodorakis et al., 2015). Event satisfaction is related to how individuals' satisfaction with an activity increases their personal well-being levels through emotional fulfillment and meaningful experiences. In a study by Kuykendall et al. (2018), it was found that leisure activities play a significant role in personal well-being. The research shows that leisure activities improve individuals' overall well-being by creating positive effects on dimensions such as emotional satisfaction, stress reduction, and overall life satisfaction. In line with this information, we propose the following hypothesis.

Hypothesis 3: Event satisfaction will have a direct positive effect on personal well-being.

Mediating Role of Event Satisfaction

Flow emerges when there is the balance between an individual's skills and the degree of difficulty of an activity and involves the individual being fully caught up in the activity (Nakamura & Csikszentmihalyi, 2002). In this situation, the individual derives maximum

satisfaction from the activity. Doğan and Ünal (2024) found that individuals experiencing flow during physical activity obtained more satisfaction. Especially for water-based activities like swimming, it was observed that individuals may more easily achieve flow due to the comforting and focus-enhancing effects of the water (Swann, 2016). Event satisfaction is the level of satisfaction an individual obtains from an activity, and this satisfaction is directly related to the individual's general happiness and life satisfaction (Funk et al., 2011). Within the self-determination theory of Ryan and Deci (2000), the satisfaction an individual feels from activities done with internal motivation increases their general personal well-being level. In other words, when an individual obtains high levels of satisfaction from an event, the satisfaction obtained from life in general, happiness, and personal well-being increase (Doğan, 2021; Kuykendall et al., 2015; Mouratidis, 2021). This correlation is supported by studies about recreational activities (Doğan & Ünal, 2024; Xu & Choi, 2023). Personal well-being means an individual feels satisfaction from life, experiences positive emotions, and feels negative emotions at a minimum level (Buecker et al., 2023). Personal well-being is directly connected to the satisfaction individuals obtain from life events (Diener et al., 2018). In research, Liu and Yu (2015) concluded that individuals experiencing high levels of satisfaction during leisure had higher general personal well-being levels. This result supports the outcome that experiencing flow increases the satisfaction individuals obtain from activities and increases personal well-being (Csikszentmihalyi, 1990). In research about recreational runners, Aydın (2022b) identified that event satisfaction played a partial mediating role in the relationship between leisure involvement and life satisfaction. In the research, as the involvement of individuals in leisure events increased, their satisfaction obtained from these events increased, and they concluded that this satisfaction was positively reflected in life satisfaction. Flow experience enables individuals to fully engage in activities and experience a sense of satisfaction, while event satisfaction makes it possible for this process to effectively enhance personal well-being. In this context, recreational physical events that individuals participate in during leisure are very important, especially for preserving and enhancing physical and mental health (Godbey, 2009; Lee, 2020). In line with this information, we propose the following hypothesis.

Hypothesis 4: Event satisfaction has a mediating role in the effect of flow on personal well-being. Accordingly, experiencing flow will increase personal well-being by elevating event satisfaction.

The type of activity is important when individuals fully focus on physical activities they participate in during leisure and achieving flow, and in supporting the personal well-being process by obtaining satisfaction. Swimming is very important in the context of these factors. Swimming developed as a natural survival skill in various cultures during the history of humanity and became professional over time. Swimming is an important leisure activity, ensuring progression of the body within water due to certain movements. Swimming is a common leisure activity performed for recreational purposes in water parks, pools or open water. Humans swim as a sporting and recreational activity, forming a basis for physical and mental health. It is important to research the flow, event satisfaction and personal well-being levels of individuals who regularly participate in swimming based on the rehabilitative power of water for humans.

In accordance with the current literature, we will investigate the mediating role of event satisfaction on flow experienced during swimming events affecting personal well-being. As stated differently, event satisfaction will increase with the increase in flow, and personal well-being will increase with the increase in event satisfaction. In the literature, there is no research focusing on these three variables simultaneously. Our model, aimed at filling this gap, seeks to analyze the effects of swimming activities on individuals' psychological well-being more comprehensively. Additionally, our study contributes to the existing literature by establishing deeper connections between event satisfaction and personal well-being in the context of individuals experiencing the rehabilitative power of water. We believe the model we create will contribute to understanding the nature of these variables and their prediction of each other.

METHODS

Participants

The sample for the study comprised a total of 301 individuals, 139 females and 162 males, regularly swimming in open and indoor swimming pools and the Sea of Marmara according to seasonal conditions in the İstanbul metropolis. Ages of participants varied from 18-60 years ($Mean_{age}$ = 35.44±7.84). When the marital status of participants are investigated, 175 were single and 126 were married. According to educational level, 28 had graduated from primary school-high school, 234 were university graduates and 39 had a master's or doctoral degree. In terms of welfare, 60 participants had welfare below average, 195 had welfare at average levels and 46 had welfare above average. According to the weekly number of days of

swimming, 113 participants swam 1-2 days per week, 161 swam 3-4 days per week, and 27 swam five or more days per week. The demographic information for participants is shown in Table 1.

The study was conducted following the principles outlined in the Declaration of Helsinki. The ethical suitability of the research was reviewed and approved by the Scientific Research and Publications Ethics Committee of the National Defense University Rectorate (20.06.2023/E-54589112-824.99-2484357).

Table 1
Demographic Characteristics of Participants

Demographic variables	**N**	%
Gender		
Female	139	46.2
Male	162	53.8
Age (years)		
18-30	90	29.9
31-40	139	46.2
41-50	57	18.9
51-60	15	5
Marital status		
Single	175	58.1
Married	126	41.9
Education		
Primary school-high school	28	9.3
University	234	77.7
Master-doctorate	39	13
Income		
Below average	60	20
Average	195	64.8
Above average	46	15.2
Days swimming per week		
1-2 days	113	37.5
3-4 days	161	53.5
5 or more days	27	9
Total	301	100

Data Collection Procedure

The study was conducted following the principles outlined in the Declaration of Helsinki. The ethical suitability of the research was reviewed and approved by the Scientific Research and Publications Ethics Committee of the National Defense University Rectorate (20.06.2023/E-54589112-824.99-2484357).

This study was completed using a cross-sectional design and quantitative research method. The relational survey model investigated the mediating effect of event satisfaction in the relationship between flow experience and personal well-being levels of individuals

regularly participating in swimming events in a recreational context. The relational survey model, explaining the relationship between two or more variables and the degree of variation between these variables (Karasar, 2016), was chosen as a suitable model for the research. In the data collection process, the convenience sampling method was used for accessibility of participants and to practically complete the research (Büyüköztürk, 2018). Convenience sampling, or haphazard or accidental sampling, is a non-probability sampling method in which individuals from the target population are selected based on practical considerations. These may include factors such as accessibility, geographical proximity, availability during the data collection period, or willingness to participate in the study (Dornyei, 2007).

Research data were collected from members of health and fitness clubs with open or indoor swimming pools and individuals swimming in the Sea of Marmara in İstanbul in July and August of 2023 after receiving ethics committee permission. The data collection process was completed after receiving the necessary consent from participants and during face-to-face interviews after the swimming event was completed. Under the aim of the research, individuals participating in swimming events at least one day per week and spending at least 20-30 minutes being active in the water were included in the research. As the research has the quality of being a general assessment, it was emphasized that participants did not need to give any information stating their identities. Only individuals volunteering to participate were included in the research; the data collection process lasted an average of seven minutes. The participants in the study responded to questions from the Recreational Flow Experience Scale (RFES), the Event Satisfaction Scale (ESS), and the Personal Wellbeing Index-Adult (PWI-A).

Data Collection Tools

Recreational Flow Experience Scale (RFES)

The Recreational Flow Experience Scale developed by Ayhan et al. (2020) comprises nine items and was designed as a 7-point Likert scale rated from 1 (strongly disagree) to 7 (strongly agree). The structure of the scale was tested with confirmatory factor analysis (CFA) and analysis results revealed the model had good fit ($\chi 2/sd$ = 1.80, GFI = 0.94, CFI = 0.98, NNFI = 0.97, SRMR = 0.03, RMSEA = 0.07). Additionally, the scale's Cronbach alpha internal consistency coefficient was calculated as 0.93. In our study, the internal consistency coefficient for the scale was found to be 0.90.

Event Satisfaction Scale (ESS)

The Event Satisfaction Scale developed by Funk et al. (2011) includes statements to measure the satisfaction individuals participating in recreational events obtain from these events. Adaptation of the scale to Turkish was completed by Aydın (2022a) and it comprises a single dimension and a total of three items. For this 7-point Likert scale, individuals respond by rating statements from (1) definitely not true of me to (7) definitely true of me. The structure of the scale was tested with CFA and the analysis results revealed the model had good fit ($\chi 2/sd = 1.68$, CFI = 0.99, NFI = 0.99, SRMR = 0.00, RMSEA = 0.04, RMR = 0.02). Additionally, the scale's Cronbach alpha internal consistency coefficient was calculated as 0.91. In this study, the internal consistency coefficient for the scale was found to be 0.94.

Personal Wellbeing Index-Adult (PWI-A)

The Personal Well-Being Index was developed for adults and is a scale tool based on self-report containing eight items. Individuals rate their well-being levels on an 11-point Likert rating from 0 (Very unsatisfied) to 10 (Very satisfied; International Wellbeing Group, 2006). The study, which adapted the scale to Turkish, determined that the internal consistency reliability coefficient was 0.86 (Meral, 2014). The structure of the scale was tested with CFA and analysis results revealed the model had good fit ($\chi 2/sd = 1.75$, AGFI = 0.93, GFI = 0.97, CFI = 0.99, NFI = 0.98, RMSEA = 0.05). Additionally, the scale's Cronbach alpha internal consistency coefficient was calculated as 0.91. In the present study, the internal consistency coefficient for the scale was found to be 0.76.

Data Analysis

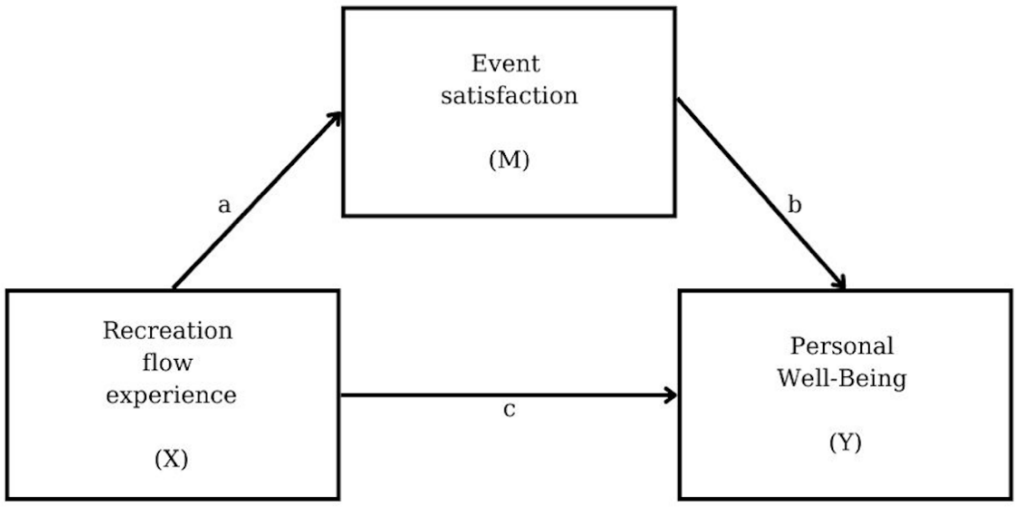
IBM SPSS and AMOS Graphics (version 21) software packages were used for data analysis. Descriptive statistics related to the sociodemographic variables of the sample group were first calculated to conduct the statistical analysis of the collected data. The skewness and kurtosis values for variables related to the research were investigated and these values were in the ±2 interval; hence, the assumption of normality was met (George & Mallery, 2016). To evaluate the reliability of the scales, the Cronbach alpha reliability method was used. The reliability coefficients were as follows: 0.90 for the Recreational Flow Experience Scale, 0.94 for the Event Satisfaction Scale, and 0.76 for the Personal Well-Being Index. To investigate correlations between research variables, the Pearson moment multiplication correlation coefficient analysis was completed.

Subsequently, confirmatory factor analysis (CFA) was conducted for the recreational flow experience, event satisfaction, and personal well-being items. The average variance extracted (AVE) values were also calculated for convergent validity. To establish convergent validity, the Composite Reliability (CR) values must be higher than the Average Variance Extracted (AVE) values (CR > AVE). This indicates that the indicators rather than measurement errors explain a larger portion of the variance in the construct. Furthermore, AVE values should be greater than 0.50 (Fornell & Larcker, 1981).

With the aim of creating a regression model and testing the mediation hypothesis, the PROCESS v.3.3 macro developed by Andrew Hayes for the SPSS program was used. The PROCESS macro has the ability to test complex models and analysis is not only based on the p value. Confidence intervals were calculated using the bootstrap method, which does not require normal distribution. As the calculated confidence intervals (BootLLCI and BootULCI) did not contain zero, the direct and indirect effects in the analysis results were accepted as statistically significant (Hayes & Preacher, 2014).

Within the scope of the research, Model 4, as recommended by Hayes (2013), was used. In this model, recreational flow experience was determined to be the independent variable, personal well-being was the dependent variable, and event satisfaction was included as the mediating variable. The significance of the indirect effects in the analysis was evaluated with resampling of 5000 using the bootstrapping method in the 95% confidence interval. In this model, the variables are coded as independent variable (X), dependent variable (Y) and mediating variable (M) with paths a, b and c (Figure 1).

Figure 1
Research Model



RESULTS

This section presents findings related to the correlations between recreational flow experience, event satisfaction, and participants' personal well-being levels. According to Table 2, the standardized factor loadings for each scale in the CFA exceed 0.50 and are significant. Items with factor loadings below 0.50 and non-significant values were removed from the model. The factor loadings exceeding the 0.50 threshold provide evidence that each item appropriately represents its corresponding factor (Hair et al., 2017). The goodness-of-fit statistic, chi-square to degrees of freedom ratio, was found to be 260.32/87 = 2.99. The fit index values were determined as RMSEA = 0.081, GFI = 0.90, CFI = 0.97, and IFI = 0.97. It can be stated that all fit indices align with the data (Anderson & Gerbing, 1988). CFA allows for testing the measurement model's reliability, convergent validity, and discriminant validity; composite reliability (CR) and average variance extracted (AVE) were calculated and examined. All constructs exhibited acceptable CR coefficients, exceeding 0.7 (Bagozzi & Yi, 1988). Fornell and Larcker (1981) recommended calculating AVE for a construct to indicate convergent and discriminant validity. Except for personal well-being, the AVE values for other constructs exceeded 0.50. Fornell & Larcker (1981) emphasized that CR coefficients greater than 0.70 and AVE values below 0.50 are acceptable. Therefore, convergent validity was achieved for all study constructs. Additionally, to provide complementary evidence of the adequacy of discriminant validity, the square root of the AVE for each construct was compared with the squared correlations between each construct. A sufficient discriminant validity criterion is that the square root of the AVE should exceed the squared correlations for all construct pairs (Fornell & Larcker, 1981; Hair et al., 2006). Based on all reliability and validity analyses, the construct scales exhibit sufficient measurement characteristics.

Table 2
The Factor Loadings, AVE, and CR Value of the Measurement Model

Variable and Item	Factor Loading	CR	AVE
Recreational flow experience			
Swimming enhances my self-confidence.	0.59	0.90	0.54
I focus all my attention while swimming.	0.65		
Swimming allows me to have an enjoyable experience.	0.87		
I feel that I have a positive experience through swimming.	0.83		
Swimming makes me feel highly motivated.	0.78		
Swimming makes me happy.	0.83		
I lose track of time while swimming.	0.64		
Swimming is enjoyable.	0.67		

Table 3 (Continued)

Variable and Item	Factor Loading	CR	AVE
Event satisfaction			
I am satisfied with my decision to participate in the swimming activity.	0.90	0.94	0.84
I am happy about participating in the swimming activity.	0.95		
I made the right decision by participating in the swimming activity.	0.90		
Personal well-being			
How satisfied are you with your achievements in life?	0.62	0.75	0.45
How satisfied are you with your relationships with other people?	0.74		
How secure do you feel?	0.63		
How satisfied are you with being part of society?	0.66		

When the skewness (-1.10 to -0.51) and kurtosis (-0.37 to 0.26) values for scores obtained from the scales are investigated in Table 3, the data appear to abide by normal distribution. When the mean scores are investigated, participants had scores of 5.88 for recreational flow experience, 6.29 for event satisfaction and 7.85 for personal well-being. Additionally, all correlations related to the variables were statistically significant. The strongest correlation was identified between recreational flow experience and event satisfaction ($r = 0.71$, $p < 0.01$). Contrary to this, there were moderate positive correlations observed between personal well-being with recreational flow experience ($r = 0.27$, $p < 0.05$) and between personal well-being with event satisfaction ($r = 0.31$, $p < 0.05$; Table 3).

Table 4
Correlations and Descriptive Statistics

Variables	Correlation		Descriptive statistics and reliability				
	1	2	*Mean*	*Sd*	Skewness	Kurtosis	α
1. Flow experience	-	-	5.88	0.97	-0.82	0.26	0.90
2. Event satisfaction	0.71**	-	6.29	0.90	-1.10	0.23	0.94
3. Personal well-being	0.27**	0.31**	7.85	1.42	-0.51	-0.37	0.76

Note. **p < 0.01

When the analysis results are investigated, recreational flow experience was identified to be a significant predictor of event satisfaction ($a = (\beta = 0.66)$, $t(299) = 17.48$, $p < 0.01$). In this correlation, flow experience explained 51% of the variance ($F(1,299) = 305.69$, $p < 0.01$). This finding supports the first hypothesis (H1) in the research. Secondly, both event satisfaction ($b = (\beta = 0.31)$, $t(298) = 2.90$, $p < 0.01$) and recreational flow experience ($c = (\beta = 0.22)$, $t(298) = 2.21$, $p < 0.01$) significantly predict personal well-being. The recreational flow experience and event satisfaction together explain 13% of the variance ($F(2,298) = 22.71$, $p < 0.01$). These findings support the research's second and third hypotheses (H2 and H3; Table 4).

Table 5
Mediation Analysis Results for Event Satisfaction Between Flow Experience and Personal Well-Being

Predictive Variables	Outcome Variables			
	Event Satisfaction		Personal Well-Being	
	β	*SH*	*β*	*SH*
(Constant)	2.401	0.22	4.326	0.50
Flow Experience	0.66	0.03	0.22	0.10
Event Satisfaction			0.31	0.11
	$R^2 = 0.51$		$R^2 = 0.13$	
	F (1, 299) = 305.69, p < 0.01		F (2, 298) = 22.71, p < 0.01	

Note. X = Recreational flow experience, M = Event satisfaction, Y = Personal well-being

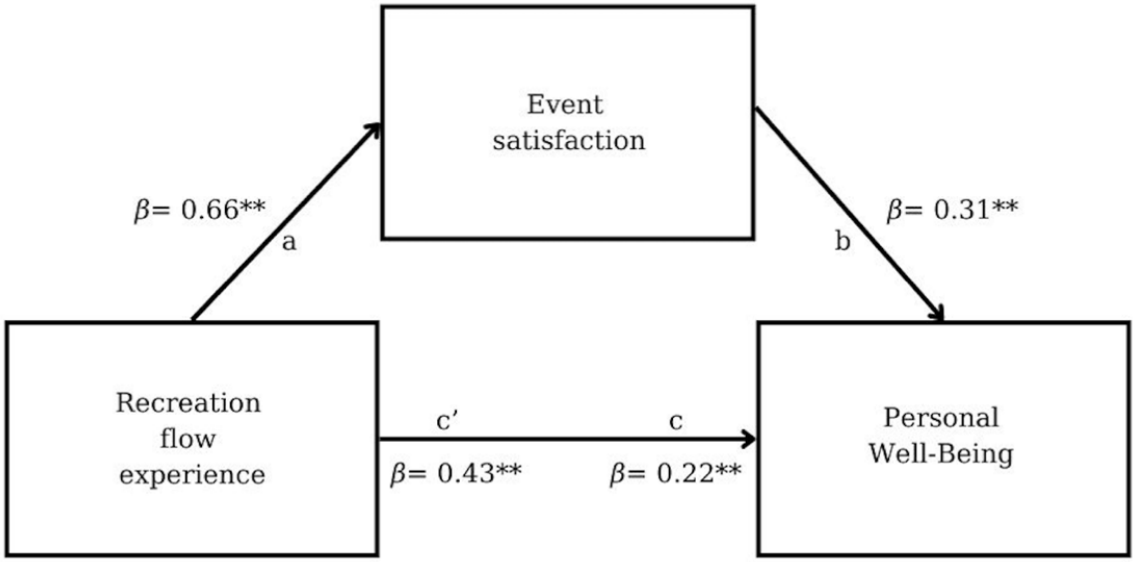
With the aim of investigating the indirect effect within the scope of the research, bootstrap analysis was performed with 5000 samples using the PROCESS macro developed by Hayes (2013; Hayes & Preacher, 2014). When the predictive power of recreational flow for personal well-being was investigated by controlling for the mediating variable of event satisfaction, a significance variation was caused (F (1,299) = 36.12, p< 0.01) and it appeared the explained variance fell to 11% *β*= 0.21, t(299) = 6.01, p< 0.01). This result indicated that event satisfaction had mediating role in the relationship between recreational flow experience and personal well-being. As a result, the fourth hypothesis (H4) was accepted and the model was confirmed. The results showed the direct and indirect effects were significant. The indirect standardized mediation effect in the model had 95% CI values interval from LLCI=0.06 to ULCI=0.35. The total effect (c'; *β*= 0.43) is found by combining the direct effect of flow experience on personal well-being (*β*= 0.22) and the mediating effect of event satisfaction (*β*= 0.21; Table 5).

Table 6
Direct and Indirect Effects Related to the Research Model

Correlations Between Variables	Coefficient	95% CI	
		LL	UL
Flow Experience → Event Satisfaction	0.66**	0.58	0.73
Flow Experience → Personal Well-Being	0.22**	0.02	0.42
Event Satisfaction → Personal Well-Being	0.31**	0.10	0.52
Flow Experience → Event Satisfaction → Personal Well-Being	0.21**	0.06	0.35
Total Effect	0.43**	0.29	0.57

Note. **p < 0.01

Figure 2
Mediation Analysis Results for Event Satisfaction Between Recreational Flow Experience and Personal Well-Being



DISCUSSION

The basic aim of this study was to test the mediating effect of event satisfaction in the relationship between recreational flow experience and personal well-being for individuals regularly participating in swimming events. When the research findings were investigated, positive and significant correlations were found between recreational flow experience, event satisfaction, and personal well-being (Figure 2).

Recreational Flow Experience → Event Satisfaction (H1)

Recreational flow experience was determined to have a positive and significant effect on event satisfaction. This result supports the first hypothesis (H1). This finding overlaps with the results of previous studies. Csikszentmihalyi (1990) stated that flow allowed individuals to be fully caught up in an activity and experience high happiness levels in this process, increasing the satisfaction obtained from this activity. A study by Kim (2022) investigated the effect of fitness content presented in the digital environment on flow experience and satisfaction. The study results showed that experiencing flow in the digital environment significantly increased the satisfaction levels of participants. This situation is related to flow experience being a process where the individual fully focuses on online fitness content, does not notice how time passes, and enjoys interaction with the content at high levels. The results of a study by Cater et al. (2021) revealed there was the strong causal relationship between flow

experience and satisfaction. Primarily, individuals who dive experienced flow during activities and found that the satisfaction they obtained from this experience significantly increased.

All these results are similar to the results of our hypothesis. The basis of the relationship between satisfaction and flow is the nature of flow, which directs the mental and emotional resources of the individual toward the activity. During flow individuals experience a continuously enjoyable state by feeling both challenged and successful due to the balance between the difficulty level and their skills. This state of psychological equilibrium, when the individual has the opportunity to concentrate their attention on the activity, reduces the effects of external negative factors and contributes to experiencing higher levels of satisfaction after the activity. In activities like swimming, this equilibrium is particularly pronounced due to the immersive nature of the environment. The sensory isolation provided by water, combined with the rhythmic and repetitive movements involved in swimming, enhances focus and minimizes external distractions. This creates an optimal environment for flow, allowing individuals to fully engage with the activity, feel a sense of mastery over their performance, and achieve a deep sense of post-activity satisfaction.

Recreational Flow Experience → Personal Well-Being (H2)

Recreational flow experience was found to have a positive and significant effect on personal well-being. This result supports the second hypothesis (H2). The findings of a study by Cheng and Lu (2015) of individuals participating in surfing events showed that recreational participation was directly and positively affected by flow experience. This flow significantly increased the well-being levels of individuals. Similarly, according to research findings by Heo et al. (2010), when elderly individuals regularly participated in serious leisure events, they experienced flow more frequently. This flow experience positively affected their personal well-being levels. The study emphasized that with flow during serious leisure events, there were contributions to the psychological well-being of the elderly individuals. The basic mechanism underlying this relationship was that flow fully directs the individual's mental resources toward the event and thus, ensures strengthening of positive emotional experiences. Suppose the individual achieves a balance between challenge and skill during flow. In that case, the enjoyment obtained from the activity reaches maximum levels, which increases the personal well-being of the individual. This flow feature contributes to the individual feeling happier, satisfied and balanced from a mental perspective both during and after the activity.

Event Satisfaction → Personal Well-Being (H3)

Event satisfaction was identified to have a positive and significant effect on personal well-being. This result supports the third hypothesis (H3). This result is consistent with previous research and supports the positive effect of event satisfaction on psychological and emotional health of the individual (Diener & Seligman, 2002; Sirgy et al., 2010). The satisfaction obtained from events, especially, increases the general life satisfaction of individuals, and this contributes to personal well-being levels of the individual. The study by Armbrecht and Andersson'un (2020) showed that participation in sports events was associated with hedonic (instantaneous pleasure) and eudaimonic (meaning of life and personal development) satisfaction and this satisfaction positively affected subjective well-being. Kim et al. (2015) obtained results that positive leisure involvement increased the satisfaction from leisure activities and positively contributed to students' psychological well-being levels. The basis of this relationship between event satisfaction and personal well-being includes positive emotional processes the individual experiences during the activity. An event providing satisfaction causes the individual to experience positive emotions, meeting their psychological needs. According to the self-determination theory of Deci and Ryan (2000), meeting the basic psychological needs of individuals, like autonomy, competence, and relatedness, increases their motivation, and this elevates the satisfaction felt from activities. This process causes the individuals to feel happier and satisfied; as a result, it contributes to general personal well-being. Ryan and Deci (2001) stated that meeting these needs did not just increase the momentary happiness of the individual, but increased long-term well-being.

Recreational Flow Experience → Event Satisfaction →Personal Well-Being (H4)

Event satisfaction was found to play a mediating role in the relationship between recreational flow experience and personal well-being. This result, forming the basic aim of the study, supports the fourth hypothesis (H4). No studies investigated the relationships of these concepts found in the literature. However, Aydın (2022b) in research with recreational runners identified that event satisfaction mediated the effect of leisure involvement on life satisfaction. Research by Sato et al. (2017) identified that the event satisfaction of individuals participating in walking activities positively affected general life satisfaction. The study showed that event satisfaction increased life satisfaction mediated by satisfaction in different areas of the individuals' lives. Theodorakis et al. (2015) investigated the effects of event service quality and event satisfaction on happiness among runners participating in regularly-held sports events.

The research revealed that high service quality increased the satisfaction participants felt with the event and this satisfaction positively affected the general happiness levels of runners. Research by Lianopoulos et al. (2024) investigated the effects of event experiences on event satisfaction and behavioral intentions of individuals participating in mass sports events. The study results, when considered in the context of swimming activities, suggest that this activity provides significant experiences for participants across sensory, emotional, behavioral, intellectual, and relational dimensions. Swimming enhances immediate satisfaction due to the relaxing effects of water and the sense of vitality created by physical activity, while also increasing participants' sensory and emotional satisfaction levels. Moreover, the requirement for swimming to be a learnable and developable skill supports individuals' intellectual fulfillment, while performing the activity in group settings or shared spaces provides positive contributions to the relational dimension. Swimming is a versatile activity that shapes individuals' quality of life by offering physical and psychological benefits. In this context, swimming activities contribute a new perspective to the literature, with the finding that flow experience positively affects individuals' well-being, highlighting the mediating role of event satisfaction.

Limitations

There are some limitations of this research. This study was completed with a sample of people who regularly participate in swimming events in a recreational context. For this reason, recreational flow, event satisfaction and personal well-being may vary in different events. In other words, the findings emerging from this study cannot be generalized to individuals participating in different events. İmamoğlu and Karakitapoğlu-Aygün (2004) revealed that individuals with different economic and educational level may display different cultural approaches based on differences within a culture. Based on this approach, the results obtained for individuals regularly swimming in open or indoor swimming pools or the Sea of Marmara according to the seasonal conditions in İstanbul metropolis may be generalized to people with similar demographic characteristics. The results are based on relational analyses, and it is necessary to pay attention to this situation for interpretations of cause-outcome relationships between variables.

This research was designed as a cross-sectional study; hence, direct inferences about cause-outcome relationships are limited. In the future, performing long-term longitudinal studies may investigate the long-term effects of participation in regular swimming events on

personal well-being in more detail. Additionally, research based on experimental designs may be completed to be able to define cause-outcome relationships between recreational swimming and personal well-being. In this way, the variation in well-being levels of individuals regularly participating in swimming events during a certain period may be directly measured.

CONCLUSION

As a result, regular swimming allows the opportunity for individuals to experience flow; this increases the satisfaction they obtain from the activity. When individuals experience flow during swimming, they are entirely within the activity and this experience elevates the satisfaction obtained from the swimming event. Increasing event satisfaction positively affects personal well-being. In other words, regular swimming supports personal well-being by increasing flow experience and event satisfaction. In this context, participating in swimming events acts as a path supporting the positive effects of flow on personal well-being.

This study considered the relationships between recreational flow, event satisfaction and personal well-being. Individuals experiencing high levels of flow during recreational activities obtained more satisfaction from the activities, and this positively impacted their personal well-being levels. Empirically determining the relationship between recreational flow and personal well-being mediated by event satisfaction provides an important contribution to the literature in this field. These studies will allow the opportunity to more deeply understand the effect of satisfaction individuals obtain from events on flow experience, personal well-being, and psychological health. This situation will enrich the available literature in theoretical and practical terms by offering new insights into the role of leisure events on personal well-being.

PRACTICAL IMPLICATIONS

Future research may focus on investigating the effect of swimming events on personal well-being in a broader framework. Instead of focusing only on swimming events, research may be performed comparing the effects of flow experience during other recreational events on event satisfaction and personal well-being. Thus, a broader perspective on which events best support personal well-being may be obtained. This study was completed with participation from a particular demographic group (individuals regularly swimming in İstanbul). Similar investigations may be performed with individuals from different age groups, socioeconomic levels, and educational levels, and the effects of these factors on

personal well-being may be investigated. The relationships between event satisfaction and flow experience may be investigated especially for individuals from different cultural contexts.

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Authors' Contributions

The first author contributed to the writing of the original draft, data curation, and resource management, while the second author contributed to validation, as well as review and editing. Both authors were equally involved in formal analysis and methodology.

Declaration of Conflict Interest

No potential conflict of interest was reported by the authors.

Ethics Statement

The study was conducted following the principles outlined in the Declaration of Helsinki. The ethical suitability of the research was reviewed and approved by the Scientific Research and Publications Ethics Committee of the National Defense University Rectorate (20.06.2023/E-54589112-824.99-2484357).

REFERENCES

Ahn, B. W., & Song, W. I. (2024). Effect of outdoor leisure participants on leisure identity, leisure flow, leisure satisfaction, and re-participation intention. *Societies, 14*(2), 17. https://doi.org/10.3390/soc14020017

Akçakese, A., Demirel, M., Yolcu, A. F., Gümüş, H., Ayhan, C., Sarol, H., Işık, Ö., Harmandar Demirel, D., & Stoica, L. (2024). Nature relatedness, flow experience, and environmental behaviors in nature-based leisure activities. *Frontiers in Psychology*, 15, 1397148. https://doi.org/10.3389/fpsyg.2024.1397148

Anderson, J. C., & Gerbing, D. W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin*, 103(3), 411–423. https://doi.org/10.1037/0033-2909.103.3.411

Andrews, F. M., & Robinson, J. P. (1991). *Measures of subjective well-being*. In Measures of personality and social psychological attitudes (Vol. 1, pp. 61-114). Academic Press.

Angner, E. (2010). Subjective well-being. *The Journal of Socio-Economics, 39*(3), 361-368. https://doi.org/10.1016/j.socec.2009.12.001

Argan, M., Argan, M. T., & Dursun, M. T. (2018). Examining relationships among well-being, leisure satisfaction, life satisfaction, and happiness. *International Journal of Medical Research & Health Sciences*, 7(4), 49-59.

Armbrecht, J., & Andersson, T. D. (2020). The event experience, hedonic and eudaimonic satisfaction, and subjective well-being among sport event participants. *Journal of Policy Research in Tourism, Leisure and Events, 12*(3), 457-477. https://doi.org/10.1080/19407963.2019.1695346

Aydın, İ. (2022a). Turkish Adaption of Event Satisfaction Scale in Recreational Activities. *MANAS Journal of Social Studies*, 11(1), 420-427. https://doi.org/10.33206/mjss.917773

Aydın, İ. (2022b). Partial mediation effect of event satisfaction in relationship between life satisfaction and leisure involvement: a sample of recreational runners. *Journal of Sports and Performance Researches*, 53-72. https://doi.org/10.17155/omuspd.911751

Ayhan, C., Eskiler, E., & Soyer, F. (2020). Measuring flow experience in recreational participants: Scale development and validation. *Journal of Human Sciences, 17*(4), 1297-1311. https://doi.org/10.14687/jhs.v17i4.6105

Beard, J. G., & Ragheb, M. G. (1980). Measuring leisure satisfaction. *Journal of Leisure Research, 12*(1), 20-33. https://doi.org/10.1080/00222216.1980.11969416

Bagozzi, R. P., & Yi, Y. (1988). On the evaluation of structure equations models. *Academic of Marketing Science*, 16(1), 74–94.

Bortes, C., Ragnarsson, S., Strandh, M., & Petersen, S. (2021). The bidirectional relationship between subjective well-being and academic achievement in adolescence. *Journal of Youth and Adolescence, 50*(5), 992-1002. https://doi.org/10.1007/s10964-021-01413-3

Buecker, S., Luhmann, M., Haehner, P., Bühler, J. L., Dapp, L. C., Luciano, E. C., & Orth, U. (2023). The development of subjective well-being across the life span: A meta-analytic review of longitudinal studies. *Psychological Bulletin, 149*(7-8), 418. https://doi.org/10.1037/bul0000401

Buecker, S., Simacek, T., Ingwersen, B., Terwiel, S., & Simonsmeier, B. A. (2021). Physical activity and subjective well-being in healthy individuals: A meta-analytic review. *Health Psychology Review, 15*(4), 574-592. https://doi.org/10.1080/17437199.2020.1760728

Büyüköztürk, Ş. (2018). *Sosyal bilimler için veri analizi el kitabı*. Pegem Akademi Yayıncılık.

Carrasco, L., Villaverde, C., & Oltras, C. M. (2007). Endorphin responses to stress induced by competitive swimming event. *Journal of Sports Medicine and Physical Fitness, 47*(2), 239.

Cater, C., Albayrak, T., Caber, M., & Taylor, S. (2021). Flow, satisfaction and storytelling: A causal relationship? Evidence from scuba diving in Turkey. *Current Issues in Tourism*, 24(12), 1749-1767. https://doi.org/10.1080/13683500.2020.1803221

Chang, H. H. (2017). Gender differences in leisure involvement and flow experience in professional extreme sport activities. *World Leisure Journal*, 59(2), 124-139. https://doi.org/10.1080/16078055.2016.1166152

Chen, M. A., & Meggs, J. (2021). The effects of Mindful Sport Performance Enhancement (MSPE) training on mindfulness, and flow in national competitive swimmers. *Journal of Human Sport and Exercise, 16*(3), 517-527. https://doi.org/10.14198/jhse.2021.163.04

Cheng, T. M., & Lu, C. C. (2015). The causal relationships among recreational involvement, flow experience, and well-being for surfing activities. *Asia Pacific Journal of Tourism Research, 20*(sup1), 1486-1504. https://doi.org/10.1080/10941665.2014.999099

Chick, G., Hsu, Y. C., Yeh, C. K., Hsieh, C. M., Ramer, S., Bae, S. Y., ... & Dong, E. (2022). Cultural consonance mediates the effects of leisure constraints on leisure satisfaction: A reconceptualization and replication. *Leisure Sciences*, 44(2), 201-220. https://doi.org/10.1080/01490400.2018.1506724

Chick, G., Hsu, Y. C., Yeh, C. K., Hsieh, C. M., Bae, S. Y., & Iarmolenko, S. (2016). Cultural consonance in leisure, leisure satisfaction, life satisfaction, and self-rated health in urban Taiwan. *Leisure Sciences, 38*(5), 402-423. https://doi.org/10.1080/01490400.2016.1141734

Choi, H., & Park, C. (2021). Relationship between participant's selection attributes, satisfaction, and continued participation according to safety awareness of water leisure sports. *International Journal of Crisis & Safety, 6*(2), 1-8. https://doi.org/10.22471/crisis.2021.6.2.01

Cooper, H., Okamura, L., & Gurka, V. (1992). Social activity and subjective well-being. *Personality and Individual Differences, 13*(5), 573-583. https://doi.org/10.1016/0191-8869(92)90198-X

Cross, M. P., Hofschneider, L., Grimm, M., & Pressman, S. D. (2018). Subjective well-being and physical health. In *Handbook of well-being* (pp. 472-489). https://doi.org/nobascholar.com

Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal experience* (pp. 75-77). Harper & Row.

Csikszentmihalyi, M. (2013). *Flow: The psychology of happiness*.

Csikszentmihalyi, M., & Larson, R. (2014). *Flow and the foundations of positive psychology* (Vol. 10, pp. 978-94). Springer.

Csikszentmihalyi, M. (2020). *Finding flow: The psychology of engagement with everyday life*. Hachette UK.

Cumming, I. (2017). *The health & wellbeing benefits of swimming*. Swim England's Swimming and Health Commission.

Deci, E. L., & Ryan, R. M. (2000). The" what" and" why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological inquiry*, 11(4), 227-268. https://doi.org/10.1207/S15327965PLI1104_01

deMatos, N. M. da S., Duarte, P. A. de O., & Sá, E. S. de. (2024). Once-in-a-lifetime leisure experiences (OLLE): The role of Flow, novelty, and interpersonal interaction on tourists' satisfaction and memories. Journal of Vacation Marketing, 30(3), 615-632. https://doi.org/10.1177/13567667231157012

Diener, E. (1984). Subjective well-being. *Psychological Bulletin, 95*(3), 542. https://doi.org/10.1037/0033-2909.95.3.542

Diener, E., & Seligman, M. E. (2002). Very happy people. *Psychological science*, 13(1), 81-84. https://doi.org/10.1111/1467-9280.00415

Diener, E., Oishi, S., & Tay, L. (2018). Advances in subjective well-being research. *Nature Human Behaviour, 2*(4), 253-260. https://doi.org/10.1038/s41562-018-0307-6

Ding, Z., Li, C. P., Lin, H. H., Hung, S. T., Tseng, C. H., & Hsu, C. H. (2023). Exploring the Flow Experience and Re-Experience Intention of Students Participating in Water Sports from the Perspective of Regional Tourism and Leisure Environment Suitability. *Sustainability*, 15(19), 14614. https://doi.org/10.3390/su151914614

Doğan, M. (2021). *The role of cultural consonance in the relationship between leisure satisfaction, happiness and perceived health* (Unpublished Doctoral Thesis). Ankara University, Ankara, Türkiye.

Doğan, M., Kuruçelik, M., & Civil, T. (2023). Investigation of the relationship between serious leisure, event satisfaction and perceived health outcomes of recreation: The outdoor sports example. *SPORMETRE Beden Eğitimi ve Spor Bilimleri Dergisi, 21*(4), 102-113. https://doi.org/10.33689/spormetre.1348479

Doğan, M., & Ünal, Y. B. (2024). The relationship between leisure involvement, flow experience, and life satisfaction levels of fitness center members. *Journal of Education and Recreation Patterns, 5*(1), 85-99. https://doi.org/10.53016/jerp.v5i1.229

Dobewall, H., Tark, R., & Aavik, T. (2018). Health as a value and its association with health-related quality of life, mental health, physical health, and subjective well-being. *Applied Research in Quality of Life, 13*(4), 859-872. https://doi.org/10.1007/s11482-017-9563-2

Dornyei, Z. (2007). *Research methods in applied linguistics*. Oxford university press.

Er, B., & Cengiz, R. (2023). The effect of digital leisure participation purposes on flow experience and leisure satisfaction. *Journal of ROL Sport Sciences*, 544-565. https://doi.org/10.5281/zenodo.10031059

Fong, C. J., Zaleski, D. J., & Leach, J. K. (2015). The challenge–skill balance and antecedents of flow: A meta-analytic investigation. *The Journal of Positive Psychology, 10*(5), 425-446. https://doi.org/10.1080/17439760.2014.967799

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. Journal of marketing research, 18(1), 39-50. https://doi.org/10.1177/002224378101800104

Funk, D., Jordan, J., Ridinger, L., & Kaplanidou, K. (2011). Capacity of mass participant sport events for the development of activity commitment and future exercise intention. *Leisure Sciences, 33*(3), 250-268. https://doi.org/10.1080/01490400.2011.564926

George, D., & Mallery, P. (2016). *IBM SPSS Statistics 23 step by step* (13th ed.). Routledge.

Godbey, G. (2009). Outdoor recreation, health, and wellness: Understanding and enhancing the relationship. *Outdoor Resources Review Group*, 09-21.

Goswami, H. (2012). Social relationships and children's subjective well-being. *Social Indicators Research, 107*, 575-588. https://doi.org/10.1007/s11205-011-9864-z

Gürbüz, B. (2017). *The conception and perception of leisure in Turkey. Leisure from International Voices, Champaign, IL*: Sagamore Publishing.

Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2017). *Primer on Partial Least Square Structural Equations Modeling (PLS-SEM)*, (2nd Ed). Sage.

Hair, J. J. F., Black, W. C., Babin, B. J., Anderson, R., & Tatham, R. (2006). *Multivariate data analysis* (6th ed.). Englewood Cliffs, NJ: Prentice-Hall.

Hayes, A. F. (2013). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*. Guilford Press.

Hayes, A. F., & Preacher, K. J. (2014). Statistical mediation analysis with a multicategorical independent variable. *British Journal of Mathematical and Statistical Psychology, 67*(3), 451-470. https://doi.org/10.1111/bmsp.12028

Heo, J., Lee, Y., McCormick, B. P., & Pedersen, P. M. (2010). Daily experience of serious leisure, flow and subjective well-being of older adults. *Leisure Studies, 29*(2), 207-225. https://doi.org/10.1080/02614360903434092

Hribernik, J., & Mussap, A. J. (2010). Research note: Leisure satisfaction and subjective wellbeing. *Annals of Leisure Research*, 13(4), 701-708. https://doi.org/10.1080/11745398.2010.9686871

International Wellbeing Group. (2006). *Personal wellbeing index-adult*. Australian Centre on Quality of Life, Deakin University.

İmamoğlu, E. O., & Karakitapoğlu-Aygün, Z. (2004). Self-construals and values in different cultural and socioeconomic contexts. *Genetic, Social, and General Psychology Monographs, 130*(4), 277–306. https://doi.org/10.3200/MONO.130.4.277-306

Jackson, S. A., Eklund, R., & Leatherman, G. (Ed.) (2004). *The Flow Scales Manual*. Publishers Graphics.

Joseph Sirgy, M., Uysal, M., & Kruger, S. (2018). *A benefits theory of leisure well-being*. Handbook of leisure, physical activity, sports, recreation and quality of life, 3-18.

Karasar, N. (2016). *Bilimsel araştırma yöntemi* (31. baskı). Nobel Akademi Yayıncılık.

Kelly, J. R. (2019). *Freedom to be: A new sociology of leisure*. Routledge.

Kim, M. (2022). How can I Be as attractive as a Fitness YouTuber in the era of COVID-19? The impact of digital attributes on flow experience, satisfaction, and behavioral intention. *Journal of Retailing and Consumer Services*, 64, 102778. https://doi.org/10.1016/j.jretconser.2021.102778

Kim, S., Sung, J., Park, J., & Dittmore, S. W. (2015). The relationship among leisure attitude, satisfaction, and psychological well-being for college students. *Journal of Physical Education and Sport, 15*(1), 70. https://doi.org/10.7752/jpes.2015.01012

Koçak, F., & Gürbüz, B. (2024). Promoting social inclusion for adult communities: The moderating role of leisure constraints on life satisfaction in five European countries. *Journal of Community & Applied Social Psychology, 34*(3), e2794. https://doi.org/10.1002/casp.2794

Kuykendall, L., Boemerman, L., & Zhu, Z. (2018). *The importance of leisure for subjective well-being*. In E. Diener, S. Oishi, & L. Tay (Eds.), Handbook of well-being. Salt Lake City, UT: DEF Publishers. https://orcid.org/0000-0003-1076-3215

Kuykendall, L., Tay, L., & Ng, V. (2015). Leisure engagement and subjective well-being: A meta-analysis. *Psychological Bulletin, 141*(2), 364. https://doi.org/10.1037/a0038508

Lamu, A. N., & Olsen, J. A. (2016). The relative importance of health, income and social relations for subjective well-being: An integrative analysis. *Social Science & Medicine, 152*, 176-185. https://doi.org/10.1016/j.socscimed.2016.01.046

Lee, K. H. (2020). Mental health and recreation opportunities. *International Journal of Environmental Research and Public Health, 17*(24), 9338. https://doi.org/10.3390/ijerph17249338

Lianopoulos, Y., Kotsi, N., Karagiorgos, T., & Theodorakis, N. D. (2024). Experiential effects on mass sport participants' event satisfaction and behavioral intentions: examining sensory, affective, behavioral, intellectual and relational dimensions. *International Journal of Event and Festival Management*, 15(2), 270-292. https://doi.org/10.1108/IJEFM-09-2023-0075

Liu, H., & Yu, B. (2015). Serious leisure, leisure satisfaction and subjective well-being of Chinese university students. *Social Indicators Research, 122*, 159-174. https://doi.org/10.1007/s11205-014-0687-6

Liu, H. (2014). Personality, leisure satisfaction, and subjective well-being of serious leisure participants. Social Behavior and Personality: an international journal, 42(7), 1117-1125. https://doi.org/10.2224/sbp.2014.42.7.1117

Marty-Dugas, J., & Smilek, D. (2019). Deep, effortless concentration: Re-examining the flow concept and exploring relations with inattention, absorption, and personality. *Psychological research*, 83(8), 1760-1777. https://doi.org/10.1007/s00426-018-1031-6

Mehta, P., & Vyas, M. (2022). A Systematic Literature Review on the Experience of Flow and its Relation to Intrinsic Motivation in Students. *Indian Journal of Positive Psychology*, 13(3), 299-304.

Meral, B. F. (2014). Psychometric properties of Turkish form of the Personal Well-Being Index-Adult. *The Journal of Happiness and Well-Being, 2*(2), 119-131.

Mouratidis, K. (2021). Urban planning and quality of life: A review of pathways linking the built environment to subjective well-being. *Cities, 115*, 103229. https://doi.org/10.1016/j.cities.2021.103229

Nakamura, J., & Csikszentmihalyi, M. (2002). The concept of flow. In *Handbook of positive psychology* (pp. 89-105).

Overbury, K., Conroy, B. W., & Marks, E. M. (2023). Swimming in nature: A scoping review of the mental health and wellbeing benefits of open water swimming. *Journal of Environmental Psychology*, 102073. https://doi.org/10.1016/j.jenvp.2023.102073

Özant, M. İ. (2024). The physical and mental effects of recreational swimming exercises. *Interdisciplinary Approaches in Sport Sciences, 17*.

Ragheb, M. G., & Beard, J. G. (1982). Measuring leisure attitude. *Journal of Leisure Research, 14*(2), 155-167. https://doi.org/10.1080/00222216.1982.11969512

Roberts, K. (2018). Writing about leisure. *World Leisure Journal, 60*(1), 3-13. https://doi.org/10.1080/16078055.2016.1261645

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*(1), 68. https://doi.org/10.1037/0003-066X.55.1.68

Ryan, R. M., & Deci, E. L. (2001). On happiness and human potentials: A review of research on hedonic and eudaimonic well-being. *Annual review of psychology*, 52(1), 141-166. https://doi.org/10.1146/annurev.psych.52.1.141

Salanova, M., Bakker, A. B., & Llorens, S. (2006). Flow at work: Evidence for an upward spiral of personal and organizational resources. *Journal of Happiness studies*, 7(1), 1-22. https://doi.org/10.1007/s10902-005-8854-8

Sato, M., Yoshida, M., Wakayoshi, K., & Shonk, D. J. (2017). Event satisfaction, leisure involvement and life satisfaction at a walking event: The mediating role of life domain satisfaction. *Leisure Studies*, 36(5), 605-617. https://doi.org/10.1080/02614367.2016.1240221

Sevim, K. U. L., Şebin, K., Şebin, H., & Birinci, M. C. (2022). Examining the recreational flow experiences of individuals participating in curling. *Anatolia Sport Research, 3*(3), 1-8. http://dx.doi.org/10.29228/anatoliasr.31

Sheard, M., & Golby, J. (2006). Effect of a psychological skills training program on swimming performance and positive psychological development. *International Journal of Sport and Exercise Psychology, 4*(2), 149-169. https://doi.org/10.1080/1612197X.2006.9671790

Shen, C. C., Tsai, C. H., & Tseng, T. A. (2022). The Influence of Flow Experience and Serious Leisure on Attachment in Board Game. *Leisure Sciences*, 47(1), 66–90. https://doi.org/10.1080/01490400.2022.2061654

Smith, S. J. (2021). Swimming in flow motion: an ecopedagogy for health and physical education. *Sport, Education and Society*, 26(4), 417-428. https://doi.org/10.1080/13573322.2020.1847065

Sran, S. K., Vats, P., & Wadhawan, P. (2021). Effect of exercise on life satisfaction and happiness. *Indian Journal of Health and Wellbeing, 12*(1), 79-82. https://doi.org/10.13140/RG.2.2.24062.25924

Stebbins, R. A. (1992). *Amateurs, professionals, and serious leisure*. McGill-Queen's Press-MQUP.

Sidorová, D. (2015). Well-being, flow experience and personal characteristics of individuals who do extreme sports as serious leisure. *Unpublished Doctoral Thesis). Masaryk University. Brno, Czech Republic. Czechia*.

Silva, L. A. D., Doyenart, R., Henrique Salvan, P., Rodrigues, W., Felipe Lopes, J., Gomes, K., Bellaver, C., Benetti, M., Oliveira, M., Costa, M., & Silveira, P. C. (2020). Swimming training improves mental health parameters, cognition and motor coordination in children with Attention Deficit Hyperactivity Disorder. *International Journal of Environmental Health Research, 30*(5), 584-592. https://doi.org/10.1080/09603123.2019.1612041

Sukur, A., Hartono, F. V., Gani, R. A., & Setiawan, E. (2023). Mindfulness training in swimming: Efforts to reduce burnout and stress in junior athletes. *Fizjoterapia Polska, 23*(3), 12-19. https://doi.org/10.56984/8ZG1436D8

Swann, C. (2016). Flow in sport. In L. Harmat, F. Ø. Andersen, F. Ullén, J. Wright, & G. Sadlo (Eds.), Flow experience: Empirical research and applications (pp. 51–64). Springer International Publishing/Springer Nature. https://doi.org/10.1007/978-3-319-28634-1_4

Tanaka, H. (2009). Swimming exercise: Impact of aquatic exercise on cardiovascular health. *Sports Medicine, 39*, 377-387. https://doi.org/10.2165/00007256-200939050-00004

Theodorakis, N. D., Kaplanidou, K., & Karabaxoglou, I. (2015). Effect of event service quality and satisfaction on happiness among runners of a recurring sport event. *Leisure Sciences*, 37(1), 87-107. https://doi.org/10.1080/01490400.2014.938846

Torkildsen, G. (2012). *Leisure and recreation management*. Routledge.

Wheaton, B. (2000). "Just do it": Consumption, commitment, and identity in the windsurfing subculture. *Sociology of Sport Journal, 17*(3), 254-274. https://doi.org/10.1123/ssj.17.3.254

White, M. P., Pahl, S., Wheeler, B. W., Fleming, L. E., & Depledge, M. H. (2017). The 'blue gym': What can blue space do for you and what can you do for blue space?. *Journal of the Marine Biological Association of the United Kingdom, 96*(1), 5-12. https://doi:10.1017/S0025315415002209

Wu, S. F., Lu, Y. L., & Lien, C. J. (2020). Detecting students' flow states and their construct through electroencephalogram: Reflective flow experiences, balance of challenge and skill, and sense of control. *Journal of Educational Computing Research*, 58(8), 1515-1540. https://doi.org/10.1177/0735633120944084

Xu, J., & Choi, M. C. (2023). Can emotional intelligence increase the positive psychological capital and life satisfaction of Chinese university students?. *Behavioral Sciences, 13*(7), 614. https://doi.org/10.3390/bs13070614

Zou, N., Shang, Y., & Wang, Q. (2024). The relationship between exercise atmosphere, flow experience, and subjective well-being in middle school students: A cross-sectional study. *Medicine, 103*(29), e38987. https://doi.org/10.1097/MD.0000000000038987

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Development and Validation of Sport Law Knowledge Test

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ABSTRACT

This study aims to develop a valid and reliable Sport Law Knowledge Test for preservice sport management students. The test was prepared by a panel including two professors having expertise on curriculum development, two university instructors lecturing sport law course and a Turkish language expert. Panel discussed and prepared 25 multiple-choice questions. Participants were 205 (122 male and 83 female) preservice sport management students who had successfully completed sport law course. Rasch modeling was used to evaluate the validity and reliability of the Sport Law Knowledge Test. Results showed that all test items demonstrated high internal consistency and reliability for both test items and person attended this study. The wright map showed that items demonstrated the cumulative norm. Overall analysis showed good evidence to support the validity and reliability of Sport Law Knowledge Test. Developed test can be used for measuring sport law knowledge level of preservice sport management students.

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INTRODUCTION

Sport, especially global sport events such as Olympic Games, have been influential trademark in societies (Milano & Chelladurai, 2011). This popularity has also turned out some challenges such as increasing professionalism (e.g. media effect), worldwide audience and commercialization (Vieweg, 2018). Sport related stakeholders and their relationships, on the other hand, triggered to conflict which affects the people' thoughts and involvement on sport events. Conflicts in sport have revealed the need for sport law. Concept of sports law has been defined as controlling, normalizing and regulating sport behaviors (Orhan & Özkurt, 2024). Sports law can also be understood as a unique branch of law that deals with rules regulating the relations among athletes, clubs, team owner companies, International Olympic Committee (IOC), international regional federations and national and international federations (Erten, 2008; International Olympic Committee, 2023).

Sport law has five distinguished features (Vieweg, 2018). First one is the system of self-regulation. National and international federations or associations have their rights to regulate their sport which they have responsibilities. Second is two-track structure which indicates coexistence and harmoniousness of rules of national and international law, and regulations of federations and associations (Vieweg, 2018). Third feature is international character of sport law. Even sport law cases were found the solutions in different process and juridical decision, those are alike in all legal law systems. Fourth feature is the multiplicity of effects. Sport law affects many people and organizations in terms of integrating their relationships into economically relevant regulations. Last feature is cross-sectional matter which means interdisciplinary awareness. Many cases related to sport law whether they are criminal, private or public has deterministic and specific role. These decisions affect each other (Vieweg, 2018).

Sport management has been accepted as an academic discipline at the beginning of 1980s even though it has existed since ancient Greek games (Batista & Pittman, 2006; Parkhouse & Pitts, 2005; Susanto, 2021). Sport management is defined by DeSensi et al. (1990) as "any combination of skills related to planning, organizing, directing, controlling, budgeting, leading, and evaluating within the context of an organization or department whose primary product or service is related to sport and/or physical activity" (p.33). It deals with many different aspects of sport related operations and organizations, as well as business of sport

(Batista & Pittman, 2006). Sport management is the process of moving the theoretical aspects of sport management to professional dimension (Laird, 2005).

Sport management professional programs were established in 1966 in Ohio, USA (Stier, 1993). Since then, these programs have been gained more popularity in USA and other countries such as Australia, Canada and New Zealand in terms of bachelor, master and doctoral programs (North American Society for Sport Management, [NASSM], 2007). The increase in the number of sports management departments has revealed the necessity of standards that will determine the quality of these departments (Jones et al., 2008; Zakrajsek, 1993). First standards for department of sport management were introduced by the National Association for Sports and Physical Education (NASPE)-NASSM in 1987 (NASPE-NASSM, 1993) and accepted in early 1994 (Stier, 1993). According to standards, programs should include finance in sport, economics in sport, marketing in sport, governance in sport, field experience in sport management, behavioral dimensions in sport, management and organizational skills in sports, ethics in sport management, communication in sport, and legal aspects of sport (Jones et al., 2008). Preservice sport management students are supposed to complete successfully these courses before they graduate from the sport management departments (NASSM, 2016; Parks et al., 2013). Sport law, also known as legal aspects of sport, is one of the important courses that is taught in sport management departments at undergraduate and graduate levels (Epstein, 2002).

Sport law courses are expected to teach in department of sport management programs. However, there is no consistency what lectures should teach and what student should learn (Batista & Pittman, 2006). Even these courses have different curriculum and standards, students who completed these courses successfully should have sufficient sport law knowledge (NASSM, 2016; Parks et al., 2013). To measure students' knowledge level, valid and reliable knowledge tests which were developed for different field (e.g. physical education) have been used in several studies (Dervent et al., 2018; 2020; Devrilmez et al., 2019; Ince & Hunuk, 2013; Miller & Housner, 1998; Santiago & Morrow, 2020; Tsuda et al., 2021; Tsuda et al., 2022). Literature indicates that there is no valid and reliable sport law knowledge test for measuring undergraduate and graduate sport management students. Given the rationale mentioned above, the purpose of this study was to develop valid and reliable sport law knowledge test.

METHODS

Participants

The participants of this study were 205 (122 male and 83 female) senior students enrolled in five state university sport management programmes. They were purposefully selected because first and second authors contacted with 25 universities and five of them accepted to attend this study. Participants had previously followed and successfully completed a compulsory sport law course in their junior year. Participants ranged in age from 20 to 27 years (M = 23.21, 2.84). All participants stated that they had no experience or did not follow seminar, educational approach, etc. about sport law.

Procedure

Participants responded the test items and data for analyzing were collected during regular sports law courses and 40 minutes were given participants to fill the test. Participants answered the test and additional time wasn't given. Rasch measurement model (Rasch, 1980) was used for analyzing the collected data which were entered into an Excel spreadsheet, then exported to Winsteps Software Version 3.72.4 (Linacre, 2008). Rasch modelling is the probability of a participant's answer to a question hinge on difficulty of the item (i.e. the question) and the participant's ability (Linacre, 2008). Generally, in literature, traditional item measurement methods such as item response theory use the data as "fit the data". However, Rasch modelling determines the data as 'fit the model' (Linacre, 2008). This study was accepted by Institutional review board of Karamanoğlu Mehmetbey University (Ethical No: 09-2023/134). Individual consent forms were also collected from the participants.

Data Collection Tools

Development of the Test

We have checked the literature to find valid and reliable sport law knowledge test before development process of the test. Review indicated that there were no valid and reliable sport law knowledge test. We followed four steps to develop the test. In this process, content validity and face validity were also checked. At the first step, an expert group consisting of two professors having expertise on curriculum development, two university instructors lecturing sport law course and a Turkish language expert was created. The group members met and argued possible main purposes and outcomes of sport law course (i.e. content validity). Following this argument, expert group determined that there should be eight main

objectives: 1) General concepts related to sport law, 2) National and international federations, 3) Turkish general statute, 4) Sport law on the prevention of violence and disorder in sport (Law 6222), 5) Turkish football federation, 6) Sport related contracts, 7) Doping in sport law, 8) Court of Arbitration for Sport (CAS). Panel created six questions for each objective and there were totally 42 questions in sport law knowledge test. Second step, a Turkish language expert checked all questions in terms of their appropriateness for sport management students (i.e. face validity). Third step, the draft test was provided to two professors in sport management department who had experience on teaching sport law. They checked the questions to decide whether they were those that completed the compulsory sport law course would be supposed to be able to answer. After checking, 17 questions were distracted from the test because these questions were determined as too easy or too difficult for sport department students. In the last step, the test was checked by another 30 sport management students who had completed compulsory sport law course successfully during 2019-2020 fall semester. These students stated that all questions were comprehensible and straightforward. At the final version of the sport law knowledge test, there were 25 questions (three questions for each objective, only four questions for general concepts related to sport law). Test consisted of multiple-choice questions with four alternative options, but only one correct answer. Example of questions are presented in Table 1.

Table 1

Sample Questions of Sport Law Knowledge Test

Question 1- General concepts related to sport law
Which of the following branches of law is related to sports law? a) International public law b) Mixed law c) Private interstate law d) Commercial law
Question 2- National and international federations
Which of the following is the headquarters of the The Fédération internationale de football association (FIFA)? a) London b) Zürich c) Paris d) Brussels
Question 3- Turkish general statute
Which of the following boards is not permanent board of the ministry of youth and sport? a) Arbitration Board b) Board of Sports Evaluation and Development c) Board of Provincial Sports Disciplinary d) General Directorate of Law Services
Question 4- Sport law on the prevention of violence and disorder in sport (Law, 6222)
Which of the following is the law regarding the prevention of violence and disorder in sports? a) Law no. 6222 b) Law no. 5894 c) Law no. 3289 d) Law no. 5253

Table 2 (Continued)

Question 5- Turkish football federation
Which of the following is not civil chambers of Turkish Soccer Federation? a) Dispute Resolution Board b) Arbitration Board c) The board of visitors d) Supreme board of referees
Question 6- Sport related contracts
Which of the following laws regulate the contracts of the athletes? a) Turkish Code of Obligations b) Law of Labor c) Law on Associations d) Law on Preventing Violence and Disorder in Sports
Question 7- Doping in sport law
Sample Question If no prohibited substance is found after the laboratory analysis of the "A" sample in the doping control, the negative result is reported to the relevant administrative committee or the International Sports Federation. Then, how long "B" sample is removed after a while? a) 1 month b) 2 months c) 3 months d) 7 days
Question 8- Court of Arbitration for Sport (CAS)
How long is the decision period in first degree arbitration in Court of Arbitration for Sport (CAS)? a) 1-3 months b) 7 days c) 6-12 months d) 3-6 months

Data Analysis

The model has four basic levels for data analysis;

Item fit: Item fit statistics is utilized how each item fits the test modelling (Bond & Fox, 2007). Infit and outfit statistics which are used to designate the fit the model (Linacre, 2008). Infit statistics are sensitive to expectations regarding potential responses from participants. If an expert in the field of sports law answered most of the questions in the test, this would indicate that the data fit the model. Outfit statistics are sensitive to unexpected responses of the participants and affect the patterns of the model. If a participant with no experience in sports law correctly answered the rather difficult questions, this would demonstrate poor fit with the model. To decide if the model has a good fit, the mean square residual (MNSQ) and the standardized mean square residual (ZSTD) are used. These concepts hinge on differences between what is expected and what is observed by Rasch modelling (Liu, 2010). The MNSQ is the square of the residual which focus on the difference between the observed and predicted responses on the pattern. ZSTD is the measurement utilizing the normalized t-score of the residual (Liu, 2010).

Person fit: Person-fit statistics is utilized to decide appropriateness of item-score pattern in the model (Bond & Fox, 2007; Linacre, 2008). Relevance of attenders' response scores are controlled by Person-fit statistics. Scores of MNSQ values should be between 0.5 to 1.5. Person-fit statistics is considered as poor if a participant got the score lower than 0.5 (e.g. little variation in responses) or higher than 1.5 (e.g. large variation in responses) in mean square statistic (Linacre, 2008).

Person item/Wright maps: Wright maps, also called person-item maps, indicate distribution of responses and item difficulties. The wright map has two sides which are left and right. The rank of the item difficulties was shown on the right side. While the most difficult items are demonstrated in uppermost, the easiest items take the position lower section. The left side, on the other hand, represents answers of the participants. The highest scores of the participants are shown on the top and lowest scores take position bottom of side.

Separation index and separation-reliability index: There are two separation indexes which are item and person. Item separation index is used to validate the hierarchy of difficulty ranking from low to high and it is related to construct validity of the model. In person separation index, Respondents are divided into those with a high level of knowledge and those who do not have the necessary level of knowledge. Both separation index scores are determined as; a) 3.00 or over is excellent level, b) 2.00 indicates good level, and c) 1.50 represents acceptable level (Bond & Fox, 2007).

The separation-reliability index is a reliability indicator used to report the likelihood of repeating placements of an item or person (Bond & Fox, 2007). Scores of both item and person range from 0 to 1. If the score is close to 1, there is a high degree of confidence. Visa versa, if the score is close to 0, there is a low level of confidence (Bond & Fox, 2007).

RESULTS

Infit and outfit results of the study were reported in table 2. MNSQ results showed that range of infit statistics were from .90 to 1.10 and those in outfit statistics were from .87 to 1.21. MNSQ values of all items were within the acceptable range of 0.5-1.5. In ZSTD results, infit values were from -1.8 to .8 and outfit values were from -1.9 to 1.7. ZSTD values of all items were within acceptable scores of -2.0- +2.0 (Boone et al., 2014). Infit and outfit statistics results supported to good fit as well as unidimensional structure of the sport low knowledge test.

Table 3
Item Difficulty, Standard Error, Fit and Point-Measure Correlation Results

Entry Number	Item Difficulty	Model Standart Error	Infit		Outfit		PT-measure
			MNSQ	ZSTD	MNSQ	ZSTD	
19	1.83	.21	1.10	.8	1.21	1.2	.20
21	1.76	.20	1.02	.2	1.20	.6	.12
18	1.71	.20	1.02	.4	1.14	1.7	.26
6	1.70	.19	1.07	.6	1.12	.7	.20
2	1.71	.18	1.01	.1	1.12	1.4	.26
8	1.83	.17	1.00	.1	1.11	.5	.15
20	1.39	.16	1.04	.6	1.07	.7	.24
25	1.31	.16	1.02	.4	1.06	.7	.26
12	1.35	.15	1.04	.6	1.05	.5	.25
1	1.28	.15	1.04	.8	1.03	.4	.26
4	1.22	.15	1.03	.4	1.03	.3	.24
17	1.19	.15	.99	-.1	1.01	.2	.26
10	1.05	.13	.99	-.1	1.00	.0	.22
14	.96	.13	.96	-.5	.94	-.5	.24
3	.86	.12	.94	-1.5	.93	-1.2	.27
7	.71	.11	.93	-.7	.85	-1.1	.22
13	.65	.11	.93	-1.7	.89	-1.7	.27
24	.52	.12	.90	-1.4	.87	-1.5	.29
X	1.24	.15	.99	.0	1.03	.2	.39
SD	.45	.03	.10	1.5	.29	1.8	.08

Table 2 reported the item difficulty of the items which were ranged from .41 (harder items) to 1.83 (easier items). The Wright map represented in figure 1 obviously indicated that difficulty of the items and person abilities were well distributed (M = 1.24, SD = .45; M = 1.95, SD = .42, respectively).

Table 4
Summary of 25 Measured Items

	Total Score	Model		Infit		Outfit	
		count	S.E.	MNSQ	ZSTD	MNSQ	ZSTD
MEAN	12.4	25.0	3.80	1.00	-.1	1.02	.0
SD	4.5	.0	.78	.23	1.1	.42	1.1
MAX.	21.0	25.0	7.40	1.67	2.9	2.60	3.5
MIN.	5.0	25.0	3.36	.66	-1.8	.46	-2.0
Real RMSE = 5.10	True SD = 3.04		Separation = 3.21		Item reliability = .90		
Model RMSE = 4.87	True SD = 3.23		Separation = 3.31		Item reliability = .91		
SE of item mean .71							

According to Boone et al. (2014), it was recommended that "real" estimate should be utilized rather than "model" estimate in education studies while checking the reliability of educational measurement models. Real estimate value is more convenient and conservative to

determine item and person reliability levels. We have followed the guidance of Boone et al. (2014). Table 3 showed that item separation index score was 3.21 represents a very good level of separation. The separation-reliability estimate score was .90. This score showed that there was a high confidence to use test items on another sample (Boone et al., 2014). The person separation index score, representing in table 4, was 4.56. This score demonstrated that sample selected and conducted for this study was excellent (Boone et al., 2014).

Figure 1

Wright Map of Sport Law Knowledge Test

Measure	Person- MAP- Item	
	more	rare
70	+	
		T
60	+S	
	X	21
	T	8
	XX	
		15
50	XXXXXX +M	
	XXXXXXX S	5
		6 19
	. XXXXXXXXXXX	
		7 9 10
	XXXXXXXXXX	
	XXXXXXXXXXXX M	4
40	+S	14 20
	. XXXXXXXXX	12 16
		2 18 25
	. XXXXXXXX	17
	S	1
	XXXXX	3 13
		11
30	X +	
	T	
	XXX	24
		22 23
20	+	
	X	
		T
10		
	less	rare

Table 5
Summary of 205 Measured Persons

	Total Score	Model		Infit		Outfit	
		Count	S.E.	MNSQ	ZSTD	MNSQ	ZSTD
MEAN	53.1	205.0	1.95	1.00	-.1	1.02	.0
SD	27.3	.0	.42	.06	.9	.10	1.0
MAX.	188.0	205.0	6.46	1.10	.8	1.21	1.7
MIN.	22.0	205.0	2.66	.90	-2.4	.85	-2.3
Real RMSE = 2.02		True SD = 9.22		Separation = 4.56		Person reliability = .95	
Model RMSE = 2.00		True SD = 9.22		Separation = 4.62		Person reliability = .96	
SE of item mean = 1.93							

DISCUSSION

The motivation of development and validating the sport law knowledge test was a need to standardized measures that could be utilized in preservice sport management students. To date, no valid and reliable sport law knowledge test has been found in literature. Absence of such measurement tool is an important barrier for improving quality of department of sport managements. To fill this gap in literature, we aimed to develop valid and reliable sport law knowledge test. Results showed that developed sport law knowledge test had high internal consistency for both item difficulty and person-ability. Overall analysis indicated good evidence to support the reliability and validity of the sport law knowledge test.

The study contributed literature in three ways. First, this test has a unidimensional trait which directly measures sport law knowledge level. There is no valid and reliable sport law knowledge test developed for preservice sport management students. This is maybe the reason of the nature of the sport law. According to Vieweg (2018), sport law is fascinating subject area because it is cross-sectional and creates a bridge between real sport life and law. The test specifically focusing on sport law will overcome this problem.

Second contribution is that validated sport law knowledge test can be used for preservice students in department of sport management and continuing professional development of sport management stakeholders such as sport managers, coaches and athletes. The test can be used for studies designed as cross-sectional, as well as pre-post experimental studies in order to demonstrate effectiveness of intervention or training related to sport law. Researchers might utilize this test to check whether sport law course in department of sport management meet the required standards in terms of course syllabi, student learning outcomes or national standards.

The last contribution of this study was to test development method. We used the Rasch modelling (Rasch, 1980) to validate sport law knowledge test and it allowed us to check item difficulty, person and item reliability. Results showed that validated test met the criteria of

reliability and construct validity. The Rasch modelling has some advantages for researchers which are; a) converting raw score to interval data (Boone et al., 2014). This trait of the model provides data from Rasch modelling which can be used in correlational and experimental studies. b) The model performs data analysis based on "fit the model", not "fit the data" which most traditional test development methods use (Bond & Fox, 2007; Linacre, 2011). The Rasch modelling also indicates that although some questions of the test do not provide the fit index, the test can be used if its general reliability is high. And c) The model proved that the test could be validated with smaller sample size. According to Chen et al. (2014), The Rasch analysis can be performed with small sample size (N>50), unlike other traditional methods (Chen et al., 2014; Linacre, 2011). The test can be validated with Rasch modelling if necessary steps are followed such as random distribution of the items (Chen et al., 2014).

Limitations

There are some limitations in this study. Firstly, the participants were preservice sport management students. Future studies can focus on in-service sport managers, coaches or athletes. Second, this study was limited to Turkish sport management setting. We developed the test according to Turkish sport management curriculum. The test can be translated to other languages and maybe it can be validated. Lastly, our sample size was moderate (N= 205) and future studies can focus on a larger sample. This will improve the representativeness of the data.

CONCLUSION

Reliable and valid sport law knowledge test is a necessary to step forward to sport management field. We have aimed to develop sport law knowledge test with using Rasch modelling. Overall, our findings indicated that developed sport law knowledge test is valid and reliable for measuring sport management students' sport law knowledge level.

PRACTICAL IMPLICATIONS

Developed sport law knowledge test can be utilized for measuring sport management students' sport law knowledge level. On the other hand, this test can be applied to sport managers who are related with sport law or legacy of sport.

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Authors' Contributions

The study was conceived and designed by the first, second, third and the fourth authors. Data collection was carried out by the first and second authors. Data analysis and interpretation were conducted by the first, fifth and the sixth authors. The manuscript was drafted and/or critically revised by the first four authors. Final approval of the version to be published was given by all six authors.

Declaration of Conflict Interest

Authors state that there is no conflict of the interest.

Ethics Statement

This study was accepted by Institutional review board of Karamanoğlu Mehmetbey University (Ethical No: 09-2023/134). Individual consent forms were also collected from the participants.

REFERENCES

Batista, P. J., & Pittman, A. (2006). Descriptive Analysis of SRLA Members and The Study of Sport Law in Academia. *Journal of Legal Aspects Sport, 16*, 217-238. https://doi.org/10.1123/JLAS.16.2.217.

Bond, T.G. & Fox, M.T. (2007). *Applying the Rasch Model. Fundamental Measurement in the Human Sciences*. 2nd edition. Mahwah, NJ: Erlbaum

Boone, W. J., Staver, J. R., & Yale, M. S. (2014). *Rasch Analysis in the Human Sciences*. Dordrecht: Springer Nature.

Chen, W. H., Lenderking, W., Jin, Y., Wyrwich, K. W., Gelhorn, H., & Revicki, D. A. (2014). Is Rasch Model Analysis Applicable in Small Sample Size Pilot Studies for Assessing Item Characteristics? An Example Using PROMIS Pain Behavior Item Bank Data. *Quality of Life Research, 23*, 485-493. https://doi.org/10.1007/s11136-013-0487-5

Dervent, F., Devrilmez, E., İnce, M. L., & Phillip, W. (2018). Beden Eğitimi Öğretmenleri için Futbol Genel Alan Bilgisi Bilgi Testinin Güvenirlik ve Geçerliği. *Spor Bilimleri Dergisi, 29*(1), 39-52. https://doi.org/10.17644/sbd.326631

Dervent, F., Tatlıcı, B. B., Yetgin, M. K., & Devrilmez, E. (2020). Handball Common Content Knowledge Test for Pre-service Physical Education Teachers. *Beden Eğitimi ve Spor Araştırmaları Dergisi, 12*(2), 66-78. https://doi.org/10.30655/besad.2020.29

Devrilmez, E., Dervent, F., Ward, P., & Ince, M. L. (2019). A Test of Common Content Knowledge for Gymnastics: A Rasch Analysis. *European Physical Education Review, 25*(2), 512-523. https://doi.org/10.1177/1356336X177512

DeSensi, J. T., Kelley, D. R., Blanton, M. D., & Beitel, P. A. (1990). Sport Management Curricular Evaluation and Needs Assessment: A Multifaceted Approach. *Journal of Sport Management, 4*(1), 31-58.

Epstein, A. (2002). Alternative Dispute Resolution in Sport Management and the Sport Management Curriculum. *Journal of Legal Aspects Sport, 12*, 153-180.

Erten, S. (2008). *Spatial Analysis of Mega-Event Hosting: Olympic Host and Olympic Bid Cities.* Unpublished Doctoral Dissertation. The Middle East Technical University. Ankara, Türkiye.

Ince, M. L., & Hünük, D. (2013). Experienced Physical Education Teachers' Health-Related Fitness Knowledge Level and Knowledge Internalization Processes. *Eğitim ve Bilim, 38*(168). https://doi.org/10.1123/jtpe.2018-0292

International Olympic Committee, (2023, April 11*). Legal Affairs*. Retrieved from https://olympics.com/ioc/legal-affairs Date: 11 April 2023.

Jones, D. F., Brooks, D. D., & Mak, J. Y. (2008). Examining Sport Management Programs in The United States. *Sport Management Review, 11*(1), 77-91. https://doi.org/10.1016/S14413523(08)70104-9

Laird, C. (2005). The Influence of Sport Management Program Characteristics On Academician Perceptions of NASPE-NASSM Approval. *The SMART Journal, 1*(2), 4-13.

Linacre, J.M. (2008, April 28) *A User's Guide to Winsteps Rasch-Model Computer Program*. Version 3.65. Available at: www.winsteps.com (accessed 11 April 2023).

Liu, X. (2010) *Using and Developing Measurement Instruments in Science Education: A Rasch Modeling Approach*. Charlotte, NC: Information Age Publishing.

Milano, M., & Chelladurai, P. (2011). Gross Domestic Sport Product: The Size of The Sport Industry in The United States. *Journal of Sport Management, 25*(1), 24-35. https://doi.org/10.1123/jsm.25.1.24

Miller, M. G., & Housner, L. (1998). A Survey of Health-Related Physical Fitness Knowledge Among Preservice and Inservice Physical Educators. *Physical Educator, 55*(4), 176.

NASPE-NASSM Joint Task Force on Sport Management Curriculum and Accreditation. (1993). Standards for Curriculum and Voluntary Accreditation of Sport Management Education Programs. *Journal of Sport Management, 7*, 159-170.

NASSM (April, 2007). *Joint Task Force on Sport Management Curriculum and Accreditation. Accreditation Update.* American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD): National Convention & Exposition, Baltimore, MD.

Orhan, Ü., & Özkurt, E. (2024). *Spor Hukuku*. Adalet Yayınevi. Ankara.

Parkhouse, B. L., & Pitts, B. G. (2005). History of Sport Management. *The Management of Sport: Its Foundation and Application,* 2-14.

Rasch, G. (1980). *Probabilistic Models for Some Intelligence and Attainment Tests*. Chicago: University of Chicago Press.

Santiago, J. A., & Morrow, J. R. (2020). A Study of Preservice Physical Education Teachers' Content Knowledge of Health-Related Fitness. *Journal of Teaching in Physical Education, 40*(1), 118-125. https://doi.org/10.1123/jtpe.2019-0138

Stier, W. F. (1993). *Alternative Career Paths in Physical Education: Sport Management*. ERIC Clearinghouse.

Susanto, N. (2021, February). *21st Century Sports Management*. In *1st International Conference on Sport Sciences, Health and Tourism (ICSSHT 2019)*. Atlantis Press.

Tsuda, E., Ward, P., Kim, J., He, Y., Sazama, D., & Brian, A. (2021). The Tennis Common Content Knowledge Measure Validation. *European Physical Education Review, 27*(3), 654-665. https://doi.org/10.1177/1356336X20982629

Tsuda, E., Ward, P., Sazama, D., He, Y., Lehwald, H., Ko, B., ... & Xie, X. (2022). Validating The Volleyball Common Content Knowledge Test. *Physical Educator, 79*(5), 569-585. https://doi.org/10.18666/TPE-2022-V79-I5-10958

Vieweg, K. (2018, March) *The Appeal of Sports Law*. http://www.irut.de/Forschung/Veroefentlichungen/OnlineVersionFaszinationSportrecht/FaszinationSportrechtEnglisch.pdf.

Zakrajsek, D. B. (1993). Sport Management: Random Thoughts of One Administrator. *Journal of Sport Management, 7*(1), 1-6.

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Effect of Perceived Stress on Sleep Quality and Nutritional Status in Professional Female Basketball Players

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ABSTRACT

Athletes face not only physical strength but also intense psychological stress that leads to sleep problems. It is known that one way to manage stress is to make changes in food intake. This study examined the relationship between perceived stress levels, sleep quality, and nutritional status in professional women basketball players. Eighty adult professional women basketball players (age ≥ 19) in the competitive season competing in the Women's Basketball Super League and the lower league Women's Basketball League affiliated with the Turkish Basketball Federation participated in the study. The survey included player characteristics, anthropometric measurements, food consumption frequency, Perceived Stress Scale (PSS-10), and Pittsburgh Sleep Quality Index (PSQI) sections. The mean score of the basketball players participating in the survey from PSS-10 was 19.3±6.66. The perceived stress level and perception of stress discomfort were significantly higher in the women's league ($p < 0.05$). The mean PSQI total score of the basketball players was 5.9±2.91. In this study, 43.75% of basketball players were found to have good sleep quality, and 56.25% had poor sleep quality. This study's findings showed that the relationship between basketball players' low self-efficacy scores and average daily fiber intake was negative, and sleep quality worsened as perceived stress levels increased ($p < 0.05$). Athletes are affected by stress, sleep quality, and dietary choices, all of which significantly affect their performance. It is essential to monitor individual athletes' energy and nutrient intake. Understanding the impact of stress on sleep disorders and nutritional factors is crucial for assessment and management.

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INTRODUCTION

Basketball is a high-intensity interval sport, and the preparation of basketball players for competition involves developing their physical, technical, tactical, and psychological qualities (Mancha-Triguero et al., 2019). Stress can be defined as any internal or external stimulus perceived as a threat to an organism's homeostasis and well-being, which triggers a biological response. The body's compensatory responses to these stimuli are called stress responses (Yaribeygi et al., 2017). Stressors can appear in various forms, including physical (environmental and physiological), psychological/mental (cognitive and emotional), or a combination. Physical stress directly induces metabolic or physiological changes in the body (Horner, 2003). Athletes often encounter situations that they perceive as threatening, challenging, or stressful during training and significant competitions. Failure to manage and adapt to stress has been linked to negative consequences such as decreased performance, mood changes, injuries, illnesses, and sleep-related issues (Charmandari et al., 2005).

Sleep is a crucial brain activity regulated by the biological clock and influenced by body activity (Richardson, 2005). As exercise is closely tied to bodily activity, the quality of sleep and alertness levels significantly impact athlete performance (Klerman & Hilaire, 2007). Furthermore, the relationship between sleep and exercise is independent of the biological clock. Athlete performance relies on the quality and quantity of sleep obtained before competition. Sleep deprivation leads to increased insomnia, cognitive impairment, memory issues, reduced alertness, and compromised response capabilities. Therefore, considering sleep quality is vital for athletes to achieve their best performance (Davenne, 2009; Richardson, 2005). While increasing the amount of time spent in bed is a valuable starting point for enhancing sleep, it is crucial to underscore the importance of sleep quality for athletes. Sleep quality pertains to the overall effectiveness of one's sleep (Ohayon et al., 2017). Athletes engage in various behaviors that can impact their competitive performance, and sleep stands out as a critical factor due to its significant influence on physiological and psychological functions, particularly endurance performance (Roberts et al., 2019).

Furthermore, sleep is vital in facilitating optimal performance and recovery (O'Donnell et al., 2018). Achieving optimal performance depends on maintaining a balance between stress and recovery. Sufficient recovery enables individuals to manage stress effectively, while inadequate recovery intensifies pressure (Heaton et al., 2017).

Athletes must consume sufficient energy at the correct times to maintain their health and optimize performance outcomes during high-intensity and long-term training periods. Nutrition's primary goal during competition is to minimize performance-limiting factors related to nutrition that can lead to fatigue and impaired function or concentration (ACSM, 2016). A study on the impact of acute stress on food selection during a meal found that stressed individuals tend to choose sweeter and higher-fat foods compared to non-stressed individuals (Oliver et al., 2000). Female athletes, especially, may experience dietary restrictions during anthropometric measurements and face pressure regarding their body weight, potentially leading to overeating during stressful times (Hamlin et al., 2021).

Dietary factors also influence the sleep status of athletes, with a reported relationship between macronutrient intake and insomnia symptoms. Low protein intake (<16% of energy from protein) has been associated with poor sleep quality and difficulty initiating sleep (Condo et al., 2022).

By contrast, high protein intake (>19% of energy from protein) can lead to difficulty maintaining sleep. Low carbohydrate intake (<50% of energy from carbohydrates) has also been linked to problems in maintaining sleep (Tanaka et al., 2013). Key amino acids related to rest include tryptophan, glutamine, tyrosine, and gamma-aminobutyric acid (Zhao et al., 2020).

Studies have shown a difference between female athletes' professionalism and stress levels (Akgün et al., 2021; Nedelec et al., 2015; Ruiz-Esteban et al., 2020). Athletes experience a lot of physical strength and intense psychological stress, leading to sleep problems (Charest & Grandner, 2022). The fact that female athletes have different hormonal, demographic, and psychological characteristics than males can make their perceptions of stress different. The research has determined that the most important source of stress for female basketball players is the pressure from fans and the stands. In addition, factors such as the referee's attitude, being away, their families being in the stands, and the frequency of matches have been shown as essential sources of stress (Uğurlu, 2018). A recent study conducted in Turkey on professional basketball players determined that 56.70% of basketball players and 41.56% of male basketball players had poor sleep quality (Parlak & Kırşan, 2024). Another study on women volleyball players determined that 53.8% of the athletes had poor sleep quality (Yüksel, 2021).

In this context, the primary aim of our study is to determine the effect of perceived stress on sleep quality and nutritional status in professional female basketball players during

the competition period. In addition, determining the differences in these parameters between basketball players in two different women's basketball leagues is the secondary aim of our study. The study included female basketball players playing in the Super League, the highest level of the women's league affiliated with the Turkish Basketball League, and athletes playing in the Women's League, a lower level of this league. Although both leagues are professional, it is thought that players in the Super League are at a more professional level due to participating in European matches and playing more matches. Therefore, their stress levels may be higher. In this context, the aim was to compare the two leagues. In this context, the research questions of our study are as follows:

Question 1: How does perceived stress affect the sleep quality of professional female basketball players?

Question 2: How does perceived stress influence the nutritional status of professional female basketball players?

Question 3: Do perceived stress levels differ between professional female basketball players in the Super League and those in the Women's League?

Question 4: Does sleep quality differ between professional female basketball players in the Super League and those in the Women's League?

Question 5: Does nutritional status differ between professional female basketball players in the Super League and Women's League players?

To the best of our knowledge, no prior research has investigated the relationship between stress, sleep, and nutrition among professional female basketball players in Turkey. Additionally, as there is a lack of research evaluating these variables in basketball players competing in two distinct professional leagues, our study is poised to contribute significantly to the existing literature.

METHODS

Participants

The sample of this study consisted of 10 women's basketball teams in Ankara that compete in the Women's Basketball Super League affiliated with the Turkish Basketball Federation and the Women's Basketball League, a lower league of this league, in the 2022-2023 season and that came to Ankara for an away game. The researcher was present at the gym where the basketball players trained and provided detailed information about the study to the basketball players. Eighty professional women basketball players (aged 19 and over) who

volunteered to participate in the study were selected from the women basketball players competing in these teams, and this number was determined according to the power analysis conducted at the beginning of the study.

The power of our study was calculated using the software G*Power (G*Power 3.1. 9.2, Düsseldorf, Germany; Faul et al., 2007). In line with a similar study (Lim et al., 2018), our analysis showed that 80 people should be included in our study with a 95% confidence level (alpha = 0.05), 80% power, and an effect size of 0.4.

Approval for this study was received from Başkent University Medical and Health Sciences Research Board and Ethics Committee on 09/08/2022 (no: KA22/281). Written informed consent forms were obtained from all participants, confirming their voluntary participation.

Data Collection Tools

Survey form

A survey form designed for the basketball players who volunteered for the study was administered using face-to-face interviews. The survey comprised seven sections covering general characteristics, training information, eating habits, height, body weight, body fat percentage measurements, food consumption frequency, the Perceived Stress Scale (PSS-10), and the Pittsburgh Sleep Quality Index (PSQI).

In order to assess the daily energy and macronutrient intakes of basketball players, a semi-quantitative Food Frequency Questionnaire (FFQ) derived from a (FFQ) validated for measuring dietary intakes in adults was applied (Gunes et al., 2015). Daily average energy, macronutrient, and caffeine intake from food and beverages were analyzed using the Nutrition Information System (BEBIS) 7.2 program. In addition, the use of dietary supplements containing caffeine was addressed through a separate question. It was determined that the basketball players participating in the study did not use such supplements.

The PSQI, a tool for assessing sleep quality, was developed initially by Buysse et al. in 1989. The index is employed to categorize sleep quality as either good or poor. A Turkish version of the scale was developed by Ağargün et al. in 1996 following a validation and reliability study. It assesses sleep quality over the past month and comprises 24 questions. The PSQI is divided into seven components: Component 1, Index; Component 2, subjective sleep quality; Component 3, sleep latency; Component 4, sleep duration; Component 5, habitual

sleep efficiency; Component 6, sleep disturbance; Component 7, use of sleeping pills. PSQI is calculated with seven subcomponent scores, including daytime dysfunction. The total PSQI score is computed from these seven subcomponent scores, ranging from 0-21. A score of less than 5 indicates good sleep quality, and a score of 5 and above indicates poor sleep quality (Ağargün et al., 1996; Buysse et al., 1989).

The PSS-10 was used to assess the stress levels of basketball players. Initially developed by Cohen et al. in 1983, the PSS-10 consists of 14 items and is a self-report-style scale designed to measure perceived stress levels in various situations. Respondents rate each item on a 5-point Likert-type scale. This study utilized a 10-item scale: "perception of inadequacy" and "perception of stress/discomfort"—adapted to Turkish as PSS-10 by Eskin et al. Scores on the scale can range from 0 to 40, with higher scores indicating higher perceived stress levels (Cohen et al., 1983; Eskin et al., 2013).

Anthropometric Measurements

Body composition measurement allows us to assess the nutritional status of individuals, optimize competitive performance, and monitor the effectiveness of training outcomes in athletes. However, reference techniques used in body composition measurement are often expensive and/or invasive. Bioelectrical impedance analysis (BIA) is an indirect method to estimate body composition in a simple, fast, economical, non-invasive, accurate, and reproducible way (de la Cruz Marcos et al., 2021).

In the anthropometric measurements section of the survey form, body weight (kg), height (cm), and body fat percentage (%) measurements were made by the researcher and filled in by the researcher. The measurements of the basketball players playing in the teams in Ankara were made before the morning training. The measurements of basketball players who came to Ankara from out of town for an away match were measured at the place where they stayed, similar to the measurements of the other basketball players, with the same device, at the same time, and in the same fasting state. Body weight and composition were measured in the morning on an empty stomach, with light clothing, without shoes or socks, using a 0.1 kg sensitive TANITA MC-780 Black professional body composition device. The manufacturer's protocols were followed in the measurements, and calibration was performed before each use. Basketball players were instructed to avoid breakfast and caffeine before body fat measurements. The height measurements of the basketball players were measured with a stadiometer in the Frankfort plane, standing and with the head upright.

Data Analysis

The obtained data were analyzed using the SPSS package program (version 28.0, IBM Inc., Chicago). All analyses determined the statistical significance level as $p<0.05$. Mean ($\bar{X}$), standard deviation (SD), median, and 25th and 75th percentile values were used for descriptive statistics. Sleep quality was defined as number (n) and percentage (%). The data conformity to normal distribution was checked with the Kolmogorov-Smirnov test. Independent sample t-tests were used to analyze participants' general characteristics, anthropometric measurements, and energy/macronutrient intakes based on the leagues they played. At the same time, PSS-10 and PSQI scores were analyzed with the independent sample t-test according to the leagues. The analysis of the leagues according to the sleep quality categories was tested with the chi-square test. The relationship between the scale scores and energy and macronutrient intakes was determined with the Pearson Correlation analysis depending on the normal distribution results. The confidence interval of statistical tests was accepted as 95%, and the significance level was evaluated as $p<0.05$.

RESULTS

This study was conducted with 80 professional women basketball players with an average age of 25.5±5.96 years. 38.75% of these athletes play in the Super League and 61.25% in the Women's League (Table 1). It was determined that the weekly and daily training hours of basketball players playing in the Super League were significantly higher than those of the women's league ($p < 0.05$). While the average height of basketball players playing in the Super League was 180.5±8.86 cm, the average height of women playing in the Women's League was 175.8±7.79 cm, and this difference was statistically significant ($p<0.05$; Table 1).

Table 1
Characteristics and Anthropometric Measurements of Basketball Players

Features	Super League (n=31)	Women's League (n=49)	Total (n=80)	p*
Age (years)	26.7±4.25	24.7±6.75	25.5±5.96	0.106
Sports age (years)	14.4±4.15	12.7±6.30	13.4±5.60	0.076
Professional license duration (years)	9.2±4.32	7.9±6.80	8.4±5.96	0.181
Weekly training time (hours)	6.5±1.12	7.3±1.89	7.0±1.67	**0.036**
Daily training time (hours)	1.9±0.15	1.8±0.27	1.9±0.23	**0.018**
Number of matches per week	1.4±0.49	1.2±0.42	1.3±0.45	0.068
Anthropometric measurements				
Height length (cm)	180.5±8.86	175.8±7.79	177.6±8.48	**0.016**
Body weight (kg)	71.6±11.18	67.1±9.03	68.8±10.09	0.052
Fat percentage (%)	17.8±3.80	18.8±3.84	18.4±3.83	0.242

Note. Data are presented as mean ± standard deviation, *independent sample t-test

When nutritional status was examined, it was determined that the daily protein intake per kilogram and animal protein intake of the basketball players playing in the Super League were significantly higher ($p < 0.05$; Table 2).

Table 2
Daily Energy, Macronutrients, Tryptophan, Tyrosine, Fatty Acid, and Caffeine Intakes of Basketball Players

Energy and Macronutrients	Super League (n=31)	Women's League (n=49)	Total (n=80)	p*
Energy (kcal)	2308.9±675.02	2025.2±950.91	2135.1±861.27	0.123
Carbohydrate (g)	225.3±117.64	194.7±103.39	206.5±109.43	0.226
Carbohydrate (%EI)	38.0±10.96	40.1±8.23	39.3±9.37	0.226
Carbohydrate (g/kg BW)	3.2±1.73	2.9±1.56	3.0±1.62	0.476
Protein (g)	120.7±29.78	100.5±45.21	108.3±40.94	**0.031**
Protein (%EI)	22.0±4.43	21.3±4.76	21.6±4.62	**0.031**
Vegetable protein (g)	28.3±11.76	28.7±15.25	28.3±13.92	0.885
Animal protein (g)	92.4±25.07	71.7±37.07	79.3±34.29	**0.008**
Fat (g)	100.4±27.99	91.3±47.85	94.9±41.33	0.287
Fat (%EI)	39.9±8.72	38.5±8.66	39.0±8.65	0.287
Amino acids				
Tryptophan (mg)	1316.9±320.15	1139.9±505.86	1208.5±449.38	0.590
Tyrosine (mg)	4023.0±985.19	3533.0±1599.65	3722.9±1407.51	0.094
Fatty acids (mg)				
Omega-3	2.6±1.76	2.3±1.63	2.4±1.68	0.458
Omega-6	13.5±3.96	12.0±7.1950	12.6±6.38	0.235
Caffeine (mg)	187.0±97.32	160.7±124.73	170.9±114.95	0.322

Note. Basketball players ' daily energy, macronutrients, tryptophan, tyrosine, fatty acid, and caffeine intakes are presented as mean±standard deviation, *independent sample t-test, BW: Body Weight, EI: Energy Intake.

When the stress and sleep quality perceived by the basketball players were examined, it was seen that the PSS-10 mean score was 19.3±5.66, and the PSQI mean score was 5.9±2.91. The perceived stress level and insufficient self-efficacy perception of the basketball players playing in the women's league were significantly higher ($p<0.05$). The sleep duration of basketball players playing in the Women's League was significantly higher than those playing in the Super League ($p<0.05$). In this study, 43.75% of basketball players had good sleep quality, while 56.25% had poor sleep quality. It was also found that basketball players in the Super League (54.8%) had better sleep quality than basketball players in the women's league (42.9%; $p<0.05$; Table 3).

Table 3
Basketball Players' PSS-10 and PSQI Subscale Scores

Parameters	Super League (n=31)		Women's League (n=49)		Total (n=80)		p*
	Mean±Standard Deviation	Median (Q1-Q3)	Mean±Standard Deviation	Median (Q1-Q3)	Mean±Standard Deviation	Median (Q1-Q3)	
PSS-10							
Insufficient self-efficacy	6.9±2.6	7(8-5)	6.8±2.66	7(8-5)	6.8±2.60	7(8-5)	0.859
Stress discomfort	10.7±3.7	10(13-8)	13.6±4.18	13(17-11)	12.5±4.22	12(15-10)	**0.002**
PSS-10 Total	17.6±5.15	18(21-14)	20.4±5.75	20(24.5-16)	19.3±5.66	19(23.75-15)	**0.029**
PSQI							
Subjective sleep quality	1.2±0.54	1(2-1)	1.2±0.63	1(2-1)	1.2±0.66	1(2-1)	0.771
Sleep latency	1.5±0.88	2(2-1)	1.3±0.96	1(2-0.5)	1.4±0.93	1(1-2)	0.562
Sleep duration	0.3±0.51	0(0-0)	0.5±0.65	0(1-0)	0.4±0.61	0(1-0)	**0.041**
Sleep efficiency	0.6±0.76	0(1-0)	0.5±0.71	0(1-0)	0.5±0.69	0(1-0)	0.249
Sleeping disorder	1.1±0.47	1(1-1)	1.2±0.58	1(1.5-1)	1.2±0.54	1(1-1)	0.388
Sleeping pill use	0.4±0.88	0(0-0)	0.3±0.69	0(0-0)	0.3±0.77	0(0-0)	0.535
Daytime dysfunction	0.8±0.65	1(1-0)	1.1±0.77	1(-1)	1.0±0.74	1(1-1)	0.81
PSQI-Total	5.8±2.75	5(7-4)	6.02±3.04	5(7.5-4)	5.9±2.91	5(4-7)	0.751
Sleep Quality	**n**	**%**	**n**	**%**	**n**	**%**	**χ^2**
Good sleep quality (PSQI<5)	14	54.8	21	42.9	35	43.75	0.041
Poor sleep quality (PSQI≥ 5)	17	45.2	28	57.1	45	56.25	

Note. Basketball players' PSS-10 and PSQI subscale scores Data are presented as mean±standard deviation, Q1:25th percentile, Q3:75th percentile, * independent sample t-test, $\chi 2$: Chi-Square test, n: number, %: percentage, PSS-10: Perceived Stress Scale, PSQI: Pittsburgh Sleep Quality Index Index

Table 4 evaluates the relationship between basketball players' PSS-10 and its sub-dimensions and their daily energy intake, macronutrients, and PSQI. A negative and weak relationship was found between basketball players' insufficient self-efficacy perception sub-dimension score and daily average fiber intake ($r = -0.284$, $p < 0.05$), and a positive and weak relationship was found between daytime dysfunction ($r = 0.289$, $p < 0.01$). A positive and weak significant relationship was found between stress/discomfort perception and PSQI total score, specific sleep quality, and sleep disturbance ($p < 0.05$). A positive and moderate relationship was found between basketball players' daytime dysfunction and stress level and stress/discomfort perception ($p < 0.001$). As the basketball players' perceived stress level increased, their sleep quality deteriorated ($r = 0.275$, $p < 0.05$). The relationship between PSS-10 scores and specific sleep quality and sleep disturbance sub-dimensions was weak and statistically significant ($p < 0.05$).

Table 4
Relationship Between Basketball Players' PSS-10 and its Sub-Dimensions and Daily Energy Intake, Macronutrients, and PSQI

Energy and Macronutrients	**PSS-10**		
	Insufficient perception of self-efficacy	**Perception of stress/discomfort**	**PSS-10 Total**
Energy (kcal)	0.565	0.400	0.718
Protein (g)	0.318	0.139	0.718
Fat (g)	0.926	0.282	0.399
Carbohydrate (g)	0.365	0.840	0.791
Fiber (g)	**-0.284***	0.800	0.179
Water (mL)	0.086	0.424	0.850
PSQI-Total	0.226	**0.284***	**0.275***
Subjective sleep quality	0.603	**0.280***	**0.236***
Sleep latency	0.651	0.449	0.439
Sleep duration	0.805	0.130	0.215
Sleep efficiency	0.975	0.819	0.876
Sleeping disorder	0.421	**0.244***	**0.224***
Sleeping pill use	0.707	0.652	0.611
Daytime dysfunction	**0.289****	**0.428*****	**0.452*****

Note. *p <0.05, **p <0.01, *** p <0.001; PSS-10: Perceived Stress Scale, PSQI: Pittsburgh Sleep Quality Index

DISCUSSION

Physical stress can induce physiological changes in athletes' bodies and contribute to sleep-related disorders (Charmandari et al., 2005). Stress levels have also been linked to alterations in food preferences examining the effect of perceived stress on sleep quality and nutritional status in professional female basketball players during the competition period (Kandiah et al., 2006).

Athletes face various stressors during training and competitions, especially at the elite level. They invest considerable time and effort into their sports, and sports-related outcomes can significantly impact their careers and lives, leading to perceptions of threats, challenges, or stress (Öz, 2018). In this study, the average score of all participating basketball players on the Perceived Stress Scale (PSS-10), a widely used psychological instrument for measuring the perception of stress, during the competition period was 19.3±5.66. Like the findings of this study, female athletes preparing for the Tokyo Paralympic Games had an average PSS score of 19.0±7.64 (Yardımcı & Kulunkoglu, 2020). In a study examining perceived stress in the National Collegiate Athletic Association (NCAA) First Division women's volleyball players over an entire calendar year, the PSS-10 score average was highest in the middle of the season (Hyatt & Kavazis, 2019). Female water polo players in a previous study had an average PSS-10 score of 17.8±5.77 (Aydın, 2017). In another study involving female basketball, rowing, hockey, and golf players, the average PSS score was 14.2±6.4 (Terry et al., 2007). A study conducted with ice hockey players in Sweden showed that the mean PSS-10 score of female hockey players was 17.4±5.6 (Wörner et al., 2024). In another survey of female basketball players, the average PSS score was 17.3±4.8 (Güvendi et al., 2016). Compared to these studies, the stress levels observed in this study's participants were higher, likely due to the professional-level competition and increased pressures associated with league matches. Notably, in a study involving professional female basketball players, the PSS-10 score was significantly higher at 30.3±6.28, indicating a perception of insufficient self-efficacy and heightened stress/discomfort (Otter et al., 2016). This extreme result highlights that stress levels may vary widely based on individual and contextual factors, such as team dynamics and personal coping mechanisms.

The study found that the PSS-10 mean score of basketball players playing in the Women's League was significantly higher than those in the Super League. This contrasts with findings from women's football teams, where no significant differences were observed between the total PSS-10 scores of 1st and 2nd League teams (İmamoğlu Kaya et al., 2020). However, similar to our study, the discomfort sub-dimension scores were higher in the lower league team, suggesting that athletes in minor leagues face unique stressors related to limited resources and uncertain career trajectories. This finding supports the notion that the financial and structural limitations faced by teams in the Women's League contribute to increased stress levels. (Cutler & Dwyer, 2020; Pascoe et al., 2022). This may lead to athletes experiencing more difficulties in training and competition. Additionally, minor league athletes may face

uncertainty about the future and increased performance stress due to the pressure to advance to the major league in their careers.

Sleep is a critical factor that significantly influences an athlete's health and performance. During sleep, energy reserves are replenished, immune responses are boosted, and cognitive function is restored (Condo et al., 2022). It has also been noted that sufficient sleep is essential for maintaining a positive mood (Mutsuzaki et al., 2018). Despite the importance of adequate sleep for athletes during training and competition, it has been reported that many athletes struggle to get enough sleep during these periods (Roberts et al., 2019). In our study, basketball players had a mean PSQI score of 5.9±2.91. Similar to our findings, a study of female basketball players on the Japanese national wheelchair basketball team found a mean PSQI score of 5.7±2.85 (Mutsuzaki et al., 2018).

In a more extensive study involving athletes from various sports, the average PSQI score of basketball players was determined to be 4.4±2.6, and this score was determined to be not significantly different from other sports ($p > 0.05$) (Randell et al., 2021). Additionally, data collected from 112 female athletes in Japan showed that 25% of basketball players had poor sleep quality (PSQI≥5), with a mean PSQI score of 4.5±2.2 (Hoshino et al., 2022). In another study examining the prevalence of risk factors for poor sleep quality, drowsiness, and obstructive sleep apnea in rugby players, female rugby players exhibited a mean PSQI score of 8.2±3.3 (Swinbourne et al., 2016). Similarly, another study found that rhythmic gymnasts had a high prevalence of poor sleep quality, with 77.6% of participants classified as having poor sleep (Silva & Paiva, 2019). In another source, female athletes had an average PSQI score of 5.4±2.6 (Zhang et al., 2017). In another study evaluating sleep quality in female athletes according to PSQI scores, it was reported that the average was 5, and 55.8% of women had poor sleep quality (PSQI ≥ 5) (Halson et al., 2022). In another study, as found by Kawasaki et al. (2020) 48.84% of female athletes were reported to have a score of six or above on the PSQI. In a different study focusing on female athletes, Knufinke et al. (2018) determined the mean PSQI score as 4.61±2.04. Similar to the study results in the literature, 56.25% of the female basketball players who participated in our study were found to have poor sleep quality. The findings of this current study support that female athletes have poor sleep quality. It is thought that the intense match schedule of the basketball players participating in our study, frequent away matches, early morning training, and, in some cases, late night training all lead to poor sleep quality (Zhao et al., 2012). A study showed that semi-professional basketball players had less sleep duration on pre-game nights, and the probability of players achieving better-

perceived sleep quality was 88% lower on congested game nights than on pre-game nights (Power et al., 2023). Similar to the findings of our study, the results regarding sleep quality in another study showed no significant difference between amateur and elite athletes in the PSQI total scale and all sleep quality subscales except sleep duration (Taheri et al., 2023). The PSQI subscale sleep duration was significantly higher in the women's league, indicating that their sleep duration was less than that of basketball players in the Super League. The fact that athletes in the women's league struggle to get to the Super League and play tough matches supports the findings of this study. This situation increases the possibility that athletes in the women's league experience more stress and sleep deprivation, explaining the background of the findings.

The bidirectional relationship between sleep and psychological well-being has been linked to increased sleep disturbances and insufficient sleep in conjunction with elevated stress, anxiety, negative mood, and emotional dysregulation (Bonnet & Arand, 2010; Buckley & Schatzberg, 2005). This relationship highlights the critical role of psychological factors in determining sleep quality, particularly in high-stress environments such as competitive sports. Athletes experience physical stress and anxiety during training and competition, which can negatively affect their sleep quality (Richmond&Godard, 2004). This study found a statistically significant relationship between the average PSS-10 score and the average PSQI score of basketball players, indicating that higher perceived stress levels are associated with lower sleep quality. These findings align with previous research, such as a study investigating the connection between pre-competition perceived stress and sleep in endurance athletes, which found that women's perceived stress was directly linked to reduced sleep duration (Roberts et al., 2022). Another study involving professional athletes indicated that those with low stress levels had better sleep quality (Brandt et al., 2017). Similarly, in a study on Irish athletes, those with poor sleep quality scored significantly higher on the stress scale than those with good sleep quality (Roberts et al., 2022). The cumulative evidence underscores the need for targeted interventions to address stress management and improve sleep quality among athletes, as these factors are deeply intertwined with optimal performance and well-being.

Chronic stress has been shown to affect food choices by affecting both homeostatic and hedonic appetite control (Berg Schmidt et al., 2018). The findings of this study showed that the relationship between basketball players' low self-efficacy scores and average daily fiber intake was negative. However, no relationship was found between the PSS-10 total score. Dietary fiber may have a beneficial effect on stress via the gastrointestinal microbiota. The gut

microbiota that improves with dietary fiber intake may play a positive role in the metabolism of neurotransmitters such as serotonin synthesis (Saghafian et al., 2021). A study on badminton athletes reported that probiotic supplementation alleviated anxiety and stress (Salleh et al., 2021). These findings highlight the potential role of dietary interventions, such as probiotics and dietary fiber, in managing stress. However, further studies are required to confirm these effects and understand their mechanisms. Similarly, in a study conducted on female endurance athletes, no significant relationship was found between carbohydrate intake and stress levels among athletes with a PSS-10 mean score of 18.27±6.42 and a daily carbohydrate intake of 258.29±65.34, which is similar to our study (Alex, 2018). Long-chain polyunsaturated omega-3 fatty acids, especially docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), have been shown to play a stress-protective role by regulating pituitary adrenal axis (HPA) activity (Barbadoro et al., 2013). A study in the literature reported a significant negative relationship between perceived stress levels and fish consumption in women (Mikolajczyk et al., 2009). However, this study observed no relationship between omega-3 intake and perceived stress, which may be attributed to differences in dietary patterns, sample size, or other confounding variables. These discrepancies underscore the need for further research to elucidate the role of omega-3 fatty acids in stress regulation and its potential impact on athletes.

Limitations

A limitation of our study is that more advanced devices cannot be used to determine body composition. While BIA analysis should be used to evaluate nutritional status, biochemical findings and additional anthropometric measurements should also be considered in new and planned studies. Another limitation of our study is that the frequency of the food consumption questionnaire depends on the declaration of basketball players, and it also takes a long time to answer. Another limitation of our study is that the validity and reliability of the PSS-10 and PSQI scales for Turkish athletes have not been determined.

CONCLUSIONS

In summary, increased perceived stress among basketball players was associated with poorer sleep quality. Our findings support the conclusion that food intake, a key factor affecting athletic performance, affects stress, highlighting the importance of monitoring energy and nutrient intake. The study also highlights the need to assess the impact of stress

levels on sleep disorders and nutrition in female basketball players. Given the limited research on the relationship between stress, sleep, and nutrition in athletes, this study fills a gap by focusing specifically on these factors in high-intensity female basketball players. Additionally, the study contributes to the literature by providing valuable insights for future research on gender, age, and sport-specific differences with larger populations.

PRATICAL IMPLICATIONS

Improving athletes' performance, especially during competition periods, requires being aware of the stress they experience. The stress athletes face affects their sleep quality, and any sleep disruption can negatively impact performance results. Inadequate and improper nutrition during this period can increase sleep quality and perceived stress. Coaches, sports nutritionists, and psychologists should collaborate to regularly monitor athletes' stress levels, sleep quality, and nutritional intake, especially during high-intensity competition periods. Therefore, it is crucial to identify the causes of stress and poor sleep quality during competition periods and to provide athletes with appropriate support and counseling to address these issues. Individual and/or team training can help athletes understand the importance of proper nutrition and stress management for optimum performance. Consequently, it is essential to understand and evaluate nutritional factors that affect athletes' stress and sleep disorders.

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Authors' Contributions

Both authors made significant contributions to the concept or design of the article, and first author contributed to the acquisition, analysis and interpretation of the data. Both authors participated in the drafting of the article, and second author revised it critically. Both authors contributed equally, read and approved the final version of the manuscript.

Declaration of Conflict Interest

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Ethics Statement

Approval for this study was received from the Başkent University Medical and Health Sciences Research Board and Ethics Committee on 09/08/2022 (no: KA22/281).

REFERENCES

Ağargün, M.Y., Kara, H., & Anlar, Ö. (1996). Pittsburgh Uyku Kalitesi İndeksi'nin geçerliliği ve güvenirliliği [Validity and reliability of the Pittsburgh Sleep Quality Index]. *Türk Psikiyatri Dergisi, 7*(2), 107-115. ISSN:1300-2163

Akgün, H., Biçer, M., & Vural, M. (2021). Investigation of mental health of amateur and professional football players in the COVID–19 pandemic period. *European Journal of Physical Education and Sport Science, 7*(2). https://doi.org/10.46827/ejpe.v7i2.3782

Alex, M. L. (2018). *Relationship Between Stress, Dietary Intake, and Perception of Performance Amongst Female Long-Distance Runners* (Master's thesis, Kent State University).

Aydın, G. (2017). Su topu sporcularının stres düzeyi ve problem çözme becerilerinin incelenmesi [Examining the stress level and problem-solving skills of water polo athletes] [Undergraduate thesis, Dumlupınar University].

Barbadoro, P., Annino, I., Ponzio, E., Romanelli, R. M., D'Errico, M. M., Prospero, E., & Minelli, A. (2013). Fish oil supplementation reduces cortisol basal levels and perceived stress: a randomized, placebo-controlled trial in abstinent alcoholics. *Molecular nutrition & food research,* 57(6), 1110–1114. https://doi.org/10.1002/mnfr.201200676

Berg Schmidt, J., Johanneson Bertolt, C., Sjödin, A., Ackermann, F., Vibeke Schmedes, A., Lynge Thomsen, H., Marie Juncher, A., & Hjorth, M. F. (2018). Does stress affect food preferences? - a randomized controlled trial investigating the effect of examination stress on measures of food preferences and obesogenic behavior. *Stress (Amsterdam, Netherlands),* 21(6), 556–563. https://doi.org/10.1080/10253890.2018.1494149

Bonnet, M. H., & Arand, D. L. (2010). Hyperarousal and insomnia: State of the science. *Sleep Medicine Reviews, 14*(1), 9-15. https://doi.org/10.1016/j.smrv.2009.05.002

Brandt, R., Bevilacqua, G. G., & Andrade, A. (2017). Perceived sleep quality, mood states, and their relationship with performance among Brazilian elite athletes during a competitive period. *Journal of Strength and Conditioning Research, 31*(4), 1033-1039. https://doi.org/10.1519/JSC.0000000000001551

Buckley, T. M., & Schatzberg, A. F. (2005). On the interactions of the hypothalamic-pituitary-adrenal (HPA) axis and sleep: Normal HPA axis activity and circadian rhythm, exemplary sleep disorders. *Journal of Clinical Endocrinology & Metabolism, 90*(5), 3106-3114. https://doi.org/10.1210/jc.2004-1056

Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. *Psychiatry Research, 28*(2), 193-213. https://doi.org/10.1016/0165-1781(89)90047-4

Charest, J., & Grandner, M. A. (2022). Sleep and athletic performance: Impacts on physical performance, mental performance, injury risk and recovery, and mental health: An update. *Sleep Medicine Clinics, 17*(2), 263-282. https://doi.org/10.1016/j.jsmc.2022.03.006

Charmandari, E., Tsigos, C., & Chrousos, G. (2005). Endocrinology of the stress response. *Annual Review of Physiology, 67*, 259-284. https://doi.org/10.1146/annurev.physiol.67.040403.120816

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. *Journal of Health and Social Behavior, 24*(4), 385-396. https://doi.org/10.2307/2136404

Condo, D., Lastella, M., Aisbett, B., Stevens, A., & Roberts, S. (2022). Sleep duration and quality are associated with nutrient intake in elite female athletes. *Journal of Science and Medicine in Sport, 25*(4), 345-350. https://doi.org/10.1016/j.jsams.2021.11.045

Cutler, B. A., & Dwyer, B. (2020). Student-athlete perceptions of stress, support, and seeking mental health services. *Journal of Issues in Intercollegiate Athletics*, *13*(1), 16.

Davenne, D. (2009). Sleep of athletes–problems and possible solutions. *Biological Rhythm Research, 40*(1), 45-52.

de la Cruz Marcos, S., Redondo del Río, M. P., & de Mateo Silleras, B. (2021). Applications of Bioelectrical Impedance Vector Analysis (BIVA) in the Study of Body Composition in Athletes. *Applied Sciences*, 11(21), 9781. https://doi.org/10.3390/app11219781

Eskin, M., Harlak, H., Demirkıran, F., & Dereboy, Ç. (2013). Algılanan stres ölçeğinin Türkçeye uyarlanması: Güvenirlik ve geçerlik analizi [Adaptation of the Perceived Stress Scale into Turkish: Reliability and validity analysis]. *Yeni Symposium, 51*(3), 132-140.

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*(2), 175-191. https://doi.org/10.3758/BF03193146

Gunes, F. E., Imeryuz, N., Akalin, A., Bekiroglu, N., Alphan, E., Oguz, A., & Dehghan, M. (2015). Development and validation of a semi-quantitative food frequency questionnaire to assess dietary intake in Turkish adults. JPMA. *The Journal of the Pakistan Medical Association*, 65(7), 756–763.

Güvendi, B., Keskin, N., Altıncı, E. E., & Türksoy, A. (2016). Perceived stress, mood states associated with optimal performance and decision making styles in elite female basketball players. *International Refereed Academic Journal of Sports Health and Medical Sciences, 21*, 27-38. https://doi.org/10.17363/SSTB.20162124013

Halson, S. L., Johnston, R. D., Appaneal, R. N., Rogers, M. A., Toohey, L. A., Drew, M. K., Sargent, C., & Roach, G. D. (2022). Sleep Quality in Elite Athletes: Normative Values, Reliability and Understanding Contributors to Poor Sleep. *Sports medicine (Auckland, N.Z.),* 52(2), 417–426. https://doi.org/10.1007/s40279-021-01555-1

Hamlin, M. J., Deuchrass, R. W., Olsen, P. D., Choukri, M. A., Marshall, H. C., Lizamore, C. A., Leong, C., & Elliot, C. A. (2021). The Effect of Sleep Quality and Quantity on Athlete's Health and Perceived Training Quality. *Frontiers in sports and active living*, 3, 705650. https://doi.org/10.3389/fspor.2021.705650

Heaton, L. E., Davis, J. K., Rawson, E. S., Nuccio, R. P., Witard, O. C., Stein, K. W., Baar, K., Carter, J. M., & Baker, L. B. (2017). Selected In-Season Nutritional Strategies to Enhance Recovery for Team Sport Athletes: A Practical Overview. *Sports medicine (Auckland, N.Z.)*, 47(11), 2201–2218. https://doi.org/10.1007/s40279-017-0759-2

Horner, K. C. (2003). The emotional ear in stress. *Neuroscience & Biobehavioral Reviews, 27*(5), 437-446. https://doi.org/10.1016/s0149-7634(03)00071-x

Hoshino, F., Inaba, H., Edama, M., Natsui, S., Maruyama, S., & Omori, G. (2022). Sleep Quality and Nutrient Intake in Japanese Female University Student-Athletes: A Cross-Sectional Study. *Healthcare (Basel, Switzerland)*, 10(4), 663. https://doi.org/10.3390/healthcare10040663

Hyatt, H. W., & Kavazis, A. N. (2019). Body Composition and Perceived Stress through a Calendar Year in NCAA I Female Volleyball Players. *International journal of exercise science*, *12*(5), 433–443.

İmamoğlu Kaya, M., Çiçek, G., & İmamoğlu, M. (2020). Kadın Futbolcularda Algılanan Stres, Sporda Güdülenme, Sürekli Öfke ve Öfke Tarzı Düzeyleri. [Perceived Stress, Motivation in Sports, Trait Anger and Anger Style Levels in Female Football Players]. *Journal Of International Social Research*, *13*(74).

Kandiah, J., Yake, M., Jones, J., & Meyer, M. (2006). Stress influences appetite and comfort food preferences in college women. *Nutrition Research, 26*(3), 118-123. https://doi.org/10.1016/j.nutres.2005.11.010

Kawasaki, Y., Kasai, T., Koikawa, N., Hanazato, N., Suda, S., Murata, A., Ozaki, R., Nagai, S., Matsumura, Y., Kaneko, H., Kubo, M., Osawa, A., Nojiri, S., Ogasawara, E., Sakuraba, K., Daida, H., Kitade, M., & Itakura, A. (2020). Sex differences in factors associated with poor subjective sleep quality in athletes. *The Journal of sports medicine and physical fitness,* 60(1), 140–151. https://doi.org/10.23736/S0022-4707.19.09875-X

Klerman, E. B., & Hilaire, M. S. (2007). On mathematical modeling of circadian rhythms, performance, and alertness. *Journal of Biological Rhythms, 22*(2), 91-102. https://doi.org/10.1177/0748730407299200

Knufinke, M., Nieuwenhuys, A., Geurts, S. A. E., Coenen, A. M. L., & Kompier, M. A. J. (2018). Self-reported sleep quantity, quality and sleep hygiene in elite athletes. *Journal of Sleep Research, 27*(1), 78-85. https://doi.org/10.1111/jsr.12509

Lim, E. X., Sim, A. Y., Forde, C. G., & Cheon, B. K. (2018). The role of perceived stress and gender on portion selection patterns. *Physiology & Behavior, 194*, 205-211. https://doi.org/10.1016/j.physbeh.2018.05.031

Mancha-Triguero, D., García-Rubio, J., Calleja-González, J., & Ibáñez, S. J. (2019). Physical fitness in basketball players: A systematic review. *Journal of Sports Medicine and Physical Fitness, 59*(10), 1513-1525. https://doi.org/10.23736/S0022-4707.19.09180-1

Mikolajczyk, R. T., El Ansari, W., & Maxwell, A. E. (2009). Food consumption frequency and perceived stress and depressive symptoms among students in three European countries. *Nutrition Journal, 8*, 31. https://doi.org/10.1186/1475-2891-8-31

Mutsuzaki, H., Tsunoda, K., Hotta, K., Yozu, A., Shimizu, Y., & Wadano, Y. (2018). Comparison of sleep status among three Japanese national wheelchair basketball teams. *Journal of Physical Therapy Science, 30*(1), 63-66. https://doi.org/10.1589/jpts.30.63

Nedelec, M., Halson, S., Delecroix, B., Abaidia, A. E., Ahmaidi, S., & Dupont, G. (2015). Sleep hygiene and recovery strategies in elite soccer players. *Sports Medicine, 45*(11), 1547-1559. https://doi.org/10.1007/s40279-015-0377-9

O'Donnell, S., Beaven, C. M., & Driller, M. (2018). Sleep/wake behavior prior to and following competition in elite female netball athletes. *Sport Sciences for Health, 14*(2), 289-295. https://doi.org/10.1007/s11332-017-0425-y

Ohayon, M., Wickwire, E. M., Hirshkowitz, M., Albert, S. M., Avidan, A., Daly, F. J., Dauvilliers, Y., Ferri, R., Fung, C., Gozal, D., Hazen, N., Krystal, A., Lichstein, K., Mallampalli, M., Plazzi, G., Rawding, R., Scheer, F. A., Somers, V., & Vitiello, M. V. (2017). National Sleep Foundation's sleep quality recommendations: first report. Sleep health, 3(1), 6–19. https://doi.org/10.1016/j.sleh.2016.11.006

Oliver, G., Wardle, J., & Gibson, E. L. (2000). Stress and food choice: A laboratory study. *Psychosomatic Medicine, 62*(6), 853-865. https://doi.org/10.1097/00006842-200011000-00016

Otter, R. T., Brink, M. S., van der Does, H. T., & Lemmink, K. A. (2016). Monitoring perceived stress and recovery in relation to cycling performance in female athletes. *International Journal of Sports Medicine, 37*(1), 12-18. https://doi.org/10.1055/s-0035-1555779

Öz, H. (2018). Türkiye kadın basketbol süper liginde oynayan basketbolcuların 8 haftalık bireysel kuvvet ve kondisyon programı sonrası antropometrik ve motorik gelişimlerinin değerlendirilmesi [Evaluation of anthropometric and motoric development of basketball players playing in the Turkish women's basketball super league after an 8-week individual strength and conditioning program] [Master's thesis, Gelişim University].

Parlak, E., & Kırşan, H. (2024). Elit Basketbolcularda Akdeniz Diyeti Uyum Ölçeği ile Uyku Kalitesi Arasındaki İlişkinin İncelenmesi. [Examination of the Relationship Between Mediterranean Diet Compliance Scale and Sleep Quality in Elite Basketball Players]. *Osmaniye Korkut Ata Üniversitesi Fen Bilimleri Enstitüsü Dergisi*, 7(5), 2158-2172. https://doi.org/10.47495/okufbed.1435102

Pascoe, M., Pankowiak, A., Woessner, M., Brockett, C. L., Hanlon, C., Spaaij, R., S. Robertson, S. McLachlan, & Parker, A. (2022). Gender-specific psychosocial stressors influencing

mental health among women elite and semielite athletes: a narrative review. *British Journal of Sports Medicine*, *56*(23), 1381-1387. https://doi.org/10.1136/bjsports-2022-105540

Power, C. J., Fox, J. L., Teramoto, M., & Scanlan, A. T. (2023). Sleep Patterns Fluctuate Following Training and Games across the Season in a Semi-Professional, Female Basketball Team. *Brain sciences*, *13*(2), 238. https://doi.org/10.3390/brainsci13020238

Randell, R. K., Anderson, R., Carter, J. M., & Rollo, I. (2021). Self-reported current sleep behaviors of adult athletes from different competitive levels and sports. *Sleep Science, 14*(1), 1-7. https://doi.org/10.5935/1984-0063.20200044

Richardson, G. S. (2005). The human circadian system in normal and disordered sleep. *Journal of Clinical Psychiatry, 66*(suppl 9), 42.

Richmond, S. R., & Godard, M. P. (2004). The effects of varied rest periods between sets to failure using the bench press in recreationally trained men. *Journal of Strength and Conditioning Research, 18*(4), 846-849. https://doi.org/10.1519/14833.1

Roberts, S. S. H., Main, L. C., Condo, D., Carr, A., Jardine, W., Urwin, C., Convit, L., Rahman, S. S., & Snipe, R. M. J. (2022). Sex differences among endurance athletes in the pre-race relationships between sleep, and perceived stress and recovery. *Journal of sports sciences,* 40(14), 1542–1551. https://doi.org/10.1080/02640414.2022.2091345

Roberts, S. S. H., Teo, W. P., & Warmington, S. A. (2019). Effects of training and competition on the sleep of elite athletes: A systematic review and meta-analysis. *British Journal of Sports Medicine, 53*(8), 513-522. https://doi.org/10.1136/bjsports-2018-099322

Ruiz-Esteban, C., Olmedilla, A., Méndez, I., & Tobal, J. J. (2020). Female soccer players' psychological profile: Differences between professional and amateur players. *International Journal of Environmental Research and Public Health, 17*(12), 4357. https://doi.org/10.3390/ijerph17124357

Saghafian, F., Sharif, N., Saneei, P., Keshteli, A. H., Hosseinzadeh-Attar, M. J., Afshar, H., Esmaillzadeh, A., Adibi, P. (2021). Consumption of dietary fiber in relation to psychological disorders in adults. *Frontiers in psychiatry*, 12, 587468. https://doi.org/10.3389/fpsyt.2021.587468

Salleh, R. M., Kuan, G., Aziz, M. N. A., Rahim, M. R. A., Rahayu, T., Sulaiman, S., Kusuma, D. W. Y., Adikari, A. M. G. C. P., Razam, M. S. M., Radhakrishnan, A. K., & Appukutty, M. (2021). Effects of Probiotics on Anxiety, Stress, Mood and Fitness of Badminton Players. *Nutrients*, *13*(6), 1783. https://doi.org/10.3390/nu13061783

Silva, M. G., & Paiva, T. (2019). Sleep, energy disturbances and pre-competitive stress in female traveller athletes. *Sleep Science, 12*(4), 279-286. https://doi.org/10.5935/1984-0063.20190093

Swinbourne, R., Gill, N., Vaile, J., & Smart, D. (2016). Prevalence of poor sleep quality, sleepiness and obstructive sleep apnoea risk factors in athletes. *European Journal of Sport Science, 16*(7), 850-858. https://doi.org/10.1080/17461391.2015.1120781

Taheri, M., Irandoust, K., Reynoso-Sánchez, L. F., Muñoz-Helú, H., Cruz-Morales, K. N., Torres-Ramírez, R., ... & Nobari, H. (2023). Effects of home confinement on physical activity, nutrition, and sleep quality during the COVID-19 outbreak in amateur and elite athletes. *Frontiers in nutrition*, *10*, 1143340. ttps://doi.org/10.3389/fnut.2023.1143340

Tanaka, E., Yatsuya, H., Uemura, M., Murata, C., Otsuka, R., Toyoshima, H., Tamakoshi, K., Sasaki, S., Kawaguchi, L., & Aoyama, A. (2013). Associations of protein, fat, and carbohydrate intakes with insomnia symptoms among middle-aged Japanese workers. *Journal of epidemiology,* 23(2), 132–138. https://doi.org/10.2188/jea.je20120101

Terry, P. C., Galambos, S. A., West, J., & Iizuka, C. A. (2007). Psychological correlates of training load among athletes. In *Proceedings of the 42nd Australian Psychological Society Annual Conference: Psychology Making an Impact* (pp. 1-5).

Thomas, D. T., Erdman, K. A., & Burke, L. M. (2016). American College of Sports Medicine Joint Position Statement. Nutrition and Athletic Performance. *Medicine and science in sports and exercise,* 48(3), 543–568. https://doi.org/10.1249/MSS.0000000000000852

Uğurlu, F. M. Kadın Basketbolcularda Algılanan Stres Nedenleri Ve Stresle Başa Çıkma Yaklaşımları [Causes of Perceived Stress in Female Basketball Players and Approaches to Coping with Stress]. *Journal of History School (JOHS),* 2018; 36; 149- 159. http://dx.doi.org/10.14225/Joh1422

Wörner, T., Kauppinen, S., & Eek, F. (2024). Same game, different worlds? General conditions, perceived stress, and associations between stress and past season injuries in elite female and male ice hockey players. *BMC Sports Science, Medicine and Rehabilitation*, *16*(1), 69. https://doi.org/10.1186/s13102-024-00862-0

Yardımcı, F. B., & Kulunkoglu, B. (2022). Tokyo 2020 paralimpik oyunlarına hazırlanan sporcuların anksiyete, depresyon ve stres düzeylerinin incelenmesi [Examination of anxiety, depression and stress levels of athletes preparing for the 2020 Paralympic Games]. *Gazi Journal of Physical Education and Sports Sciences, 27*(2), 89-100. https://doi.org/10.53434/gbesbd.987452

Yaribeygi, H., Panahi, Y., Sahraei, H., Johnston, T. P., & Sahebkar, A. (2017). The impact of stress on body function: A review. *EXCLI Journal, 16*, 1057-1072. https://doi.org/10.17179/excli2017-480

Yüksel, A. (2021). COVID-19 Pandemi Döneminde Elit Sporcuların Uyku Kalitesi ile Beslenme Durumunun Değerlendirilmesi. *OPUS International Journal of Society Researches*, 17(Pandemi Özel Sayısı), 3918-3942. https://doi.org/10.26466/opus.909434

Zhang, Y., Xun, P., Wang, R., Mao, L., & He, K. (2017). Can magnesium enhance exercise performance? *Nutrients, 9*(9), 946. https://doi.org/10.3390/nu9090946

Zhao, J., Tian, Y., Nie, J., Xu, J., & Liu, D. (2012). Red light and the sleep quality and endurance performance of Chinese female basketball players. J*ournal of athletic training*, 47(6), 673–678. https://doi.org/10.4085/1062-6050-47.6.08

Zhao, M., Tuo, H., Wang, S., & Zhao, L. (2020). The effects of dietary nutrition on sleep and sleep disorders. *Mediators of Inflammation, 2020*, 3142874. https://doi.org/10.1155/2020/3142874

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Acute Effects of Aerobic Endurance Training with Different Glycogen Levels on Some Biochemical Parameters in Football Players

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ABSTRACT

This study aims to determine the acute effects of aerobic endurance exercises performed at different body glycogen levels on biochemical parameters related to energy metabolism. The study included 14 male amateur football players with an average age of 20.38 ± 2 years. Aerobic endurance exercises were performed under conditions of low liver glycogen after a 10-12 hour fasted (FST) state and under a postprandial (PPD) state, as well as under conditions of full and low body glycogen (partially reduced by the first exercise). These exercises consisted of two 60-minute sessions on a cycle ergometer with a 60-minute rest interval in between. Blood samples were collected from participants before and after all exercises. Statistical analyses were performed using SPSS 28.0 software, utilizing the paired simple t-test, Wilcoxon test, one-way ANOVA, Friedman analysis, and post-hoc tests with a significance level of $p < 0.05$. In PPD with low glycogen, glucose levels decreased during exercise, whereas in FST with low glycogen, insulin levels decreased in both exercises. Cortisol levels increased in the FST low glycogen exercise. Triglycerides also increased in the FST low glycogen exercise. Albumin levels increased in the FST, and the PPD and low glycogen exercise; similarly, levels increased in the PPD low glycogen exercise ($p < 0.05$). In conclusion, glucose levels were maintained during the FST and PPD low glycogen exercises, while the highest triglyceride breakdown occurred during the FST low glycogen exercise.

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INTRODUCTION

The human body is designed for movement (Şerare et al., 2024). Physical activity plays a crucial role in maintaining overall health, while training is essential for enhancing physical performance (Potteiger, 2018). Coaches increasingly rely on evidence-based medicine to design training programs and off-field strategies that optimize performance (Bhandari & Giannoudis, 2006). Among these off-field methods, experimenting with different combinations of training and nutrition plans to indirectly influence an athlete's energy metabolism is of primary importance. However, the literature review highlights the complexity and incomplete understanding of carbohydrate and fat utilization during aerobic endurance exercises. (Paşaoğlu et al., 2019).

Moreover, there is growing evidence that starting exercise with reduced glycogen reserves activates lipolysis to a greater extent, resulting in less dependence on glycogen (Earnest et al., 2019) and affecting biochemical parameters (Andrade-Souza et al., 2019; Lundberg et al., 2014). These studies generally involve pathological examinations through muscle biopsies, yielding findings that support muscle adaptation (Hansen et al., 2005). Additionally, increased research suggests that altering dietary intake can modify the metabolic responses associated with exercise (Earnest et al., 2019). Various methods have been employed to enhance metabolic efficiency, such as increasing carbohydrate consumption before and during exercise or performing exercise in a FST state (10-12 hours of fasting; Jeukendrup, 2017). A 12-hour FST period is known not to alter muscle glycogen stores; however, evidence has increasingly indicated that training under conditions of low liver glycogen reserves (Iwayama et al., 2021) may potentially influence metabolic efficiency (Gonzalez et al., 2015). Furthermore, carbohydrate and lipid metabolism changes during during aerobic exercise are recognized as significant factors affecting exercise performance (Fernández-Verdejo et al., 2018; Maunder et al., 2018). In addition to these studies, there is research investigating the impact of fasting on the performance of football players during Ramadan. These studies focus on the effects of exercise performed in a FST state on aerobic capacity, endurance (Meckel et al., 2008), speed, power, and ball dribbling skills (Kirkendall et al., 2008; Zerguini et al., 2007). The literature indicates that many exercises conducted with low glycogen stores are typically performed at 70% VO_2 peak, with durations ranging from 60 to 105 minutes, predominantly among cyclists and triathletes (Rosa et al., 2019; Webster et al., 2016; Yeo et al., 2008). Although football is considered one of the most popular sports worldwide, the application of such

endurance exercises lasting 120 minutes or more, often consisting of two 45-minute halves with potential extra time, is relatively rare among football players.

It is known that aerobic exercise does not increase cortisol hormone (COR) levels (Setiakarnawijaya et al., 2022; Torres et al., 2021), may reduce plasma glucose (GLU), insulin (INS), and insulin resistance index (Sabzikar et al., 2018), lead to significant reductions in serum triglyceride (TG) concentrations (Santiago et al., 2020), and cause no significant changes in serum albumin (ALB) levels immediately after exercise (Zhang et al., 2023).

This study aims to evaluate the acute effects of aerobic endurance exercises performed under FST and PPD conditions, and with full and partially reduced (low) body glycogen reserve on some biochemical parameters indicative of energy metabolism in male amateur soccer players. It was hypothesized that aerobic endurance exercises in soccer players may have different effects on biochemical parameters indicative of energy metabolism depending on different body glycogen levels.

METHODS

Participants

The research group consisted of 14 healthy adult amateur male football players with a mean age of 20.38±2, who had participated in football-specific training for at least 8-weeks during the season and were actively competing in local amateur leagues (n = 14; Table 1). After the potential risks were explained in detail, participants signed the informed consent form and were included in the study. Although the study began with 14 participants, it was completed with 13 participants due to one individual being unable to finish the exercise trial.

Table 1
Anthropometric Characteristics and Years of Education of Participants Evaluated Once

Anthropometric Characteristics	Mean±SD	Min	Max
Age (years)	20.38±2.06	18.00	25.00
Training Years (years)	9.07±3.06	5.00	16.00
Height (cm)	175.61±6.15	167.00	184.00
Body Weight (kg)	66.06±7.05	53.50	78.20
BMI (kg/m²)	21.03±1.52	17.90	23.80
Body Fat Percentage (%)	7.27±3.65	2.80	13.95
Body Muscle Mass (kg)	57.95±7.41	45.40	71.40

Note. SD: Standard Deviation, Min: Minimum, Max: Maximum, BMI: Body Mass Index, kg: Kilogram, %: Percentage, n = 13

Procedures

The experimental research model derived from the doctoral thesis was supported by the Gazi University "Scientific Research Projects Coordination Unit" (Project Code: 2022-8055). The research was conducted at the Performance Laboratory and the Cardiopulmonary Rehabilitation Unit of Gazi University. This study, conducted in accordance with the procedures outlined in the Helsinki Declaration and derived from a doctoral dissertation, was approved by the "Ethics Committee for Non-Invasive Clinical Research" of Gazi University (Date: July 25, 2022, Decision No: 586).

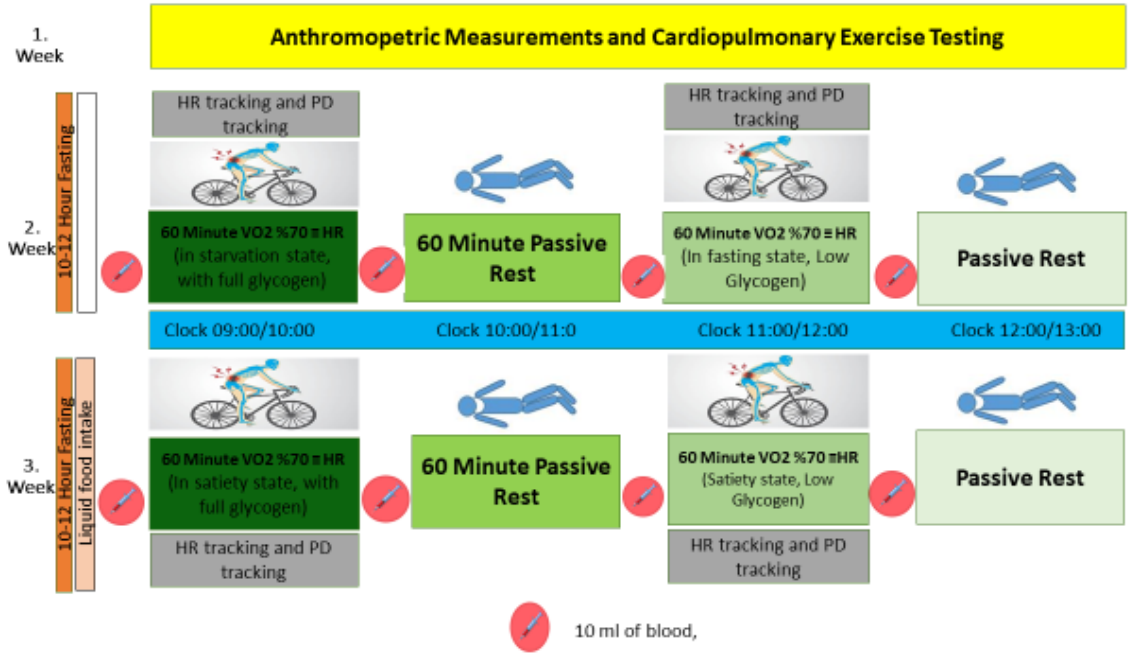
The participants visited our laboratory and unit a total of three times: once for anthropometric measurements and cardiopulmonary exercise tests, with a one-week interval between visits, and twice for experimental exercise sessions. Participants were instructed to arrive between 08:00 and 08:30, and all measurements, tests, and experimental exercises were conducted at the same time of day (±1 hour) between 09:00 and 13:00.

In the first week, anthropometric measurements were taken, body composition was assessed, and cardiopulmonary exercise tests were conducted once. In the second and third weeks, two 60-minute aerobic endurance exercises were conducted under different liver and body glycogen storage conditions, as detailed below (see Figure 1).

Second Week: The first 60-minute exercise (FE) was performed with low liver glycogen reserves (10-12 hours fasting) and full body glycogen reserves, followed by 60 minutes of passive rest. The second 60-minute exercise (SE) was conducted with both liver glycogen reserves (10-12 hours fasting) and body glycogen reserves at a low level (partially reduced from the first exercise).

Third Week: The first 60-minute exercise was performed with full liver glycogen reserves (liquid food intake) and full body glycogen reserves. After 60 minutes of passive rest, the second 60-minute exercise was conducted with full liver glycogen reserves (liquid food intake) and low body glycogen reserves (partially reduced from the first exercise). 10-12 hours of fasting is known to deplete liver glycogen stores (Learsi et al., 2019). The conditions of low liver and body glycogen have been validated by recent studies conducted with a population of elite male cyclists (Bulut & Turnagöl, 2018; Hulston et al., 2010). The acute effects of aerobic endurance exercises performed in both fasting and fed states, and full and partially reduced body glycogen reserves on biochemical parameters indicative of energy metabolism were assessed through statistical analyses of numerical data obtained from blood samples.

Figure 1
Study Protocol



Note. PD: Perceived Difficulty, HR: Heart Rate, VO_2max (ml kg-1 min-1): Maximum Amount of Oxygen (milliliters) Used Per Minute by 1 Kilogram of Muscle, VO_2max 70% ≡ HR: Heart Rate Corresponding to 70% of Maximum Oxygen Utilization, HR ≡ Power (watts) Corresponding to Heart Rate, ml: Mililitre.

Data Collection Tools

Anthropometric Measurements and Assessment of Body Composition

The participants' height measurements were taken once using a TEM EKO (Made in Turkey) brand electronic scale and stadiometer with a precision of one millimeter. Body compositions were determined using the TANITA MC 580 S (Tokyo, Japan) Bioelectrical Impedance Analysis (BIA) method. BIA estimates parameters such as body weight (kg), fat mass (%), muscle mass (kg), and body mass index (kg/m²) based on previously entered personal information and the body's electrical conductivity (Maliqi et al., 2022). (Table1). The participants' estimated maximum heart rate (HRmax) was calculated using the Karvonen formula (She et al., 2015).

Cardiopulmonary Exercise Test (CPET)

The Astrand Bicycle Ergometer Test protocol was applied once to determine the participants' aerobic capacities. The test used a Monark LC 6 model bicycle ergometer (Monark Exercise AB, Vansbro, Sweden; Stavrinou et al., 2019). During the test, oxygen consumption was recorded using a Cosmed Quark CPET device (Rome, Italy), which was calibrated according to the manufacturer's instructions before each test for cardiopulmonary indices.

Heart rate was measured using a REF: D41480 ANT+ chest strap, part of the Cosmed Quark CPET system, with accuracy reported similarly to electrocardiography (±1 beat/minute). A Cosmed Quark CPET gas analyzer was utilized throughout the data collection process (Price et al., 2022). In the CPET, measurements of key variables such as heart rate, oxygen consumption, respiratory rate, pulmonary ventilation (PVE), oxygen pulse, respiratory exchange ratio (RER), ventilation equivalents for oxygen (VE/VO_2), and ventilation equivalents for carbon dioxide (VE/VCO_2) were obtained.

In the Astrand protocol, participants began with a 5-minute warm-up at 50 Watts and a cadence of 60 revolutions per minute. Subsequently, a workload of 100 Watts was applied, and the intensity was increased by 50 Watts every two minutes until each participant reached voluntary exhaustion. A metabolic cart continuously recorded expired breath (COSMED, Quark CPET, Italy). The peak VO_2 value was defined as the highest oxygen uptake achieved during the final 30 seconds of the test. To assess maximum aerobic fitness levels, participants were verbally encouraged to exert themselves to their fullest potential (Naharudin & Yusof, 2018). The exercise was terminated by the operator when participants felt they could no longer maintain their effort, indicated by a failure of VO_2 or heart rate to increase with rising speed/power, a respiratory rate exceeding 45 breaths per minute, and a perceived exertion on the Borg scale above 18 (Price et al., 2022; Table 2).

Table 2
The Training Status and Aerobic Capacities of The Participants were Evaluated Once (n = 13)

Variables	Mean±SD	Min	Max
Resting HR (beats/min)	69.23±5.38	58.00	76.00
Max HR (beats/min)	186.00±8.66	165.00	197.00
VO_2max (ml kg-1 min-1)	44.78±4.02	37.00	51.70
Max Power (watts)	265.38±37.55	200.00	350.00
VO_2max 70% (ml kg-1 min-1)	32.33±4.17	25.90	42.70
VO_2max 70% ≡ HR (beats/min ±10)	153.76±5.34	141.00	159.00
70% HR ≡ Power (watts)	118.46±23.75	75.00	170.00
Perceived Difficulty (PD)	19.23±.72	18.00	20.00
70% of Perceived Difficulty	13.46±.50	12.60	14.00

Note. SD: Standard Deviation, Min: Minimum, Max: Maksimum, HR (beats/min): Heart Rate Per Minute, Max HR: Maximum Heart Rate, VO_2max (ml kg-1 min-1): Maximum Amount of Oxygen (milliliters) Used Per Minute by 1 Kilogram of Muscle, VO_2max 70% ≡ HR: Heart Rate Corresponding to 70% of maximum Oxygen Utilization, HR ≡ Power (watts): Power (watts) Corresponding to Heart Rate, PD: Perceived Difficulty

Determination of Exercise Intensity

At the end of the Astrand protocol applied to determine aerobic capacity, the heart rate range corresponding to 70% of VO_2max was identified in the CPET table and was designated as the intensity to be maintained in all aerobic exercises (Cabral et al., 2020; Fang et al., 2021; Rogers et al., 2021; Table 2).

Dietary Control Before and During Exercise

To maintain the participants' body glycogen levels and ensure energy balance, they were instructed to cease strenuous training 48 hours before the testing days, minimize caffeine intake especially in the last 24 hours and abstain from alcohol consumption (Ramos et al., 2021). Participants were also asked to avoid significant dietary changes during this period and consume the same food types the day before each exercise day (Hulston et al., 2010).

A specialist in nutrition and dietetics calculated the evening meals, pre-exercise PPD, and interim fluid nutrient intakes. The final evening meals before both exercise days were standardized and calculated to provide an average of 1013.48 ± 64.39 kcal (Fink & Mikesky, 2015). This meal was designed to consist of 55-65% carbohydrates, 30% fats, and 12-15% proteins (Nikolaidis & Theodoropoulou, 2014). The caloric values of the participants' last evening meals were calculated based on their Basal Metabolic Rates (BMR), daily energy requirements, and 25% of the calculated daily caloric needs. For male football players aged 18-30, BMR was calculated using the formula: BMR = (15.3 x Body Weight) + 679 = kcal. Daily energy requirements were determined using the formula: BMR x activity factor = BMR x (1.6 or 2.4) = kcal/day (Eskici, 2015). The recommended 25% of the calculated daily caloric needs was used to determine the last evening meal caloric intake (Şakar, 2009; Table 3).

On the FST exercise day, participants performed 60 minutes of aerobic endurance exercises after a 10-12 hour FST period. During the one-hour rest interval, they could consume water up to 0.5 milliliters (Hulston et al., 2010). On the PPD exercise day, participants consumed a liquid meal two hours before exercise, consisting of 55% carbohydrates, 30% fats, and 15% proteins, calculated at kg/10 kcal based on their body weight. After 60 minutes of aerobic endurance exercise and one-hour rest interval, they ingested a liquid meal containing 44% carbohydrates, 24% fats, and 28% proteins, calculated at kg/2 kcal (Bulut & Turnagöl, 2018). The liquid food beverages were sourced from Nestlé Turkey Food Inc. (Table 3).

Aerobic Endurance Exercise

Aerobic endurance exercises were conducted on an electronic-braked bicycle ergometer (Monark 928 E, Sweden; Jones et al., 2021). The exercise intensity was maintained at a pedaling rate of 70 RPM, corresponding to 70% of VO_2max, using heart rate (HR) data (Fang et al., 2021; Rogers et al., 2021). During the exercise, HR was monitored using a Polar H1 chest strap (Dennis et al., 2021) and a Polar FT80 watch (Polar Electro Oy, Kempele, Finland; Manjunath et al., 2019). In the first week of the experimental exercises, participants performed 60 minutes of aerobic endurance exercises at a pedaling rate of 70 RPM, aiming to maintain the HR corresponding to 70% VO_2max after a 10-12 hour fast. This was repeated twice with a 60-minute rest interval. In the second week of the experimental exercises, the same protocol was followed under fed conditions (liquid food intake; Bulut & Turnagöl, 2018). The aim was to reduce body glycogen reserves with the first 60-minute exercise and to begin the second exercise with partially reduced glycogen reserves (Bulut, 2014; Yeo et al., 2010).

Table 3
Dietary Calories and FST - PPD Blood Glucose Levels for Before - After FST and PPD Status Exercises (n = 13)

Variables	Mean±SD	Min	Max
Basal Metabolic Rate (BMR; kcal)	1689.15±107	1497.55	1875.46
Daily Calorie Needs (kcal)	4053.92±257	3594.12	4501.10
Last Evening Diet (kcal)	1013.48±64.39	898.75	1125.27
Week 2 PPD blood GLU (mg/dL)	118.69±11.41	99.00	137.00
FST blood GLK (mg/dL) after 10-12 hours	92.69±6.66	83.00	101.00
Week 3 PPD blood GLU (mg/dL)	121.38±15.34	93.00	146.00
FST blood GLU (mg/dL) after 10-12 hours	92.92±9.85	80.00	111.00
PPD PRE-FE diet (kcal)	653.07±68.25	535.00	732.00
PPD POST-FE diet (kcal)	132.89±16.96	107.00	167.40

Note. SD: Standard Deviation, Min: Minimum, Max: Maximum, GLU: Glucose, kcal: Kilocalories, mg/dL: Milligrams per Deciliter, PPD: Postprandial, FST: Fasting, PRE-FE: Pre-First Exercise, POST-FE: Post-First Exercise.

Biochemical Sample Collection and Measurement

Venous blood samples were collected from participants a total of four times, both before and after each exercise session, by cardiology specialists. For hormone and metabolite measurements, 5 mL gel tubes (serum) were used, with particular attention to measuring the levels of hormones such as cortisol (COR) and insulin (INS), as well as metabolites including albumin (ALB), glucose (GLU), and triglycerides (TG). The venous blood samples collected

from participants were transported to the biochemistry laboratory, where they were centrifuged at 3500 RPM at -4 °C to separate plasma and serum. Different devices were used to determine the levels of each serum component. Hormone and metabolite levels were measured using a fully automated clinical biochemistry analyzer (Cobas 6000, Roche Hitachi, Mannheim, Germany). Blood samples taken for gas analysis were measured using a blood gas analyzer (ABL800™, Radiometer, Copenhagen, Denmark).

Data Analysis

The determination of the number of participants was conducted by a biostatistics expert, with the PRE-FE glucose parameter (75.7 ± 15.1) under the PPD condition in Bulut's (2014) study primarily referenced (Bulut, 2014). A power analysis conducted using *GPower 3.1 with $\alpha = 0.05$, $\beta = 0.10$, and $1-\beta = 0.90$ determined that 14 volunteer participants should be included in the study, with the test power calculated as $p = 0.90431$. Data analysis was performed using SPSS 28.0 statistical software. Normality assumptions were tested using the Shapiro-Wilk test. Equality of variances among all relevant group combinations was determined using Levene's test. When parametric assumptions were met, measurements obtained from the same individuals under different conditions were compared using the paired sample t-test. For comparisons involving more than two measurements, one-way ANOVA, Bonferroni test, and post-hoc tests were employed. When parametric assumptions were not met, the Wilcoxon test was used to compare measurements from the same individuals under different conditions, and the Friedman test was applied to compare measurements involving more than two measurements. The significance level was set at $p < 0.05$.

RESULTS

As shown in Table 4, in all exercise trials conducted in a fasting state (FST), there were significant differences in repeated measurements: INS levels decreased between POST-FE and the second exercise post (POST-SE), TG levels decreased between POST-FE and PRE-SE, TG measurements increased between PRE-SE and POST-SE, COR measurements increased between PRE-SE and POST-SE, ALB measurements increased between PRE-FE and POST-FE, decreased between POST-FE and PRE-SE, and increased between PRE-SE and POST-SE ($p < 0.05$). Table 5 presents a comparison of blood parameters collected from participants during exercise trials under the PPD condition.

Table 4
The Statistical Comparison of Blood Levels Obtained From All Exercise Trials in the FST Condition (n=13).

FST		Mean±SD	p	Friedman Test		p
GLU (mg/dL)	PRE-FE	88.53±9.76	0.071			
	POST-FE	86.30±9.66				
	PRE-SE	85.00±8.80				
	POST-SE	82.00±13.65				
INS (µIU/mL)	PRE-FE	6.32±2.97	**0.0001***	PRE-FE	POST-FE	0.055
	POST-FE	4.37±2.70		POST-FE	PRE-SE	0.420
	PRE-SE	3.54±2.32		POST-FE>	PRE-SE	**0.0001***
	POST-SE	2.39±2.38		PRE-SE	POST-SE	0.055
COR (micg/dl)	PRE-FE	14.94±2.72	**0.0001***	PRE-FE	POST-FE	0.664
	POST-FE	13.53±4.01		POST-FE	PRE-SE	0.082
	PRE-SE	11.90±2.84		POST-FE	POST-SE	0.172
	POST-SE	16.43±5.17		PRE-SE<	POST-SE	**0.0001***
TG (micg/dl)	PRE-FE	67.23±26.24	**0.0001***	PRE-FEB	POST-FE	0.710
	POST-FE	71.61±23.89		POST-FE>	PRE-SE	**0.0001***
	PRE-SE	60.07±18.78		POST-FE	POST-SE	0.094
	POST-SE	78.38±17.88		PRE-SE<	POST-SE	**0.0001***
				Bonferroni Test		
ALB (g/dL)	PRE-FE	50.23±2.56	**0.0001***	PRE-FE<	POST-FE	**0.0001***
	POST-FE	52.37±0.98		POST-FE>	PRE-SE	**0.0001***
	PRE-SE	48.98±2.18		POST-FE	POST-SE	1.000
	POST-SE	52.54±1.22		PRE-SE<	POST-SE	**0.0001***

Note. GLU: Glucose, INS: Insulin, COR: Cortisol, TG: Triglyceride, ALB: Albumin, Mean ± SD: Mean ± Standard Deviation, mg/dl: Milligram/Deciliter, µIU/mL: Micro-International Units Per Millilite, micg/dl: Micrograms/Decilitre, g/DL: Gram/Decilitre <: Less than, >: Greater than, PRE-FE: Pre-first exercise, POST-FE: Post-first exercise, PRE-SE: Pre-second exercise, POST-SE: Post-second exercise, p*: p value between tests. Significance level: $p < 0.05$.

Table 5
Statistical Comparison of Blood Levels Obtained From All Exercise Trials in the PPD Condition Among Participants (n = 13)

FST	PDD	Mean±SD	p	Pairwise		p
GLU (mg/dL)	PRE-FE	93.92±15.45	**0.0001***	PRE-FEB	POST-FE	0.969
	POST-FE	93.84±6.41		POST-FE	PRE-SE	0.059
	PRE-SE	86.38±12.39		POST-FE>	POST-SE	**0.0001***
	POST-SE	84.92±5.78		PRE-SE	POST-SE	0.944
INS (µIU/mL)	PRE-FE	38.07±23.93	**0.0001***	PRE-FE>	POST-FE	**0.0001***
	POST-FE	15.61±17.21		POST-FE	PRE-SE	0.055
	PRE-SE	21.95±18.10		POST-FE	POST-SE	0.239
	POST-SE	7.63±14.37		PRE-SE>	POST-SE	**0.0001***
COR (micg/dl)	PRE-FE	13.43±4.01	0.107			
	POST-FE	11.04±2.42				
	PRE-SE	10.93±2.64				
	POST-SE	12.77±3.66				
				Bonferroni		
TG (mg/dL)	PRE-FE	114.75±62.44	0.489			
	POST-FE	127.46±52.13				
	PRE-SE	121.07±50.34				
	POST-SE	125.23±44.74				
ALB (g/dL)	PRE-FE	49.91±3.50	**0.0001***	PRE-FE	POST-FE	0.348
	POST-FE	51.60±2.80		POST-FE>	PRE-SE	**0.0001***
	PRE-SE	48.68±3.15		POST-FE	POST-SE	1.000
	POST-SE	51.70±2.87		PRE-SE<	POST-SE	**0.0001***

As shown in Table 6, when comparing the blood parameters measured in the PRE-FE, FST, and PPD conditions, there is a difference between the FST and PPD conditions regarding INS and TG levels. Similarly, when comparing the blood parameters measured in the POST-FE, FST, and PPD conditions, there are differences between the FST and PPD conditions regarding GLU, COR, and TG levels ($p<0.05$).

Table 6
Statistical Comparison of the Blood Parameters Before and After the First Exercise in the FST and PPD Conditions Among Participants (N=13)

Variables	FST (Mean±SD)	PPD(Mean±SD)	t	Z	P
Pre-First Exercise (PRE-FE)					
GLU(mg/dL)	88.53±9.76	93.92±15.45	-.978		0.348
INS(µIU/mL)	6.32±2.97	38.07±23.93	-5.113		**0.0001***
COR(micg/dl)	14.94±2.72	13.43±4.01	1.118		0.286
TG(mg/dL)	67.23±26.24	114.75±62.44		-2.132	**0.0001***
ALB(g/dL)	50.23±2.56	49.91±3.50	.293		0.774
Post-First Exercise (POST-FE)					
GLU(mg/dL)	86.30±9.66	93.84±6.41	-3.458		**0.0001***
INS(µIU/mL)	4.37±2.70	15.61±17.21		-1.818	0.069
COR(micg/dl)	13.52±4.01	11.04±2.42	3.004		**0.0001***
TG(mg/dL)	71.61±23.89	127.46±52.13	-3.950		**0.0001***
ALB(g/dL)	52.37±0.98	51.60±2.80	1.043		0.317

Mean ± SD: Mean ± Standard Deviation, Glucose, INS: Insulin hormone, COR: Cortisol hormone, ALB: Albumin enzyme, TG: Triglycerides, p*: p value between tests. Significance level: $p < 0.05$

As shown in Table 7, when comparing the blood parameters measured in the PRE-SE, FST, and PPD conditions, there is a difference between the FST and PPD conditions regarding INS and TG levels. Similarly, when comparing the blood parameters measured in the POST-SE, there are differences between the FST and PPD conditions regarding COR and TG levels ($p<0.05$).

Table 7
Statistical Comparison of the Blood Parameters Before and After the Second Exercise in the FST and PPD Conditions Among Participants (N = 13)

Variables	FST (Mean±SD)	PPD (Mean±SD)	t	Z	P
Pre-Second Exercise (PRE-SE)					
GLU(mg/dL)	85.00±8.80	86.38±12.39		-.035	0.972
INS(µIU/mL)	3.54±2.32	21.95±18.10	-3.723		**0.0001***
COR(micg/dl)	11.90±2.84	10.93±2.64	1.123		0.283
TG(mg/dL)	60.07±18.78	121.07±50.34	-4.789		**0.0001***
ALB(g/dL)	48.98±2.18	48.68±3.15	.352		0.731
Post-Second Exercise (POST-SE)					
GLU(mg/dL)	82.00±13.65	84.92±5.78	-.895		0.389
INS(µIU/mL)	2.39±2.38	7.63±14.37		-1.782	0.075
COR(micg/dl)	16.43±5.17	12.77±3.66	2.599		**0.0001***
TG(mg/dL)	78.38±17.88	125.23±44.74	-3.938		**0.0001***
ALB(g/dL)	52.54±1.22	51.70±2.87	1.331		0.208

DISCUSSION

Although it has been demonstrated that diet and exercise intensity can significantly alter skeletal muscle glycogen content, which in turn can affect exercise capacity (Ramonas et al., 2023; Guest et al., 2021), many questions remain unanswered regarding how the full and depleted states of liver and body glycogen reserves affect blood parameters related to energy metabolism during exercise. Therefore, this study investigated the acute effects of 60 minutes of aerobic endurance exercise at four different glycogen reserve levels: low liver glycogen FST, filled liver glycogen PPD, and body glycogen reserves that were either filled or low (partially reduced). The most significant findings related to energy metabolism are that GLU levels decreased following exercise with low body glycogen under the PPD condition and remained low after all other exercise trials. Additionally, TG levels increased following exercise with low body glycogen under the FST condition, whereas no significant increase in TG was observed in any exercise trials under the PPD condition.

It is known that as the duration of low to moderate intensity exercise increases, carbohydrate reserves decrease, leading to a reduction in carbohydrate oxidation (Potteiger, 2011). In our study, while the GLU level in the resting state for the filled liver glycogen PPD condition was not significantly higher than that in the state FST, it was observed to be higher nonetheless. Indeed, Turan (2010) reported higher GLU levels in the resting state for PPD compared to FST levels (Turan, 2010). After aerobic endurance exercise performed with filled body glycogen reserves, the GLU levels in the PPD condition were found to be significantly higher than in the FST condition ($p<0.05$; Table 6). Supporting our findings, de Lima et al. (2015) conducted a study on physically active individuals. They found that during moderate intensity aerobic exercise lasting over 30 minutes at 65% of VO_2max, GLU levels were maintained in the FST condition, while GLU concentration increased in the PPD condition (de Lima et al., 2015). In our study, a significant decrease in GLU levels was observed in the post-exercise state with low body glycogen (POST-SE) for the PPD condition ($p<0.05$; Table 5).

Bulut & Turnagöl (2018) conducted a study involving nine male triathletes with a mean age of 21.5±2.06 years, performing 60 minutes of aerobic endurance exercise under filled and low muscle glycogen reserves in FST and PPD conditions. They found that total carbohydrate oxidation significantly decreased after the second PPD exercise compared to the first PPD exercise (Bulut & Turnagöl, 2018). Although our participants were football players, the findings of Bulut & Turnagöl (2018) support our results.

According to Haub et al. (2003), maximal effort exercise in trained cyclists did not significantly differ in pre- and post-exercise blood GLU levels (Haub et al. 2003). In our study, under the FST condition, a non-significant decrease in blood GLU levels was observed following exercise performed with full and low body glycogen stores, indicating that GLU levels were maintained. Numerous studies conducted under FST conditions have reported that the exercise trials increase fat utilization without causing a significant change in GLU utilization (Van Proeyen et al., 2011). In the FST condition, where liver glycogen reserves are low, gluconeogenesis likely remains active, thereby preserving the already low blood GLU levels, particularly for glucose-dependent tissues such as brain tissue (Quintard et al., 2016).

Prolonged fasting leads to the inability of liver reserves to meet metabolic demands. (Hall & Hall, 2020). It has been reported that after an overnight fast, the blood GLU levels decrease, accompanied by a reduction in INS levels when no food is consumed (Atkinson et al., 2020). In our study, the significantly lower INS levels in the FST condition compared to the PPD condition, observed prior to exercises conducted with both filled and low body glycogen, align with the literature ($p<0.05$; Tables 6-7). In the FST condition, where INS levels were much lower, a linear decrease in blood INS was found, indicating that the reduction in POST-SE after exercise with low glycogen was greater compared to that with filled body glycogen ($p<0.05$) (Table 4). Conversely, in the PPD condition, which had higher INS levels, significant decreases were observed post-exercise compared to the aerobic endurance exercise trials conducted with both filled and low body glycogen reserves ($p<0.05$; Table 5). In a study by Chycki et al. (2019), involving 18 individuals (6 obese, 6 athletic, and 6 with endurance training), participants performed treadmill exercises for 20 minutes at 30% VO_2max, 10 minutes at 50% VO_2max, and 5 minutes at 70% VO_2max. They found that blood INS levels decreased across all groups ($p<0.05$; Chycki et al., 2019). Although the exercise protocols employed were significantly shorter than those employed in our study, the findings of Chycki and colleagues strongly support our results.

INS secretion inhibits COR, thereby enhancing carbohydrate entry into cells (Lin et al., 2012). On the other hand, during aerobic endurance exercise, free fatty acids (FFA) are stimulated by catecholamines such as epinephrine, norepinephrine (Jaworski et al., 2007), glucagon, and cortisol, which are derived from adipose tissue triglycerides (Birbrair et al., 2013; Lafontan & Langin, 2009). The opposing effects of the anabolic hormone INS and the catabolic hormone COR significantly impact glycogen reserves (Ferlazzo et al., 2020; Robyn et al., 2017). In the FST condition, the COR levels were found to be higher after aerobic endurance

exercises conducted with both filled and low body glycogen reserves compared to the PPD condition ($p<0.05$; Tables 6-7). It has been noted that there are no significant changes in COR levels during short-duration low-intensity exercises; however, a significant increase occurs following exercises performed at or above 60% of VO_2 max (Civan et al., 2018). In our study, while there were no significant changes in COR levels across all exercise trials in the PPD condition, a significant increase in COR was observed post-exercise in the FST condition compared to the PRE-SE with low body glycogen reserves ($p<0.05$; Table 4). Moreover, Terink et al., (2021) reported that exercising with reduced muscle glycogen reserves elevated FFA and COR levels between the 90th and 120th of exercise (Terink et al., 2021). Our findings, particularly the significant increase in POST-SE COR levels in the FST condition, align with the results of Terink et al., (2021). The data indicate that aerobic endurance exercises performed under FST conditions and with low body glycogen reserves increase COR levels due to metabolic stress. The rise in COR levels suggests the activation of gluconeogenesis to maintain blood GLU levels.

Ruíz-Moreno et al. (2020) stated that exercise intensity significantly affects substrate utilization, with intramuscular triglycerides (IMTG) contributing more to fat oxidation as exercise intensity increases. Their findings indicate that the contribution of IMTG to fat oxidation is particularly significant during moderate-intensity exercise, when fat oxidation rates peak (Ruíz-Moreno et al., 2020). Howard and Margolis, (2020) demonstrated that muscle triglycerides (TG) are significantly utilized during prolonged submaximal exercise (Howard & Margolis, 2020). In our study, the TG levels that converted to free FFA after lipolysis were found to be significantly higher in the PPD condition compared to the FST condition in all measurements taken before and after exercise ($p<0.05$; Tables 6-7). Turan (2010) also reported that resting TG levels were higher in the PPD condition than FST, supporting our findings of resting TG levels in both FST and PPD before exercise (Turan, 2010). Rothschild et al. (2021) found that fat oxidation rates remained significant even in a glycogen-depleted state, suggesting that intramuscular triglycerides (IMTG) are a crucial energy substrate during prolonged exercise. Their study further supported the notion that IMTGs are readily utilized as an energy source, as fat oxidation levels during moderate-intensity cycling were similar between fasting and protein-fed states (Rothschild et al., 2021). De Lima et al. (2015) found that in physically active individuals, plasma TG levels increased significantly more after FST exercise compared to PPD exercise during moderate-intensity aerobic trials performed at 65% of VO_2max for over 30 minutes ($p<0.05$; de Lima et al., 2015). Our study determined that

aerobic endurance exercises performed in the PPD condition, whether with filled or low body glycogen reserves, did not alter TG levels. However, the second aerobic endurance exercise performed in the FST condition with low body glycogen resulted in increased blood TG levels ($p<0.05$; Tables 4-5). Furthermore, Hulston et al. (2010) conducted a study with trained cyclists divided into low and high glycogen groups. The low group performed 90 minutes of aerobic endurance exercise at 70% VO_2max every other day, followed by eight bouts of five-minute high-intensity interval training (HIIT) one hour later. The high group performed aerobic endurance exercises on one day and HIIT on the next for three weeks. They found that during aerobic endurance exercise, the low muscle glycogen group showed a higher rate of FFA utilization in parallel with increased usage of muscle IMTG (Hulston et al., 2010). Although our participants were amateur football players, the significant increase in TG levels observed post-exercise in both the FST condition and the partially reduced body glycogen reserves aligns with the findings of Hulston et al. (2010), which noted a corresponding increase in lipolysis of muscle triglycerides in the low muscle glycogen group. Bulut & Turnagöl (2018) studied trained male triathletes and found that during 60 minutes of aerobic endurance exercises in the PPD and FST conditions, the FFA levels were higher in the PPD condition compared to those performed post-exercise with low glycogen reserves ($p<0.05$; Bulut & Turnagöl, 2018).

According to the findings, a significant increase in TG utilization was observed when exercise was performed with low glycogen reserves compared to filled glycogen reserves, At the same time, the same result was not found in the PPD condition. We believe the PPD condition positively affects glycogen reserves compared to the FST condition. Indeed, significant decreases in GLU measurements during exercise trials were observed in the PPD condition. In contrast, such decreases were not found in the FST condition, which already had lower GLU levels. This suggests that the PPD condition may help preserve glycogen reserves, albeit with a delay.

During exercise with low glycogen, an increase in circulating catecholamine levels is observed (López-Soldado et al., 2021). Elevated catecholamine levels increase fat metabolism by activating hormone-sensitive lipase (HSL) via protein kinase A. When HSL activity triggers lipolysis in adipose tissue and skeletal muscle, free FFA are released from both adipose and intramuscular tissues (Muscella et al., 2020). Once triglycerides are reduced to FFAs, they bind to plasma albumin and are transported to active tissues for energy use (Günay et al., 2018). There was no significant difference in ALB levels between FST and PPD conditions in all

measurements involving circulating FFA. Bulut & Turnagöl (2018) also found no significant differences between FST and PPD exercises in their study on male triathletes who performed 60 minutes of aerobic endurance exercise with filled and low glycogen (Bulut & Turnagöl, 2018). These findings support our results. It was determined that aerobic endurance exercises performed in both FST conditions with filled and low body glycogen reserves elevated blood ALB levels. In contrast, in the PPD condition, only the second aerobic exercise with low body glycogen reserves increased blood ALB levels ($p<0.05$; Tables 4-5).

The results indicate that in the FST condition, an increase in ALB levels after POST-FE coincided with an increase in the transport of FFAs. In the PPD condition, an increase in FFA transport was observed during POST-SE, parallel to the increase in ALB levels when body glycogen reserves were low.

Limitations

This study's limitations are that the participants were individuals who play amateur football, and the analysis of blood parameters, which are indicators of energy metabolism, was restricted to the current tests conducted at the Biochemistry Laboratory of Sivas Cumhuriyet University Hospital.

CONCLUSIONS

According to the findings obtained from aerobic endurance exercises performed under conditions of low liver glycogen reserves (FST) and filled satiety (PPD), as well as with filled and partially reduced (low) body glycogen reserves, the following conclusions can be drawn:

- *GLU Metabolism:* In the FST condition, where glycogen levels were low, GLU levels were maintained during both filled and low glycogen exercises, while a significant decrease was observed during low glycogen exercise in the PPD condition.
- *Insulin Levels*: Insulin levels decreased in the FST condition during low glycogen exercise. In the PPD condition, significant reductions in insulin levels were observed in both filled and low glycogen exercises.
- *Cortisol Levels:* Cortisol levels increased only during low glycogen exercise in the FST condition, stimulating gluconeogenesis. In the PPD condition, there were no changes in cortisol levels during either filled or low glycogen exercises.

- *Blood TG Levels:* Blood TG levels were higher in the PPD condition compared to the FST condition across all measurements. In the FST condition, low glycogen exercise increased TG levels, whereas no changes in TG levels were observed in both filled and low glycogen exercises during the PPD condition.
- *Albumin Levels:* Blood ALB levels increased in the FST condition during both filled and low glycogen exercises, whereas in the PPD condition, an increase was only noted during low body glycogen exercise.

Therefore, it can be concluded that aerobic endurance exercises performed by male amateur football players under conditions of filled liver glycogen (PPD) and low liver glycogen (FST), as well as with filled and low body glycogen reserves, resulted in the highest fat oxidation, particularly during FST and low glycogen exercises.

PRATICAL IMPLICATIONS

This study reveals the effects of glycogen levels on aerobic endurance exercises in male amateur football players. The findings suggest that coaches and athletes need to pay attention to glycogen status, providing a basis for enhancing athletic performance and reducing the risk of injuries. It is crucial for coaches to regularly monitor athletes' glycogen levels to optimize training. Customized training programs can be adjusted based on the athletes' glycogen status. Aerobic endurance exercises performed under low liver glycogen levels (fasted state) can be integrated to enhance fat utilization. Carbohydrate loading is important prior to critical competitions. Nutrition should aim to optimize glycogen stores. Nutritionists can develop individualized diet plans that consider glycogen levels before training. Future research should focus on evaluating the long-term effects of this training model and nutrition strategies on performance outcomes in football players. Additionally, the applicability of these strategies at different levels of competition should be examined.

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Authors' contributions

The first and second authors designed the manuscript; the first, third, fourth, fifth, and sixth authors were responsible for data collection, while the first author analyzed and interpreted the data. The first author also prepared the draft of the manuscript. All authors, except for the first author, performed a critical review, and all authors read and approved the final version of the manuscript.

Declaration of conflict interest

The authors have no conflicts of interest to disclose.

Ethics Statement

The study was approved by the Gazi University Non-Interventional Clinical Research Ethics Committee (Date: July 25, 2022, Decision No: 586).

REFERENCES

Andrade-Souza, V. A., Ghiarone, T., Sansonio, A., Santos Silva, K. A., Tomazini, F., Arcoverde, L., Fyfe, J., Perri, E., Saner, N., Kuang, J., Bertuzzi, R., Leandro, C. G., Bishop, D. J., & Lima-Silva, A. E. (2019). Exercise twice-a-day potentiates markers of mitochondrial biogenesis in men. *The FASEB Journal, 34*(1), 1602–1619. Portico. https://doi.org/10.1096/fj.201901207rr

Atkinson, F., Heruc, G., Tan, V. M. H., Petocz, P., & Brand-Miller, J. (2020). Extending the overnight fast: sex differences in acute metabolic responses to breakfast. *Nutrients, 12*(8), 2173. https://doi.org/10.3390/nu12082173

Birbrair, A., Zhang, T., Wang, Z. M., Messi, M. L., Enikolopov, G. N., Mintz, A., & Delbono, O. (2013). Role of pericytes in skeletal muscle regeneration and fat accumulation. *Stem Cells and Development, 22*(16), 2298-2314. https://doi.org/10.1089/scd.2012.0647

Bhandari, M., & Giannoudis, P. V. (2006). Evidence-based medicine: what it is and what it is not. *Injury,* 37(4), 302-306. https://doi.org/10.1016/j.injury.2006.01.034

Bulut, S. (2014). *Vücut glikojen depo düzeylerinin akut egzersiz metabolizmasına etkisi,* Doktora Tezi, Hacettepe Üniversitesi Sağlık Bilimleri Enstitüsü, Ankara, 51.

Bulut, S., & Turnagöl, H. (2018). Glikojen depolarının ve sıvı besin alımının egzersiz sırasında yağ ve karbonhidrat kullanımına etkisi. *Beslenme ve Diyet Dergisi, 46*,(11), 30-39. https://doi. org/10.33076/2018. bdd.285

Cabral, L. L., Nakamura, F. Y., Stefanello, J. MF., Pessoa, L. CV., Smirmaul, B. PC., & Pereira, G. (2020). Initial validity and reliability of the portuguese borg rating of perceived exertion 6-20 scale. *Measurement in Physical Education and Exercise Science, 24*(2), 103-114. https:// doi.org/10. 1080/1091367x.2019. 1710709

Chycki, J., Zajac, A., Michalczyk, M., Maszczyk, A., & Langfort, J. (2019). Hormonal and metabolic substrate status in response to exercise in men of different phenotype. *Endocrine Connections, 8*(7), 814-821. https://doi.org/10.1530/ec-19-0216

Civan, A., Özdemir, İ., Gencer, Y.G., & Durmaz, M. (2018). Egzersiz ve stres hormonları. *Türkiye Spor Bilimleri Dergisi, 2*(1), 1-14.

de Lima, F. D., Correia, A. L. M., Teixeira, D. D. S., da Silva Neto, D. V., Fernandes, Í. S. G., Viana, M. B. X. & Alves, S. T. (2015). Acute metabolic response to fasted and postprandial exercise. *InternationalJournal of General Medicine,* (8)255-260. http://dx.doi.org/10.2147/ijgm. s87429

Dennis, M. C., Goods, P. SR., Binnie, M. J., Girard, O., Wallman, K. E., Dawson, B. T., & Peeling, P. (2021). Heat added to repeated-sprint training in hypoxia does not affect cycling performance. *International Journal of Sports Physiology and Performance, 16*(11), 1640-1648. http://dx. doi.org/10.1123/ijspp.2020-0676

Earnest, C. P., Rothschild, J., Harnish, C.R., & Naderi, A. (2019). Metabolic adaptations to endurance training and nutrition strategies influencing performance. *Research in Sports Medicine,* 27(2), 134-146. http://dx.doi.org/10.1080/15438627.2018.1544134

Eskici, G. (2015). Nutrition in team sports takım sporlarında beslenme. *Journal of Human Sciences, 12*(2), 244-265. https://doi.org/10.14687/v12i2.3190

Fang, B., Kim, Y., & Choi, M. (2021). Effect of cycle-based high-ıntensity ınterval training and moderate to moderate-ıntensity continuous training in adolescent soccer players. *Healthcare* 9, 1628. http://dx.doi.org/10.3390/healthcare9121628

Ferlazzo, A., Cravana, C., Fazio, E., & Medica, P. (2020). The different hormonal system during exercise stress coping in horses. *Veterinary world, 13*(5), 847. http://dx.doi.org/10.14202/vetworld.2020.847-859

Fernández-Verdejo, R., Bajpeyi, S., Ravussin, E., & Galgani, J. E. (2018). Metabolic flexibility to lipid availability during exercise is enhanced in individuals with high insulin sensitivity. *American Journal of Physiology-Endocrinology and Metabolism, 315*(4), 715-722. http://dx.doi.org/10. 1152/ ajpendo.00126.2018

Fink, H. H., & Mikesky, A. E. (2015). *Practical applications in sports nutrition*. (4th Edition) Burlington: Jones and Bartlett Learning, 415-510.

Gonzalez, J. T., Fuchs, C. J., Smith, F. E., Thelwall, P. E., Taylor, R., Stevenson, E., Trenell, M. I., Cermak, N. M., & Loon, L. J. C. v. (2015). Ingestion of glucose or sucrose prevents liver but not muscle glycogen depletion during prolonged endurance-type exercise in trained cyclists. *American Journal of Physiology-Endocrinology and Metabolism, 309*(12), 1032-1039. https://doi.org/10.1152/ajpendo. 00376.2015

Guest, N. S., VanDusseldorp, T. A., Nelson, M. T., Grgic, J., Schoenfeld, B. J., Jenkins, N. D. M., Arent, S. M., Antonio, J., Stout, J. R., Trexler, E. T., Smith-Ryan, A. E., Goldstein, E. R., Kalman, D. S., & Campbell, B. I. (2021). International society of sports nutrition position

stand: caffeine and exercise performance. *Journal of the International Society of Sports Nutrition, 18*(1), 1. https://doi.org/10.1186/s12970-020-00383-4

Günay, M., Cicioğlu, H., Şıktar, E., & Kara, E. (2018). *Egzersiz enerji metabolizma ve ısı uyumu*. Ankara: Gazi Kitabevi, 209-233.

Hall, J. E., & Hall, M. E. (2020). *Guyton and hall textbook of medical physiology e-Book:* Elsevier, Health Sciences.

Hansen, A. K., Fischer, C. P., Plomgaard, P., Andersen, J. L., Saltin, B., & Pedersen, B. K. (2005). Skeletal muscle adaptation: training twice every second day vs. training once daily. *Journal of Applied Physiology, 98*(1), 93-99. http://dx.doi.org/10.1152/japplphysiol.00163.2004

Haub, M.D., Haff, G. G., & Potteıger, J. A. (2003). The effect of liquid carbohydrate ıngestion on repeated maximal effort exercise in competitive cyclists. *Journal of Strength and Conditioning Research, 17*(1), 20–25. https://doi.org/10.1519/00124278-200302000-00004

Howard, E. E., & Margolis, L. M. (2020). Intramuscular Mechanisms Mediating Adaptation to Low-Carbohydrate, High-Fat Diets during Exercise Training. *Nutrients, 12*(9), 2496. https://doi.org/10.3390/nu12092496

Hulston, C. J., Venables, M. C., Mann, C. H., Martin, C., Philp, A., Baar, K., & Jeukendrup, A. E. (2010). Training with low muscle glycogen enhances fat metabolism in well-trained cyclists. *Medicine and Science in Sports and Exercise, 42*(11), 2046-2055. http://dx.doi.org/10. 1249/mss. 0b013e3181dd5070

Iwayama, K., Tanabe, Y., Tanji, F., Ohnishi, T., & Takahashi, H. (2021). Diurnal variations in muscle and liver glycogen differ depending on the timing of exercise. *The Journal of Physiological Sciences, 71*(1). https://doi.org/10.1186/s12576-021-00821-1

Jaworski, K., Sarkadi-Nagy, E., Duncan, R. E., Ahmadian, M., & Sul, H. S. (2007). Regulation of triglyceride metabolism. IV. Hormonal regulation of lipolysis in adipose tissue. *American Journal of Physiology-Gastrointestinal and Liver Physiology, 293*(1), 1-4. http://dx.doi. org/10.1152/ajpgi.00554.2006

Jeukendrup, A. E. (2017). Periodized nutrition for athletes. *Sports Medicine, 47*(1), 51-63. http://dx. doi.org/10. 1007/s40279-017-0694-2

Jones, M. D., Munir, M., Wilkonski, A., Ng, K., Beynon, G., & Keech, A. (2021). Post-exercise hypotension time-course is influenced by exercise intensity: a randomised trial comparing moderate-intensity, high-intensity, and sprint exercise. *Journal of Human Hypertension, 35*(9), 776-784. http://dx.doi.org/10. 1038/s41371-020-00421-3

Kirkendall, D. T., Leiper, J. B., Bartagi, Z., Dvorak, J., & Zerguini, Y. (2008). The influence of ramadan on physical performance measures in young muslim footballers. *Journal of Sports Sciences, 26*(3), 15-27. http://dx.doi.org/10.1080/02640410802422199

Lafontan, M., & Langin, D. (2009). Lipolysis and lipid mobilization in human adipose tissue. *Progress in lipid research, 48*(5), 275-297. http://dx.doi.org/10.1016/j.plipres.2009.05.001

Learsi, S. K., Ghiarone, T., Silva-Cavalcante, M. D., Andrade-Souza, V. A., Ataide-Silva, T., Bertuzzi, R., Aroujo, G. G., McConnel, G., & Lima-Silva, A. E. (2019). Cycling time trial performance is improved by carbohydrate ingestion during exercise regardless of a fed or fasted state. *Scandinavian journal of medicine & science in sports, 29*(5), 651-662. https://doi.org/ 10.1111/sms.13393

Lin, C. H., Liao, Y. H., Kuo, C. H., Hou, C. W., Chen, C. Y., & Hsu, M. C. (2012). The effect of insulin and carbohydrate supplementation on glycogen replenishment among different hindlimb muscles in rats following prolonged swimming. *Biology of Sport, 29*(2), 145-150. http://dx.doi.org/10. 5604/2083 1862.990465

Lundberg, T. R., Fernandez-Gonzalo, R., & Tesch, P. A. (2014). Exercise-induced ampk activation does not interfere with muscle hypertrophy in response to resistance training in men. *Journal of Applied Physiology, 116*(6), 611-620. https://doi.org/10.1152/japplphysiol.01082.2013

Maliqi, A., Sylejmani, B., & Myrtaj, N. (2022). Effect of recreational futsal on body composition in passive football players. *Physical Education Theory and Methodology, 22*(2), 255-259. http://dx.doi.org/10. 17309/tmfv.2022.2.16

Manjunath, G., Aravindhakshan, R., & Varghese, S. (2019). Effect of fasting during ramadan on thermal stress parameters. *East Mediterr Health Journal, 25*(1), 34-39. http://dx.doi.org/10. 26719/emhj.18.013

Maunder, E., Plews, D. J., & Kilding, A. E. (2018). Contextualising maximal fat oxidation during exercise: determinants and normative values. *Frontiers in Physiology, 9*,1-13. http://dx. doi. org/10.3389/fphys. 2018.00599

Meckel, Y., Ismaeel, A., & Eliakim, A. (2008). The effect of the Ramadan fast on physical performance and dietary habits in adolescent soccer players. *European Journal of Applied Physiology, 102*, 651-657. http://dx.doi.org/10.1007/s00421-007-0633-2

Muscella, A., Stefàno, E., Lunetti, P., Capobianco, L., & Marsigliante, S. (2020). The regulation of fat metabolism during aerobic exercise. *Biomolecules, 10*(12), 1699. https://doi.org/10.3390/biom10121699

Naharudin, M. N. B., & Yusof, A. (2018). The effect of 10 days of intermittent fasting on wingate anaerobic power and prolonged high-intensity time-to-exhaustion cycling performance. *European Journal of Sport Science, 18*(5), 667-676. http://dx.doi.org/10.1080/ 17461391. 2018. 1438520

Nikolaidis, PT. and Theodoropoulou, E. (2014). Relationship between nutrition knowledge and physical fitness in semiprofessional soccer players. *Scientifica, 2014*,1–5. https://doi.org/10. 1155/2014/180353

Paşaoğlu, H., Günay, M., Paşaoğlu, Ö., & Keskin, K. (2019). *Egzersiz biyokimyası spor, egzersiz, sağlık: İnsan performansının biyokimyasal temelleri*. Ankara: Gazi Kitabevi, 77-275.

Potteiger, J. A. (2011). ACSM's Introduction to exercise science: Wollters Kluwer. *Lippincott Williams and Wilkins Health. Powers, HJ (2003). Riboflavin (Vitamin B-2) and Health. The American journal of clinical nutrition, 77*(6), 1352-1360. http://dx.doi.org/10.1093/ajcn/77.6.1352

Potteiger, J. A. (2018). *ACSM's introduction to exercise science*. (Third Edition). Philadelphia: Wolters Kluwer Health,17.

Price, S., Wiecha, S., Cieśliński, I., Śliż, D., Kasiak, P., Lach, J., & Mamcarz, A. (2022). Differences between treadmill and cycle ergometer cardiopulmonary exercise testing results in triathletes and their association with body composition and body mass index. *International Journal of Environmental Research and Public Health, 19*(6), 3557. http://dx.doi.org/10.3390/ ijerph 19063557

Quintard, H., Patet, C., Zerlauth, J.-B., Suys, T., Bouzat, P., Pellerin, L., Meuli, R., Magistretti, P. J., & Oddo, M. (2016). Improvement of neuroenergetics by hypertonic lactate therapy in patients with traumatic brain injury is dependent on baseline cerebral lactate/pyruvate ratio. *Journal of Neurotrauma, 33*(7), 681-687. https://doi.org/10.1089/neu.2015.4057

Ramos, C., Cheng, A. J., Kamandulis, S., Subocius, A., Brazaitis, M., Venckunas, T., & Chaillou, T. (2021). Carbohydrate restriction following strenuous glycogen-depleting exercise does not potentiate the acute molecular response associated with mitochondrial biogenesis in human skeletal muscle. *European journal of applied physiology, 121*(4), 1219-1232. http://dx.doi. org/10.1007/s00421-021-04594-8

Ramonas, A., Laursen, P. B., Williden, M., Chang, W. L., & Kilding, A. E. (2023). Carbohydrate intake before and during high intensity exercise with reduced muscle glycogen availability affects the speed of muscle reoxygenation and performance. *European Journal of Applied Physiology, 123*(7), 1479-1494. https://doi.org/10.1007/s00421-023-05162-y

Robyn, J., Plancke, L., Boshuizen, B., de Bruijn, M., & Delesalle, C. (2017). Substrate use in horses during exercise: the'fasted'compared to the postprandial state. *Vlaams Diergeneeskundig Tijdschrift, 86*(5), 275-285. https://doi.org/10.21825/vdt.v86i5.16166

Rogers, B., Giles, D., Draper, N., Hoos, O., & Gronwald, T. (2021). A new detection method defining the aerobic threshold for endurance exercise and training prescription based on fractal correlation properties of heart rate variability. *Frontiers in Physiology, 11*, 596567. http://dx.doi. org/10.3389/fphys.2020.596567

Rosa, R. G. d., Oliveira, H. B., Ardigò, L. P., Gomeñuka, N. A., Fischer, G., & Peyré-Tartaruga, L. A. (2019). Running stride length and rate are changed and mechanical efficiency is preserved after cycling in middle-level triathletes. *Scientific Reports, 9*(1). https://doi.org/10. 1038/s41598-019-54912-6

Rothschild, J., Kilding, A. E., Broome, S. C., Cronin, J., & Plews, D. J. (2021). Pre-exercise carbohydrate or protein ingestion influences substrate oxidation but not performance or hunger compared with cycling in the fasted state. *Nutrients, 13*(4), 1291. https://doi.org/10.3390/ nu13041291

Ruiz-Moreno, C., Gutiérrez-Hellín, J., Amaro-Gahete, F. J., González-García, J., Giráldez-Costas, V., Pérez-García, V., & Del Coso, J. (2020). Caffeine increases whole-body fat oxidation during 1 h of cycling at fatmax. *European Journal of Nutrition, 60*(4), 2077-2085. https://doi.org/10.1007/s00394-020-02393-z

Sabzikar, S., Fathi, M., Darzabi, T., & Hejazi, K. (2018). The effect of 12 weeks of bariatric and aerobic exercises on metabolic syndrome indices in women. *Physical Treatments: Specific Physical Therapy Journal, 8*(2)77-84. https://doi.org/10.32598/ptj.8.2.77

Santiago, É., Costa, R. D. D., Delevatti, R. S., Bracht, C. G., Preissler, A. A. B., Silveira, G. P. G. d., … & Kruel, L. F. M. (2020). Continuous and interval aerobic sessions: effects on triglyceride concentrations. *Revista Brasileira De Atividade Física and Amp; Saúde, 25*, 1-8. https://doi.org/10.12820/rbafs.25e0173

Setiakarnawijaya, Y., Widiastuti, W., Taufik, M. S., Kuswahyudi, K., Awaluddin, A., Sina, I., … & Muharram, N. A. (2022). Moderate-intensity exercise decreases cortisol response in overweight adolescent women. *Physical Education Theory and Methodology, 22*(3s), 30-36. https://doi.org/10.17309/tmfv.2022.3s.04

She, J., Nakamura, H., Makino, K., Ohyama, Y., & Hashimoto, H. (2015). Selection of suitable maximum-heart-rate formulas for use with Karvonen formula to calculate exercise intensity. *International Journal of Automation and Computing,* 12(1), 62-69. http://dx.doi.org/10.1007/s11633-014-0824-3

López-Soldado, I., Guinovart, J. J., & Durán, J. (2021). Increased liver glycogen levels enhance exercise capacity in mice. *Journal of Biological Chemistry, 297*(2), 100976. https://doi.org/ 10.1016/j.jbc.2021.100976

Stavrinou, P. S., Bogdanis, G. C., Giannaki, C.D., Terzis, G., & Hadjicharalambous, M. (2019). Effects of high-intensity interval training frequency on perceptual responses and future physical activity participation. *Applied Physiology, Nutrition, and Metabolism, 44*(9), 952-957. http://dx. doi.org/10.1139/apnm-2018-0707

Şakar, Ş. (2009). Sporcu beslenmesi. *Klinik Gelişim, 22*(1), 1-9.

Şerare, S., Şenel, Ö., Hazar, S., & Pazarcı, Ö. (2024). Düşük arklı ayak pes planus ve yüksek arklı ayak pes kavus ayak deformitelerine sahip bireylerin anaerobik egzersiz performanslarının incelenmesi. *International Journal of Social and Humanities Sciences Research (JSHSR), 11*(103), 15-23. http://dx.doi.org/10.5281/zenodo.10616518

Terink, R., Witkamp, R. F., Hopman, M. T., Siebelink, E., Savelkoul, H. F., & Mensink, M. (2021). A 2 week cross-over intervention with a low carbohydrate, high fat diet compared to a high carbohydrate diet attenuates exercise-induced cortisol response, but not the reduction of exercise capacity, in recreational athletes. *Nutrients, 13*(1), 157. https://doi.org/10.3390/nu 13010157

Torres, R., Koutakis, P., & Forsse, J. S. (2021). The effects of different exercise intensities and modalities on cortisol production in healthy individuals: a review. *Journal of Exercise and Nutrition, 4*(4). https://doi.org/10.53520/jen2021.103108

Turan, E. (2010). *Biyokimyasal ve hematolojik parametrelerin açlık-tokluk karşılaştırması.* Tıpta Uzmanlık Tezi, Seçkuk Üniversitesi, Meram Tıp Fakültesi, Konya, 27.

Van Proeyen, K., Szlufcik, K., Nielens, H., Ramaekers, M., & Hespel, P. (2011). Beneficial metabolic adaptations due to endurance exercise training in the fasted state. *Journal of Applied Physiology,* (110),236–245. http://dx.doi.org/10.1152/japplphysiol.00907.2010

Webster, C. C., Noakes, T. D., Chacko, S., Swart, J., Kohn, T. A., & Smith, J. (2016). Gluconeogenesis during endurance exercise in cyclists habituated to a long-term low carbohydrate high-fat diet. *The Journal of Physiology, 594*(15), 4389-4405. https://doi.org/10.1113/jp271934

Yeo, W. K., McGee, S. L., Carey, A. L., Paton, C. D., Garnham, A. P., Hargreaves, M., & Hawley, J. A. (2010). Acute signalling responses to intense endurance training commenced with low or normal muscle glycogen. *Experimental Physiology, 95*(2), 351-358. http://dx.doi.org/ 10.1113/ expphysiol. 2009.049353

Yeo, W. K., Paton, C. D., Garnham, A. P., Burke, L. M., Carey, A. L., & Hawley, J. A. (2008). Skeletal muscle adaptation and performance responses to once a day versus twice every second day endurance training regimens. *Journal of Applied Physiology, 105*(5), 1462-1470. http:// dx.doi.org/10.1152/japplphysiol. 90882.2008

Zhang, W., Liu, H., & Zhang, T. (2023). Immediate and short-term effects of single-task and motor-cognitive dual-task on executive function. *Plos One, 18*(8), 0290171. https://doi.org/10.1371/journal.pone.0290171

Zerguini, Y., Kirkendall, D., Junge, A., & Dvorak, J. (2007). Impact of ramadan on physical performance in professional soccer players. *British journal of Sports Medicine, 41*(6), 398-400. https://doi.org/10.1136/bjsm.2006.032037

https://doi.org/10.54141/psbd.1599620

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Pamukkale J Sport Sci, 16(1), 112-132, 2025 Research Article

Acute Effects of Whole-Body Vibration Exercise on Hemorheological and Oxidative Stress Parameters: A Preliminary Study

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ABSTRACT

Previous studies reported that WBV can increase peripheral blood flow and oxygenation. Investigating the acute effects of a single WBV exercise session on hemorheological parameters, blood glucose levels, balance, flexibility, and oxidative stress markers (total oxidant status [TOS], total antioxidant status [TAS], and oxidative stress index [OSI]) was the goal of this study. All participants engaged in a WBV exercise program consisting of nine exercises, each lasting 60 seconds, for a total of 13 minutes. Flexibility, balance, visual analog pain scale (VAS) scores, heart rate, blood pressure, capillary blood glucose levels, hemorheological parameters, and TOS/TAS were assessed before and immediately after the WBV session. Twelve healthy active male volunteers (mean age: 20.83±2.59 years; mean height: 174.79±5.26 cm; mean weight: 79.21±14.87 kg) participated in the study. Hematocrit values and heart rate significantly increased, while blood glucose levels decreased following the WBV protocol ($p<0.05$). A single session of WBV exercise did not affect TAS, TOS, or OSI; however, erythrocyte deformability measured at 5.33 and 9.49 Pa significantly increased post-exercise ($p<0.05$). No significant differences were found in the other parameters. A single session of WBV exercise appears to acutely improve erythrocyte deformability while not affecting oxidative stress parameters.

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INTRODUCTION

Whole-body vibration (WBV) exercise is a moderate neuromuscular resistance training method that induces automatic physiological adaptations (Rittweger et al., 2010). Additionally, WBV has been demonstrated to be a successful strategy for lowering body fat and improving muscle strength, bone mineral density, balance, and coordination (de Ruiter et al., 2003; Trans et al., 2009). During WBV, individuals stand on a vibrating platform at a specific frequency and amplitude while performing various exercises. WBV exercise is a practical, safe, and cost-effective method to improve health across various populations (Gusso et al., 2016; Hidalgo-Santamaria et al., 2017). Research indicates that acute vibration exercise may have a distinct warm-up effect and increase muscle power, even though the benefits of WBV over traditional resistance training are still unclear (Rittweger, 2010). WBVE acutely increases heart rate, blood flow, and oxygen consumption while enhancing muscle activation, neuromuscular efficiency, and proprioception (Kerschan-Schindl et al., 2001; Martin & Park, 1997). It also stimulates hormone secretion (e.g., growth hormone, testosterone) and improves respiratory function and blood rheology. These effects vary based on vibration parameters and individual characteristics (AlBaiti et al., 2024).

Given the association between increased blood flow and shear stress with exercise intensity or muscle contraction, WBV may enhance endothelial function more effectively than traditional exercise regimens. Within the field of biorheology, hemorheology investigates the properties of blood flow and its interaction with the blood vessels (Muravyov et al., 2002). Hemorheological parameters, such as erythrocyte deformability, erythrocyte aggregation, whole blood, and plasma viscosity, are critical for optimal blood flow (Marossy et al., 2009). These parameters play key roles in tissue perfusion due to their contribution to hydrodynamic resistance in blood vessels.

The primary elements of hemorheology-erythrocyte deformability, red blood cell (RBC) aggregation, and plasma viscosity-are closely related to changes in oxidative stress (Tikhomirova et al., 2011). Furthermore, depending on the type, intensity, and duration of the exercise, there can be significant changes in blood rheology and oxidative stress levels (Findikoglu et al., 2014; Kilic-Toprak et al., 2012, 2015; Yalcin et al., 2003). Athletic ability is another important factor influencing these changes (Yalcin et al., 2003).

Given the above-mentioned cardiovascular consequences of WBV exercise, we postulated that hemorheological parameters—intimately linked to blood flow—might change

after an acute episode of WBV exercise. However, it remains unclear whether changes in plasma viscosity, RBC deformability, and oxidative stress parameters occur after performing WBV exercise. Our study hypothesis was that WBVE may have acute positive effects on the circulatory system, including oxidative stress markers, plasma viscosity, and RBC deformability.

METHODS

Participants

In the study, twelve male volunteers who were in good health and engaged in daily physical activities but did not participate in organized sports took part (mean age: 20.83 ± 2.59 years; mean height: 174.79 ± 5.26 cm; mean weight: 79.21 ± 14.87 kg). The participants were students at Pamukkale University Faculty of Sport Sciences, generally healthy, but had not engaged in any resistance training for at least six months before the study and did not regularly participate in sports (Table 1). The study followed the standards specified by the Declaration of Helsinki (60116787-020/77490; November 13, 2018).

Table 1
Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Age 18-25 years	
Healthy male	Presence of chronic health issues (e.g., cardiovascular, respiratory, musculoskeletal disorders)
Sedentary lifestyle	Use of alcohol, tobacco, or performance-enhancing substances during the study period
Signed informed consent form	Non-compliance with the study protocol or withdrawal of consent during the study
No injuries or conditions preventing physical activity	

Data Collection Tools

To evaluate the effects of a single WBV exercise session, various physiological and biochemical parameters were assessed both before and immediately after the session. Flexibility was measured using the sit-and-reach test, while balance was evaluated with one-leg stance test. Pain perception was assessed using the Visual Analog Scale (VAS). Heart rate and blood pressure were recorded with automated devices, and capillary blood glucose levels were measured using a glucometer. Hematocrit values were analyzed with a blood analyzer, and erythrocyte deformability was assessed using ektacytometry. Oxidative stress markers,

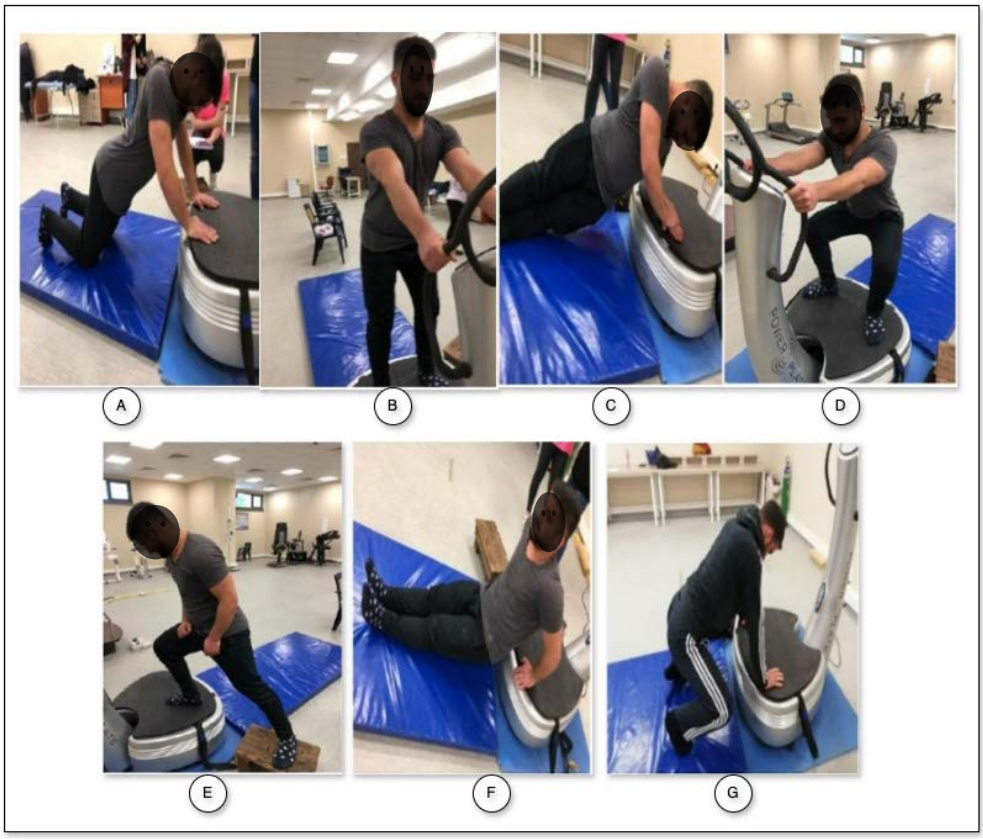
including total oxidant status (TOS) and total antioxidant status (TAS), were measured spectrophotometrically, with the oxidative stress index (OSI) calculated from the TOS/TAS ratio. The following methods were employed for data collection:

Whole Body Vibration Exercise Protocol

All participants completed a WBV exercise program consisting of nine exercises (push-up, squat, right plank, sumo squat, left plank, right lunge, triceps dip, left lunge, and shoulder press). Each exercise was performed for 60 seconds on a vibration device following a 5-minute warm-up at Pamukkale University Faculty of Sport Sciences. The training used a vibrating platform (Compex Power Plate®, London, UK) set at 35 Hz and amplitude of 4 mm. A 30-second rest was given between exercises (Rauch et al., 2010). To standardize the damping effects, participants wore only socks. The exercise session lasted 13 minutes, including a warm-up and cool-down with active stretching. The Borg scale (6-20) was used to record participants' perceived difficulty. Exercises were performed under the supervision of a physiotherapist at the same time each day (Figure 1).

Figure 1

Exercise Executed During the Main Phase of a Training Session on a Vibration Platform



Note. (A) Push Up; (B) Squat; (C) Right and left plank; (D) Sumo squat; (E) Right and left lunge; (F) Triceps dip; (G) Shoulder press

One-Leg Standing Test for Balance

Subjects were instructed to stand on one leg while the other was elevated, ensuring the foot did not touch the standing ankle. They focused on a point at eye level during the open-eye test. Arms were crossed over the chest, and timing began when the subject was stable. The test was terminated if the subject uncrossed their arms, adjusted their foot, or touched the floor (Springer et al., 2007).

Sit-and-Reach Test for Flexibility

Flexibility was assessed using a sit-and-reach box. Participants removed their shoes, stretched their legs, and pressed their feet against the box. If a person received a positive score, they went above and beyond, but if they received a poor score, they did not. The best trial was recorded after participants held the position for five seconds while reaching as far forward as possible (Mayorga-Vega et al., 2014).

Visual Analog Pain Scale (VAS)

Pain severity was measured using the Visual Analog Scale (VAS). With "no pain" at one end and "maximum pain" at the other, the VAS was a 100 mm horizontal line (Collins et al., 1997).

Heart Rate, Blood Pressure, and Blood Glucose Level

An automated oscillometric monitor (Rossmax S150) was used to assess blood pressure and heart rate. Capillary blood glucose levels were measured with a digital device (On Call Plus).

Samples and Measurements

Venous blood samples (10 mL) were collected before and immediately after exercise, following an 8-hour fasting period. Samples were transferred to the Physiology Laboratory, and hemorheological tests were conducted within three hours. Blood samples were centrifuged to assess oxidative stress markers, and the serum was stored at -80°C for later analysis (Baskurt et al., 2009).

Erythrocyte Deformability Measurements

Using an ektacytometer and laser diffraction analysis, the deformability of red blood cells was assessed (LORCA, RR Mechatronics). A low hematocrit suspension of red blood cells

was subjected to shear stress in a Couette system, and the elongation index (EI) was computed based on the geometry of the diffraction pattern (Hardeman et al., 2007).

Plasma Viscosity Determination

A wells–brookfield cone-plate rotating viscometer was used to measure the viscosity of plasma at 37°C and a shear rate of 375 s^{-1}. Plasma was obtained by centrifugation at 1400g for 6 minutes (Rosencranz & Bogen, 2006).

Total Oxidant Status (TOS) Determination

Erel's colorimetric method measured the total oxidant status (TOS). The assay involved oxidation reactions that correlated with the concentration of oxidants in the serum. Results were reported in micromolar hydrogen peroxide equivalents per liter (μmol H_2O_2 Equiv./L) (Erel, 2005).

Total Antioxidant Status (TAS) Measurement

Erel also developed an automated colorimetric method for measuring total antioxidant status (TAS). The serum's antioxidant properties inhibited the formation of radicals, allowing for the calculation of TAS, reported in mmol Trolox Equiv./L (Erel, 2004).

Calculation of Oxidative Stress Index (OSI)

The oxidative stress index (OSI) was determined using the following formula as the percentage ratio of TOS to TAS (Kosecik et al., 2005).

$$OSI = TOS\ (\mu mol\ H_2O_2\ Equiv./L) / TAS\ (mmol\ Trolox\ Equiv./L) \times 100.$$

Data Analysis

SPSS 25.0 was used for statistical analysis. The mean ± standard deviation (SD) was used to express continuous variables. For normalcy, the Shapiro-Wilk test was employed. The Wilcoxon Signed Rank test or the Paired Samples t-test was employed depending on the parametric test assumptions. p-values less than 0.05 were regarded as statistically significant. A power analysis indicated that including 10 subjects would provide 80% power with a 95% confidence level.

RESULTS

The study group consisted of ten male participants with a mean age of 20.83 ± 2.59 years, an average height of 174.79 ± 5.26 cm, and a mean body weight of 79.21 ± 14.87 kg.

Several parameters such as flexibility, balance, pain intensity, plasma viscosity, and blood pressure showed no statistically significant changes from baseline after completing the WBV exercise protocol ($p > 0.05$; Table 2- 3).

Table 2
Flexibility, Balance and Pain Values of the Subjects

Variables	Before exercise	After exercise	p
Flexibility (cm)	20.54 ± 12.44	22.54 ± 12.17	0.072
Balance (right; second)	50.92 ± 21.22	52.58 ± 17.28	1.000
Balance (left; second)	54.67 ± 14.86	55.67 ± 15.01	0.655
Pain (VAS)	0 ± 0	0.83 ± 1.64	0.109

*Note.*Values are expressed as means ± SD

Table 3
Plasma Viscosity, Hematocrit, Heart Rate Values, Blood Glucose Level and Blood Pressure of the Subjects

Variables	Before exercise	After exercise	p
Plasma Viscosity (375 s^{-1})	1.50 ± 0.23	1.88 ± 0.52	0.076
Hematocrit (%)	46.92 ± 3.03	51.08 ± 4.48 *	0.021
Heart Rate (beats/min)	76.27 ± 12.56	90.45 ± 21.59 *	0.011
Blood glucose level (mmol/L)	94.75 ± 15.12	76.92 ± 3.58*	0.008
Blood pressure (systolic; mm Hg)	119.75 ± 12.78	117.08 ± 10.1	0.439
Blood pressure (diastolic; mm Hg)	74.75 ± 7.23	78 ± 5.38	0.253

Note. Values are expressed as means ± SD. *p < 0.05 difference from before exercise

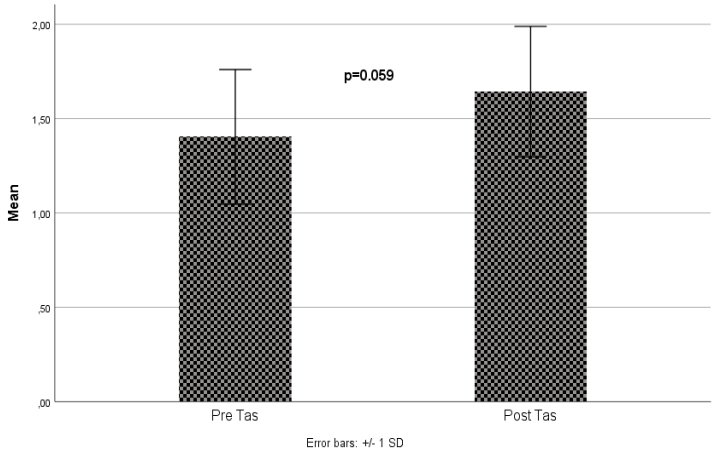
However, three key parameters did show significant changes. Hematocrit values increased notably after the WBV exercise ($p = 0.021$). Heart rate also significantly increased following the WBV protocol ($p = 0.011$). Blood glucose levels decreased significantly after the WBV session ($p = 0.008$; Table 3). Erythrocyte deformability, measured at shear stresses of 5.33 and 9.49 Pa, significantly increased post-exercise ($p = 0.042$ and $p = 0.043$, respectively; Table 4). The WBV protocol did not produce any significant changes in TAS, TOS, or OSI regarding oxidative stress markers (Figures 2-4).

Table 4
Erythrocyte Deformability (EI) Values of the Subjects at Different Shear Stresses

Shear stress (Pa)	Before Exercise	After Exercise	p
0.30	0.06 ± 0.04	0.07 ± 0.02	0.298
0.53	0.13 ± 0.08	0.14 ± 0.04	0.476
0.95	0.20 ± 0.1	0.23 ± 0.05	0.202
1.69	0.30 ± 0.1	0.34 ± 0.04	0.111
3.00	0.40 ± 0.08	0.44 ± 0.04	0.070
5.33	0.48 ± 0.07	0.52 ± 0.03*	**0.042**
9.49	0.54 ± 0.05	0.57 ± 0.02*	**0.043**
16.87	0.58 ± 0.04	0.61 ± 0.02	0.084
30.00	0.60 ± 0.05	0.63 ± 0.03	0.171

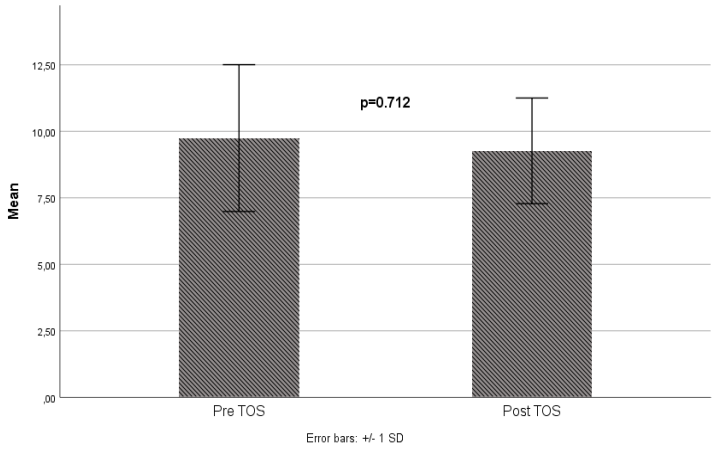
Note. Values are expressed as means ± SD; EI: elongation index; Pa: pascal. *p < 0.05 difference from before exercise

Figure 2
Total Antioxidant Status (TAS) of the Subjects



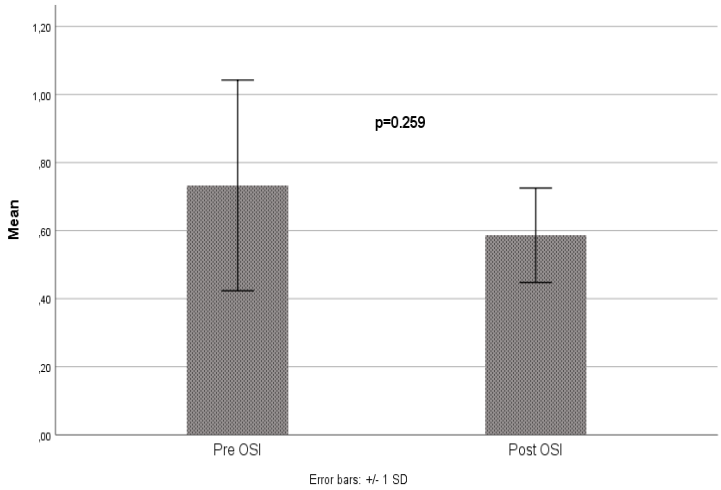
Note. Values are expressed as means ± SD

Figure 3
Total Oxidant Status (TOS) of the Subjects



Note. Values are expressed as means ± SD.

Figure 4
Oxidative Stres Index (OSI) of the Subject



Note. Values are expressed as means ± SD

DISCUSSION

This research investigated the acute effects of WBV exercise on hemorheological parameters, oxidative stress parameters, cardiovascular response, and musculoskeletal responses in young, healthy men. The current study highlighted several findings. First, erythrocyte deformability improved following a single session of WBV exercise. Second, WBV exercise was associated with elevated hematocrit and heart rate values while blood glucose levels decreased. Third, there were no significant effects on TAS, TOS, OSI, plasma viscosity, and blood pressure after acute WBV exercise.

To our knowledge, this study is the first to look into how WBV exercise affects oxidative stress markers, plasma viscosity, and RBC deformability in young, healthy people. In recent years, WBV exercise has gained popularity as a form of physical activity, utilizing mechanical vibrations from oscillating platforms as an alternative to resistance training. WBV exercise is widely applied in various fields, including sports, general health, and the rehabilitation of clinical disorders such as fibromyalgia, cerebral palsy, and chronic obstructive pulmonary disease (Aoyama et al., 2019; Brun et al., 2010).

In the current literature, studies exploring the effects of vibration exercise on postural stability and flexibility present inconsistent results. Some of the acute influences of vibration exercise is the development of flexibility; some studies report no effect on flexibility (Dallas et al., 2015; Donahue et al., 2016). It was suggested that WBV might change the properties of the intramuscular connective tissue, reduce the tendon's stiffness and hysteresis, and possibly change the properties of other passive skeletal structures linked to the range of motion of a particular joint, such as the knee (Donahue et al., 2016). Dallas et al. have reported that the acute effect of vibration training increases flexibility. There is no common fact about how long this increase continues (Dallas et al., 2015). Di Giminiani et al. found in a single study of young adults that WBV significantly improves hamstring and lower back flexibility and seems useful in increasing flexibility in clinical populations (Di Giminiani et al., 2010). Conversely, Dichin et al. discovered that postural sway modifications occurred in various sensory contexts when repeated bouts of personalized WBV were applied (Dickin et al., 2012). In our study, we found an increase in flexibility, consistent with the data in the literature, but it was not statistically significant. We think that its reason is timecontinues, which continues until flexibility evaluation.

Some publications have evaluated the acute efficiency of vibration training for balance as beneficial (Daray et al., 2011). Nevertheless, not all authors have identified such favorable effects. It is reported that no significant alterations in balance or joint position sensation occurred after vibration (Cunha et al., 2019). However, we found no differences in balance after vibration. The reason for this difference may be that we measured the equilibrium measurement with a one-leg standing test instead of a digital measurement such as postural sway.

According to evidence, vibration exercise may lower blood glucose levels (Di Loreto et al., 2004). The most plausible explanation would be increased glucose absorption from the blood, most likely into the muscles, since insulin and glucagon levels were unaffected in that study (Rittweger et al., 2010). The decrease in blood glucose levels we observed in response to acute exercise is consistent with the data in the literature.

However, the precise mechanical effects of vibrations combined with physical activity, particularly regarding internal body alterations induced by WBV exercise, are still not fully understood. The literature indicates that repetitive and cumulative vibration, combined with physical exercise, can enhance blood flow (Gattner et al., 2024; Sá-Caputo et al., 2017). Previous studies suggest that WBV exercise may improve peripheral blood circulation and hemodynamics, potentially leading to increased blood flow velocity and shear stress due to heightened oxygen uptake demands during WBV training (Button et al., 2007; Games et al., 2015; Kerschan-Schindl et al., 2001; Sá-Caputo et al., 2017). While many authors report positive effects of vibration training on the human body, some studies have failed to demonstrate similar benefits (Beijer et al., 2015; Gattner et al., 2024; Sá-Caputo et al., 2018).

Endothelial dysfunction is recognized as a modifiable risk factor influenced by exercise, which has been documented as an effective approach for improving endothelial function, irrespective of the training modality (Ashor et al., 2015). Numerous studies indicate that high-intensity resistance training or aerobic activities may not enhance endothelial function or reduce arterial stiffness (Choi et al., 2016; Kitzman et al., 2013. Over-exertion during exercise training can lead to a sudden increase in plasma noradrenaline and inflammatory cytokines; thus, the exercise environment must be carefully controlled to ensure effective treatment (Harris et al., 2008; Okamoto et al., 2009). One mechanism behind these effects is vasodilation brought on by elevated nitric oxide (NO) levels in the vascular endothelium, which causes smooth muscle relaxation (Johnson et al., 2014). Although WBV exercise increases blood flow and shear stress, leading to elevated levels of vasodilatory

chemicals like NO, it also affects the release of vascular endothelial growth factor (VEGF), a key proangiogenic factor found in muscle fibers and endothelial cells (Gattner et al., 2024).

Games et al.'s investigation shows that WBV improves tissue oxygenation and nourishment by increasing peripheral blood flow (Games et al., 2015). According to the findings, applying vibration caused a tendency for peripheral blood flow to rise by about 14% more than that seen in the placebo condition (Button et al., 2007). The peripheral vascular system is extremely sensitive to vibration exposure (Robbins et al., 2014). Cochrane et al. demonstrated the beneficial impact of vibration therapies on circulatory system efficiency, particularly regarding oxygen absorption capacity, in both young and older individuals (Cochrane et al., 2008).

Hemoconcentration is a widely accepted phenomenon documented in the literature, occurring due to a single activity-whether submaximal or maximal-. This phenomenon arises from at least five distinct mechanisms: redistribution of erythrocytes within the vascular system, an increase in red blood cell count due to splenic contraction, plasma enrichment with lymphatic proteins, water loss through sweating during thermoregulation, and translocation of water into muscle cells (Brun et al., 1998; 2010). A single session of prolonged physical exertion can cause a 15% drop in plasma volume, leading to hemoconcentration (a rise in blood viscosity and hematocrit, but no discernible change in the total quantity and volume of erythrocytes; Kenney et al., 2022). Ahmadizad observed a concomitant reduction in plasma volume accompanied by elevations in plasma viscosity, red blood cell count, hemoglobin, and hematocrit following a single session of resistance exercise in young, healthy males (Ahmadizad & El-Sayed, 2005). These temporary alterations in hemorheological markers validate the phenomenon of hemoconcentration. A study by Romagnoli et al. yielded analogous results, evaluating the effects of a single aerobic workout on a cycle ergometer in young, untrained individuals (Romagnoli et al., 2014). According to Gattner H. et al., the first and last physical training sessions on the vibration platform led to a greater decrease in plasma volume percentage than a group of women who performed physical activities without the vibration element. However, no research has looked into how the WBV exercise model affects plasma viscosity in the short term (Gattner et al., 2024). Our data suggest that a single session WBV exercise seems to lead to an acute increase in plasma viscosity and hematocrit values, in accordance with the literature. The above scenario matches hemoconcentration. Hct determines the blood's ability to carry oxygen. Raising Hct to supra-normal levels to improve exercise performance in fit, well-trained athletes (Reinhart, 2016). However, when the

vasomotion ability of arteries is overreached, the increase in blood viscosity and systemic resistance may also result in a decline in performance for higher levels. It may be inferred from the post-exercise Hct readings that hemoconcentration occurred in our physically active subjects because the type, duration, and intensity of WBVE were insufficient to cause an extra Hct rise.

Physical exercise is one of the many variables that can affect blood hemorheology (Kenney et al., 2022; Szanto et al., 2021). However, scientific reports do not evaluate RBC deformability and plasma viscosity in response to WBV exercise. Although our study did not examine blood flow, endothelial dysfunction, arterial stiffness, and/or plasma inflamatuary inflammatory cytokine levels, changes in plasma viscosity, RBC deformability, and hematocrit levels, which are the main determinants of blood flow, were investigated. An increase was found in all parameters with a single session of WBV exercise. As far as we know, this study is the first to examine RBC deformability, plasma viscosity, and oxidative stress markers in response to vibration exercise. The significant improvement in erythrocyte deformability found in our study is beneficial for tissue perfusion from a hemorheological perspective. The degree of training may be a determinant of RBC deformability (Cakir-Atabek et al., 2009; Connes et al., 2004). According to Connes et al., when exercise causes local hypoxia beyond the anaerobic threshold, lactate builds up in the body, leading to decreased deformability in physically inactive individuals and increased deformability in trained individuals (Connes et al., 2004). Gattner H et al. found that individual training in the experimental and control groups did not alter the elongation index (Gattner et al., 2024). Given that the impact of WBV can be regarded as the cumulative effect of vibrations and physical activity, these findings indicate that incorporating vibrations into training does not diminish RBC deformability in physically inactive individuals (Gattner et al., 2024). Among women undergoing repeated WBV training, Gattner H et al. observed a slight enhancement in erythrocyte deformability at low shear stress, suggesting a beneficial effect on capillary blood flow and an increase in long-term tissue oxygenation. The validity of these alterations is supported by the substantial elevation in elongation index values noted in these experiments under shear stresses of 0.3 and 0.58 Pa following the most recent WBV session, compared to the initial training condition (Gattner et al., 2024). Prolonged exposure to vibrations may elicit a more pronounced response from the circulatory system. Resistance training improves erythrocyte deformability in young, healthy people, according to research by Kilic-Toprak et al. The erythrocyte index increased throughout the third and fourth weeks of exercise when compared to baseline values.

Furthermore, following the recent training conducted in week 12, this measure experienced another rise (Kilic-Toprak et al., 2012). Given the growing interest in these techniques, it is wise to investigate how vibration affects the human body because there is little empirical evidence of its impact on blood hemorheological indices. A significant barrier to comparing results from various studies is the methodological approach employed. A review of the literature highlights the need for meticulous selection of vibration parameters, including intensity, frequency and amplitude. A committee of specialists has recently developed guidelines for the application of vibration (van Heuvelen et al., 2021; Wuestefeld et al., 2020). Since greater erythrocyte deformability enhances oxygen transport to muscle capillaries even at high levels of Hct, it is possible to interpret the increase in RBC deformability that we observed in response to WBVE in our study population as an adaptive mechanism to WBVE regimen. We selected 35 Hz frequency, as the literature reports that 30–35 Hz is the most commonly used frequency range in WBVE for inducing physiological changes (Donahue et al., 2016; Tan et al., 2024).

Exercises of varied intensity have substantially affected oxidative stress and blood rheology (Kilic-Toprak et al., 2012; Yalcin et al., 2003). Exercise's effects on blood rheology depend on the type, duration, and intensity of the activity and the athlete's athletic ability (Yalcin et al., 2003). Serum TAS, TOS, and OSI levels did not significantly alter during our investigation. In contrast to the current study, a prior investigation in our lab revealed that a single session of eccentric isokinetic exercise did not affect oxidative stress measures (Kilic-Toprak et al., 2018). Oxidative stress is critical in the pathogenesis of various diseases and is influenced by factors such as age and physical fitness level. Our results are particularly notable as this is the first study in the literature to examine the acute effects of WBV exercise in healthy, young, active males. However, there are limited studies investigating the short- and long-term relationship between WBV exercise and oxidative stress in humans. The interventions have neutral or potentially positive effects on blood coagulation, fibrinolysis, inflammation, oxidative stress, and cardiovascular, microvascular, and endothelial functions. A study on 21 females examined the effects of WBV exercise on oxidative stress markers in women with fibromyalgia (FM) compared to healthy controls (CT). The results showed that a single WBV session improved oxidative and antioxidant balance by increasing SOD and CAT in CT, while in FM, it reduced TBARS and FRAP, lowered CAT, and increased SOD, indicating enhanced stress response adaptation (Santos et al., 2019). Another study investigated the effects of six weeks of WBVT on oxidative

stress markers, plasma irisin levels, and body composition in women with FM. Forty participants were randomized into WBVT or untrained (UN) groups. After the intervention, the WBVT group showed higher irisin levels, lower TBARS levels, and reduced visceral adipose tissue mass compared to the UN group. These findings suggest that WBVT enhances redox balance, increases irisin levels, and reduces visceral fat, promoting better oxidative status in women with FM (Dos Santos et al., 2023).

These studies also investigated the effect of long-term WBV exercise. For example, Dos Santos JM et al. investigated the effects of WBVE on oxidative stress markers and in women with fibromyalgia. They showed that 6 weeks of WBVE provided lower thiobarbituric acid reactive substances (TBARS) levels in patients with fibromyalgia (Dos Santos et al., 2023).

Limitations

The relatively small sample size, the absence of a control group, and the lack of data on the homogeneity of the subject group can be considered limitations of the current study.

CONCLUSION

This pilot study suggests that acute WBV exercise improves erythrocyte deformability, which can be considered an advantage for improved tissue perfusion from a hemorheological perspective. On the other hand, plasma viscosity, blood pressure and oxidative stress parameters seem not to be affected after acute WBV exercise. However, additional studies are warranted to reassess these findings in a larger group over a longer training period using the WBV exercise model.

PRACTICAL IMPLICATIONS

Overall, our findings demonstrated that a single WBV exercise session initially had a favorable impact on erythrocyte deformability but had no effect on oxidative stress indicators. Our results could be used as a guide for coaches and exercise physiologists in future research utilizing this workout regimen.

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Authors' Contributions

The study was conceived and designed by all authors. Data collection was carried out by the first and second authors. Data analysis and interpretation were conducted by the first, third, and fourth authors. The drafting of the manuscript and/or its critical revision was a joint effort by all four authors. All authors read and approved the final version of the manuscript to be published.

Declaration of Conflict Interest

There are no conflicts of interest, according to the authors. The sponsor had no role in the research that might have affected the findings of this study, according to the authors. The authors assume full responsibility for the accuracy and objectivity of the data they give and the interpretation they discuss. The 1st and 2nd authors contributed equally to this work.

Ethics Statement

According to the most recent version of the Declaration of Helsinki and the guidelines set forth by the Pamukkale Non-Interventional Clinical Research Ethics Committee (60116787-020/77490; 13/11/2018), the study was carried out. Written agreement was obtained from each participant once they were briefed about the study and its tests.

REFERENCES

Ahmadizad, S., & El-Sayed, M. S. (2005). The acute effects of resistance exercise on the main determinants of blood rheology. *Journal of sports sciences*, *23*(3), 243–249. https://doi.org/10.1080/02640410410001730151

AlBaiti, S., Arumugam, A., & Nawayseh, N. (2024). Acute neuromuscular responses to whole-body vibration in healthy individuals: A systematic review. *J Electromyogr Kinesiol*, 77:102888. https://doi.org/10.1016/j.jelekin.2024.102888

Aoyama, A., Yamaoka-Tojo, M., Obara, S., Shimizu, E., Fujiyoshi, K., Noda, C., Matsunaga, A., & Ako, J. (2019). Acute Effects of Whole-Body Vibration Training on Endothelial Function and Cardiovascular Response in Elderly Patients with Cardiovascular Disease. *International heart journal*, *60*(4), 854–861. https://doi.org/10.1536/ihj.18-592

Ashor, A. W., Lara, J., Siervo, M., Celis-Morales, C., Oggioni, C., Jakovljevic, D. G., & Mathers, J. C. (2015). Exercise modalities and endothelial function: a systematic review and dose-response meta-analysis of randomized controlled trials. *Sports medicine (Auckland, N.Z.)*, *45*(2), 279–296. https://doi.org/10.1007/s40279-014-0272-9

Baskurt, O. K., Boynard, M., Cokelet, G. C., Connes, P., Cooke, B. M., Forconi, S., Liao, F., Hardeman, M. R., Jung, F., Meiselman, H. J., Nash, G., Nemeth, N., Neu, B., Sandhagen, B., Shin, S., Thurston, G., & Wautier, J. L. (2009). New guidelines for hemorheological laboratory techniques. *Clinical hemorheology and microcirculation*, *42*(2), 75–97. https://doi.org/10.3233/CH-2009-1202

Beijer, Å., Degens, H., Weber, T., Rosenberger, A., Gehlert, S., Herrera, F., Matthias Kohl-Bareis, Jochen Zange, Bloch, W., & Rittweger, J. (2014). Microcirculation of skeletal muscle adapts differently to a resistive exercise intervention with and without superimposed whole-body vibrations. *Clinical physiology and functional imaging*, *35*(6), 425–435. https://doi.org/10.1111/cpf.12180

Brun, J. F., Khaled, S., Raynaud, E., Bouix, D., Micallef, J. P., & Orsetti, A. (1998). The triphasic effects of exercise on blood rheology: which relevance to physiology and pathophysiology?. *Clinical hemorheology and microcirculation*, *19*(2), 89–104.

Brun, J. F., Varlet-Marie, E., Connes, P., & Aloulou, I. (2010). Hemorheological alterations related to training and overtraining. *Biorheology*, *47*(2), 95–115. https://doi.org/10.3233/BIR-2010-0563

Button, C., Anderson, N., Bradford, C., Cotter, J. D., & Ainslie, P. N. (2007). The effect of multidirectional mechanical vibration on peripheral circulation of humans. *Clinical physiology and functional imaging*, *27*(4), 211–216. https://doi.org/10.1111/j.1475-097X.2007.00739.x

Cakir-Atabek, H., Atsak, P., Gunduz, N., & Bor-Kucukatay, M. (2009). Effects of resistance training intensity on deformability and aggregation of red blood cells. *Clinical hemorheology and microcirculation*, *41*(4), 251–261. https://doi.org/10.3233/CH-2009-1176

Choi, Y., Akazawa, N., Zempo-Miyaki, A., Ra, S. G., Shiraki, H., Ajisaka, R., & Seiji, M. (2016). Acute Effect of High-Intensity Eccentric Exercise on Vascular Endothelial Function in Young Men. *Journal of strength and conditioning research*, *30*(8), 2279–2285. https://doi.org/10.1519/JSC.0000000000000536

Cochrane, D. J., Sartor, F., Winwood, K., Stannard, S. R., Narici, M. V., & Rittweger, J. (2008). A comparison of the physiologic effects of acute whole-body vibration exercise in young and older people. *Archives of physical medicine and rehabilitation*, *89*(5), 815–821. https://doi.org/10.1016/j.apmr.2007.09.055

Collins, S. L., Moore, R. A., & McQuay, H. J. (1997). The visual analogue pain intensity scale: what is moderate pain in millimetres?. *Pain*, *72*(1-2), 95–97. https://doi.org/10.1016/s0304-3959(97)00005-5

Connes, P., Bouix, D., Py, G., Prefaut, C., Mercier, J., Brun, J. F., & Caillaud, C. (2004). Opposite effects of in vitro lactate on erythrocyte deformability in athletes and untrained subjects. *Clinical hemorheology and microcirculation*, *31*(4), 311–318.

Cunha, P. M., Ribeiro, A. S., Nunes, J. P., Tomeleri, C. M., Nascimento, M. A., Moraes, G. K., Sugihara, P., Barbosa, D. S., Venturini, D., & Cyrino, E. S. (2019). Resistance training performed with single-set is sufficient to reduce cardiovascular risk factors in untrained older women: The randomized clinical trial. Active Aging Longitudinal Study. *Archives of gerontology and geriatrics*, *81*, 171–175. https://doi.org/10.1016/j.archger.2018.12.012

Dallas, G., Paradisis, G., Kirialanis, P., Mellos, V., Argitaki, P., & Smirniotou, A. (2015). The acute effects of different training loads of whole body vibration on flexibility and explosive strength of lower limbs in divers. *Biology of sport*, *32*(3), 235–241. https://doi.org/10.5604/20831862.1163373

Daray, L., Henagan, T., Zanovec, M., Earnest, C., Johnson, L., Winchester, J., Tuuri, G., & Stewart, L. (2011). Endurance and resistance training lowers C-reactive protein in young, healthy females. *Applied physiology, nutrition, and metabolism = Physiologie appliquee, nutrition et metabolisme*, *36*(5), 660–670. https://doi.org/10.1139/h11-077

de Ruiter, C. J., van der Linden, R. M., van der Zijden, M. J., Hollander, A. P., & de Haan, A. (2003). Short-term effects of whole-body vibration on maximal voluntary isometric knee extensor force and rate of force rise. *European journal of applied physiology*, *88*(4-5), 472–475. https://doi.org/10.1007/s00421-002-0723-0

Di Giminiani, R., Manno, R., Scrimaglio, R., Sementilli, G., & Tihanyi, J. (2010). Effects of individualized whole-body vibration on muscle flexibility and mechanical power. *The Journal of sports medicine and physical fitness*, *50*(2), 139–151.

Di Loreto, C., Ranchelli, A., Lucidi, P., Murdolo, G., Parlanti, N., De Cicco, A., Tsarpela, O., Annino, G., Bosco, C., Santeusanio, F., Bolli, G. B., & De Feo, P. (2004). Effects of whole-body vibration exercise on the endocrine system of healthy men. *Journal of endocrinological investigation*, *27*(4), 323–327. https://doi.org/10.1007/BF03351056

Dickin, D. C., McClain, M. A., Hubble, R. P., Doan, J. B., & Sessford, D. (2012). Changes in postural sway frequency and complexity in altered sensory environments following whole body vibrations. *Human movement science*, *31*(5), 1238–1246. https://doi.org/10.1016/j.humov.2011.12.007

Donahue, R. B., Vingren, J. L., Duplanty, A. A., Levitt, D. E., Luk, H. Y., & Kraemer, W. J. (2016). Acute Effect of Whole-Body Vibration Warm-up on Footspeed Quickness. *Journal of strength and conditioning research*, *30*(8), 2286–2291. https://doi.org/10.1519/JSC.0000000000001014

Santos, Redha Taiar, Gonçalves, V., Kelly, V., Henrique, P., Henrique Silveira Costa, Vanessa Pereira Lima, Borja Sañudo, Mário Bernardo-Filho, da, D., Fabrício, M., Vanessa Amaral Mendonça, Rapin, A., & Cristina, A. (2023). Whole-Body Vibration Training on Oxidative Stress Markers, Irisin Levels, and Body Composition in Women with

Fibromyalgia: A Randomized Controlled Trial. *Bioengineering (Basel, Switzerland)*, *10*(2), 260. https://doi.org/10.3390/bioengineering10020260

Erel O. (2004). A novel automated direct measurement method for total antioxidant capacity using a new generation, more stable ABTS radical cation. *Clinical biochemistry*, *37*(4), 277–285. https://doi.org/10.1016/j.clinbiochem.2003.11.015

Erel O. (2005). A new automated colorimetric method for measuring total oxidant status. *Clinical biochemistry*, *38*(12), 1103–1111. https://doi.org/10.1016/j.clinbiochem.2005.08.008

Findikoglu, G., Kilic-Toprak, E., Kilic-Erkek, O., Senol, H., & Bor-Kucukatay, M. (2014). Acute effects of continuous and intermittent aerobic exercises on hemorheological parameters: a pilot study. *Biorheology*, *51*(4-5), 293–303. https://doi.org/10.3233/BIR-14012

Gattner, H., Adamiak, J., Czerwińska-Ledwig, O., Mętel, S., Kępińska-Szyszkowska, M., & Piotrowska, A. (2024). Whole Body Vibration Training Has No Effect on Vascular Endothelial and Inflammatory Markers in Young Healthy Women. *Journal of clinical medicine*, *13*(14), 4228. https://doi.org/10.3390/jcm13144228

Games, K. E., Sefton, J. M., & Wilson, A. E. (2015). Whole-body vibration and blood flow and muscle oxygenation: a meta-analysis. *Journal of athletic training*, *50*(5), 542–549. https://doi.org/10.4085/1062-6050-50.2.09

Gusso, S., Munns, C. F., Colle, P., Derraik, J. G. B., Biggs, J. B., Cutfield, W. S., & Hofman, P. L. (2016). Effects of whole-body vibration training on physical function, bone and muscle mass in adolescents and young adults with cerebral palsy. *Scientific reports*, *6*, 22518. https://doi.org/10.1038/srep22518

Hardeman, M.R., Goedhart, P., Shin, S. (2007). In: Baskurt OK, Hardeman MR, Rampling MR, Meiselman HJ, eds. Handbook of Hemorheology and Hemodynamics. Netherlands: IOS Press; 242-266.

Harris, R. A., Padilla, J., Hanlon, K. P., Rink, L. D., & Wallace, J. P. (2008). The flow-mediated dilation response to acute exercise in overweight active and inactive men. *Obesity (Silver Spring, Md.)*, *16*(3), 578–584. https://doi.org/10.1038/oby.2007.87

Hidalgo-Santamaria, M., Fernandez-Montero, A., Martinez-Gonzalez, M. A., Moreno-Galarraga, L., Sanchez-Villegas, A., Barrio-Lopez, M. T., & Bes-Rastrollo, M. (2017). Exercise Intensity and Incidence of Metabolic Syndrome: The SUN Project. *American journal of preventive medicine*, *52*(4), e95–e101. https://doi.org/10.1016/j.amepre.2016.11.021

Johnson, P. K., Feland, J. B., Johnson, A. W., Mack, G. W., & Mitchell, U. H. (2014). Effect of whole body vibration on skin blood flow and nitric oxide production. *Journal of diabetes science and technology*, *8*(4), 889–894. https://doi.org/10.1177/1932296814536289

Kenney, W.L.; Wilmore, J.H.; Costill, D.L. (2022). Cardiorespiratory Responses to Acute Exercises. In Physiology of Sport and Exercise, 8th ed.; Human Kinetics Inc.: Champaign, IL, USA, 214–238.

Kerschan-Schindl, K., Grampp, S., Henk, C., Resch, H., Preisinger, E., Fialka-Moser, V., & Imhof, H. (2001). Whole-body vibration exercise leads to alterations in muscle blood volume. *Clinical physiology (Oxford, England)*, *21*(3), 377–382. https://doi.org/10.1046/j.1365-2281.2001.00335.x

Kilic-Toprak, E., Ardic, F., Erken, G., Unver-Kocak, F., Kucukatay, V., & Bor-Kucukatay, M. (2012). Hemorheological responses to progressive resistance exercise training in healthy young males. *Medical science monitor : international medical journal of experimental and clinical research*, *18*(6), CR351–CR360. https://doi.org/10.12659/msm.882878

Kilic-Toprak, E., Yapici, A., Kilic-Erkek, O., Koklu, Y., Tekin, V., Alemdaroglu, U., & Bor-Kucukatay, M. (2015). Acute effects of Yo-Yo intermittent recovery test level 1 (Yo-YoIR1) on hemorheological parameters in female volleyball players. *Clinical hemorheology and microcirculation*, *60*(2), 191–199. https://doi.org/10.3233/CH-141844

Kilic-Toprak, E., Unver, F., Kilic-Erkek, O., Korkmaz, H., Ozdemir, Y., Oymak, B., Oskay, A., & Bor-Kucukatay, M. (2018). Increased erythrocyte aggregation following an acute bout of eccentric isokinetic exercise does not exceed two days. *Biorheology*, *55*(1), 15–24. https://doi.org/10.3233/BIR-180175

Kitzman, D. W., Brubaker, P. H., Herrington, D. M., Morgan, T. M., Stewart, K. P., Hundley, W. G., Abdelhamed, A., & Haykowsky, M. J. (2013). Effect of endurance exercise training on endothelial function and arterial stiffness in older patients with heart failure and preserved ejection fraction: a randomized, controlled, single-blind trial. *Journal of the American College of Cardiology*, *62*(7), 584–592. https://doi.org/10.1016/j.jacc.2013.04.033

Kosecik, M., Erel, O., Sevinc, E., & Selek, S. (2005). Increased oxidative stress in children exposed to passive smoking. *International journal of cardiology*, *100*(1), 61–64. https://doi.org/10.1016/j.ijcard.2004.05.069

Marossy, A., Svorc, P., Kron, I., & Gresová, S. (2009). Hemorheology and circulation. *Clinical hemorheology and microcirculation*, *42*(4), 239–258. https://doi.org/10.3233/CH-2009-1192

Martin, B. J., & Park, H. S. (1997). Analysis of the tonic vibration reflex: influence of vibration variables on motor unit synchronization and fatigue. *European journal of applied physiology and occupational physiology*, *75*(6), 504–511. https://doi.org/10.1007/s004210050196

Mayorga-Vega, D., Merino-Marban, R., & Viciana, J. (2014). Criterion-Related Validity of Sit-and-Reach Tests for Estimating Hamstring and Lumbar Extensibility: a Meta-Analysis. *Journal of sports science & medicine*, *13*(1), 1–14.

Muravyov, A. V., Draygin, S. V., Eremin, N. N., & Muravyov, A. A. (2002). The microrheological behavior of young and old red blood cells in athletes. *Clinical hemorheology and microcirculation*, *26*(3), 183–188.

Okamoto, T., Masuhara, M., & Ikuta, K. (2009). Low-intensity resistance exercise with slow lifting and lowering does not increase noradrenalin and cardiovascular responses. *Clinical physiology and functional imaging*, *29*(1), 32–37. https://doi.org/10.1111/j.1475-097X.2008.00829.x

Rauch, F., Sievanen, H., Boonen, S., Cardinale, M., Degens, H., Felsenberg, D., Roth, J., Schoenau, E., Verschueren, S., & Rittweger, J. (2010). Reporting whole-body vibration intervention studies: recommendations of the International Society of Musculoskeletal and Neuronal Interactions. *Journal of musculoskeletal & neuronal interactions*, *10*(3), 193–198.

Reinhart, W. H. (2016). The optimum hematocrit. *Clinical hemorheology and microcirculation*, *64*(4), 575–585. https://doi.org/10.3233/CH-168032

Rittweger, J. (2010). Vibration as an exercise modality: how it may work, and what its potential might be. *European journal of applied physiology*, *108*(5), 877–904. https://doi.org/10.1007/s00421-009-1303-3

Rittweger, J., Moss, A. D., Colier, W., Stewart, C., & Degens, H. (2010). Muscle tissue oxygenation and VEGF in VO-matched vibration and squatting exercise. *Clinical physiology and functional imaging*, *30*(4), 269–278. https://doi.org/10.1111/j.1475-097X.2010.00937.x

Robbins, D., Yoganathan, P., & Goss-Sampson, M. (2014). The influence of whole body vibration on the central and peripheral cardiovascular system. *Clinical physiology and functional imaging*, *34*(5), 364–369. https://doi.org/10.1111/cpf.12103

Romagnoli, M., Alis, R., Martinez-Bello, V., Sanchis-Gomar, F., Aranda, R., & Gómez-Cabrera, M. C. (2014). Blood rheology effect of submaximal exercise on young subjects. *Clinical hemorheology and microcirculation*, *56*(2), 111–117. https://doi.org/10.3233/CH-121657

Rosencranz, R., & Bogen, S. A. (2006). Clinical laboratory measurement of serum, plasma, and blood viscosity. *American journal of clinical pathology*, *125 Suppl*, S78–S86. https://doi.org/10.1309/FFF7U8RRPK26VAPY

Sá-Caputo, D. C., Paineiras-Domingos, L. L., Oliveira, R., Neves, M. F. T., Brandão, A., Marin, P. J., Sañudo, B., Furness, T., Taiar, R., & Bernardo-Filho, M. (2018). Acute Effects of Whole-Body Vibration on the Pain Level, Flexibility, and Cardiovascular Responses in Individuals With Metabolic Syndrome. *Dose-response: a publication of International Hormesis Society*, *16*(4), 1559325818802139. https://doi.org/10.1177/1559325818802139

Sá-Caputo, D., Paineiras-Domingos, L., Carvalho-Lima, R., Dias-Costa, G., de Paiva, P. C., de Azeredo, ... & Bernardo-Filho, M. (2017). Potential Effects Of Whole-Body Vibration Exercises On Blood Flow Kinetics Of Different Populations: A Systematic Review With A Suitable Approach. *African journal of traditional, complementary, and alternative medicines: AJTCAM*, *14*(4 Suppl), 41–51. https://doi.org/10.21010/ajtcam.v14i4S.6

Santos, J. M., Mendonça, V. A., Ribeiro, V. G. C., Tossige-Gomes, R., Fonseca, S. F., Prates, A. C. N., Flor, J., Oliveira, A. C. C., Martins, J. B., Garcia, B. C. C., Leite, H. R., Figueiredo, P. H. S., Bernardo-Filho, M., & Lacerda, A. C. R. (2019). Does whole body vibration exercise improve oxidative stress markers in women with fibromyalgia? *Braz J Med Biol Res,* 52(8):e8688. https://doi.org/10.1590/1414-431X20198688

Springer, B. A., Marin, R., Cyhan, T., Roberts, H., & Gill, N. W. (2007). Normative values for the unipedal stance test with eyes open and closed. *Journal of geriatric physical therapy (2001)*, *30*(1), 8–15. https://doi.org/10.1519/00139143-200704000-00003

Szanto, S., Mody, T., Gyurcsik, Z., Babjak, L. B., Somogyi, V., Barath, B., Varga, A., Adam Attila Matrai, & Nemeth, N. (2021). Alterations of Selected Hemorheological and Metabolic Parameters Induced by Physical Activity in Untrained Men and Sportsmen. *Metabolites*, *11*(12), 870. https://doi.org/10.3390/metabo11120870

Tan, J., Lei, J., Wu, S.S.X., Adam,s. R., Wu, X., Zhang, Q., et al. (2024). Modulation of Heart Rate Variability and Brain Excitability through Acute Whole-Body Vibration: The Role of Frequency. *J Hum Kinet,*25;92:111-120. https://doi.org/10.5114/jhk/183745

Tikhomirova, I. A., Oslyakova, A. O., & Mikhailova, S. G. (2011). Microcirculation and blood rheology in patients with cerebrovascular disorders. *Clinical hemorheology and microcirculation*, *49*(1-4), 295–305. https://doi.org/10.3233/CH-2011-1480

Trans, T., Aaboe, J., Henriksen, M., Christensen, R., Bliddal, H., & Lund, H. (2009). Effect of whole body vibration exercise on muscle strength and proprioception in females with knee osteoarthritis. *The Knee*, *16*(4), 256–261. https://doi.org/10.1016/j.knee.2008.11.014

van Heuvelen, M. J. G., Rittweger, J., Judex, S., Sañudo, B., Seixas, A., Fuermaier, A. B. M., Tucha, O., Nyakas, C., Marín, P. J., Taiar, R., Stark, C., Schoenau, E., Sá-Caputo, D. C., Bernardo-Filho, M., & van der Zee, E. A. (2021). Reporting Guidelines for Whole-Body Vibration Studies in Humans, Animals and Cell Cultures: A Consensus Statement from an International Group of Experts. *Biology*, *10*(10), 965. https://doi.org/10.3390/biology10100965

Wuestefeld, A., Fuermaier, A. B. M., Bernardo-Filho, M., da Cunha de Sá-Caputo, D., Rittweger, J., Schoenau, E., Stark, C., Marin, P. J., Seixas, A., Judex, S., Taiar, R., Nyakas, C., van der Zee, E. A., van Heuvelen, M. J. G., & Tucha, O. (2020). Towards reporting guidelines of research using whole-body vibration as training or treatment regimen in human subjects-A Delphi consensus study. *PloS One*, *15*(7), e0235905. https://doi.org/10.1371/journal.pone.0235905

Yalcin, O., Erman, A., Muratli, S., Bor-Kucukatay, M., & Baskurt, O. K. (2003). Time course of hemorheological alterations after heavy anaerobic exercise in untrained human subjects. *Journal of applied physiology (Bethesda, Md.: 1985)*, *94*(3), 997–1002. https://doi.org/10.1152/japplphysiol.00368.2002

Zago, M., Capodaglio, P., Ferrario, C., Tarabini, M., Galli, M. (2018). Whole-body vibration training in obese subjects: A systematic review. *PLoS One*, 13(9):e0202866. https://doi.org/10.1371/journal.pone.0202866

https://doi.org/10.54141/psbd.1573314

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Enhancing Balance, Strength, Flexibility and Spatiotemporal Gait Parameters in Pediatric Cerebral Palsy: Treadmill Training at Variable Inclinations

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ABSTRACT

This study aimed to evaluate the effect of treadmill training at different inclinations on balance, strength, flexibility, and gait parameters in children with cerebral palsy in addition to traditional physiotherapy applications. Forty-two participants with cerebral palsy aged 7–18 years and at Gross Motor Function Classification System level II were randomized into three groups: downhill walking, uphill walking, and walking with no incline. Balance, isometric strength, flexibility, and gait parameters were assessed at baseline (2nd week) and at 11th week. The groups were provided with treadmill training and conventional treatment. All groups showed improvement in balance. Isometric strength values showed improvement in knee flexion on the affected side for both downhill walking and uphill walking groups, as well as in knee extension force for the uphill walking and walking with no incline groups. In flexibility, hip flexion, hip extension, and ankle dorsiflexion improved in all groups, while knee flexion and ankle plantar flexion improved only in downhill walking and walking with no incline. The duration of the modified timed up-and-go test showed significant improvements in both the downhill walking and uphill walking groups. Treadmill training performed at different inclinations improved balance, isometric strength, flexibility, and gait parameters on both the affected and less affected sides.

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INTRODUCTION

Cerebral Palsy (CP) is a common cause of motor disability among children (Cortés-Pérez et al., 2022). Individuals with CP have problems with daily activities such as walking and climbing stairs due to neuromuscular disorders including spasticity, muscle weakness, decreased joint flexibility, and poor coordination (Valadão et al., 2021). Improvement of the motor function of children with CP, particularly their ability to walk independently, is crucial for clinicians (Cherng et al., 2007).

Walking is an essential and important activity for daily living and social participation. Because of the complexity of gait, particularly pathological gait, it is often difficult to identify, quantify, understand the deficits of a particular patient, detect gait disorders, and make clinical decisions. Clinical gait analysis is used to facilitate this process and make the right decisions (Armand et al., 2016). Clinical gait analysis in individuals with CP has shown that these individuals have short step lengths and step widths, reduced cadence of gait, and poor dynamic gait stability (Dimakopoulos et al., 2022).

Treadmill training (TT) is a therapeutic technique in the rehabilitation of children with CP. Positive effects of different TT protocols have been observed in patients with CP; however, no study has examined the effects of forward-downhill TT. Therefore, this study aimed to investigate the effect of TT with forward downhill walking (DW), forward uphill walking (UW), and forward walking with no incline (WWI) on balance, strength, flexibility, and gait parameters in 7–18-year-old children with hemiparetic and diparetic CP in addition to traditional physiotherapy applications.

METHODS

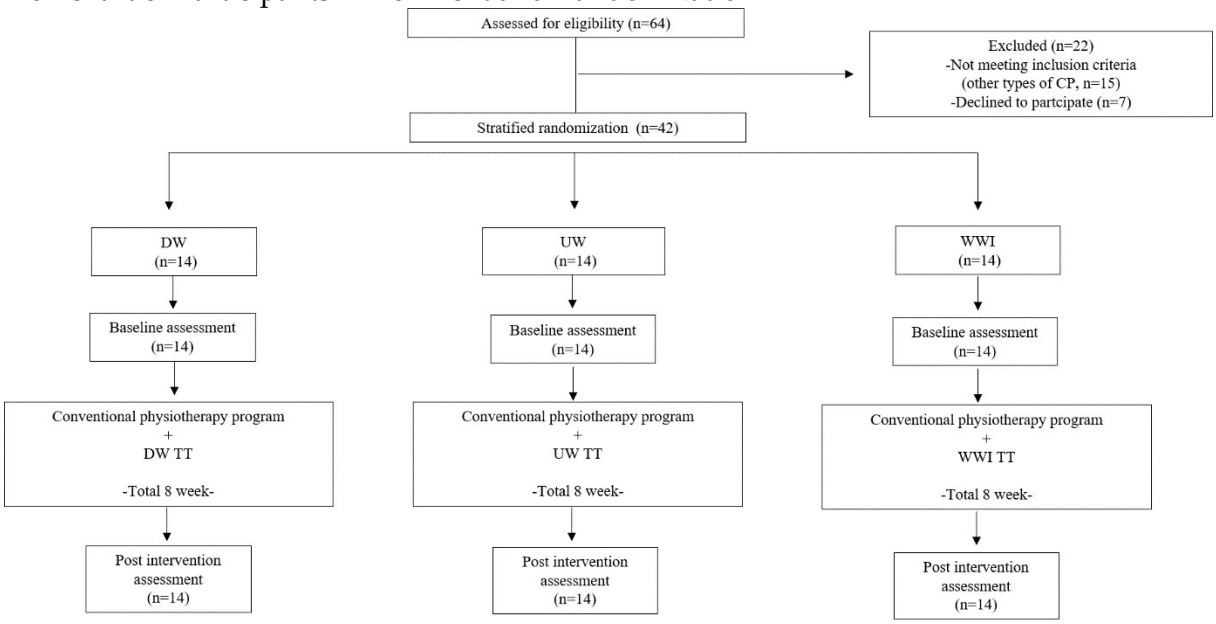
Participants

Forty-two participants (18 females, 24 males) with hemiparetic and diparetic CP completed the study (Figure 1). The inclusion criteria for the study were (a) age between 7–18 years old, (b) being at Gross Motor Functional Classification System (GMFCS) level II, (c) no cooperation problems that would interfere with communication, (d) no surgical treatment or neuromuscular injection in the last six months (e) no uncontrolled epileptic seizures, (f) asymmetric lower extremity shortness >4 cm and (g) no any health problems except CP. Exclusion criteria from the study included trauma during the study period, not participating in the exercise program by more than 20%, and being willing to quit voluntarily. The study

was approved by the Pamukkale University Clinical Research Ethics Committee (Number: 60116787-020-35801 and year: March 24, 2021).

Figure 1

Flowchart of Participants' Enrollment and Randomization



Note. DW: downhill walking, UW: forward uphill walking, WWI: forward walking with no incline, TT: Treadmill Training

Procedures

To ensure that the gender and age distributions in the groups were similar, a randomization table was prepared using a stratified randomization method prior to the study. The study lasted a total of 11 weeks. In the first week, for familiarization, both the measurements to be applied and walking trials on the treadmill were performed. Measurements were performed on two days in the second and the 11th weeks. While demographic information of the participants was obtained only at the beginning of the measurements, balance and strength measurements were taken on day one, flexibility and gait parameters measurements were taken on day two. The affected side (AS) / less affected side (LAS) of the participants were determined according to the first step they took after standing up in the Modified Up and Go Test. The first step was considered the LAS.

After the initial measurements, all participants received a conventional physiotherapy program, two days a week, and 40 minutes a day. In addition to this program, the first group performed DW TT, the second group performed UW TT, and the third group performed WWI TT walking exercise on the treadmill for two days a week, 30 minutes a day, on different days for 8 weeks. A conventional physiotherapy program, walking exercises, and measurements were conducted by the same physiotherapist.

Measurements

Balancing ability was evaluated using the functional reach test (FRT), which is a reliable and valid assessment tool for assessing balance among children with CP (Niznik et al., 1996). Participants were instructed to stand upright next to the wall and extend their arms straight ahead with their hands in fists. Then, they were instructed to reach as far forward as they could without falling, without their heels lifting off the floor and touching the wall. The distance between the first and last projections of the 3rd metacarpal joint was recorded in centimeters. Three repetitions were made, the average of the last two was taken (Duncan et al., 1990).

The isometric muscle strength is a reliable assessment tool for assessing isometric strength among children with CP (Willemse et al., 2013). Knee flexion force (KFF) and knee extension force (KEF) measurements were taken using a hand-held dynamometer (JTECH Medical PowerTrack II Commander, Salt Lake City, UT, USA) while the participants were sitting on a chair. The hands were crossed on the chest, and the legs were fixed with a belt. The force was applied from the front and back of the tibia, 5 cm above the malleolus. A performance test was conducted in which the researcher stabilized the dynamometer, and the participant pushed the dynamometer hard for 3 s, during which the peak force was assessed. The mean scores of the three tests were used for the analysis (Scholtes et al., 2008).

For flexibility measurements, the joint range of motion (ROM) was assessed manually using a goniometer. Hip flexion (HF), hip extension (HE), knee flexion (KF), ankle dorsiflexion (AD), and ankle plantar flexion (APF) were measured twice with the participant's active participation. In the active ROM measurement, the researcher moved the limb with the active arm of the goniometer to the end during the movement (Otman & Köse, 2014).

Participants' gait performance was assessed with the LEGSystm spatiotemporal gait analyzer (LegSys/BioSenics, Watertown, USA) (Aminian et al., 2002). Two sensors (left and right) were placed at the midpoint of the participant's tibia. The data was sent via Bluetooth™ to a computer using the device's own software. The modified timed up-and-go (MTUG) test, which is also available on the device interface, was used for evaluation. The participant was seated on a chair. On the command "go," the participant stood up from the chair, walked 3 m, turned around, walked back to the chair, and sat down again. The time elapsed between the moment of standing up from the chair and the moment of sitting down again was recorded in seconds (Dhote et al., 2012). Participants completed the test barefoot, without any auxiliary aids, and physical assistance. Participants were given two trials, and the average time of the

two trials was recorded as MTUG total time (MTUGTT) for data analysis (Tekin & Kavlak, 2021). Stride length (SL), stride times (ST), stride velocity (SV), average velocity (AV), cadence (CD), swing phase (SWP), stance phase (STP), and double support phase (DSP) parameters were also recorded (LEGSysTM, 2015).

Conventional physiotherapy intervention

The conventional physiotherapy program consisted of various active and passive motion exercises, as well as stretching and strengthening exercises. The program also included postural control exercises, joint mobilization for joint alignment, spasticity inhibition, approximation exercises, muscle facilitation, functional exercises, balance exercises, gait exercises, and sensory exercises, and was tailored to each case (Berker & Yalçın, 2010).

Treadmill Training Intervention

Participants engaged in familiarization trials in the first week. For the next eight weeks, the first group walked downhill on a treadmill with a 9% inclination (Figure 2A), the second group walked uphill with a 9% inclination (figure 2B), and the third group walked parallel to the ground with a 0% inclination (Figure 2C). The literature emphasizes that as the incline increases, it becomes more challenging for children with CP to walk without assistance or support (Willerslev-Olsen et al., 2015). In this study, it was also observed that during familiarization, walking without assistance or support was not possible at inclines greater than 9%, and walking patterns were disrupted. Therefore, a 9% incline was chosen. During the 30-min walking period, the speed of the treadmill was set at 1.5 km/h, the speed at which all participants were able to complete the walk. Five minutes of warm-up and five minutes of active stretching exercise before walking, and five minutes of cool down and five minutes of passive stretching exercises were performed after walking.

Figure 2
Treadmill Traning Intervention

Note. Treadmill Walking for A) -9% Downhill Incline, B) +9% Uphill Incline, C) with No Incline

Data Analysis

All statistical analyses were performed using IBM SPSS Statistics software (version 25.0; IBM Corp., Armonk, NY). Continuous variables were expressed as mean ± standard deviation, median (interquartile range), and categorical variables as number and percentage. The Shapiro–Wilk test was used to test for normality. For data satisfying parametric test conditions, a one-way analysis of variance with Tukey's post-hoc test was used for comparisons among groups. For data not satisfying parametric test conditions, Kruskal–Wallis variance analysis (post hoc: Mann–Whitney *U* test with Bonferroni correction) was used for comparisons among groups. For pairwise comparisons, the paired samples t-test was used when parametric test conditions were satisfied, and the Wilcoxon signed-rank test was used when parametric test conditions were not satisfied. The chi-square test was used to compare the categorical variables. A p-value of less than 0.05 was considered statistically significant. Pre-intervention values were subtracted from post-intervention values during the calculation of difference or delta values.

RESULTS

Table 1 presents the demographic characteristics of all participants for each group, including their classifications and the homogeneity between groups (p>0.05).

Table 1
Demographic Characteristics and Classifications of All the Participants

Variables		DW (n=14)		UW (n=14)		WWI (n=14)		p (F/ χ^2)
		Mean ± S.D.	Med (IQR)	Mean ± S.D.	Med (IQR)	Mean ± S.D.	Med (IQR)	
Age (yr)		13.64±2.27	13.00 (11.75-16.00)	12.64±2.68	12.00 (10.75-14.25)	13.07±2.64	12.5 (11.00-14.75)	p = 0.583 (F=0.547)
Height (cm)		152.07±11.84	151.00 (142.75-163.50)	145.00±15.09	140.5 (135.00-161.25)	148.14±15.06	148 (138.00-163.50)	p = 0.42 (F=0.887)
Weight (kg)		53.00±7.10	54.50 (47.25-59.25)	47.14±8.33	47.00 (40.75-54.5)	51.21±10.75	51.50 (42.00-60.75)	p= 0.213 (F=1.607)
BMI (kg/m^2)		22.87±1.17	23.00 (21.7-23.85)	22.35±1.44	22.05 (21.52-23.65)	23.09±1.45	23.15 (22.15-23.92)	p= 0.342 (F=1.103)
Gender (n / %)	Female	6	43	6	43	6	43	p=1.00
	Male	8	57	8	57	8	57	(χ^2=0.000)
Affected side (n / %)	Right	8	57	7	50	9	64	p=0.747
	Left	6	43	7	50	5	36	(χ^2=0.583)
MAS (n / %)	1	10	71	11	79	8	57	p=0.46
	1+	4	29	3	21	6	43	(χ^2=1.551)
Diagnose (n / %)	Hemiparetic	10	71	5	36	9	64	p=0.13
	Diaparetic	4	29	9	64	5	36	(χ^2=4.083)

Note. BMI: Body mass index, S.D.: Standard Deviation, Med (IQR): Median (25th – 75th percentiles), *p <0,05 statistically significant, F: One Way Anova; χ^2: Chi Square Test

Balance

The FRT results in Table 2 showed a significant increase in all groups after the intervention compared with the results before the intervention ($p<0.05$). In the intergroup analysis, the differences in values obtained from the pre- and post-intervention values were statistically significant ($p = 0.001$). The change in the UW group was significantly lower than that in the DW and WWI groups.

Table 2
Results of the Balance

Tests	DW (n=14)		UW (n=14)		WWI (n=14)		Inter Group p (F/kw)
	Mean ± S.D.	Med (IQR)	Mean ± S.D.	Med (IQR)	Mean ± S.D.	Med (IQR)	
FRT Pre-Test (cm)	24.70±6.90	26.4 (17.75-30.17)	20.79±6.60	22.15 (16.30-24.87)	20.22±6.22	21.20 (14.88-25.25)	p=0.159 (F=1.93)
FRT Post-Test (cm)	30.31±7.36	31.7 (25.38-34.70)	24.45±8.56	25 (18.44-30.72)	25.17±7.07	26.40 (18.83-30.38)	p=0.102 (F=2.418)
Intra Group p	**p = 0.0001** * (t=-13.678; d=-3.654)		**p= 0.001** * (z=-3.296; d=-0.881)		**p= 0.0001** * (t= -9.885; d=-2.642)		
Difference	5.61±1.53		3.67±5.52		4.95±1.87		**p=0.001* (kw=14.116)ac**

Note. S.D: Standard Deviation, Med (IQR): Median (25th – 75th percentiles), *p <0,05 statistically significant, F: One Way Anova, kw: Kruskal Wallis Variance Analysis, t: Paired Samples t test, z: Wilcoxon signed rank test, a: Statistically significant difference between DW and UW groups, b: Statistically significant difference between DW and WWI groups, c: Significant difference between UW and WWI groups; d = Cohen d effect size for paired samples

Strength

Table 3 presents the isometric muscle strength test results. Analysis of the AS KFF results revealed a statistically significant increase in the DW and UW groups after the intervention compared to before the intervention ($p<0.05$). Examination of the differences between the groups showed that the differences in values obtained from the pre-and post-intervention values were statistically significant ($p = 0.022$). The change in the DW and UW groups was significantly higher than that in the WWI group. Analysis of the LAS KFF results showed a statistically significant increase in all groups after the intervention compared to the pre-intervention ($p<0.05$). Examination of the differences between the groups showed that the differences in values obtained from the pre-and post-intervention values were statistically significant ($p = 0.004$). The change in the UW group was significantly higher than that in the WWI group.

Analysis of the AS KEF results showed a statistically significant increase in the UW and WWI groups after the intervention compared with that before the intervention ($p<0.05$). Analysis of LAS KEF results within groups revealed a statistically significant increase only in

the WWI group after the intervention, compared with the results before the intervention ($p<0.05$). Examination of the differences between the groups showed that the difference in values obtained from the pre- and post-intervention values were statistically significant ($p = 0.012$). While the KEF value decreased in the DW group, it increased in the WWI group.

Table 3
Results of the Lower Extremity Isometric Strength

Tests	DW (n=14)		UW (n=14)		WWI (n=14)		Inter Group P (F)
	Mean ± S.D.	Med (IQR)	Mean ± S.D.	Med (IQR)	Mean ± S.D.	Med (IQR)	
AS KFF Pre-test (N)	97.47 ± 23.46	98 (76.65 - 116)	101.23 ± 37.16	98 (73.75 - 127.5)	94.79 ± 49.18	110 (52.75 - 131.05)	p=0.904 (F=0.101)
AS KFF Post-test (N)	108.41 ± 27.38	117 (83.03 - 132)	111.58 ± 37.23	111.67 (85.5 - 135.5)	97.62 ± 49.57	106.92 (64.9 - 133.83)	p=0.616 (F=0.49)
Intra Group p	**p=0.001*** (z=-3.296; d=-0.881)		**p=0.001*** (z=-3.298; d=-0.88)		p=0.1 (t=-1.771; d=-0.47)		
Difference	10.95 ± 10.11		10.36 ± 10.47		2.83 ± 5.98		**p=0.022*** (kw=7.648)bc
LAS KFF Pre-test (N)	118.66 ± 29.01	123 (92 - 146.25)	118.56 ± 35.58	116.5 (91 - 142.75)	110.81 ± 51.28	120.5 (75.9 - 147.25)	p=0.836 (F=0.179)
LAS KFF Post-test (N)	123.71 ± 28.39	131.5 (95.5 - 149.5)	128.8 ± 37.45	119.5 (106.25 - 161.75)	112.76 ± 51.59	122.5 (77.1 - 151.25)	p=0.565 (F=0.58)
Intra Group p	**p=0.001*** (t=-4.54; d=-1.21)		**p=0.001*** (z=-3.175; d=-0.85)		**p=0.033*** (t=-2.391; d=-0.64)		
Difference	5.06 ± 4.17		10.24 ± 12.73		1.94 ± 3.04		**p=0.004*** (kw=10.972)c
AS KEF Pre-test (N)	149.5 ± 32.16	158 (132.5 - 170.75)	141.09 ± 54.77	135.5 (109 - 189)	138.7 ± 44.94	147 (91.85 - 170.25)	p=0.801 (F=0.223)
AS KEF Post-test (N)	153.75 ± 32.57	160.5 (141 - 175)	148.96 ± 61.28	139 (114.75 - 195)	148.94 ± 45.75	159 (96.95 - 177)	p=0.955 (F=0.047)
Intra Group p	p=0.122 (t=-1.655; d=-0.44)		**p=0.003*** (z=-2.998; d=-0.8)		**p=0.016*** (z=-2.42; d=-0.65)		
Difference	4.25 ± 9.61		7.88 ± 11.31		10.24 ± 5.16		p=0.055 (kw=5.801)
LAS KEF Pre-test (N)	165.71 ± 35.47	171.5 (150.75 - 186)	157.91 ± 51.91	152.5 (118.25 - 202)	152.94 ± 49.15	165 (125.25 - 184.75)	p=0.762 (F=0.273)
LAS KEF Post-test (N)	163.07 ± 35.06	172 (145.75 - 182)	158.72 ± 49.69	158.5 (122 - 205.25)	158.75 ± 46.17	167.5 (127.25 - 189)	p=0.956 (F=0.045)
Intra Group p	p=0.182 (z=-1.334; d=-0.36)		p=0.115 (z=-1.576; d=-0.42)		**p=0.0001*** (t=-7.43; d=-1.99)		
Difference	-2.64 ± 6.5		0.81 ± 6.25		5.81 ± 8.85		**p=0.012*** (kw=8.906)b

Note. S.D: Standard Deviation, Med (IQR): Median (25th – 75th percentiles), *p <0,05 statistically significant, F: One Way Anova, kw: Kruskal Wallis Variance Analysis, t: Paired Samples t test, z: Wilcoxon signed rank test, a: Statistically significant difference between DW and UW; b: Statistically significant difference between DW and WWI, c: Statistically significant difference between UW ve WWI; d= Cohen d effect size for paired samples.

Flexibility

Table 4 presents the active ROM results for participants in each group of this study. Analysis of the AS HF results showed a statistically significant increase in all groups after the

intervention than that after the pre-intervention (p<0.05). LAS HF results within groups showed a statistically significant increase in the DW and UW groups after the intervention compared with that before the intervention (p<0.05).

Analysis of the AS HE results revealed a statistically significant increase in all groups after the intervention compared to before the intervention (p<0.05). AS KF results within groups showed a statistically significant increase in the DW and WWI groups after the intervention compared with that before the intervention (p<0.05). Examination of the differences between the groups showed that the differences in values obtained from the pre- and post-intervention values were statistically significant (p=0.006). The change in the UW group was significantly lower than that in the WWI group.

An analysis of the AS-AD results showed a statistically significant increase in all groups after the intervention compared with that of the pre-intervention (p<0.05). The LAS AD results showed a statistically significant increase in the UW and WWI groups after the intervention compared with the results before the intervention (p<0.05).

Analysis of the AS APF within groups showed a statistically significant increase in the DW and WWI groups after the intervention compared with that before the intervention (p<0.05).

Table 4
Results of the Flexibility

Tests	DW (n=14)		UW (n=14)		WWI (n=14)		Inter Group P (F/kw)
	Mean ± S.D.	Med (IQR)	Mean ± S.D.	Med (IQR)	Mean ± S.D.	Med (IQR)	
AS HF Pre-test (º)	107.50±21.19	110.00 (93.75-123.75)	95.00±29.55	97.50 (82.50-112.50)	96.79±23.99	95.00 (90.00-116.25)	p=0.373 (F=1.012)
AS HF Post-test (º)	111.43±21.52	112.50 (90.00-135.00)	102.86±23.67	110.00 (85.00-116.25)	106.43±14.86	110.00 (93.75-120.00)	p=0.54 (F=0.626)
Intra Group p	**p= 0.031*** (z= -2.156; d=-0.58)		**p= 0.018*** (z= -2.375; d=-0.63)		**p= 0.018*** (z= -2.371; d=-0.63)		
Difference	3.93 ± 5.94		7.86 ± 9.75		9.64 ± 12.63		p=0.479 (kw=1.472)
LAS HF Pre-test (º)	113.21 ± 16.71	115 (107.5 - 122.5)	101.07 ± 28.97	110 (77.5 - 120)	105.36 ± 20.42	110 (95 - 120)	0.476 (kw=1.485)
LAS HF Post-test (º)	116.43 ± 17.7	117.5 (108.75 - 131.25)	105 ± 23.37	112.5 (86.25 - 120)	106.79 ± 16.36	110 (98.75 - 120)	0.257 (F=1.409)
Intra Group p	**p=0.024*** (z=-2.264; d=-0.61)		**p=0.041*** (z=-2.041; d=-0.55)		p=0.414 (z=-0.816; d=-0.22)		
Difference	3.21 ± 4.64		3.93 ± 7.12		1.43 ± 5.69		0.205 (kw=3.174)
AS HE Pre-test (º)	6.07±5.94	10.00 (3.75-10.00)	0.00±10.00	2.50 (-2.5-6.25)	3.93±5.94	5.00 (0.00-10.00)	p=0.126 (kw=4.145)
AS HE Post-test (º)	8.93±5.61	10.00 (7.50 – 10.00)	5.71±8.52	10.00 (0.00-10.00)	9.29±3.31	10.00 (10.00-10.00)	p=0.397 (kw=1.85)
Intra Group p	**p= 0.023*** (z=-2.271; d=-0.61)		**p= 0.004*** (z= -2.889; d=-0.77)		**p= 0.004*** (z= -2.879; d=-0.77)		
Difference	2.86 ± 3.78		5.71 ± 4.32		5.36 ± 4.14		p=0.144 (kw=3.871)

Table 4 (Continued)

Tests	DW (n=14)		UW (n=14)		WWI (n=14)		Inter Group P (F/kw)
	Mean ± S.D.	Med (IQR)	Mean ± S.D.	Med (IQR)	Mean ± S.D.	Med (IQR)	
LAS HE Pre-test (º)	8.21 ± 5.41	10 (5 - 10)	6.79 ± 6.08	5 (0 - 10)	8.57 ± 6.02	10 (5 - 10)	0.654 (kw=0.851)
LAS HE Post-test (º)	8.57 ± 5.69	10 (5 - 11.25)	8.21 ± 5.41	10 (5 - 10)	9.64 ± 5.71	10 (5 - 11.25)	0.783 (F=0.246)
Intra Group p	p= 0.317 (z=-1; d=-0.27)		p= 0.102 (z=-1.633; d=-0.44)		p= 0.083 (z=-1.732; d=-0.46)		
Difference	0.36 ± 1.34		1.43 ± 3.06		1.07 ± 2.13		0.499 (kw=1.388)
AS KF Pre-test (º)	113.57±17.03	120.00 (97.50-123.75)	107.86±17.94	105.00 (93.75-122.50)	102.14±14.77	102.50 (90.00-108.75)	p=0.205 (F=1.652)
AS KF Post-test (º)	115.00±16.98	120.00 (101.25-127.50)	106.79±19.08	105.00 (90.00-122.50)	106.07±13.04	107.50 (95.00-112.50)	p=0.296 (F=1.257)
Intra Group p	**p= 0.046*** (z= -2.000; d=-0.53)		p= 0.276 (z= -1.089; d=-0.29)		**p= 0.008*** (z= -2.636; d=-0.7)		
Difference	1.43 ± 2.34		-1.07 ± 4.01		3.93 ± 4.46		p=**0.006*** (kw=10.142)c
LAS KF Pre-test (º)	118.93 ± 17.45	125 (100 - 135)	111.43 ± 16.34	110 (97.5 - 126.25)	110 ± 17.21	110 (97.5 - 126.25)	0.322 (kw=2.269)
LAS KF Post-test (º)	119.64 ± 16.81	125 (107.5 - 135)	111.07 ± 15.95	110 (97.5 - 126.25)	112.5 ± 14.64	110 (100 - 126.25)	0.294 (kw=2.446)
Intra Group p	p=0.317 (z=-1; d=-0.27)		p=0.564 (z=-0.577; d=-0.15)		p=0.197 (z=-1.289; d=-0.34)		
Difference	0.71 ± 2.67		-0.36 ± 2.37		2.5 ± 7.27		0.392 (kw=1.875)
AS AD Pre-test (º)	3.21±8.68	2.50 (-1.25-10.00)	2.86±10.32	0.00 (-2.5-11.25)	3.21±6.96	0.00 (0.00-6.25)	p=0.995 (kw=0.011)
AS AD Post-test (º)	7.14±5.79	5.00 (3.75-10.00)	7.86±7.52	10.00 (0.00-11.25)	7.14±5.79	7.50 (5.00-10.00)	p=0.944 (F=0.058)
Intra Group p	**p= 0.009*** (z= -2.598; d=-0.69)		**p= 0.006*** (z= -2.739; d=-0.73)		**p= 0.015*** (z= -2.428; d=-0.65)		
Difference	3.93 ± 4.01		5 ± 4.39		3.93 ± 4.46		p=0.742 (kw=0.595)
LAS AD Pre-test (º)	11.43 ± 6.91	10 (8.75 - 20)	8.57 ± 9.89	7.5 (0 - 20)	12.86 ± 8.48	15 (8.75 - 20)	0.42 (kw=1.733)
LAS AD Post-test (º)	11.79 ± 6.68	10 (10 - 20)	11.07 ± 8.59	12.5 (0 - 20)	15.71 ± 6.75	20 (10 - 20)	0.212 (kw=3.106)
Intra Group p	p=0.317 (z=-1; d=-0.27)		**p=0.034*** (z=-2.121; d=-0.57)		**p=0.039*** (z=-2.06; d=-0.55)		
Difference	0.36 ± 1.34		2.5 ± 4.27		2.86 ± 4.69		0.136 (kw=3.989)
AS APF Pre-test (º)	33.93±12.43	35.00 (20.00-46.25)	39.29±19.89	45.00 (32.50-50.00)	28.57±15.98	30.00 (18.75-41.25)	p=0.237 (F=1.496)
AS APF Post-test (º)	37.14±11.22	35.00 (28.75-50.00)	42.14±15.65	45 (32.5 - 50)	33.57±11.34	32.50 (23.75-45.00)	p=0.223 (F=1.559)
Intra Group p	**p= 0.014*** (z= -2.460; d=-0.66)		p= 0.102 (z= -1.633; d=-0.44)		**p= 0.017*** (z= -2.388; d=-0.64)		
Difference	3.21 ± 3.72		2.86 ± 6.11		5 ± 6.5		p=0.39 (kw=1.882)
LAS APF Pre-test (º)	43.57 ± 7.19	45 (38.75 - 50)	40.71 ± 19.1	47.5 (31.25 - 50)	36.79 ± 14.09	45 (23.75 - 45)	0.39 (kw=1.881)
LAS APF Post-test (º)	43.93 ± 6.56	45 (38.75 - 50)	41.79 ± 18.36	47.5 (37.5 - 50)	37.5 ± 14.64	45 (28.75 - 46.25)	0.471 (kw=1.505)
Intra Group p	p= 0.317 (z=-1; d=-0.27)		p= 0.18 (z=-1.342; d=-0.36)		p= 0.317 (z=-1; d=-0.27)		
Difference	0.36 ± 1.34		1.07 ± 2.89		0.71 ± 2.67		0.826 (kw=0.382)

Note. S.D: Standard Deviation, Med (IQR): Median (25th – 75th percentiles), *p <0,05 statistically significant, F: One Way Anova, kw: Kruskal Wallis Variance Analysis, t: Paired Samples t test, z: Wilcoxon signed rank test, a: Statistically significant difference between DW and UW, b: Statistically significant difference between DW and WWI, c: Statistically significant difference between UW and WWI; d = Cohen d effect size for paired samples

Spatiotemporal Gait Parameters

Basic Gait Parameters Results

Table 5 shows the results of the basic gait parameters of the participants in each group in this study. Analysis of the ST results within groups showed a statistically significant decrease only in the DW group after the intervention compared with that before the intervention ($p<0.05$). CD results within groups showed a statistically significant increase only in the DW group after the intervention, compared with the results before the intervention ($p<0.05$). MTUGTT results within groups showed a statistically significant decrease only in the DW and UW groups after the intervention compared with that before the intervention ($p<0.05$). A comparison of the results after the intervention showed a significant difference ($p = 0.0001$). The values of the UW group were significantly lower than those of the DW and WWI groups. Examination of the differences between the groups showed that the differences in values obtained from the pre-and post-intervention values were statistically significant ($p = 0.0001$). The values of the UW group were significantly lower than those of the DW and WWI groups, and the values of the DW group were significantly lower than those of the WWI group.

Table 5
Results of the Basic Gait Parameters

Tests	DW (n=14)		UW (n=14)		WWI (n=14)		Inter Group p (F/kw)
	Mean ± S.D.	Med (IQR)	Mean ± S.D.	Med (IQR)	Mean ± S.D.	Med (IQR)	
SL Pre-test (m)	0.79± 0.06	0.79 (0.74-0.82)	0.78±0.10	0.76 (0.71-0.85)	0.76±0.15	0.72 (0.69-0.88)	p=0.863 (F=0.147)
SL Post-test (m)	0.78± 0.09	0.80 (0.76-0.83)	0.79±0.09	0.80 (0.71-0.84)	0.77±0.14	0.74 (0.69-0.90)	p=0.612 (kw=0.982)
Intra Group p	p=0.552 (z=-0.595; d=-0.16)		p= 0.078 (t= -1.914; d=-0.51)		p= 0.945 (t= -0.070; d=-0.02)		
Difference	-0.01 ± 0.06		0.01 ± 0.03		0 ± 0.04		p=0.56 (kw=1.159)
ST Pre-test (s)	1.17± 0.10	1.18 (1.09-1.23)	1.21±0.14	1.19 (1.09-1.28)	1.21±0.08	1.21 (1.17-1.26)	p=0.649 (F=0.438)
ST Post-test (s)	1.14± 0.09	1.1 (1.05-1.21)	1.18±0.09	1.20 (1.10-1.24)	1.21±0.07	1.20 (1.15-1.25)	p=0.09 (kw=4.82)
Intra Group p	**p= 0.007*** (t= 3.229; d=0.86)		p= 0.575 (z= -0.561; d=-0.15)		p= 1.000 (t= 0.000; d=0)		
Difference	-0.04 ± 0.04		-0.03 ± 0.1		0 ± 0.05		p=0.158 (kw=3.686)
SV Pre-test (m/s)	0.68± 0.08	0.68 (0.61-0.74)	0.65±0.12	0.68 (0.57-0.72)	0.63±0.10	0.60 (0.57-0.71)	p=0.48 (F=0.748)
SV Post-test (m/s)	0.69± 0.10	0.72 (0.65-0.75)	0.67±0.09	0.68 (0.61-0.72)	0.63±0.10	0.62 (0.57-0.72)	p=0.199 (kw=3.231)

Table 5 (Continued)

Tests	DW (n=14)		UW (n=14)		WWI (n=14)		Inter Group p (F/kw)
	Mean ± S.D.	Med (IQR)	Mean ± S.D.	Med (IQR)	Mean ± S.D.	Med (IQR)	
Intra Group p	p= 0.096 (z=-1.664; d=-0.44)		p= 0.220 (t= -1.289; d=-0.34)		p= 0.693 (t= -0.403; d=-0.11)		p=0.429 (kw=1.693)
Difference	0.01 ± 0.06		0.02 ± 0.05		0 ± 0.04		
AV Pre-test (m/s)	0.67 ± 0.07	0.67 (0.61 - 0.71)	0.65 ± 0.12	0.68 (0.57 - 0.71)	0.63 ± 0.1	0.6 (0.57 - 0.71)	p=0.564 (F=0.582)
AV Post-test (m/s)	0.69 ± 0.1	0.71 (0.64 - 0.74)	0.68 ± 0.09	0.68 (0.61 - 0.73)	0.64 ± 0.11	0.63 (0.58 - 0.71)	p=0.432 (F=0.858)
Intra Group p	p=0.115 (z=-1.575; d=-0.42)		p=0.247 (z=-1.158; d=-0.31)		p=0.343 (t=-0.984; d=-0.26)		
Difference	0.02 ± 0.06		0.02 ± 0.06		0.01 ± 0.04		p=0.699 (kw=0.717)
CD Pre-test (step/dk)	104.49±8.70	104.74 (97.76-113.03)	101.29±9.97	101.27 (94.74-110.88)	99.82±7.29	99.65 (94.82-103.67)	p=0.359 (F=1.051)
CD Post-test (step/dk)	106.95±7.77	109.09 (100.02-114.29)	101.9±8.28	101.74 (95.08-109.29)	101.75±6.39	102.09 (97.65-106.89)	p=0.128 (F=2.17)
Intra Group p	**p= 0.008*** (t= -3.114; d=-0.83)		p= 0.726 (t= -0.358; d=-0.1)		p= 0.064 (z= -1.852; d=-0.49)		
Difference	2.46 ± 2.96		0.61 ± 6.37		1.93 ± 4.07		p=0.41 (kw=1.784)
MTUGTT Pre-test (s)	13.53 ±1.14	13.82 (12.61-14.43)	14.31±1.82	14.44 (13.61-15.42)	14.13±1.35	14.3 (13.49-14.99)	p=0.345 (F=1.094)
MTUGTT Post-test (s)	11.71 ±1.39	11.34 (10.55-12.91)	10.87±0.94	10.98 (10.39-11.60)	14.02±1.71	13.93 (13.08-15.02)	**p=0.0001*** (F=19.445)bc
Intra Group p	**p=0.0001*** (t=5.453; d=1.46)		**p= 0.0001*** (t= 8.118; d=2.17)		p= 0.690 (t= 0.408; d=0.11)		
Difference	-1.81 ± 1.24		-3.44 ± 1.59		-0.11 ± 1.04		**p=0.0001*** (F=22.654)abc

Note. S.D: Standard Deviation, Med (IQR): Median (25th – 75th percentiles), *p <0,05 statistically significant, F: One Way Anova, kw: Kruskal Wallis Variance Analysis, t: Paired Samples t test, z: Wilcoxon signed rank test, a: Statistically significant difference between DW and UW, b: Statistically significant difference between DW and WWI, c: Statistically significant difference between UW ve WWI; d= Cohen d effect size for paired samples

Table 6 presents the percentages of SWP, STP, and DSP for participants in each group in this study. Analysis of the AS SWP results within groups revealed a statistically significant decrease only in the DW group after the intervention, compared with the results before the intervention ($p<0.05$). The comparison of the results between the groups after the intervention showed a significant difference ($p = 0.0001$). The values of the DW group were significantly lower than those of the UW and WWI groups. LAS SWP results within groups showed a statistically significant increase only in the WWI group after the intervention, compared with the results before the intervention ($p<0.05$). Comparison of the results between the groups after the intervention showed a significant difference ($p = 0.03$). The values of the UW group were significantly higher than those of the WWI group. There was no statistically significant

difference between the DW, UW, and WWI groups. Examination of the differences between the groups revealed significant differences between the pre-and post-intervention values (p = 0.004). The values of the WWI group were significantly higher than the increase in the DW and UW groups.

Examination of the AS STP results between the groups revealed a statistically significant difference when the results after the intervention were compared (p = 0.0001). The values of the DW group were significantly higher than those of the UW and WWI groups. LAS STP results within groups showed a statistically significant decrease only in the WWI group after the intervention compared with that before the intervention (p<0.05). A comparison of the results after the intervention between the groups showed a significant difference (p = 0.031). The values of the UW group were significantly lower than those of the WWI group. Examination of the differences between the groups revealed significant differences between the pre- and post-intervention values (p = 0.004). The values of the UW group were significantly lower than those of the DW and WWI groups.

Analysis of the AS DSP results within groups revealed a statistically significant increase only in the DW group after the intervention, compared with the results before the intervention (p<0.05). Examination of the differences between the groups revealed significant differences between the pre- and post-intervention values (p = 0.022). The change in the WWI group was in the direction of decrease, whereas the change in the DW and UW groups was in the direction of increase. LAS DSP results within groups showed a statistically significant increase only in the DW group after the intervention compared with the pre-intervention period, while there was a significant decrease in the WWI group (p<0.05). Examination of the differences between the groups revealed significant differences between the pre- and post-intervention values (p = 0.002). The change in the DW group was in the direction of increase, whereas the change in the WWI group was in the direction of decrease.

Table 6
Results of the Swing Phase, Stance Phase, and Double Support Phase

Tests	DW (n=14)		UW (n=14)		WWI (n=14)		Inter Group P (F/kw)
	Mean ± S.D.	Med (IQR)	Mean ± S.D.	Med (IQR)	Mean ± S.D.	Med (IQR)	
AS SWP Pre-test (%)	42.06±2.27	41.80 (41.24-43.91)	42.27±2.02	42.06 (41.31-44.01)	42.98±2.57	43.69 (41.88-44.66)	p=0.382 (kw=1.926)
AS SWP post-test (%)	40.76±0.84	41.08 (40.09-41.27)	42.72±1.79	42.63 (41.27-43.82)	43.24±1.87	43.37 (42.63-44.76)	p=**0.0001*** (kw=17.309)ab
Intra Group p	**p= 0.013*** (t= 2.859; d=0.76)		p= 0.513 (t= -0.673; d=-0.18)		p= 0.508 (t= -0.680; d=-0.18)		
Difference	-1.3 ± 1.7		0.45 ± 2.49		0.26 ± 1.43		p=0.083 (kw=4.968)

Tablo 6 (Continued)

Tests	DW (n=14)		UW (n=14)		WWI (n=14)		Inter Group P (F/kw)
	Med (IQR)	Mean ± S.D.	Med (IQR)	Med (IQR)	Mean ± S.D.	Med (IQR)	
LAS SWP Pre-test (%)	40.59±2.10	40.55 (39.15-41.72)	41.07±1.61	41.31 (40.61-42.28)	38.96±3.06	37.66 (36.74-42.12)	p=0.071 (kw=5.291)
LAS SWP post-test (%)	40.17±1.36	40.22 (39.35-41.30)	41.43±1.56	41.27 (40.82-41.70)	40.34±2.68	39.38 (38.71-41.57)	p=**0.03*** (kw=7.008)c
Intra Group p	p= 0.219 (t= 1.293; d=0.35)		p= 0.975 (z= -0.031; d=-0.01)		**p= 0.0001*** (t= -4.835; d=-1.29)		
Difference	-0.42 ± 1.23		0.36 ± 1.82		1.39 ± 1.07		p=**0.004*** (kw=11.142)bc
AS STP Pre-test (%)	58.39±2.71	58.23 (56.09-60.14)	57.73±2.02	57.95 (55.99-58.69)	57.02±2.57	56.32 (55.35-58.13)	p=0.283 (kw=2.524)
AS STP post-test (%)	59.24±0.84	58.92 (58.74-59.91)	57.4±2.18	57.37 (56.18-58.73)	56.76±1.87	56.63 (55.24-57.37)	p=**0.0001*** (kw=17.367)ab
Intra Group p	p= 0.211 (t= -1.317; d=-0.35)		p= 0.661 (t= 0.448; d=0.12)		p= 0.508 (t= 0.680; d=0.18)		
Difference	0.85 ± 2.41		-0.33 ± 2.78		-0.26 ± 1.43		p=0.317 (F=1.183)
LAS STP Pre-test (%)	59.41±2.10	59.45 (58.29-60.85)	58.93±1.61	58.69 (57.73-59.4)	61.04±3.06	62.35 (57.88-63.26)	p=0.071 (kw=5.291)
LAS STP post-test (%)	59.83±1.36	59.78 (58.70-60.65)	58.57±1.56	58.74 (58.31-59.19)	59.66±2.68	60.62 (58.44-61.29)	p=**0.031*** (kw=6.948)c
Intra Group p	p= 0.228 (t= -1.266; d=-0.34)		p= 0.975 (z= -0.031; d=-0.01)		**p= 0.0001*** (t= 4.837; d=1.29)		
Difference	0.42 ± 1.23		-0.36 ± 1.82		-1.39 ± 1.07		p=**0.004*** (kw=11.142)bc
AS DSP Pre-test (%)	6.69 ± 1.54	6.63 (5.5 - 8.06)	6.24 ± 1.54	6.43 (5.2 - 7.49)	7.26 ± 2.18	7.01 (5.51 - 8.63)	p=0.332 (F=1.134)
AS DSP post-test (%)	7.99 ± 1.72	7.7 (6.92 - 9.27)	6.88 ± 0.83	6.74 (6.28 - 7.5)	7.07 ± 2.22	6.44 (5.69 - 7.69)	p=0.086 (kw=4.918)
Intra Group p	**p=0.002*** (t=-3.776; d=-1.01)		p=0.086 (t=-1.858; d=-0.5)		p=0.656 (t=0.457; d=0.12)		
Difference	1.3 ± 1.29		0.64 ± 1.28		-0.18 ± 1.49		**p=0.022*** (F=4.207)b
LAS DSP Pre-test (%)	11.3 ± 2.04	11.46 (9.73 - 13.48)	11.88 ± 3.24	11.46 (9.52 - 12.95)	11.74 ± 2.96	12.47 (11.74 - 13.7)	p=0.376 (kw=1.955)
LAS DSP post-test (%)	12.85 ± 2.08	12.38 (11.96 - 14.45)	11.34 ± 4.24	12.54 (9.24 - 14.31)	10.82 ± 3.01	11.27 (10.05 - 12.54)	p=0.237 (F=1.493)
Intra Group p	**p=0.0001*** (t=-6.363; d=-1.7)		p=0.778 (z=-0.282; d=-0.08)		**p=0.037*** (t=2.317; d=0.62)		
Difference	1.55 ± 0.91		-0.54 ± 3.83		-0.92 ± 1.49		**p=0.002*** (kw=12.82)b

Note. S.D: Standard Deviation, Med (IQR): Median (25th – 75th percentiles), *p <0,05 statistically significant, F: One Way Anova, kw: Kruskal Wallis Variance Analysis, t: Paired Samples t test, z: Wilcoxon signed rank test, a: Statistically significant difference between DW and UW, b: Statistically significant difference between DW and WWI, c: Statistically significant difference between UW ve WWI; d = Cohen d effect size for paired samples

DISCUSSION

Children with CP have difficulty maintaining balance when walking, running, or standing. Several investigations have also demonstrated that various TT protocols can enhance balance in children with CP (Grecco et al., 2013; Kurz et al., 2011). This study

demonstrated that TT performed in addition to the conventional physiotherapy program is an important tool in the development of dynamic balance in children with hemiparetic and diparetic CP with GMFCS level II. However, unlike other studies, this study compared different slopes of TT. Analysis of the FRT results showed that the improvement in the DW and WWI groups is significantly higher than that in the UW group. The two groups have no advantage over each other. The results of the study suggest that the increases in isometric muscle strength and ROM, particularly the increase in HF ROM on the LAS only in DW and WWI, may have affected the balance results.

In individuals with CP, reduced muscle size, abnormal muscle structure, and altered neural control lead to less muscle strength development and muscle weakness compared with individuals with normal development (Verschuren et al., 2018). In the present study, AS KFF increased significantly in both the DW and UW groups, whereas it increased significantly in the UW and WWI groups. LAS KFF was significantly increased in all groups. LAS KEF increased significantly in the WWI group, whereas it decreased in the DW group, although not statistically significant. In physics, force is analyzed under two classes: contact and field forces. Contact forces are the forces that arise as a result of physical contact between two objects (Serway & Beichner, 2000), and various training methods (fitness, partner training, own body weight, etc.) to increase muscle strength fall into this category. The increase in the KFF on the AS and LAS in the DW and UW groups compared with that of the WWI group may be due to the fact that the lower extremities have to exert more force in the STP of the gait. Similarly, the increase in KEF on both sides in the WWI group may be due to the lower extremities trying to maintain balance and stabilization in the STP of gait. Our study results support the outcomes of prior investigations, which have observed that TT improves the strength of the lower extremity (Kurz et al., 2011; Serway & Beichner, 2000). However, the improvements reported in the aforementioned studies are for different TT protocols (type, duration, frequency, and severity). Strength score measurement differences and participant group differences in the studies (different CP subtypes and GMFCS levels) also make comparison difficult.

With decreased ROM, there is an increase in energy expenditure during walking and other functional activities, making it difficult to perform movements (Ballaz et al., 2010). Hösl et al. (2018), compared the effectiveness level of passive stretching applied to the plantar flexor muscles with backward DW in ten children with CP. In a 9-week study conducted for three days/a week, no increase in passive dorsiflexion angle was observed in ROM, whereas

dorsiflexion angle in the mid-STP of walking increased, and KF in swing decreased. There was also an increase in forward walking speed, attributed to enhanced neuromuscular control. In the aforementioned study, walking exercise on a treadmill was not superior to passive stretching; however, a significant increase in AD was observed. In another study, 16 children with CP aged 5–14 years performed walking exercises on a treadmill for 30 minutes per day for 4 weeks. The results showed that voluntary AD and heel weight increased significantly in the early mid STP (Millichap, 2015). In the present study, HF/HE and AD increased similarly in all groups in ROM. In contrast, AS KF decreased in the UW group, although the change was not statistically significant, and increased significantly in the DW and WWI groups. These two groups had no advantage over each other. The increase in APF was higher in the DW and WWI groups; however, neither group had an advantage over the other.

CP is highly likely to lead to gait disorders, which limit the child's participation in activities of daily living such as self-care, education, and recreation (Hoffman et al., 2018; Qian et al., 2023). Previous studies have shown that the use of different types of TT interventions may improve walking performance (Cherng et al., 2007; Ameer et al., 2019; Grecco et al., 2013; Kurz et al., 2011; Hoffman et al., 2018; Hösl et al., 2018; Millichap, 2015). These studies were conducted in different CP subtypes with groups of participants at varying GMFCS levels, and gait performance was evaluated using various gait parameters. Two important parameters determine SV: SL and CD. Based on the findings of this study, although there was an increase in CD in the DW group, there was no increase in SL and AV. This may be explained by the fact that although there was no statistical difference in the DW group, there was a decrease in SL. Children with CP tend to carry their body weight preferentially on the LAS side because of the loss of strength and poor balance on the AS, which leads to impaired gait symmetry. In particular, there is a decrease in the percentage of STP and an increase in the SWP of the lower limb on the AS, which typically has a ratio of 60% STP and 40% SWP. The DSP is also reduced for the same reason. In normal walking, this rate is around 11% (Niznik et al., 1996). In the present study, a decrease in the percentage of SWP and an increase in the percentage of STP of the AS was observed in the DW group. Examination of the rates of increase and decrease showed that it approaches the normal gait symmetry values (swing 40% and stance 60%). This may be because children with CP have to take more controlled and slower steps with eccentric contraction in DW. In the WWI group, an increase in percentage SWP and a decrease in percentage STP was observed on the intact side. The lack of slope may have contributed to a rhythmic and easy walking pattern. In their study, Grecco et al. (2013) reported that walking

exercise on a treadmill had positive effects on mediolateral oscillation. In the present study, the favorable improvement in percentage SWP and percentage STP coincides with the mediolateral release. No statistically significant change was observed only in UW. This may be because children who have difficulty with dorsiflexion may have to break their gait to walk fluently when going uphill. In the study by Grecco et al. (2013), the slope was increased weekly, whereas in this study, the slope remained the same throughout the process. There was a significant increase in the percentage of DSP in AS and LAS in the DW group. When this data was evaluated in conjunction with the improvements in AS KFF, AS HF, and HE, as well as AS KF, AS AD, and APF in the DW group, the contact with the ground increased, balance improved, and asymmetry in gait decreased in the DW group. In the present study, a significant improvement in MTUGTT results was observed in both the DW and UW groups, whereas no statistically significant improvement was observed in the WWI group. Although not statistically significant, AV increased, and MTUGTT decreased in all three groups. The increase in AS and LAS KFF in the DW and UW groups, the increase in AS KEF in the UW and WWI groups, and the increase in LAS KEF in the WWI group contributed to the decrease in MTUGTT in the rising from the chair and sitting sections. Therefore, statistically significant improvements were observed in balance, strength, and gait parameters in the DW group. Although there were significant improvements in the UW group in some data and in the WWI group in some data, the highest improvement was in the DW group. In CP, dead nerve cells cannot be replaced, but function can be improved by increasing the connections between existing cells. This increase in connectivity, called neuroplasticity, is achieved by optimally surprising the brain, gaining new experiences, and frequent repetition. The improvements seen in children who have never experienced DW on a treadmill can be attributed to this reason. Walking exercises performed on a flat surface are not rhythmic in children with CP, as they occur at a self-selected pace and remain at the cerebral cortex level. However, in daily life, walking is not controlled at the cerebral cortex level but rather at lower levels such as the cerebellum, meaning the movement becomes automatic. From this perspective, shifting walking to a subconscious level is important for transferring it to daily life (Hikosaka et al., 2002).

The present study has some strengths that can support therapists and researchers in future studies. They include the high number of individuals who participated and completed the assessment, the homogeneity of the groups, the use of three different slopes simultaneously in a single study, and the evaluation of multiple variables. However, there are

also some limitations. In children with CP, the training program should be specific and functional to the individual. The results of this study are specific to the sample group in question.

CONCLUSION

The main findings were that gait exercises performed at different inclinations in children with CP were related to AS balance, strength, ROM, and gait parameters. Balance improved significantly in all groups. DW and WWI groups showed the highest improvement in balance. Evaluation of isometric KFF in lower extremity strength showed an increase in DW and UW groups in AS and in all groups in LAS. Evaluation of isometric KEF showed an increase in AS UW and WWI groups. Evaluation of ROM in all groups showed a significant increase in HF, HE, and AD angle in AS. There was an increase in KF and APF in the DW and WWI groups, with the highest increase in the DW group.

Downhill and no incline TT resulted in a significant improvement in the acquisition of gait symmetry. In gait parameters, improvement was observed in ST and CD only in the DW group. Evaluation of SWP showed improvement in the DW group in AS and the WWI group in LAS. Evaluation of STP showed that LAS improved only in the WWI group. Evaluation of DSP showed that both AS and LAS increased in the DW group, whereas only LAS decreased in the WWI group. In DSP, the highest increase in AS was observed in the DW group.

In children with CP, the stance phase percentage on the affected side decreases, and there is a tendency to shift more weight to the less affected side (Acavedo, 1999). Since downhill walking requires greater attention to maintain balance during movement, it may promote increased weight shifting toward the affected side. Evaluation of MTUGTT revealed a decrease in duration in both the DW and UW groups, with the greatest decrease observed in the UW group.

PRACTICAL IMPLICATIONS

Downhill and uphill gait training is an effective method for improving walking parameters in children with CP. Treadmill training, particularly at different inclinations, can be used in the clinic. Treadmill exercises with different inclinations can be used to adapt to daily living activities. If the clinician's goal is to improve lower extremity strength, an inclined surface is recommended for knee flexion strength, while a flat surface is suggested for knee extension strength. If the goal is to increase flexibility in the lower extremity (especially on the

affected side) and/or improve balance, treadmill exercises with varying inclinations can be recommended. If the goal is to increase walking speed, inclined treadmill exercises are preferred. Conversely, if the aim is to make walking more fluid and symmetrical (especially on the affected side), downhill treadmill exercises are recommended.

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Authors' Contributions

The first, second and third authors were responsible for the research design, data collection, data analysis and interpretation and writing the manuscript. Fourth and fifth authors were responsible for data analysis and interpretation, writing the manuscript. All authors read and approved the final version of the manuscript.

Declaration of Conflict Interest

The authors have no conflicts of interest to report.

Ethics Statement

The study was approved by the Pamukkale University Clinical Research Ethics Committee (Number: 60116787-020-35801 and year: March 24, 2021).

REFERENCES

Acavedo, S. J. (1999). Physical Therapy for the Child with Cerebral Palsy. In: Tecklin, J. S. (Ed). Pediatric Physical Therapy. 3. ed. Philadelphia: Saunders WB. p.: 107-162.

Ameer, M. A., Fayez, E.S., & Elkholy, H.H. (2019). Improving spatiotemporal gait parameters in spastic diplegic children using treadmill gait training. *Journal of Bodywork and Movement Therapies.* 23(4):937-942. https://doi.org/10.1016/j.jbmt.2019.02.003

Aminian, K., Najafi, B., Büla, C., Leyvraz, P. F., & Robert, P. (2002). Spatio-temporal parameters of gait measured by an ambulatory system using miniature gyroscopes. *Journal of Biomechanics.* 35(5):689-699. https://doi.org/10.1016/S0021-9290(02)00008-8

Armand, S., Decoulon, G., & Bonnefoy-Mazure, A. (2016). Gait analysis in children with cerebral palsy. *EFORT open reviews.* 1(12):448-460. https://doi.org/10.1302/2058-5241.1.000052

Ballaz, L., Plamondon, S., & Lemay, M. (2010). Ankle range of motion is key to gait efficiency in adolescents with cerebral palsy. *Clinical Biomechanics.* 25(9):944-948. https://doi.org/10.1016/j.clinbiomech.2010.06.011

Berker, N., & Yalçın, S. (2010). The Help Guide to Cerebral Palsy. Merrill Corporation Washington.

Cherng, R.J., Liu, C.F., Lau, T.W., & Hong, R.B. (2007). Effect of treadmill training with body weight support on gait and gross motor function in children with spastic cerebral palsy. *American Journal of Physical Medicine & Rehabilitation.* 86(7):548-555. https://doi.org/10.1097/PHM.0b013e31806dc302

Cortés-Pérez, I., González-González, N., Peinado-Rubia, A.B., Nieto-Escamez, F.A., Obrero-Gaitán, E., & García-López, H. (2022). Efficacy of robot-assisted gait therapy compared to conventional therapy or treadmill training in children with cerebral palsy: A systematic review with meta-analysis. *Sensors.* 22(24):9910. https://doi.org/10.3390/s22249910

Dhote, S.N., Khatri, P.A., & Ganvir, S.S. (2012). Reliability of "modified timed up and go" test in children with cerebral palsy. *Journal of Pediatric Neurosciences.* 7(2):96. https://doi.org/10.4103%2F1817-1745.102564

Dimakopoulos, R., Syrogiannopoulos, G., Grivea, I., Dailiana, Z., Youroukos, S., & Spinou, A. (2022). Kinematic and temporospatial changes in children with cerebral palsy during the initial stages of gait development. *Developmental Neurorehabilitation.* 25(1):10-18. https://doi.org/10.1080/17518423.2021.1914763

Duncan, P. W., Weiner, D. K., Chandler, J., & Studenski, S. (1990). Functional reach: a new clinical measure of balance. *Journal of Gerontology.* 45(6):M192-M197. https://doi.org/10.1093/geronj/45.6.M192

Grecco, L. A., Tomita, S. M., Christovão, T. C., Pasini, H., Sampaio, L. M., & Oliveira, C. S. (2013). Effect of treadmill gait training on static and functional balance in children with cerebral palsy: a randomized controlled trial. *Brazilian Journal of Physical Therapy.* 17:17-23. http://dx.doi.org/10.1590/S1413-35552012005000066

Hikosaka, O., Nakamura, K., Sakai, K., & Nakahara, H. (2002). Central mechanisms of motor skill learning. *Current opinion in neurobiology.* 12(2),217–222. https://doi.org/10.1016/s0959-4388(02)00307-0

Hoffman, R. M., Corr, B. B., Stuberg, W. A., Arpin, D. J., & Kurz, M. J. (2018). Changes in lower extremity strength may be related to the walking speed improvements in children with cerebral palsy after gait training. *Research in Developmental Disabilities.* 73:14-20. https://doi.org/10.1016/j.ridd.2017.12.005

Hösl, M., Böhm, H., Eck, J., Döderlein, L., & Arampatzis, A. (2018). Effects of backward-downhill treadmill training versus manual static plantarflexor stretching on muscle-joint pathology and function in children with spastic Cerebral Palsy. *Gait & Posture.* 65:121-128. https://doi.org/10.1016/j.gaitpost.2018.07.171

Kurz, M. J., Corr, B., Stuberg, W., Volkman, K. G., & Smith, N. (2011). Evaluation of lower body positive pressure supported treadmill training for children with cerebral palsy. *Pediatric Physical Therapy.* 23(3):232-239. https://doi.org/10.1097/PEP.0b013e318227b737

LEGSysTM User's Guide. Version 2.3: BioSensics LLC; 2015.

Millichap, J. G. (2015). Gait training and ankle dorsiflexors in cerebral palsy. *Pediatric Neurology Briefs.* 22-22. https://doi.org/10.15844/pedneurbriefs-29-3-5

Niznik, T. M., Turner, D., & Worrell, T. W. (1996). Functional reach as a measurement of balance for children with lower extremity spasticity. *Physical & Occupational Therapy in Pediatrics.* 15(3):1-16. https://doi.org/10.1080/J006v15n03_01

Otman, A. S., & Köse, N. (2014). Tedavi Hareketlerinde Temel Değerlendirme Prensipleri. Hipokrat Kitabevi.

Qian, G., Cai, X., Xu, K., Tian, H., Meng, Q., Ossowski, Z., & Liang, J. (2023). Which gait training intervention can most effectively improve gait ability in patients with cerebral palsy? A systematic review and network meta-analysis. *Frontiers in Neurology.* 13:1005485. https://doi.org/10.37766/inplasy2022.10.0108

Scholtes, V. A., Dallmeijer, A.J., Rameckers, E.A., Verschuren, O., Tempelaars, E., Hensen, M., & Becher, J.G. (2008). Lower limb strength training in children with cerebral palsy–a randomized controlled trial protocol for functional strength training based on progressive resistance exercise principles. *BMC Pediatrics*. 8(1):1-11. https://doi.org/10.1186/1471-2431-8-41

Serway, R. A., & Beichner, R. J. (2000). Physics for Scientists and Engineers with Modern Physics. 5th Edition: Saunders College Publishing.

Tekin, F., & Kavlak, E. (2021). Short and long-term effects of whole-body vibration on spasticity and motor performance in children with Hemiparetic cerebral palsy. *Perceptual and Motor Skills.* 128(3):1107-1129. https://doi.org/10.1177/0031512521991095

Verschuren, O., Smorenburg, A. R., Luiking, Y., Bell, K., Barber, L., & Peterson, M. D. (2018). Determinants of muscle preservation in individuals with cerebral palsy across the lifespan: a narrative review of the literature. *Journal of Cachexia, Sarcopenia and Muscle.* 9(3):453-464. https://doi.org/10.1002/jcsm.12287

Valadão, P., Piitulainen, H., Haapala, E. A., Parviainen, T., Avela, J., & Finni, T. (2021). Exercise intervention protocol in children and young adults with cerebral palsy: the effects of strength, flexibility and gait training on physical performance, neuromuscular mechanisms and cardiometabolic risk factors (EXECP). *BMC Sports Science, Medicine and Rehabilitation.* 13(1):1-19. https://doi.org/10.1186/s13102-021-00242-y

Willemse, L., Brehm, M. A., Scholtes, V. A., Jansen, L., Woudenberg-Vos, H., & Dallmeijer, A. J. (2013). Reliability of isometric lower-extremity muscle strength measurements in children with cerebral palsy: implications for measurement design. *Physical Therapy.* 93(7):935-941. https://doi.org/10.2522/ptj.20120079

Willerslev-Olsen, M., Petersen, T. H., Farmer, S. F., & Nielsen, J. B. (2015). Gait training facilitates central drive to ankle dorsiflexors in children with cerebral palsy. *Brain : a journal of neurology*. 138(Pt 3), 589–603. https://doi.org/10.1093/brain/awu399

https://doi.org/10.54141/psbd.1588327

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The Effects of Smartphone Use During Resistance Training

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ABSTRACT

Several health risks are associated with sedentary behavior; therefore, it is important to better understand behaviors such as smartphone use and how it may influence physical activity and/or exercise. This study assessed the effects of smartphone use during resistance training (RT) exercise on volume load, intensity, liking, and productivity. Twenty college-age students participated in two separate 30-minute RT workouts (smartphone ALL and smartphone MUSIC) on two different days. One condition was assigned an upper-body workout, while the other condition was assigned a lower-body workout. During the *smartphone ALL* condition, participants were instructed to use their smartphone for any function (e.g., texting, apps, music, etc.). For the other *smartphone MUSIC* conditions, participants were instructed to only use their smartphone for music. There were no significant differences in volume-load and exercise intensity between *smartphone ALL* upper body exercises and *smartphone MUSIC* upper body exercises and *smartphone ALL* lower body exercises and *smartphone MUSIC* lower body exercises ($t \leq 0.59$, $p > 0.05$). There was a significant difference in liking and productivity between *smartphone ALL* upper body exercises and *smartphone MUSIC* upper body exercises and *smartphone ALL* lower body exercises and *smartphone MUSIC* lower body exercises ($t \leq 3.01$, $p \leq 0.01$). In conclusion, using your smartphone for all functions, rather than limiting it to music purposes only, can interfere with RT exercise, resulting in a significant decrease in liking (i.e., enjoyment) and perceived productivity.

INTRODUCTION

Smartphone use has been found to be positively associated with sedentary behavior (Fennell et al., 2019). Excessive sedentary behavior has been found to result in an increased likelihood of several potentially deleterious health effects, such as cardiovascular disease (CVD), metabolic disease, and type 2 diabetes (Biswas et al., 2015). Due to the health risks associated with sedentary behavior, it is crucial to better understand behaviors such as smartphone use and their potential influence on physical activity and exercise (e.g., RT). Resistance training (RT) is inversely associated with CVD, metabolic disease, and type 2 diabetes (American College of Sports Medicine, 2021). These findings suggest a favorable influence of RT on several chronic diseases and, therefore, should be included in one's weekly engagement in physical activity/exercise, with the American College of Sports Medicine (ACSM) recommending engaging in RT 2-3 $d \bullet wk^{-1}$ (American College of Sports Medicine, 2021). However, many individuals are not meeting the physical activity/exercise and RT guidelines, with only 24.2% of those adults 18 and older meeting both aerobic and RT exercise (CDC National Center for Health Statistics, 2022). According to Peterson (2006), the number one reason why adults 18 and older are not meeting both aerobic and RT exercise guidelines is that they do not have enough time to exercise. There are numerous reasons why people may not have enough time to exercise or meet the physical activity and exercise guidelines, but smartphone use may be a contributing factor. Previous studies have found smartphone use to have a negative impact on several areas of physical activity/exercise (Duke & Montag, 2017; Fortes et al., 2020; Lepp et al., 2013; Rebold et al., 2015; 2019). The following sections will be divided into exercise *productivity*, *cognition*, and *intensity*.

Smartphone use and its effects on *productivity*: One study examined the relationship between smartphone addiction, daily interruptions caused by smartphone use, and work-related productivity (Duke & Montag, 2017). Researchers asked participants to self-report their level of smartphone addiction, the frequency of smartphone interruptions, and their productivity levels. The study found a significant negative correlation between smartphone addiction and self-reported productivity ($r_s = 0.436$, $p < 0.01$). They revealed that individuals with higher smartphone addiction and more interruptions reported lower levels of productivity compared to those with lower smartphone addiction and fewer interruptions (Duke & Montag, 2017). These findings support that frequent smartphone use during work-related tasks decreases overall productivity. While this study did not focus on resistance

training (RT) exercise, it is an important finding because it highlights the general impact of excessive cell phone use on productivity, which can be related to the volume-load completed during RT exercise. Gantois and colleagues (Gantois et al., 2021) investigated the effects of smartphone use on resistance training sessions. Thirty minutes prior to exercise, participants were asked to scroll through their social media apps. Findings revealed that the volume-load was significantly lower ($p = 0.006$) compared to the control condition, which involved watching a 30-minute documentary prior to exercise (Gantois et al., 2021). These findings suggest that using social media on smartphones immediately before exercise may lead to mental fatigue, which can negatively impact performance during resistance training.

Smartphone use and its effects on *cognition*: One study examined the effects of 30 minutes of smartphone texting while completing a cycle ergometer exercise (Rebold et al., 2019). Researchers used the Stroop Test to measure pre- and post-exercise reaction time and accuracy in smartphone and no smartphone conditions. The findings revealed that participants who engaged in texting during aerobic exercise had significantly worse accuracy ($F = 4.97$, $p = 0.003$) from pre- to post-exercise testing. They also found that the no-smartphone condition yielded a significantly better reaction time ($F = 10.16$, $p < 0.001$) from pre- to post-exercise testing (Rebold et al., 2019). These findings suggest that texting during aerobic exercise impairs cognitive performance. While this study also did not focus on RT exercise, it is an important finding because impaired cognition (e.g., mental fatigue) from cell phone use can cause perceived fatigue; therefore; possibly negatively impacting the productivity of RT exercise. Bangsbo (2015) suggested that sports performance can be negatively affected due to the athlete's attention allocation being disrupted during training by smartphone dependence. Sports performance training can be restricted by smartphone dependence through athletes dividing their attention between their smartphones and training, with the majority of their attention being directed towards their smartphones. This concept of dividing attention amongst multiple tasks is known as dual-tasking (MacPherson, 2018) and has been a concept proposed in other investigations that have investigated the effects of smartphone use on exercise (Fortes et al., 2020; Lepp et al., 2013; Rebold et al., 2015; 2019).

Smartphone use and its effects on *exercise intensity*: Fortes et al. (2020) investigated the influence of smartphone use on endurance, power, and swimming performance in high-level swimmers. For eight weeks, immediately before each training session, the control group watched videos about the Olympic games for 30-minutes, while the smartphone group used social media apps for 30-minutes. Findings revealed that swimmers who reported spending

more time on social media had decreased endurance, reduced power output, and lower swimming performance compared to the control group (p = 0.02, p = 0.01, p = 0.01). These findings indicate that excessive cell phone use before exercise has a negative impact on physical performance (Fortes et al., 2020). Similarly, Lepp et al. (2013) investigated the relationship between smartphone use, physical activity, and cardiorespiratory fitness in college students. Findings revealed a significant, negative relationship between total daily smartphone use and VO_2 max (p = 0.047; Lepp et al., 2013). In a study performed by Rebold et al. (2015), the impact of smartphone use on the intensity and liking of a bout of treadmill exercise was examined. Four conditions —control, texting, talking, and music —were administered on separate days in a random order during a 30-minute bout of treadmill exercise. The findings revealed that smartphone use for music yielded significantly higher treadmill speeds ($p \leq 0.008$), increased liking to the exercise ($p < 0.001$), and higher exercise intensity ($p \leq 0.014$). On the other hand, smartphone use for texting and talking yielded a significantly lower ($p \leq 0.04$) average speed than the control and average heart rate was lower (p = 0.04) in the texting when compared to the control, suggesting that texting during aerobic exercise can decrease workload and intensity (Rebold et al., 2015). The research focusing on smartphone use and its effects on exercise are intense in that it provides quality evidence that smartphone use during exercise results in decreased performance. Once again, these studies did not specifically focus on RT exercise but can possibly be connected in that smartphone use during RT exercise can possibly result in decreased productivity.

Overall, the findings from the studies mentioned above strongly support that smartphone use before and during exercise diverts attention and compromises overall productivity, decreases participation in high-intensity exercise, and disrupts physical fitness gains (Duke & Montag, 2017; Fortes et al., 2020; Gantois et al., 2021; Lepp et al., 2013; Rebold et al., 2015; 2019). The purpose of this study is to determine whether full smartphone access during RT exercise reduces the participants' volume load, intensity, liking, and productivity of their workout. We hypothesized that restricting smartphone use to music purposes only would increase volume load, intensity, liking, and productivity.

METHODS

Participants

Twenty recreationally active college-aged participants were recruited to take part in this study. An a priori power analysis was conducted using G*Power version 3.1.9.7 (Faul et

al., 2007) to determine the minimum sample size required. Results indicated the required sample size to achieve 80% power for detecting a medium effect at a significance criterion of $\alpha = 0.05$. Each participant completed two separate, 30-minute RT exercise conditions (*smartphone ALL*, *smartphone MUSIC*) on separate days. The order of the two conditions was counterbalanced, and each participant completed both conditions (i.e., within-subjects design). A counterbalanced design was employed, as participants completed an upper body resistance training (RT) workout in one condition and a lower body RT workout in the other condition (e.g., *smartphone ALL* - upper, *smartphone MUSIC* - lower). All participants had prior RT experience and on average, had been engaged in RT session 3-4 times per week. In addition, they all reported using their smartphone for various functions during RT sessions. Participants were excluded if they did not have access to a gym, did not have a smartphone, or had any contraindications to exercise (e.g., musculoskeletal conditions such as strains). Prior to participation in this study, participants were notified of the risks and benefits and signed an informed consent form. The Hiram College Institutional Review Board approved this study.

Table 1
Average Height, Weight, and Age of All Participants

Physical Characteristics	Females (n = 10)	Males (n = 10)
Height (cm)	163.7±6.66 cm	173.3±10.79 cm*
Weight (kg)	72.61±22.74 kg	76.13±12.59 kg
Age (years)	20.67±0.65 years	23±2.56 years*

Note. All data are means ± SD; *: males significantly greater than females for height and age; $p < 0.05$ for all

Procedures

Participants reported to a gym of their choice on two separate days, with one week in between the two days that they selected to provide a washout period between conditions. During each visit, participants were instructed to complete a 30-minute RT workout under two exercise conditions: smartphone ALL and smartphone MUSIC. Participants were also informed which workout (upper body or lower body) they would be completing for each condition (smartphone ALL or *smartphone MUSIC*). Resistance training (RT) was defined as a form of exercise where external weights provide progressive overload to skeletal muscles to improve power, strength, endurance, or hypertrophy (Haff & Triplett, 2021). Participants were instructed to only use free weights, body weight, and/or circuit machines throughout their workout. Plyometric exercises were prohibited since this is a mode of RT that recreationally active individuals usually do not complete. Participants were also informed that they could self-select their RT workouts (Table 2) because if they were told to adhere to a specific

percentage of their one repetition maximum (1RM), this may have then negatively affected their liking (i.e., enjoyment). During the *smartphone ALL* condition, participants were allowed full access to their smartphones, including music, playing games, searching the web, checking emails, texting, calling, and social media. During the *smartphone MUSIC* condition, participants were allowed to listen to music only and music of their choice. Participants were also instructed to turn off notifications from all other apps. Research personnel allowed participants to self-select the type of music they wanted to listen to. Research personnel allowed participants to self-select the type of music they wanted to listen to because it was believed that if participants were "forced" to listen to a specific type of music, this could have possibly affected their liking (i.e., enjoyment) in a negative way due to them possibly not liking that specific type of music (Stork et al., 2015). Immediately after each condition, participants were instructed to:

1. Indicate whether music was listened to and, if so, what genre of music was most commonly listened to.
2. Indicate the types of smartphone functions used, the frequency of use, and the duration.
3. Indicate the exercises completed, along with the weight, sets, and repetitions.
4. Mark a line on the OMNI resistance exercise scale to indicate the intensity of the workout (intraclass correlation coefficient = 0.69-0.80; Robertson et al., 2003).
5. Mark a vertical line on a 10 cm visual analogue scale, ranging from "do not like it at all" to "like it very much", to rate the liking (i.e., enjoyment) of the workout (intraclass correlation coefficient = 0.80-0.95; Roemmich et al., 2008).
6. Circle a number from 0-10 to indicate the productivity of the workout was. The range was 0-10; 0 = the worst you could perform, and 10 = the absolute best you could perform.
7. After completing both conditions, indicate your preference for the condition (smartphone ALL or smartphone MUSIC).

Table 2
Resistance Training Exercises Completed by the Participants

Free Weights	Machines
Barbell bench press	Lat pulldowns
Dumbbell rows	Leg press
Dumbbell shoulder press	Leg extensions
Dumbbell biceps curls	Leg curls
Triceps push downs	Hip adductions
Barbell squat	Hip abductions
Trap bar deadlift	
Barbell Romanian dead lifts	
Dumbbell calf raises	

Statistical Analyses

All data were analyzed with SPSS version 20.0 (SPSS Incorporated, Chicago IL, USA), with an a-priori α level of ≤ 0.05. Males' and females' physical characteristics (age, height, weight) were compared using independent samples T-tests. Two conditions (smartphone ALL, smartphone MUSIC) conditions (smartphone ALL, smartphone MUSIC), repeated measures ANOVA was used to examine differences in volume load, intensity, liking, and productivity. Post-hoc analysis for all significant main effects were completed using paired samples T-tests with the Benjamini-Hochberg false discovery rate correction (Benjamini & Hochberg, 1995). Additionally, a chi-square analysis was performed to assess any differences in the participant's preference of the two conditions.

RESULTS

Physical Characteristics

Independent samples t-tests revealed no significant differences in males' and females' physical characteristics for height, weight, and age (Table 1).

Smartphone Applications and Music Usage

During the *smartphone ALL* condition, 100% of participants reported using text messaging and social media applications; 35% reported checking their email, 20% reported playing games, and 10% reported talking. On average, participants checked their smartphone 17 times. During the *smartphone MUSIC* condition, 50% of participants reported listening to pop music, 30% to hip-hop, and 20% to rock.

Volume-Load

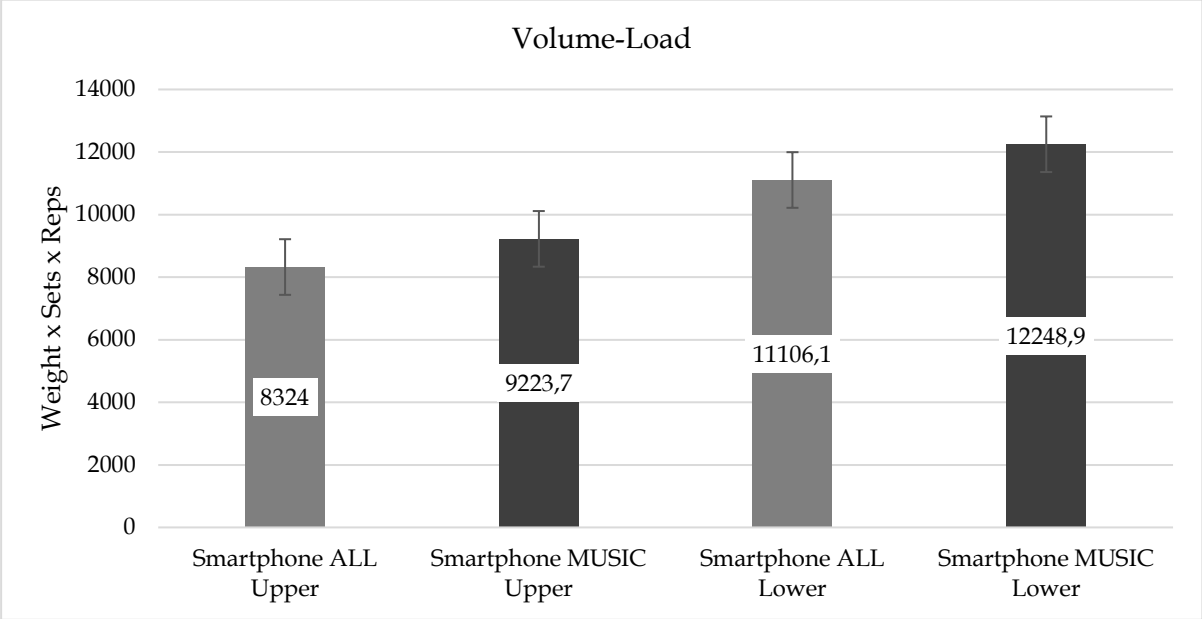
There were no significant differences in volume-load between *smartphone ALL* upper body RT exercises and *smartphone MUSIC* upper body RT exercises and *smartphone ALL* lower body RT exercises and *smartphone MUSIC* lower body RT exercises (d = 0.33, 95% CI, $t \leq 0.88$, $p \leq 0.69$). *Smartphone ALL* upper (8,324 ± 6,065.27) compared to smartphone MUSIC upper (9,223.7±6,929.89); smartphone ALL lower (11,106.1±4,138.89) compared to smartphone MUSIC lower (12,248.9 ± 9,019.26; Figure 1).

Exercise Intensity

There were no significant differences in exercise intensity between *smartphone ALL* upper body RT exercises and *smartphone MUSIC* upper body RT exercises and *smartphone ALL* lower body RT exercises and *smartphone MUSIC* lower body RT exercises (d = 0.21, 95% CI, t

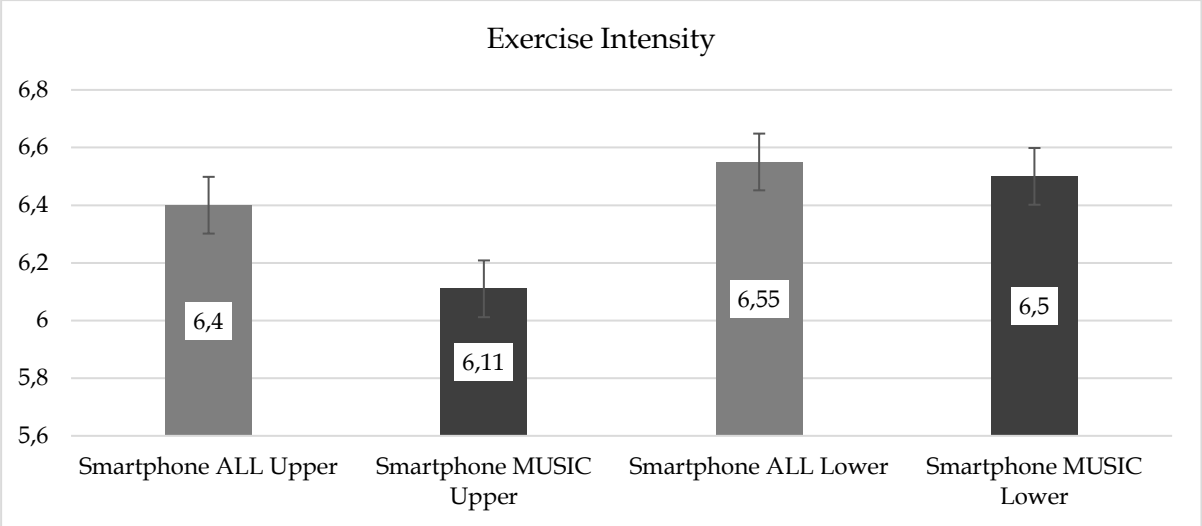
≤ 0.59, $p \leq 0.96$). *Smartphone ALL* upper (6.4±2.07) compared to *smartphone MUSIC* upper (6.11±1.19); *smartphone ALL* lower (6.55±2.51) compared to *smartphone MUSIC* (6.5±1.18; Figure 2).

Figure 1
Results for Volume-Load



Note. The above figure displays results for volume-load from *smartphone ALL* upper body RT exercise, *smartphone MUSIC* upper body RT exercise, *smartphone ALL* lower body RT exercise, and *smartphone MUSIC* lower body RT exercise. All data are means ± SD.

Figure 2
Results for Exercise Intensity

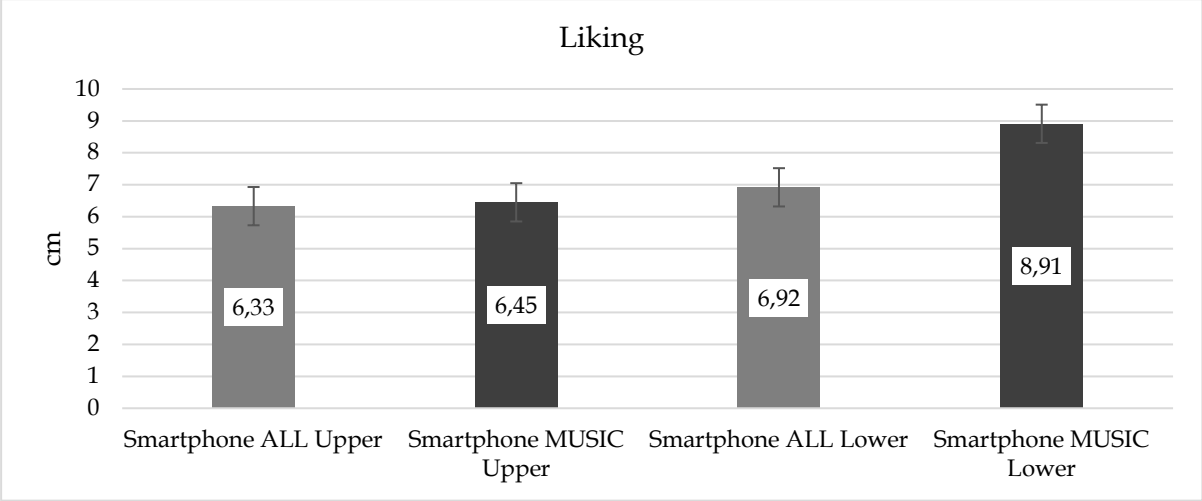


Note. The above figure displays results for exercise intensity from smartphone ALL upper body RT exercise, smartphone MUSIC upper body RT exercise, smartphone ALL lower body RT exercise, and smartphone MUSIC lower body RT exercise.

Liking

There was a significant main effect of the condition for liking (F = 13.03, $p \leq 0.001$). There was a significant difference in liking between *smartphone ALL* lower body RT exercises and *smartphone MUSIC* lower body RT exercises ($d = 0.82$, 95% CI, $t = 3.01$, $p = 0.01$). There was no significant difference between *smartphone ALL* upper body RT exercises and *smartphone MUSIC* upper body RT exercises ($d = 0.22$, 95% CI, $t = 0.12$, $p = 0.91$). *Smartphone ALL* upper (6.33±3.31 cm) compared to smartphone MUSIC upper (6.45±2.09 cm); smartphone ALL lower (6.92±1.67 cm) compared to smartphone MUSIC lower (8.91±1.56 cm; Figure 3).

Figure 3
Results for Liking

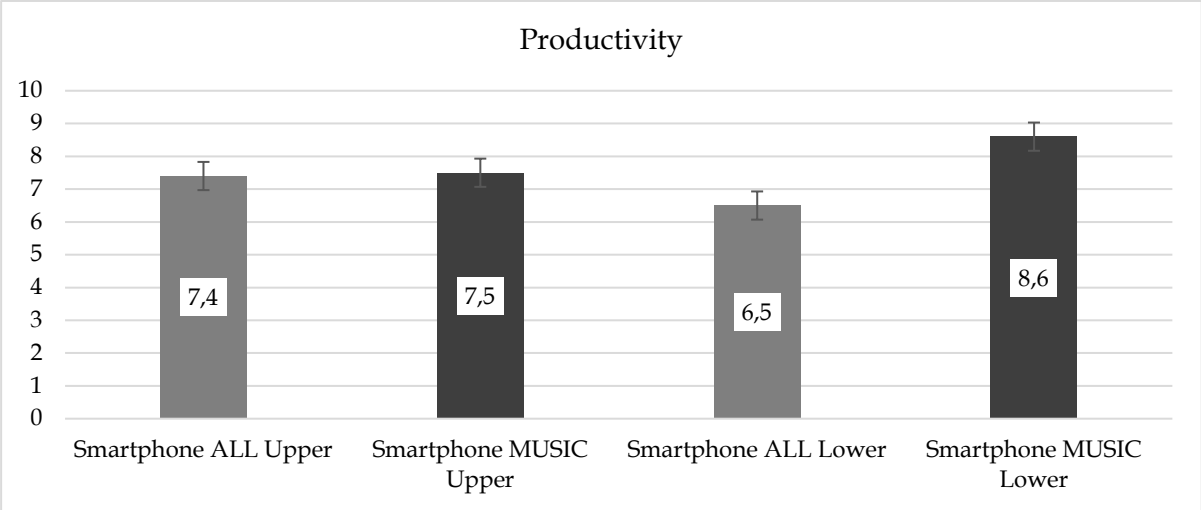


Note. The above figure displays results for liking from smartphone ALL upper body RT exercise, smartphone MUSIC upper body RT exercise, smartphone ALL lower body RT exercise, and smartphone MUSIC lower body RT exercise.

Productivity

There was a significant main effect of the condition for productivity (F = 13.03, $p \leq 0.001$). There was a significant difference in productivity between *smartphone ALL* lower body RT exercises and *smartphone MUSIC* lower body RT exercises ($d = 0.99$, 95% CI, $t = 3.84$, $p \leq 0.001$). There was no significant difference between *smartphone ALL* upper body RT exercises and *smartphone MUSIC* upper body RT exercises ($d = 0.26$, 95% CI, $t = 0.20$, $p = 0.85$). *Smartphone ALL* upper (7.4±2.37) compared to *smartphone MUSIC* upper (7.5±1.96); *smartphone ALL* lower (6.5±1.51) compared to *smartphone MUSIC* (8.6±1.07; Figure 4).

Figure 4
Results for Productivity



Note. The above figure displays results for productivity from smartphone ALL upper body RT exercise, smartphone MUSIC upper body RT exercise, smartphone ALL lower body RT exercise, and smartphone MUSIC lower body RT exercise.

DISCUSSION

This study utilized a within-subjects design to analyze how smartphone use (i.e., texting, social media interactions, etc.) during 30 minutes of RT exercise would affect volume load, intensity, liking, and productivity. Our results were mixed, with significant findings for liking and productivity; however, no significant findings were observed for volume-load and intensity. A possible explanation for the significant findings in both liking and productivity during the *smartphone MUSIC* lower body RT exercises could be that these exercises are generally more intense, leading to greater physical exertion, characterized by increased sweating and rapid breathing, which may give participants a stronger sense of productivity. Furthermore, allowing participants to multitask on smartphones during the *smartphone ALL* lower body RT exercises may have diminished their enjoyment. This reduction likely stems from the challenge of performing complex, multi-joint RT exercises requiring significant neuromuscular control alongside the simultaneous operation of various smartphone functions. It is important to continue to investigate the effects smartphone use has on RT exercise, so further recommendations can be made.

Although previous research has focused on various activities influenced by smartphone use, our results were not entirely dissimilar. Duke and Montag (2017) revealed that individuals with higher smartphone addiction and more smartphone interruptions reported lower levels of productivity compared to those with lower smartphone addiction and

fewer interruptions (Duke & Montag, 2017). This was also observed in the current study, with participants who reported using their smartphone for more functions (e.g., playing games, texting, etc.) reporting significantly lower levels of perceived productivity. This provides evidence that greater smartphone use and interruptions from smartphone functions (e.g., playing games, texting, etc.) can decrease one's level of perceived productivity during an RT workout. In addition, though not significant, there were decreases in both volume load and intensity for the *smartphone ALL* condition when compared to the *smartphone MUSIC* condition.

Rebold and colleagues (2019) investigated smartphone use during cycle ergometer exercise, and their findings suggested that texting during aerobic exercise impairs cognitive performance. Although cognition was not assessed in the current study, previous research has shown that smartphone use can lead to mental fatigue (Gantois et al., 2021). Mental fatigue has been defined as a cognitive condition that occurs after prolonged cognitive activity and is characterized by feelings of fatigue, tiredness, boredom, reluctance to continue the task, increased distractibility, and decreased focus (Boksem et al., 2005). In the current study, although not significant, participants rated their RT workouts as slightly more strenuous in the smartphone ALL condition compared to the *smartphone MUSIC* condition, which may have had an impact on volume-load, productivity, and liking.

A few studies, such as those conducted by Fortes et al. (2020) and Lepp et al. (2013), found that smartphone use during different modes of exercise (e.g., swimming and aerobic exercise) resulted in decreased performance. Our findings are in agreement with these previous studies because our participants had a reduced volume load for both upper and lower RT workouts in the *smartphone ALL* condition when compared to the *smartphone MUSIC* condition. It is important to note, though, our findings were not significant like they were in these previously mentioned studies, which can possibly suggest that smartphone use does not influence RT as much as these other modes of exercise.

Limitations

Provides useful information, it is not without limitations. The participants were all college-aged students who were all accustomed to using smartphones during RT exercise, so we are not able to generalize our findings to other populations (e.g., middle- and older-aged adults) nor to those who are not accustomed to using such devices while engaging in RT exercise. Future research should consider focusing on other populations, such as older adults

and athletes, so we can better understand how smartphone use would affect them while engaging in RT exercise. For example, older adults were not raised entirely in the digital age, so it is possible that there may be more negative outcomes. Another limitation was that participants were allowed to self-select the type of music that they wanted to listen to. The type of music (genre, tempo, and loudness) participants listened to may have influenced their exercise intensity and motivation to complete more work (Edworthy & Waring, 2006). Although one condition was completed each week, future studies should consider monitoring variables such as sleep quality, muscle soreness, fatigue, and/or stress, as these variables may influence RT performance. In addition, identifying participants as low- moderate- or high-frequency smartphone users would possibly provide more insights into how smartphone addiction affects RT performance. Allowing participants to self-select their RT workouts may have influenced volume load and exercise intensity. Future research should consider assessing 1RM and prescribing a specific percentage of 1RM to complete. Finally, participants were exposed to each condition only once. Future studies should focus on introducing a time factor by repeating each condition at least once more. This can offer insights into time-related effects or adaptation trends.

CONCLUSION

Smartphone use has been identified as a distraction during physical activity/exercise and now, RT. Presently, we demonstrated that being allowed to use your smartphone for all functions during an RT session lowered upper and lower body volume load by 10.9% and 10.3%, exercise intensity by 4.5% and 0.76%, liking by 1.9% and 28.76%, and productivity by 1.35% and 32.31%, respectively. Organizations such as the ACSM and National Strength and Conditioning Association (NSCA) advocate the importance of RT exercise because higher levels of muscular strength are associated with a significantly better cardiometabolic risk profile, lower risk of developing physical limitations, improvements in body composition, and enhances bone mass, therefore; improving independence and quality of life (American College of Sports Medicine, 2021; Haff & Triplett, 2021). It is for these reasons that smartphone use should be limited during RT exercise to music purposes only so one can achieve the previously mentioned guidelines and reap the benefits of RT exercise.

In conclusion, it appears that using your smartphone for a variety of different functions while not limiting it to music purposes only during a RT workout has the potential to interfere

with volume load, intensity, liking, and productivity. If one wants to maximize the benefits of RT exercise, it is recommended to only use your smartphone for music purposes only.

PRACTICAL IMPLICATIONS

Resistance training offers numerous health and fitness benefits, including reducing the risk of morbidity and enhancing physical performance. To fully maximize these benefits, it is crucial to be mindful of how smartphones are used during exercise. Currently, using your smartphone solely for music while engaging in RT does not negatively impact performance.

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Authors' Contributions

All authors contributed to the study design; First, second and third authors implemented the study's procedures and collected data. Fourth and fifth authors analyzed the study's data. All author's contributed to the preparation of the study's manuscript.

Declaration of Conflict Interest

All authors have no conflicts of interest to declare.

Ethics Statement

This study was approved by the Hiram College Institutional Review Board on October 3rd, 2023.

REFERENCES

American College of Sports Medicine. (2021). *ACSM's Guidelines for Exercise Testing and Prescription*. Philadelphia, PA: Lippincott Williams & Wilkins.

Bangsbo, J. (2015). Performance in sports – with specific emphasis on the effect of intensified training. *Scand J Med Sci Sports*, *25*, 88-99.

Benjamini, Y., & Hochberg, Y. (1995). Controlling the false discovery rate: a practical and powerful approach to multiple testing. *J R Stat Soc Series B*, *57*(1), 289-300.

Biswas, A., Oh, P. I., Faulkner, G. E., Bajaj, R. R., Silver, M. A., Mitchell, M. S., & Alter, D. A. (2015). Sedentary time and its associated with risk for disease incidence, mortality, and hospitalization in adults: a systematic review and meta-analysis. *Ann Intern Med*, *162*(2), 123-132.

Boksem, M. A. S., Meijman, T. F., & Lorist, M. M. (2005). Effects of mental fatigue on attention: an ERP study. *Brain Res Cogn, 25*(1), 107-116.

CDC National Center for Health Statistics. *Exercise or Physical Activity*. Published December *15,* 2022. Retrieved January 20, 2024.

Duke, É., & Montag, C. (2017). Smartphone addiction, daily interruptions and self-reported productivity. *Addict Behav Rep, 6*, 90-95. https://doi.org/10.1016/j.abrep.2017.07.002

Edworthy, J., & Waring, H. (2006). The effects of music tempo and loudness on treadmill exercise. *Ergon, 49*(15), 1597-1610.

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav Res Methods*, *39*, 175-191. https://doi.org/10.3758/BF03193146

Fennell, C., Barkley, J. E., & Lepp, A. (2019). The relationship between cell phone use, physical activity, and sedentary behavior in adults aged 18-80. *Comput Human Behav*, *90,* 53-59. https://doi.org/10.1016/j.chb.2018.08.044

Fortes, L. S., Nakamura, F. Y., Lima-Junior, D., Ferreira, M. E., & Fonseca, F. S. (2020). Does social media use on smartphones influence endurance, power, and swimming performance in high-level swimmers? *Res Q Exercise Sport*, *93*(1), 120-129. https://doi.org/10.1080/02701367.2020.1810848

Gantois, P., de Lima-Junior, D., de Sousa Fortes, L., Batista, G. R., Nakamura, F. Y., & de Souza Fonseca, F. (2021). Mental fatigue from smartphone use reduces volume-load in resistance training: a randomized, single-blinded cross-over study. *Percept Mot Skills*, *128*(4), 1640-1659.

Haff, G., & Triplett, N. T. (2021). *Essentials of Strength Training and Conditioning*. Champaign, IL: Human Kinetics.

Lepp, A., Barkley, J. E., Sanders, G. J., Rebold, M., & Gates, P. (2013). The relationship between cell phone use, physical and sedentary activity, and cardiorespiratory fitness in a sample of U.S. college students. *Int J Behav Nutr Phys Act*, *10*(1), 79. https://doi.org/10.1186/1479-5868-10-79

MacPherson, S. E. (2018). Definition: dual-tasking and multitasking. *Cereb Cortex*, *106,* 313-314. https://psycnet.apa.org/doi/10.1016/j.cortex.2018.06.009

Peterson, J. A. (2006). Take ten: take-and-save: ten (lame) reasons people commonly give for not exercising. *ACSMs Health Fit J, 10*(1), 44.

Rebold, M. J., Kobak, M. S., Croall, C. A., Cumberledge, E. A., Dirlam, M. T., & Sheehan, T. P. (2019). The impact of cell phone texting during aerobic exercise on measures of cognition. *Int J Exerc Sci*, *12*(5), 646-656. https://digitalcommons.wku.edu/ijes/vol12/iss5/9

Rebold, M. J., Lepp, A., Sanders, G. J., & Barkley, J. E. (2015). The impact of cell phone use on the intensity and liking of a bout of treadmill exercise. *PloS one*, *10*(5). https://doi.org/10.1371/journal.pone.0125029

Robertson, R., Gross, F., Rutkowski, J., Lenz, B., Dixon, C., Timmer, J., Frazee, K., Dube, J., & Andreacci, J. (2003). Concurrent validation of the OMNI perceived exertion scale for resistance exercise. *Med Sci Sports Exerc*, *35*, 333-341.

Roemmich, J. N., Barkley, J. E., Lobarinas, C. L., Foster, J. H., White, T. M., & Epstein, L. H. (2008). Association of liking and reinforcing value with children's physical activity. *Physiol Behav*, *93*, 1011-1018.

Stork, M. J., Kwan, M. Y., Gibala, M. J., & Martin Ginis, K. A. (2015). Music enhances performance and perceived enjoyment of sprint interval exercise. *Med Sci Sports Exerc*, *47*(5), 1052-1060. https://doi.org/10.1249/mss.0000000000000494

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The Ever-Evolving Dark Side Emotions of the Football Supporters: A Study on Adaptation of Schadenfreude Scale

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ABSTRACT

Enjoying from others' maleficence, defined as schadenfreude, is a common emotion among football team supporters. Based on the social identity of supporters, schadenfreude develops as part of the rivalry, which the main sources of it are 'similarity', 'repeated competition', and 'competitiveness'. This study is aimed to understand and classify supporters' schadenfreude reasons based on an adapted scale. For this aim, the data gathered from a questionnaire consisting of a sample of 1.163 supporters of 14 Turkish football teams is examined by SPSS in order to reveal participants' schadenfreude and their reasons for evaluating their rivals. As a result of participants' rivalry classifications, the most common reasons for considering a team as a rival are determined respectively as 'image', 'neighborhood', and 'worldview difference'. Moreover, schadenfreude is mostly felt towards the archrival, and supporters would be happiest with negativities experienced by the rival team's managers. However, damage to rival team facilities is found as an unhappy situation. The study is the first that demonstrates the relationship between schadenfreude and rivalry and proposes 'unique incident' and 'feasible contingencies' as new rivalry factors. With these factors, different perspectives on the formation and continuity of rivalry are presented.

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INTRODUCTION

Today, football has become a global phenomenon. This sports branch, legitimated in different cultures and at all levels of society, has now gone beyond "just a game" in which only two teams compete for 90 minutes. 2022 World Cup Final was watched by 1.5 billion people, and a total of 6 billion interactions were recorded as a result of 93.6 million shares on social media in the one-month period until the cup was held. This indicates how much the phenomenon has grown (FIFA, 2023). Dominantly formed by political and socio-cultural factors, the unique culture of football, which has continuously developed until today, causes permanent changes on individuals. This changing process begins with interest in matches; after that, individuals first become fans of football. It is not enough for fans to support a team and watch their matches, as they become increasingly immersed in the phenomenon over time. Not only the team but all elements of their club form a part of their daily lives, and this becomes their routine. Consequently, large communities with supporter identities emerge.

The socio-cultural factors that are effective in forming and strengthening supporter identity also have the power to deepen differences. While these factors strengthen football fans' identities, the continuation of the polarizations is further accepted, which can be observed from examples around the world. In contrast to mostly Catholic Celtic fans who support the independence of Ireland and Scotland, there are mainly Protestant fans of Glasgow Rangers who want to keep the idea of the 'United Kingdom' alive (BBC, 2006). While the elites of Buenos Aires support the River Plate team, Boca Juniors has adopted the adjectives 'poor' and 'immigrant' as a huge part of their identity (Reuters, 2013). The archrival of Roma, which has mainly left-wing fans, is Lazio, which continues its far-right and yet fascist fan structure even today (The Athletic, 2023). For such rivalries shaped by religious, class, and political factors respectively, countless violent incidents, chants containing criminal elements, or derogatory banners have been recorded in history. However, the globalizing phenomenon of 'being a supporter' has now begun to produce news that comes at unexpected moments, in addition to the usual events among specific teams. For instance, an upset fan of Manchester United which lost the Champions League Final in 2009, could not control his anger and quickly drove his car to the bus stop where Barcelona fans were waiting and celebrating the victory. The remarkable aspect of this misfortune in which four people lost their lives is that the incident took place in Nigeria, and the fans were Nigerian, not British or Spanish (BBC, 2009). Although this incident is a radical example, it shows that supporters' emotions have dark sides

and must be investigated. In the dark emotional spectrum of football supporters, matches are no longer for fun and sympathetic jokes are old-fashioned things of the past: "The favorite team must win at all times and under all circumstances". Moreover, winning is not enough to be happy; different malign events must happen to the opponent beyond losing a match. One of the concepts that offer insight into this increasingly darkening structure of supporter identity is schadenfreude. Focusing on this emotion, this study investigates the supporters' schadenfreude and their reasons for evaluating and classifying rivals. Following the literature discussion on schadenfreude, rival teams' classification is explained in detail in the methodology part, and schadenfreude level and its reasons are determined based on supporters' rival classifications. The study concludes with a discussion of findings, suggestions for revised scale and limitations.

Schadenfreude Literature

Schadenfreude and Its Historical Reflections in Different Cultures

Schadenfreude is derived from the German words *Schaden*, meaning harm, and *Freude*, meaning pleasure. The word, which means *"rejoicing from harms of other persons"* in German, is a common concept in many languages today. English has a leading role in terms of usage in different languages. The word was used in different texts in the first half of the 19th century and was first defined in the Oxford English Dictionary (OED) in 1895 (van Dijk et al., 2015). However, the first word that means *"rejoicing at someone else's loss"* was derived at the Ancient Greek Period. In this context, the oldest example encountered is the works of Aristotle. The famous Greek Philosopher, using the word *Epichairekakia*, analyzed rejoicing at the loss of others on an emotional and actional basis. Thus, the word was transferred to the conceptual dimension for the first time (Simon, 2017).

There are different words meaning *"rejoicing from harms of other persons"* in many languages with widespread usage in daily life. In countries such as Denmark, Hungary, Russia and China, words with the same meaning have found their place in routine jargon. On the contrary, no specific words match the meaning in Italian, Japanese and Spanish. The number of examples where the word has a conceptual dimension, as in Ancient Greece, is limited. Apart from schadenfreude in German, similar conceptual and cultural usage is encountered with the example of *joie maligne* term in French (van Dijk & Ouwerkerk, 2014). On the other hand, *şematet* word in Turkish, is equivalent to rejoicing from harms suffered by others. This word, which has extremely limited daily usage and is not considered conceptually, has important historical roots. During the Siege of Constantinople, Akşemseddin, mentor of

Mehmed II, stated that the Ottoman Navy could not pass the Great Chain of the Golden Horn in the first trials and emphasized that this situation corresponded to "şematet" by the enemy (İnalcık, 2007). Another remarkable use of the word was during the Second Constitutional Monarchy Period, approximately 455 years after the Conquest of İstanbul. In this period, it was emphasized that any educational reform whose implementation was postponed would weaken the Ottoman Empire and the enemy states were feeling "şematet" to these delays (Gündüz, 2007).

Schadenfreude in Social Sciences Literature

'Schadenfreude' term in social sciences has the same meaning as the German word: that is, "rejoicing from harms of other persons" (Li et al., 2019). German psychologist Martha Moers used the term for the first time in social sciences in 1930. Moers (1930) described the concept of schadenfreude as a human emotion and aimed to analyze its moral dimensions. She stated that a momentary event and emotional instincts such as long-term hate or jealousy could trigger this emotion. According to her study, schadenfreude is an emotion dependent on different factors, can become permanent, is a sign of moral corruption, and should be condemned. Despite this classification for the emotion, Moers (1930) stated that schadenfreude has an overly complex structure (van Dijk & Ouwerkerk, 2014). The main focus of schadenfreude research, which became widespread after Moers's study, was identification of the sources of emotion. Factors like income level, education, and gender have been identified as its effective sources. However, individuals' subjective evaluations have been determined as the primary source of schadenfreude. If an individual think that the possible harm to be experienced by other people will benefit him/her, (s)he begins to feel schadenfreude (Roseman & Steele, 2018).

In the studies that followed pioneer research, the complex structure of emotion and its dependence on different factors was generally accepted. However, those theoretical debates on schadenfreude, which started on a moral basis, turned into determining the expectations of individual benefits from suffering harm by others created great changes in the examination of schadenfreude research. At this point, the major implication that "schadenfreude is an expected result of being a bad person" was abandoned; rigid definitions such as immorality or corruption were evaluated within the scope of personality disorders, especially psychopathy (Boddy et al., 2010). In the newly drawn framework, schadenfreude is described as a negative emotion with cynical dimensions. Being motivated for a specific goal or the pleasure felt after achievements are not related to the emotion. Schadenfreude is a whole of

opportunistic emotions that the individual experiences in his/her inner world and tries not to show with his/her actions (Leach et al., 2003).

The development process of theoretical knowledge on schadenfreude has increased interest in field studies. Researchers have focused on determining under what conditions, against whom, and when individuals will develop this emotion. The analysis conducted in this context shared that biological, evolutionary and cultural factors trigger personality differences. It has been found that individuals constantly make social comparisons, especially when resources are limited or when there is a specific goal. As a result of the comparisons, those who are advantageous in reaching the reward or resources are determined. Each identified individual becomes a natural target for schadenfreude. Social comparisons and schadenfreude have a systematic relation since almost the beginning of human life. According to research findings, schadenfreude has been observed even in 24-month-old babies (Shamay-Tsoory et al., 2014). It is important that the subjective evaluations made by individuals as a result of social comparisons are aimed at being ahead of the competition. Briefly, schadenfreude is an instinctive feeling that will develop regardless of gender, culture, education or income level; any person can feel this emotion when they determine a competitor (James et al., 2014).

Even though recent research about schadenfreude has diverted to different areas, the similarities for the sources of the emotion include major topics, which are social comparisons, competition, resources, and rewards. One of the remarkable studies was completed by Abell and Brewer (2018). The authors suggested that even close friends began to develop a high level of schadenfreude against each other as competition and reward came to the fore in business life. This proposal was explored by focusing on women whose close friendships have more intense characteristics than men. Schadenfreude was found to be more likely to develop especially for women with Machiavellian characteristics with increase in competition (Abell & Brewer, 2019). In addition, it has been analyzed that social comparisons are not only between individuals but also could be occurred for purchased products. Individuals tend to learn about the preferences of other consumers after purchasing a product. The fact that other consumers are less satisfied with the same product or are unhappy for buying a different product triggers schadenfreude and improves consumer satisfaction (Moisieiev et al., 2020).

Schadenfreude mostly leads to negative outcomes. For instance, the relationship between depression, which is a negative situation for human health, and schadenfreude has been studied among students in the USA and Poland. It was determined that individuals who

are competitive and focused on individual achievement have a tendency of schadenfreude. It has been observed that students with high levels of schadenfreude have an increased chance of becoming depressed over time (Pietraszkiewicz & Chambliss, 2015). Another recent study examined the relationship between social media, which is a part of daily life with different applications, and schadenfreude. It was found that social media users, when evaluating a person, primarily focused on similar or opposite characteristics. The subjective evaluation mechanism is quite simple; similarities increase empathy, while contrasts increase prejudice. With increasing prejudices, people with opposite characteristics are considered first as strangers and then as enemies. The reason that reveals schadenfreude is a social media post stating that the person who is described as a foreigner or an enemy has been harmed. It's normal to feel happy with these posts because enemies deserve to be hurt (Wei & Liu, 2020).

Schadenfreude within Social Identity Theory

The concept of identity answers individuals' questions of "who am I" from different perspectives. The answers to individuals' personalities are replied within the scope of personal identity, while the answers to the conditions under which they are a part of a group are considered in the context of social identity. Many studies are conducted in order to understand these identities, which often reveal different behaviors (Korte, 2007). The concept of social identity was theorized by Tajfel (1972) in order to understand how individuals, define their place in society and how they express themselves among groups (Hogg, 2001). After becoming a member of a group, individuals try to have a positive social identity by exalting their group from other groups. At the core of these efforts of individuals is the need for self-esteem (Tajfel & Turner, 1986). Another characteristic of the social identity gained through group membership is the exclusion and rejection of other groups and their members along with the feelings of belonging developed to the group they are a member of (Huddy, 2001).

Schadenfreude is related to individuals' social identity. Although individual-oriented analyses are more common in schadenfreude research, currently developing research areas have focused on how this subjectively experienced emotion is responded to at the social level. In the studies, the emotions of individuals in the groups they belong to are examined. According to the findings, schadenfreude is an emotion that can be shared and spread within the group boundaries. The schadenfreude experience within the group directs individual feelings to new targets. Feelings have started to develop against individuals or groups that are different or opposite to the characteristics that make up the group and its boundaries (Combs et al., 2009). In order for the schadenfreude to become a phenomenon at the social level, social

comparisons at the group level are required. Each of the comparisons to be made should refer to the values around which the group is organized and group members belong. With the increase in intra-group interactions, shared values are more embraced. Individuals or groups with different values are perceived as a threat to the group itself. Each of the threats is considered a rival for the survival of the group. In-group support becomes increasingly stronger with interactions among rivals. Schadenfreude will develop against these rivals at the group level (Smith et. al, 2009).

Social comparisons made specifically for the group level schadenfreude should be multi-layered, complex, and continuous. Human nature leads each individual to classify them according to their basic physical characteristics such as gender or height. In situations where interaction will increase, the classification process encourages learning more detailed characteristics such as ethnicity or occupation. Every learned detail is used in the process of creating identity. Finally, in-groups formed according to similar characteristics, this identity is considered as a social identity (Tajfel & Turner, 1986). The most important issues for social identities are the protection of the values that determine the group boundaries and the achievement of a homogeneous structure within the group. It is aimed to keep the differences at minimum possible level. Homogeneous social identities shape the relationships of each individual in the group with those inside or outside the group. This situation is also true for individual emotions (Ouwerkerk et al., 2018). A prototype, defined as "definition and prescription of attitudes, feelings, norms, and behaviors that characterize one group and distinguish it from other groups" (Hogg, 2001), is formed, which is ideal for everyone in the group. Ideal members are represented as group prototypes, as viewed by in-group members (Hogg et al., 1995), and based on these prototypes, group members compare their attributes with other groups. According to Hogg and Reid (2006), group members evaluate other members as not individuals but as in-group prototypes. When any individual matches the prototype closely, they become socially attractive so that others like and respect them. For sport fans, Behrens and Uhrich (2019) suggest that to gain acceptance as a group member, individuals are expected to behave like a prototypical team fan. The prototypicality of a team extensively focuses on the perception of others' prototypicality (Hoffman et al., 2020). Social comparisons and rivalry continue by acting in accordance with the prototype characteristics. Owning or accessing resources is only possible with the collective action of the group. Social identities also determine what the rewards are. Accepted social identities increase in-group

favoritism and marginalization of the different. At this stage, schadenfreude is a natural consequence of the social identity (Li et al., 2019).

Role of Schadenfreude in Emergence of Social Identity of Sport Clubs' Supporters

Currently, sports competitions mean much more than just a few hours of good time. Regardless of sports, being a supporter of a football team requires constant allocation of financial resources and time. Watching the competitions on the spot or from the broadcast, purchasing official merchandise, and following all the possible news of the football team became major duties of supporters. Supporters who fulfill these duties are able to interact with each other, even if they continue their lives in completely different environments (Wann et al., 2011). Countless interactions between supporters in daily life, sports arenas, or social media are based on the values of the supported football team. The team's history, special traditions, culture, and unique features should be known, shared, and maintained by the supporters. Thus, being a supporter turns into a social identity and the characteristics of the ideal supporter design the prototype. For the supporter identity, similarity to the prototype is more important than support for the team (Katz et al., 2020).

In addition to individuals' social identities of professional, political, religious and other origin, being a supporter is also a social identity. Their subjective feelings and thoughts change, and their actions and behaviors develop in accordance with the prototype. Supporters think they have a paradigm that gives meaning to life. They can be described as fanatics who rely on their team's values, even in routine social comparisons in their daily lives. There are no longer any resources or rewards determined by subjective evaluations. All players of the football team are a resource, all match wins are a reward. Rivalry is identified between different teams and their supporters. The team and its supporters, which have similar conditions and socio-cultural interaction opportunities at the national or global level, are determined as the archrival that should be defeated to achieve desired awards (Kilduff et al., 2010). In other words, conditions and interactions can be able to create many rivalries, but the most repeated and most intense one becomes an archrival, which makes the difference from other rivals.

Victories against the archrival are enjoyable but they are short-term entertainment for supporters and it is not enough to defeat the rival. Supporters always want their team to be the biggest team due to their social identity, and this position can only be reached if their team remains unrivaled. Because of these unlimited demands, rivals are considered a threat. Any

event that reduces the strength of the rivals is a benefit for the supported team. Schadenfreude arises with these kinds of thoughts and can reach an aggressive level, such as being happy for the injuries of the rival's players and being sad for their recovery (Hoogland et al., 2015). Moreover, an intensely experienced schadenfreude may not be able to accurately assess the damage taken by the supported team, as they focus too much on the rival's negativity. As an example, the early elimination of the Netherlands in the 1998 World Cup was quickly forgotten as the archrival Germany was eliminated in the previous rounds (Leach et al., 2003).

The Influence of Schadenfreude on the Development Process of Rivalries

Schadenfreude, which is a part of the supporter prototype today, has turned into a common emotion shared by different football team supporters living in different geographies. By examining eleven major rivalries in six popular sports in the USA, researchers determined that all team supporters who participated in the study had schadenfreude. Within the scope of the same research, it was found that as the match dates between the rivals approached, the special campaigns organized by the sponsors brought more income and increased schadenfreude level among all supporters (Tyler et al., 2021). The fact that schadenfreude is considered as a part of rivalry for supporters has led researchers to identify the main sources of rivalry. In the studies conducted in this context, it has been determined that the teams that continue their major rivalries have values and similarities which they share almost as much as their differences. As a result of the analysis conducted for the main sources of rivalry and therefore schadenfreude, *similarity*, *repeated competition* and *competitiveness* were classified as the main factors (Kilduff et al., 2010).

The first-factor, 'similarity,' can be defined as the origin point of rivalry because it represents organizations in close geographies. Increasing proximity between football teams, includes having similar environmental conditions. Teams that are stakeholders of the same environment are the first visible rivals of each other. Even in today's globalizing conditions, proximity continues to be the first trigger of rivalry (Yu & Cannella, 2007). However, the similarity factor is not enough for the ongoing interactions to turn into rivalry. For the social identity of supporters, victories are not enough. Better players, more supporters, larger facilities, and increased team budgets are major goals. But the result of more interaction with a particular team on the way to these goals initiates social comparisons. In addition to the performance of the football team, social comparisons include supporter groups, manager status, sponsor support, and facilities' features. The acceptance of the two sides will encounter and struggle against each other not only in the game but also in everyday life, brings out the

other factor named 'repeated competition'. Explained as the last source of rivalry, 'competitiveness' factor indicates who the archrival is, due to the common history between the teams. Competition has existed since the teams were founded and will continue to exist in the future. Supporters learn that their team can't get all the awards through their archrivals (Kilduff et al., 2010).

METHODS

Participants

A total of 1.217 football supporters participated in the study. The answers of those who filled out the survey incorrectly or the questionnaires completed by the participants of a football team that total number of supporters do not exceed 30 of their favourite team, are deemed invalid. The 19 incorrect answers consist of the unstated team and rival teams' names. In addition, 'same team answers' for the supported team and rival classification (n = 14) are also considered as invalid. Furthermore, this study follows the assumption of Central Limit Theorem, which identifies the minimum data limit as 30. Therefore, 21 questionnaires of different team supporters (ie. Bodrumspor; İzmirspor) are disregarded. After elimination of these 54 questionnaires, the analysis is completed with the answers of 1.163 supporters. Most of the participants (n = 746, 64%) are male and single (n = 826, 71%); the average age of participants is 28. 54% of the participants' birthplaces are either İstanbul, Ankara or Adana. While 491 (42%) participants stated that they are students, the rate of full-time employees constituted approximately 1/4 of the sample (n = 278; 24%). The supporters of 14 different football teams participated in the study, and most of the participants were supporters of Galatasaray football team (n = 203; 17.5%). Summary of descriptive statistics of the sample is demonstrated in Table 1.

The population of the study consists of Turkish football team supporters who live in nine cities, which are İstanbul, Ankara, İzmir, Bursa, Adana, Kayseri, Eskişehir, Trabzon, and Sivas. In order to evaluate the schadenfreude of supporters living in these cities, the snowball sampling method is used, and the supporters who form the sample are reached through special events organized by supporter groups during 12-week period covering October-November and December 2023. Although snowball technique incurs uncooperative and inaccessible cases for the research as a drawback (Akpan & Piate, 2023), this technique made it possible to reach a large number of supporters of many different teams. Supporter groups and managers of these groups are identified initially as key contacts, and later, they were

communicated via their phone numbers. Group officials who responded positively were interviewed face to face by the authors; and later the supporters that they referred were asked to fill the questionnaires. Before filling out the questionnaires, participants completed 'approval form' indicating their voluntary participation to the study.

The required ethical approval is received from Çankaya University (2023 & E-90705970-050.99-120694) to use the schadenfreude scale of Dalakas and Melancon (2012). The required ethical approval for the study was received by Çankaya University Humanities and Social Sciences Scientific Research and Publication Ethics Committee with document number E-90705970-050.99-120694 dated 12.01.2023.

Table 1
Descriptive Statistics of the Sample

Gender	**f**	**%**	**Supported Teams**	**Location**	**Foundation Year**	**f**	**%**
Male	746	64	Galatasaray	İstanbul	1905	203	17.5
Female	417	36	Fenerbahçe	İstanbul	1907	188	16.2
Marital Status	**f**	**%**	Beşiktaş	İstanbul	1903	146	12.6
Single	826	71	Trabzonspor	Trabzon	1967	98	8.4
Married	337	29	Eskişehirspor	Eskişehir	1965	71	6.1
Occupation	**f**	**%**	Ankaragücü	Ankara	1910	66	5.7
Student	491	42	Bursaspor	Bursa	1963	65	5.6
Full-time Employee	278	24	Adana Demirspor	Adana	1940	63	5.4
Other (retired, unemployed)	394	34	Adanaspor	Adana	1954	62	5.3
Birthplace	**f**	**%**	Sivasspor	Sivas	1967	56	4.8
İstanbul	277	24	Göztepe	İzmir	1925	43	3.7
Ankara	218	19	Gençlerbirliği	Ankara	1923	38	3.3
Adana	131	11	Kayserispor	Kayseri	1966	34	2.9
Other	537	46	Karşıyaka	İzmir	1912	30	2.6

Data Collection Tools

Scale utilized to measure Schadenfreude

In order to determine the scale to measure supporters' schadenfreude, a comprehensive literature review is conducted. The widely used scale of Crysel and Webster (2018) is not preferred since this scale evaluates the emotion at the individual level and is not related to sports. Considering the scales focusing on sports fandom, initially, Leach et al.'s (2003) scale is examined. It is important that researchers focus on football supporters and inter-group differences at the country level; however, measurement method has remained at a superficial level rather than analyzing the emotion towards various dimensions. Asking to the

supporters how happy they will be to defeat the national teams of other countries (Leach et al., 2003), have been considered to degrade the emotion to the result of the played matches. Consequently, Dalakas and Melancon's (2012) scale, which consists of one dimension with four items, was chosen to be used in the study. Focusing on football team supporters, the authors aimed for a holistic analysis and examined the inter-group relations; by measuring the feeling against rival's sponsors, managers, players, and stadiums, they included out-of-field dimension. The use of the scale in different studies (Angell et al., 2016; Amani, 2019; Tyler et al., 2021) and the reliability findings are other reasons for preference.

The five-stage method (Brislin et al., 1973) is followed in translating the scale from English, the source language, to Turkish. The only change made before the adaptation of the scale is the use of the "manager" term instead of "owner" in the second item since the transition process of Turkish football teams from association status to sports club continues. The researchers decided this change in the fifth stage after receiving the opinion of four professional football club managers.

Data Analysis

Based on the obtained data, reliability analysis of the scale is conducted and internal consistency reliability technique is adopted. The Cronbach's Alpha coefficient (α) value of 0.849 obtained as a result of the analysis is at the central point of the *good reliability* interval defined between 0.70 and 0.80 (Schrepp, 2020). Kaiser – Meyer – Olkin (KMO) analysis is preferred for validity, and the value of 0.786 indicates suitability of the scale for factor analysis (Field, 2000). The total explained variance is 61.238% which is above the 60% threshold; is considered as a good result in studies with a sample size of 50 or more (Hair et al., 2010). For the analysis conducted specific to factor weights, sample size is considered. In studies whose sample size is 300 and more, the 0.32 level is described as the lower limit for the significance of factor loadings (Yong & Pearce, 2013). The factor weights of the items in the scale vary between 0.618 and 0.742, and the single-factor structure is found to be valid.

Validity analyses for the schadenfreude scale are completed with the structural equation modeling. Analyses are performed in accordance with the single-factor structure of the scale and aimed to reduce the margin of error (Carter, 2006). The structural model of the scale, which is shown in Figure 1, is tested using the IBM AMOS-24 software program. The structural equality of the model is confirmed, but recommendations for improvement are suggested, and a single path is added for error variances (Hox and Bechger, 1998).

Finally, within the scope of structural equality analyses, the modification indices of the scale are checked. Although there are many modification indices in the literature, it cannot be suggested that a general consensus has been reached on them (Çapık, 2014). Within the scope of the study, the indices defined by Byrne (2016) are taken as basis by considering the sample size and total observable variable in the scale. The ideal variables, the details of which are presented in Table 2, are valid for studies where the sample is more than 250, and the number of items in the scale is less than or equal to 12. As a result of the analysis, it is determined that the model to be fit because the obtained data are found to be ideal and it is proven to be structurally correct. However, these data should not be considered satisfactory for an ever-evolving industry like football and a complex emotion like schadenfreude.

Figure 1
Final Path Diagram for Structural Equation Modeling

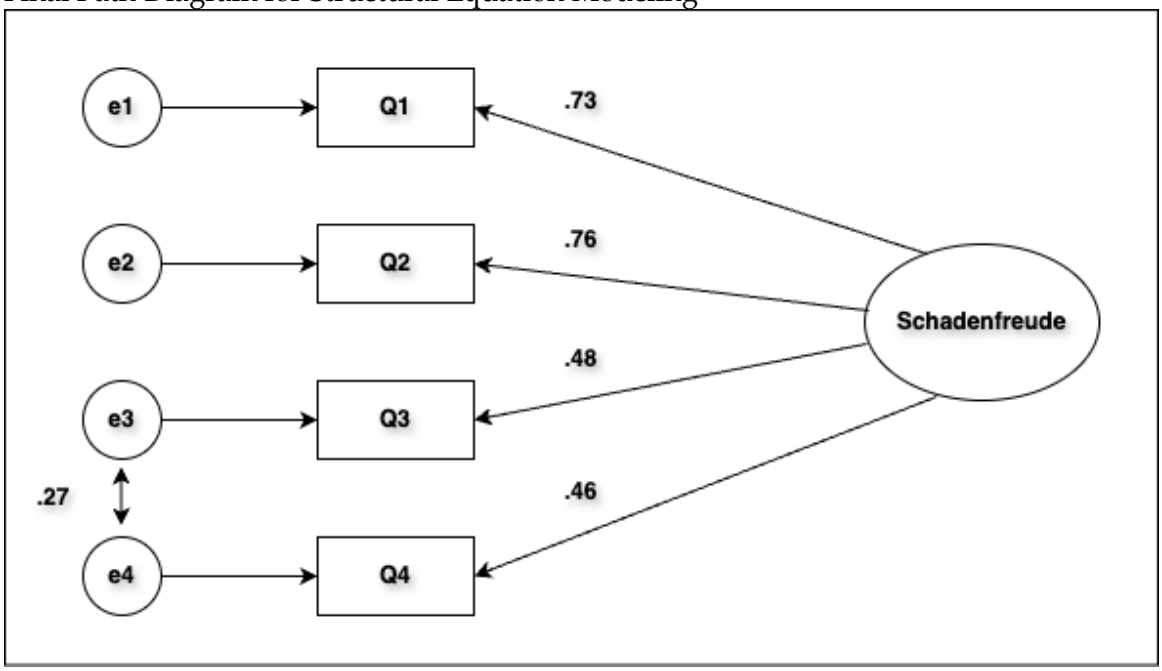


Table 2
Modification Indices of the Study

Sample Size: > 250; Observable Variable: < = 12		
Modification Indices	**Ideal Variables**	**Model Data**
χ2/df	< 5	4.039
GFI	> 0.90	0.921
CFI	> 0.92	0.987
NFI	> 0.95	0.998
RMSEA	< 0.07	0.066

RESULTS

Rivalry Classification

Within the scope of the conceptual framework of the study, it is aimed to examine the participants' schadenfreude and their reasons for evaluation and classification of rivals. The participants are first asked about the archrival of their football team. Then, they are requested to complete the schadenfreude questionnaire, which will be valid for the indicated archrival. In order to analyze the complex nature of the emotion in more detail, an additional option is provided to the participants to clarify their possible second and third rivals. At this point, each participant who identified second and third rival is asked to complete additional schadenfreude questionnaire, which will be valid only for the specified rival football teams. No additional requests are made to participants who filled out the questionnaire about their archrival and did not identify any second or third rivals.

The participants of this study indicated their schadenfreude in accordance with the 5-point Likert scale for the stated rival team, and they were also asked the reasons for this team to be considered as a rival. The findings are analyzed with IBM SPSS-25 program. The answer options are designed based on competition factors (Kilduff et al., 2010); besides the options determined as neighborhood, glories, worldview difference, image, and incidents, 'other option' is also defined. In this regard, a holistic analysis could be conducted among competition factors, schadenfreude, and reasons for considering the team as a rival. In the analysis of the rival teams chosen by the participants, the majority principle is taken into consideration. The reason for this is to understand which teams are the prominent competitors and to avoid possible errors in the analysis of the teams with which few supporters consider as rivals.

In this context, Galatasaray football team (n = 203) is represented by the maximum number of participants of the study; and in order to classify any team as a rival, the minimum number is calculated as 102 (50.2%). Based on the majority principle, other examples (i.e., Başakşehir football team considered as the archrival only by 5 (5.1%) Trabzonspor supporters; Mersin İdman Yurdu football team considered as the second rival by 11.2% of Adana Demirspor supporters) also are not included in the analysis.

Table 3 shows the participants' rival classifications and evaluations of suitability for competition factors. The teams are classified according to the number of times they are mentioned as rivals and expressed with their percentages. In order to understand the

competition beyond the defined factors, the answer to the question "why do you consider this team a rival" should be examined.

Table 3
Rival Classification of Turkish Football Team Supporters

Rival	Classified by	Classification	Total Number of Supporters	%
Fenerbahçe	Galatasaray	Archrival	161	0.79
	Beşiktaş	Archrival	109	0.75
	Trabzonspor	Archrival	89	0.91
Beşiktaş	Bursaspor	Archival	56	0.86
	Fenerbahçe	2nd Rival	121	0.64
	Galatasaray	2nd Rival	114	0.56
	Ankaragücü	2nd Rival	51	0.77
Galatasaray	Fenerbahçe	Archrival	153	0.81
	Beşiktaş	2nd Rival	106	0.73
Trabzonspor	Fenerbahçe	3rd Rival	133	0.71
Adanaspor	Adana Demirspor	Archrival	58	0.92
Adana Demirspor	Adanaspor	Archrival	54	0.87
Bursaspor	Eskişehirspor	Archrival	53	0.75
Amedspor	Bursaspor	2nd Rival	50	0.77
Gençlerbirliği	Ankaragücü	Archrival	49	0.74
Kayserispor	Sivasspor	Archrival	47	0.84
Eskişehirspor	Bursaspor	Archrival	41	0.63
Karşıyaka	Göztepe	Archrival	40	0.93
Altay	Göztepe	2nd Rival	33	0.77
Ankaragücü	Gençlerbirliği	Archrival	32	0.84
Göztepe	Karşıyaka	Archrival	29	0.97
Sivasspor	Kayserispor	Archrival	27	0.79

Fenerbahçe football team, which is described as the archrival by most participants (n = 359), is considered as the archrival by the highest number of Galatasaray supporters (n = 161); and in proportional terms, Trabzonspor football team supporters came to the fore (91%). The football team most described as rival after Fenerbahçe is Beşiktaş football team, with the choice of 342 participants. The majority of those (68.7%) who consider Beşiktaş as their rival are their neighbor team supporters (Fenerbahçe and Galatasaray). 51 Ankaragücü football team supporters also described Beşiktaş football team as their "second rival", just like İstanbul teams. Only supporters of Bursaspor football team (n = 56; 86%) evaluated Beşiktaş as their archrival. In the classification of rivals, Fenerbahçe and Beşiktaş are followed by Galatasaray with the selection of 259 participants. The football team is considered as the archrival by the majority of Fenerbahçe supporters (81%) and is positioned as the second rival for 106 supporters of Beşiktaş. Trabzonspor, which is followed after three İstanbul teams, is considered a rival only for supporters of Fenerbahçe and is described as the third rival by 133 other participants (71%).

In the classification of rivals, İstanbul's big three football team and Trabzonspor football team are followed by Adana teams. For 58 Adana Demirspor football team supporters (92%), Adanaspor is the only rival. The feelings of Adana Demirspor supporters are requited. For 87% (n = 54) of Adanaspor football team supporters, Adana Demirspor is the only rival. Considered as the archrival by 53 Eskişehirspor football team supporters, Bursaspor followed the Adana teams. With the opinion of 50 participants, the second rival choice of Bursaspor football team supporters after Beşiktaş is Amedspor football team. Gençlerbirliği football team (n = 49), which is the archrival of Ankaragücü supporters, and Kayserispor football team (n = 47), which is the archrival of Sivasspor supporters, ranked after Amedspor. Eskişehirspor is described as the third rival by 63% (n = 41) of Bursaspor supporters. In the rivalries within the borders of İzmir, Karşıyaka football team is chosen as the archrival by 41 Göztepe supporters. In addition, Göztepe supporters chose Altay football team as their second rival (n = 33). The last three ranks in the classification are shared by Gençlerbirliği supporters' archrival Ankaragücü (n = 32), Karşıyaka supporters' archrival Göztepe (n = 29) and Kayserispor supporters' archrival Sivasspor football team (n = 27).

Reasons of Rival Classification

When examined based on the key factors of competition, defined by Kilduff et al. (2010) as similarity, repeated competition, and competitiveness, classification findings are mostly self-explanatory. It is no surprise that the three big İstanbul football teams are the teams considered as the rivals. The fact that Fenerbahçe and Galatasaray supporters consider each other as the archrivals depends on Turkey's most deep-rooted competition. The football match between the two teams was played for the first time on January 17, 1909. These two football teams have played the most matches against each other, defeated each other the most, and won the most championships at the national level. Fenerbahçe and Galatasaray football teams' older and closer relations can be assessed as the basis of Beşiktaş football team's more passive position in the triple competition. The beginning of Beşiktaş's competition with its archrivals occurred in the later years. Beşiktaş played against Galatasaray for the first time on 22 August 1922. At that time, the number of matches played between Fenerbahçe and Galatasaray was 28. Within two years, when Beşiktaş played with Fenerbahçe for the first time on 22 November 1924, this number was 34 (Tuncay, 2002). When the current match numbers are evaluated, this difference appears to continue. While Fenerbahçe and Galatasaray played their 400th match, the number of times the two teams have played against Beşiktaş has not yet reached 365

matches. Beşiktaş follows these two football teams in terms of received trophies and achievements. Nevertheless, the competition between the three football teams, which has been going on for a century with all its factors, will most likely continue at the highest level as long as football is played in Turkey.

The impact of the places where football teams are established is decisive on their competitiveness. Football clubs located in cities with high populations and high Gross Domestic Product (GDP) have a higher chance of success. With the addition of factors such as the city's geographical location, traditions, institutions, and culture, success becomes almost inevitable. Major capitals such as Madrid and London are home to global brand football clubs like themselves. However, football teams in historical capitals such as Berlin and Rome have fallen behind teams in industrially richer metropolises such as Munich and Milan (Garcia et al., 2007). In this context, the characteristics of İstanbul city affect not only the competition between Galatasaray, Fenerbahçe and Beşiktaş but also the general competition in Turkey. The aim of the competition of these football teams is national and even international success. Ankara, İzmir, and Adana are cities that host many well-established football teams, but the lower resources compared to İstanbul affect competition factors. For the competition in these cities, similarity and repeated competition are at the forefront; however, the competitiveness factor is behind İstanbul teams. None of the teams from these cities, which were sometimes successful in regional championships or different cups, became national league champions. The main goal of the ongoing competitions for the football teams competing in these cities is to preserve the authentic features and disseminate them as much as possible (Evans & Norcliffe, 2016).

The competition of the football teams of Ankara city is between the educated and elitist Gençlerbirliği supporters and Ankaragücü supporters who are the representatives of the poor districts and workers. 'The tribunes filled with loyal supporters' constitute the power of Ankaragücü, whereas Gençlerbirliği football team supporters consist of few but distinguished supporters (Bora & Cantek, 2000). The main competition in İzmir is between Göztepe and Karşıyaka. Karşıyaka is the first football team of İzmir; and those supporters who left Altay football team laid the foundations of Göztepe football team. Göztepe represents İzmir, while Karşıyaka separates itself from İzmir and considers itself as superior (Güngör, 2015). Adana's most important products, citrus fruits, and cotton combine in the colors of Adanaspor. The team appeals to the middle classes who are engaged in trade. Adana Demirspor is a team founded by railway workers and has gained the support of the working class (Bilir & Sangün,

2014). In the rivalry that started in 1956, the transformation of Adana into a metropolis is an important factor. The advantageous geographical location of the city and the developing trade sectors caused an increase in population with large waves of migration. In the 1970s, the rivalry began to continue in a multicultural city, becoming richer in terms of human resources and capital. However, the fact that both clubs started to be managed by capital owners prevented their institutionalization processes and because of this 'the clubs could not transform into sustainable structures'. As a result, Adana clubs continued their regional rivalries far from achieving success at the national or global level (Yıldırım & Uçar, 2009).

In times when there is no ongoing competition within the same city, football teams are based on different authentic characteristics, and it is possible for teams to develop around identities that encompass the whole city or region. In such cases, competition may occur between cities or regions. The borders of the settlements are actually the limits that determine the identities of the supporters (Edensor & Millington, 2008). The rivalry, called the Anatolian Derby, between Bursa city's team, Bursaspor, and Eskişehir city's team, Eskişehirspor, is the reflection of the challenge of two neighboring provinces on the football field (Fotomaç, 2012). Similar competition continues between Sivasspor, the team of Sivas city which is Turkey's most migratory province (Başel, 2009; Sivas Ekspres, 2024), and Kayserispor, the team of Kayseri city, which attracts attention with its trade and rapid development. There are tensions among supporters of the two neighbor cities due to development and income differences (İlhan, 2014). While these two competitions can be easily explained in terms of similarity and repeated competition, it differs from İstanbul competitions as the goal in terms of competitiveness is limited to intercity superiority.

The research findings demonstrate exceptional results in terms of factors explaining competition. The first of these is between Fenerbahçe and Trabzonspor. Fenerbahçe supporters indicate their rival priorities as Galatasaray and Beşiktaş; however, most described Trabzonspor as their third rival (71%). For Trabzonspor supporters, Fenerbahçe is stated as the only and absolute rival. In this case, the similarity factor (Kilduff et al., 2010), defined as the beginning of competition between two teams, is not observed. There are reasons for the emergence of repeated competition and competitiveness factors, such as the 2-point system of the 1970s, which emphasized defensive football and the ban on foreign players. Trabzonspor took advantage of these restrictions that reduced the advantages of İstanbul city football teams. Founded in 1967, the team became champion at the national level for the first time in 1976, and following the continuity of the team's successes, it was called the 'Anatolian

Revolution'. In the background of the Anatolian Revolution, there is nearly half a century of football experience of citizens of Trabzon and the decision to merge the four football teams that created Trabzonspor. As the team began to experience its golden age, the managers successfully continued the tradition of training Black Sea region's football players. Trabzonspor is the prominent brand of the region and a cultural element completely identified with the city. During this period, Black Sea region's people who migrated from around Turkey began to provide material and moral support to this team that emerged from their region (Aydın & Taner, 2022; Tunç, 2011). In this period when Beşiktaş and Galatasaray were far from winning cups or glories, the greatest obstacle for Trabzonspor's success was Fenerbahçe. In the early days of the rivalry, Fenerbahçe was perceived as a representative of İstanbul bourgeoisie, with its star football players, financial power, and charm that constantly brought new fans. Conversely, Trabzonspor represented Anatolia and demonstrated that all kinds of inequality could be overcome with systematic practice (Keddie, 2018). The competition between two non-similar teams, which started on the football field in 1974, includes the factors of repeated competition and competitiveness. The question is whether this half-century-old rivalry can be explained by two factors.

In order to find the answer to this question, it is first necessary to examine the classifications that are unrequited and where the factors of competition cannot be determined. According to participants' views, Beşiktaş is determined as the archrival for Bursaspor and the second rival for Ankaragücü. However, Beşiktaş supporters did not identify these two teams as their rivals. The finding that Bursaspor supporters consider Amedspor as a second rival can also be evaluated in this context. But, since a sufficient number of Amedspor supporters could not be included in the research sample, this unilateral classification is doubtful. However, the common feature of all three classifications is the lack of similarity, repeated competition and competitiveness factors (Kilduff et al., 2010) that constitute competition.

As a result of a total of 1.606 classifications identified by 1.163 participants, the most common reason for considering a team as a rival is its image (n = 394, 24.5%). The second selected option is neighborhood (n = 323) and the third is 'worldview difference' (n = 318). 17.2% (n = 276) of the participants based their rival selection on 'incidents'. For 257 participants (16%), glories are the reasoning for their rival teams. The rate of participants who identified their preferences for rival evaluation apart from the provided answers is 2.3% (n = 38). The classifications of rivals by the participants and the reasons considered in the classification are shown in Table 4.

Table 4
Reasons of Rival Classification

Rival	Classified by	Neighborhood	Glories	Worldview Difference	Image	Incidents	Other	Total
Fenerbahçe	Galatasaray (1)	25	33	14	**78**	8	3	161
	Beşiktaş (2)	7	18	18	**63**	2	1	109
	Trabzonspor (3)	0	9	7	22	**47**	4	89
Beşiktaş	Bursaspor (1)	1	6	2	9	**32**	6	56
	Fenerbahçe (2)	**41**	13	39	22	4	2	121
	Galatasaray (3)	**43**	7	26	31	6	1	114
	Ankaragücü (4)	0	4	9	10	**26**	2	51
Galatasaray	Fenerbahçe (1)	23	**78**	26	19	4	3	153
	Beşiktaş (2)	4	**53**	19	22	7	1	106
Trabzonspor	Fenerbahçe	1	2	15	33	**79**	3	133
Adanaspor	Adana Demirspor	17	2	**26**	9	3	1	58
Adana Demirspor	Adanaspor	19	5	**21**	7	1	1	54
Bursaspor	Eskişehirspor	**29**	11	4	8	1	0	53
Amedspor	Bursaspor	0	0	18	4	**27**	1	50
Gençlerbirliği	Ankaragücü	15	2	**28**	2	0	2	49
Kayserispor	Sivasspor	**16**	3	4	12	9	3	47
Eskişehirspor	Bursaspor	**24**	4	5	7	1	0	41
Karşıyaka	Göztepe	**16**	3	8	7	4	2	40
Altay	Göztepe	**14**	1	5	4	8	1	33
Ankaragücü	Gençlerbirliği	9	2	**13**	8	0	0	32
Göztepe	Karşıyaka	6	0	9	**12**	2	0	29
Sivasspor	Kayserispor	**13**	1	2	5	5	1	27
Total		323	257	318	**394**	276	38	1606

In the detailed examination of the participants' choices, priority is given to Fenerbahçe, Beşiktaş, and Galatasaray, respectively most described as a rival. Among the supporters of İstanbul's three most prominent teams, who live across Turkey; differences have been identified in the reasons for considering rivals. The reason why Fenerbahçe is considered as a rival is its image for both Galatasaray supporters (n = 161) and Beşiktaş supporters (n = 109). The reason why Galatasaray is considered as a rival are the team's glories for both Fenerbahçe supporters (n = 78; 51%) and Beşiktaş supporters (n = 53; 50%). For Fenerbahçe (n = 121) and Galatasaray (n = 114) supporters who identify Beşiktaş as a rival, the neighborhood response indicating 'being the team of the same city' came to the fore. It is noteworthy that glories option is ranked behind in the classification. In this context, it can be evaluated that by focusing on different areas, social comparisons among supporters continue. It can be claimed that Beşiktaş supporters give priority to similarity factor whereas Galatasaray supporters give priority to competitiveness factor.

The findings obtained for the ongoing competition in Ankara, İzmir and Adana support the assumption (Evans & Norcliffe, 2016) of preserving authentic values and disseminating them as much as possible. 'Competing in the same city' and 'worldview differences' came to the fore for competitions where the glories answer is far behind. The majority of Ankaragücü supporters (57.1%) identify Gençlerbirliği as a rival due to 'worldview

difference'. For Gençlerbirliği supporters, although this rate is 40.6% (n = 13), it ranks first. For both teams, 'neighborhood' option is followed by 'worldview difference'. The same ranking is also valid for Adanaspor and Adana Demirspor competition. The priority option of Göztepe supporters in İzmir can be evaluated through the similarity factor. Neighborhood option is at the forefront for evaluating Karşıyaka (n = 16, 40%) and Altay (n = 14, 42.5%) as rivals. Karşıyaka's supporters' choice of Göztepe as a rival is based on image (41.3%). Sufficient number of Altay supporters could not be reached, which prevented rival classification and the reasons for their rival evaluations.

The proposition of competition between cities or regions sustained by overarching identities (Edensor & Millington, 2008) can be supported in the classifications of Bursaspor – Eskişehirspor and Sivasspor – Kayserispor competitions. The majority of Bursaspor supporters (58.5%) identified Eskişehirspor as a rival due to 'neighborhood' option. This rate is 54.8% (n = 29) for Eskişehirspor supporters. Although 'neighborhood' is not the majority option for Sivasspor and Kayserispor supporters, it is the reason for choosing the first rival. In this competition, the sociological differentiation of cities has been observed with the increase in 'worldview difference' and 'image' answers. However, the similarity factor is at the forefront for the competition between the football teams of neighboring cities, and competitiveness factors remain passive.

The adequacy of repeated competition and competitiveness factors among two non-similar teams is examined for Fenerbahçe–Trabzonspor competition. The reason is the 'incidents' for 79 (59.3%) Fenerbahçe supporters, who identify Trabzonspor as a rival. The majority of Trabzonspor supporters (52.8%) also indicated the 'incident' response for Fenerbahçe. The 'incidents' response, which is too prominent among supporters, has a history of approximately 30 years. In the championship match of 1996, Fenerbahçe defeated its rival in Trabzon. In 1998, during the match played in Trabzon, Fenerbahçe team withdrew from the field due to a thrown object that hit the coach. In the match played in İstanbul in 2010, Fenerbahçe lost points to Trabzonspor, and this enabled Bursaspor to become the champion. The process, which started with the match-fixing case for the 2010-2011 season (Hürriyet, 2017), has been the source of ongoing disputes to this day.

The 'incidents' response is not only ranked as the first factor for Fenerbahçe–Trabzonspor competition. 'Incidents' factor received a majority response in classifications where none of the competitive factors are valid. The 'incident' rate for Beşiktaş to be identified as a rival is 57.1% (n = 32) for Bursaspor supporters and 51% (n = 26) for Ankaragücü

supporters. It is necessary to examine approximately 20 years of history of the incidents for the background of this choice. While Bursaspor was relegated in the 2003-2004 season, Beşiktaş lost against the teams Bursaspor competed with in the last two weeks. Bursaspor supporters claimed that this situation occurred consciously and held Beşiktaş responsible for their relegation (Habertürk, 2007). The reason why Ankaragücü supporters identify Beşiktaş as a rival is due to the friendship between Bursaspor and "BursAnkara", which was established at the funeral of the tribune leader who was martyred in the military. Ankaragücü supporters started to dislike Beşiktaş, which upset their friends (Yavuz, 2007). The fact that the fanatic supporters who entered the field and kicked Beşiktaş players in the match played in Ankara on 5 September 2022, showed that the events continue to maintain their freshness.

Another evaluation for Bursaspor supporters in which none of the competitive factors could be determined is Amedspor classification. While the majority of supporters (54%) describe Amedspor as a rival due to the 'incidents', the other 18 (36%) supporters' preference for 'worldview difference' also actually depends on the 'incidents'. The first incident between the two teams occurred in 2010, when Amedspor supporters boo Turkish National Anthem allegedly during a match played in Bursa. The match played in Diyarbakır in the same year could not be completed. Allegedly of political origin, incidents continued in the matches played in 2019, 2022, and 2023 (Akdemir & Erbay, 2023).

Schadenfreude Level

After analyzing the supporters' rival choices and the reasons considered for being a rival, the data regarding the schadenfreude is examined. During the analysis, 1.606 rival classifications completed by 1.163 supporters participating in the research are considered as basis, and schadenfreude data is obtained for 16 teams. As a result of the questionnaires filled out in 5-point Likert format, the average schadenfreude level is calculated (Table 5), and it is found that supporters would be most happy with the negativities experienced by rival team's managers (3.56). The second item is about sponsors of rivals (3.02), and the third item is about their players (2.64). The least negative aspect supporters would be happy about for their rivals is the damage to stadiums (2.05). The general average for the schadenfreude scale is found as 2.82, indicating an average point of 5 level Likert-scale.

Table 5
Average Schadenfreude Level of the Sample

Schadenfreude Scale (Dalakas & Melancon, 2012)	Average Schadenfreude Level
I will feel great joy if a company that sponsors a team I hate goes out of business.	3.02
I will feel great joy if a manager of a team I hate faces legal troubles.	3.56
I will feel great joy if a player of a team I hate gets suspended for a year, even if the suspension was not completely deserved.	2.64
I will feel great joy if the stadium of a team I hate suffers damage.	2.05

Trabzonspor supporters, who declare Fenerbahçe as their only rival and mostly prefer 'incidents' as the reason for this consideration, are the leader in schadenfreude (3.84). In addition to the general average, schadenfreude that Trabzonspor supporters feel towards Fenerbahçe managers (4.79) and their sponsors (4.22) ranks the top. Bursaspor supporters are the ones stating that they would be happiest with the 1-year punishment the players would receive, even if they did not deserve it. The target of the most intense schadenfreude (4.89) obtained in the study is towards Amedspor, with whom Bursaspor has been experiencing constant events for 12 years and which has recently taken a large place in the country's agenda. Regarding the schadenfreude that supporters feel towards their rivals, the damage to the stadiums makes the supporters least happy. However, the level of Karşıyaka supporters' feelings towards Göztepe stadium (4.13) is an exception of this study findings. It is not surprising to note that the reason behind these feelings is that the stadium project that started earliest in İzmir belongs to Karşıyaka, but the facility could not be completed for 12 years, and Göztepe and Altay had their new stadiums during this time (TRT Haber, 2022).

In the research, 22 schadenfreude emotions are determined based on the source and target. The first thing that draws attention in the emotional analysis is the level of competition arising from 'incidents'. In this context, the most intense schadenfreude is experienced for Fenerbahçe–Trabzonspor rivalry. Schadenfreude that Fenerbahçe supporters feel towards Trabzonspor is at the level of 3.56 and is especially towards the managers. Apart from this intense schadenfreude of the two teams, Bursaspor's supporters' schadenfreude towards Amedspor is also high (3.80). The feelings of Bursaspor and Ankaragücü supporters against Beşiktaş ranked seventh and tenth, respectively. The supporters of both teams feel schadenfreude towards Beşiktaş team managers. As a difference, Bursaspor supporters' schadenfreude is more intense towards the sponsors (2.82) and Ankaragücü supporters' schadenfreude is more towards the players (3.57).

Among the three major İstanbul teams that constitute the oldest rivalries of Turkish football, the highest schadenfreude is the feelings of Galatasaray supporters towards Fenerbahçe. With a mean of 3.12, schadenfreude towards managers (4.38) and sponsors (3.84) came to the fore. Similarly, Beşiktaş supporters also feel schadenfreude for Fenerbahçe at a level of 2.96, focusing on sponsors (3.71) and managers (3.65). Behind these feelings, the financial support provided to the team due to the individual and corporate identity of Ali Koç, who was elected as the Chairman of Fenerbahçe Football Team in 2018, has a large share (Fotomaç, 2021). The schadenfreude towards Galatasaray, which Fenerbahçe supporters classify as their archrival, is found to be 2.81; the most intense feeling is towards managers (4.11). The schadenfreude of Beşiktaş supporters towards Galatasaray, which is at the level of 2.28, are distributed evenly in terms of sponsors, managers and players.

The schadenfreude felt towards Beşiktaş, which is seen as the second rival for Fenerbahçe and Galatasaray supporters and whose similarity is emphasized among the competitive factors due to being in the same city, is low. The schadenfreude towards Beşiktaş is determined as 2.28 for Fenerbahçe supporters and 2.21 for Galatasaray supporters. When the general level of supporters of İstanbul teams is evaluated, it can be said that the rivalry that has been going on for a long time and will continue in the future has been legitimized. In cases where legitimacy is established in competition unless an extraordinary incident occurs, schadenfreude will occur due to periodical effects. Similar to Ali Koç example, the presences of unpopular players of Galatasaray or Beşiktaş gaining sponsorships from global brands are among the examples that will increase schadenfreude.

Schadenfreude data in local competitions in Ankara, İzmir, and Adana differ from each other. In this context, Ankara is with the lowest schadenfreude levels. Gençlerbirliği supporters' schadenfreude towards Ankaragücü, is found to be 2.13, which is the lowest schadenfreude data of the study; and Ankaragücü supporters' schadenfreude towards Gençlerbirliği is also low (2.20). It can be evaluated that due to the sporting and financial difficulties in recent years experienced by these two well-established teams (Anadolu Ajansı, 2021), the priorities are towards their own teams instead of each other. Karşıyaka supporters' stadium priority feelings towards Göztepe are the highest schadenfreude data (3.38) among İzmir teams. While Göztepe supporters' schadenfreude towards Karşıyaka, as their archrival, is at 2.75, their possible joy at the bankruptcy of their sponsors came to the fore with 3.61. The fact behind this choice of Göztepe supporters likely depends on Pınar company's sponsorship of Karşıyaka's basketball team since 1998; because the national and global successes of İzmir

in the 21st century were achieved by Pınar Karşıyaka (Fotomaç, 2021). The feeling of schadenfreude against Altay, which Göztepe supporters consider the second rival, is lower than Karşıyaka, despite the events in 2022.

In local rivalries, a weak schadenfreude is detected in Ankara and a moderate schadenfreude in İzmir. However, schadenfreude is experienced intensely among Adana teams. The emotion level of Adanaspor supporters against Adana Demirspor, determined as 3.45, ranks fourth after the incidents-based competition. Adana Demirspor supporters' feelings for their rivals are also at the level of 2.98. The fact that the teams share the same stadium has ensured that the emotion is directed towards managers, sponsors and players. Adana Demirspor's goal of national championship and world-famous transfers are the factors that increase emotion of Adanaspor supporters. The architect of the team's conscious structuring, President Murat Sancak, has much contribution for schadenfreude preference at 4.66 level (İlkhaber, 2023).

Different levels of schadenfreude are identified in the rivalries of the standing out neighboring cities. The schadenfreude values of 2.16 and 2.14 revealed, respectively, between Sivasspor and Kayserispor constitute the lowest values among neighboring cities. The feeling of schadenfreude among Bursaspor and Eskişehirspor supporters is at a medium level. Sponsors' bankruptcy (3.73) came to the fore among Eskişehirspor supporters' feelings towards Bursaspor (2.76). Similarly, for Bursaspor supporters' feelings towards Eskişehirspor sponsors (3.23) have priority. The continuous support provided by internationally known important brands representing the identity of their cities, which are Uludağ Beverage (of Bursa) and Eti (of Eskişehir) to their teams (Cumhuriyet, 2015), can explain the sponsor-oriented feelings of rival team supporters. Based on these explanations, schadenfreude detected according to the findings is summarized in Table 6.

Within the scope of the study, two issues are researched based on the feelings of Turkish football team supporters: First, the issues of ‘supporters’ excluding different groups by adopting the values of the groups they belong to’ and ‘the approach that schadenfreude will develop against rival groups by considering frequently encountered groups as rivals for shared resources and similar success standards’ (Combs et al., 2009; Smith et al., 2009). In this context, the relationship between schadenfreude and rival classification is analyzed. Table 7 compares the schadenfreude feelings of supporters who chose more than one rival.

Table 6
Schadenfreude Levels of Turkish Football Team Supporters

Schadenfreude Resource	Schadenfreude Target	Sponsors	Managers	Players	Stadium	Average
Trabzonspor	Fenerbahçe	**4.22**	**4.79**	3.67	2.68	**3.84**
Bursaspor	Amedspor	2.46	4.14	**4.89**	3.69	3.80
Fenerbahçe	Trabzonspor	3.69	4.44	3.85	2.25	3.56
Adanaspor	Adana Demirspor	3.25	4.66	3.70	2.20	3.45
Karşıyaka	Göztepe	3.47	3.34	2.56	**4.13**	3.38
Galatasaray	Fenerbahçe	3.84	4.36	2.41	1.87	3.12
Bursaspor	Beşiktaş	2.82	4.38	2.99	2.22	3.10
Adana	Adanaspor	3.22	3.93	2.87	1.88	2.98
Beşiktaş	Fenerbahçe	3.71	3.65	2.48	1.99	2.96
Ankaragücü	Beşiktaş	2.39	3.83	3.57	1.91	2.93
Fenerbahçe	Galatasaray	2.67	4.11	2.53	1.94	2.81
Eskişehirspor	Bursaspor	3.73	2.89	2.22	2.18	2.76
Göztepe	Karşıyaka	3.61	3.17	2.33	1.89	2.75
Bursaspor	Eskişehirspor	3.23	3.05	2.09	2.34	2.68
Göztepe	Altay	2.39	3.97	2.12	1.52	2.50
Beşiktaş	Galatasaray	2.70	2.57	2.25	1.60	2.28
Fenerbahçe	Beşiktaş	2.46	2.56	2.24	1.79	2.26
Galatasaray	Beşiktaş	2.28	3.33	1.93	1.28	2.21
Ankaragücü	Gençlerbirliği	2.38	2.91	2.17	1.33	2.20
Sivasspor	Kayserispor	2.79	2.57	1.81	1.48	2.16
Kayserispor	Sivasspor	2.29	2.76	1.97	1.53	2.14
Gençlerbirliği	Ankaragücü	2.86	2.89	1.41	1.35	2.13
Average Schadenfreude Level		**3.02**	**3.56**	**2.64**	**2.05**	**2.82**

Table 7
Schadenfreude Levels of Supporters Choosing Multiple Rivals

Schadenfreude Resource	Schadenfreude Target	Rival Classification	Schadenfreude Level
Ankaragücü	Gençlerbirliği	Archrival	**2.20**
	Beşiktaş	**2nd Rival**	**2.93**
Beşiktaş	Fenerbahçe	Archrival	**2.96**
	Galatasaray	2nd Rival	**2.28**
Bursaspor	Beşiktaş	Archrival	**3.10**
	Amedspor	**2nd Rival**	**3.80**
	Eskişehirspor	3rd Rival	**2.68**
Fenerbahçe	Galatasaray	Archrival	**2.81**
	Beşiktaş	2nd Rival	**2.26**
	Trabzonspor	**3rd Rival**	**3.56**
Galatasaray	Fenerbahçe	Archrival	**3.12**
	Beşiktaş	2nd Rival	**2.21**
Göztepe	Karşıyaka	Archival	**2.75**
	Altay	2nd Rival	**2.50**

Supporters of Ankaragücü, Beşiktaş, Bursaspor, Fenerbahçe, Galatasaray, and Göztepe football teams defined more than one team as rivals as a meaningful rival for appropriate analysis. According to the findings, Beşiktaş, Galatasaray, and Göztepe football teams' supporters felt the highest schadenfreude against their archrivals, similar to the literature findings; and they experienced the emotion at a lower level for their second rivals. Ankaragücü supporters identified two rivals and felt schadenfreude towards Beşiktaş, which they described as their second rival, with a difference of 0.76 over their archrival Gençlerbirliği. Bursaspor supporters classified three rivals and positioned their neighbor city football team Eskişehirspor as the last rival. Against Amedspor, which they consider as their second rival, they shared the second highest schadenfreude (3.80) identified in the study. Fenerbahçe supporters, like Bursaspor supporters, classified three rivals and evaluated their archrivals in the first two places. The feeling of schadenfreude (3.56) against the last rival, Trabzonspor, is the third highest average in the study.

DISCUSSION

Based on the findings of study, first of all additional competitive factors is proposed. The first suggestion is to consider the incidents between teams as a 'unique incident' factor. When defining this factor, it should not be forgotten that the events that will occur may develop suddenly, may have sociological or cultural contexts, may be due to wrong personal or social choices, may be forgotten, or may be normalized in competition. It is a 'unique incident' which is considered the first big scuffle in Turkish football history during the Galatasaray–Fenerbahçe match dated February 23, 1934, but this incident is forgotten in the ongoing competition. Kayserispor–Sivasspor match, played on September 17, 1967, resulted in 43 deaths, has become an unpleasant memory (Arslan, 2010). Mutual incidents such as Fenerbahçe–Trabzonspor and rivalries of Bursaspor and Ankaragücü against Beşiktaş are unfortunately no longer periodic and are becoming normalized.

The last thing to consider regarding the content of the formation process of the rivalries is that each country, region or city may have 'unique incidents' in accordance with its conditions. The acquisition of English football clubs by foreign investors in recent years is an example of incident differentiation. Chelsea and Manchester City football clubs have reached global power through strategies followed by their owners. For supporters of these football clubs, the old rivalry is continuing routinely. In addition, to achieve global success, the newly developed competition with teams of different countries became more preferred (Weber et al.,

2020). However, it is also possible to observe similar characteristics in different geographies regarding the 'unique incident' factor. A similar match to the chaotic Galatasaray–Fenerbahçe match played in 1934 was played between Athletic Bilbao and Barcelona in 1984. The King's Cup Final, played in Madrid by clubs representing Basque and Catalan nationalism, began as a show of force at the home of the "common enemy", but eventually, the players of the two teams got into a very violent fight. The effect of this unique incident continued for a while, but over time, Real Madrid became the focus of the two clubs again (The Guardian, 2021). Another example of a 'unique incident' between teams from different countries is the Heysel Disaster in Belgium. A total of 39 people, 32 of whom were Italian, died as a result of the stand incidents between Liverpool and Juventus fans at the 1985 Champions' Cup final. However, these two teams met in the European Super Cup Final approximately 5 months ago, and the match ended without any bad experience. This incident, which is similar to the disaster that occurred between Sivasspor and Kayserispor, has never been forgotten, and despite the commemoration ceremonies held every year, the tension, especially among Juventus fans, still continues (Chisari, 2004).

Rivalry factors defined in current literature are accepted and used in studies conducted in different disciplines. The generally recommended situation is to examine the relationship between factors and different variables. Kawarasaki et al (2023) stated in their study in the field of education that competition factors are valid and indicated that the relationship between the performance of students competing in the classroom and the factors should be examined in more detail. Milstein et al. (2022), in their study, which examined similarity, repeated competition, and competitiveness items in depth, suggested that the relationship between rivalry and performance should be investigated in more detail. The number of studies suggesting new factors is exceptionally few. Yip et al. (2018) included trash-talking between individuals among the rivalry factors. The unique incident factor proposed in this study supports the existing factors as well as arguing that rivalries can change and develop adventitious at unexpected times. In this context, an event such as trash-talk can be a unique incident under certain conditions. The main purpose of the proposed factor is to cover individuals or institutions, reject reductionism, and provide a better understanding of the continuity of rivalries in different disciplines.

The second suggestion for competitive factors is to change the narrative to include continuity between similarity, repeated competition, and competitiveness items. In this context, it is thought that each factor can develop independently of each other and interact

with each other. Instead of similarity, the proposed factor should share the primary strategies and constraints of the environment in which the two teams are established. For this reason, 'feasible contingencies' concept is proposed. Due to the effect of comparisons among teams based on the repeated competition factor, an update of social comparisons is recommended. The positions of teams at different levels should be considered when updating the competitiveness factor. It is difficult for competition to develop between the team that has international-level goals and the other team that aims not to be in relegation. Conflicting goals will reveal the competition.

In this context, there are studies in the literature that interpret the factors. Sharapov and Ross (2023) first interpreted the similarity factor. They included the definitions of 'long-term similarity' and 'geographical similarity' in their studies. While evaluating the competitiveness factor within a specific occupational group, they defined 'status dissimilarity' in order to emphasize that people in professional competition differ according to their achievements. Xu et al. (2020) similarly emphasized the similarity factor as 'similarity between actors' and explained that contingencies such as position or rank reveal the factor. Sung et al. (2017) used the competitiveness factor as 'historical competitiveness' but did not explain why the interpretation was made. This study's proposed concept of 'feasible contingencies' suggests examining all environmental conditions in more detail and flexibly instead of interpreting the factors. This concept will be helpful in understanding and classifying competitive processes by considering dissimilarities as well as similarities.

Limitations

The study's main limitation is the conduct of the research within a certain time period. Additionally, the sample consists only of football supporters. The supporter groups that could be reached are limited to 14 teams, and therefore, the schadenfreude of other teams' supporters could not be analyzed. Conducting research at certain intervals, pursuing the research over longer periods of time, and analyzing the competition and schadenfreude for different branches will reveal opportunity for more detailed analysis. Future research about supporters of football teams or sports clubs of different cities or regions will reveal a more holistic schadenfreude map of Turkey.

CONCLUSION

The literature indicating that schadenfreude increases with increasing competition is contradictory with the findings of more intense feelings towards the second or third rivals, so

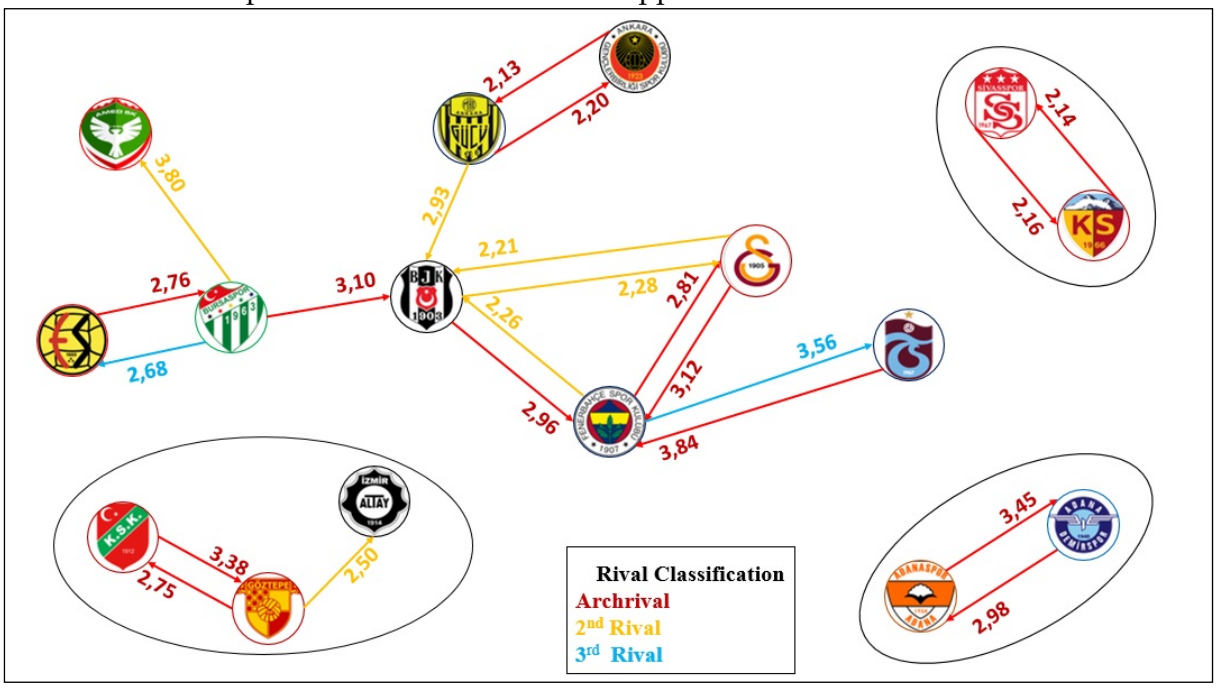
this situation requires further analyses for theoretical updates. It is expected that schadenfreude will be felt most towards the archrival, and within the scope of the current study this is found to be repeated more than once. However, competition with the archrival, which is normalized by time factor, may cause schadenfreude to persist at an average level. Normalization of competition could mean gaining legitimacy among supporters. Instead of "being happy about the losses that their rivals suffer", supporters may be prone to the feeling of "their rivals falling behind or failing". At this point, considering the continuity of the relationship of schadenfreude and competition, a distinction can be made between "legit rivalry and incidental matches". In the cases of the three exceptions mentioned above, the definition of incidental matches takes place specifically in rivalries originating from incidents by supporters. In this context, it can be claimed that schadenfreude will be experienced constantly for legit rivalries and intensely for incidental matches. Finally, it should not be forgotten that incidental matches may turn into legit rivalries over time or become history once the incident is resolved.

As a result of the holistic evaluation of the current study's findings, the supporters' schadenfreude levels can be demonstrated. As shown in Figure 2, competition in the cities of İzmir and Adana is not interacted with teams from other cities or regions. The regional competition between Kayseri and Sivas continues to be non-interactive and with low levels of schadenfreude. The arch-rivalry between Beşiktaş, Fenerbahçe and Galatasaray continues with mutual feelings of schadenfreude. The status gained by Trabzonspor over time caused the feeling of schadenfreude especially towards Fenerbahçe. The competition between Beşiktaş and Bursaspor, as well as the intensity of feelings of schadenfreude, should be examined in a way that will extend the existing literature.

On the other hand, Dalakas and Melancon's (2012) scale allows for inferences about supporters' multidimensional schadenfreude, it has shortcomings. First of all, the existing scale items direct the feeling of schadenfreude to elements that a standard supporter has very little chance of viewing or interacting with in daily life, such as a facility, manager or football player. However, all supporters are part of same society and frequently interact with each other in daily life. Moreover, interactions between supporters are not limited only in daily life. Interactions on social media are much faster and more numerous. For this reason, in addition to the existing single-factor structure of the scale, the factor named 'Feelings against Rival Supporters' is proposed. Under this factor, there should be questions about the supporters' feelings of schadenfreude in daily life. Because individuals who consider rival supporters

suffering material and moral damage are likely to feel happier. In today's global world, supporters who want to form or increase their schadenfreude personally have a lot of options. Doing anything to upset their rival supporters or delivering upsetting news to them in person as soon as possible can be cruel alternatives. Another common behavior of supporters is to make provocative comments on the opposing team's social media accounts after defeats.

Figure 2
Schadenfreude Map of Turkish Football Team Supporters



However, with additional items to the existing ones, a more detailed understanding of the feeling can be provided. The factor that can be restated under the dimension 'Feelings against Rival Club' can be a guide for new items on what news the supporters would like to hear from the rival. Spreading bad news about the rival team on social media will help supporters develop more schadenfreude. Additionally, the fact that sports clubs compete in different branches should be considered when updating the schadenfreude scale. A football supporter will be happy when he or she hears that the rival sports club lost a volleyball or basketball game. Although it is indicated that solidarity replaces rivalries in international matches because of the national representation against different countries, this discourse should be examined in terms of schadenfreude. Finally, it should be remembered that a supporter has the potential to damage any object belonging to rival team. In this context, the possible new items that could enable the scale to examine schadenfreude in more detail are listed in Table 8.

Table 8
Possible Items for Updated Schadenfreude Scale

Proposed Items for Current Scale First Dimension: "Schadenfreude against Rival Club"
I would be happy if unfavorable news about my rival is spreading on social media.
I would be happy if my rival loses in different branches.
I would be happy if my rival team loses in international matches.
If I get the opportunity, I would be happy to damage an object related to the opposing team.
Proposed Items for Second Dimension: "Schadenfreude against Rival Supporters"
I would be happy if I witness the material and moral damage caused to rival fans that I don't know.
I would be happy if I witness the material and moral damage of the rival fans that are close to me.
I would be happy to do things that might upset the rival team's fans.
I would like to immediately inform the fans of rival team about a bad event regarding their team.
When the rival team loses, I would be happy if I wrote sarcastic comments on their social media accounts to upset and anger their supporters.

Additionally, relationship of the emotion and periodic or legit rivalries can also be examined. Finally, due to the size of the study sample, the majority principle is applied to analyze rivals. In studies to be conducted with the target of a determined number of supporters, it may be possible to reach the number of rival classifications that are satisfactory to make an analysis instead of the majority principle. Due to the increase of the sample size, rival classification can be made for many more teams and schadenfreude can be examined in detail**.**

PRACTICAL IMPLICATIONS

Schadenfreude has been evaluated from various perspectives in different periods and there have been detailed discussions about the feeling. It is quite normal that, the emotion currently defined as rejoicing at someone else's harm finds a response in industrial football, which has become a part of daily life. This study, which provides extensive attention to the relationship between competition and schadenfreude, is set out to learn how Turkish football team supporters experience the emotion. While searching for answers to the classification of rivals and why they are considered as rivals, the focus of the study is on the off-field elements of football rather than the impact of the matches played in determining schadenfreude. In this context, it has been determined that the schadenfreude of Turkish supporters is primarily focused on the managers of the rivals. Except for specific examples, damage to rival team facilities is an unhappy situation. The impact of periodic incidents played a role on the emotion focusing on sponsors and football players.

Moreover, it should also be noted that schadenfreude can easily be affected by major events or daily incidents. One of the significant examples of such major events is the

earthquakes that occurred in Turkey in February 2023, which deeply affected the country. In that period, all sports clubs working together for the Turkish people who suffered from the earthquakes probably reduced schadenfreude. It can be indicated that a similar event that reduced schadenfreude occurred during Super Cup final planned to be played in Saudi Arabia. Galatasaray and Fenerbahçe, the parties of Turkey's biggest rivalry, acted together out of common principles and did not play the match. This common stance, exhibited on December 29, 2023, almost turned the supporters' perceptions from arch-enemies into eternal friendship. However, this friendly ceasefire period was very short-lived; mutual social media posts about daily events like referee decisions returned the supporters to their old schadenfreude routines. The tension between the two clubs has risen so much that even the highly possible 'unique incident' example of Adana Demirspor withdrawal from the field against Galatasaray in response to the referee's penalty decision on 9 February 2025, has turned into an incident in which the two clubs blame each other, despite Adana Demirspor's former president and current owner Murat Sancak stating that it had nothing to do with Fenerbahçe and Galatasaray. As a result of continuously growing tension, Turkish Football Federation had to appoint a foreign referee for the derby played on February 24, 2025, in order to prevent the two clubs from blaming each other and the stakeholders of football. But even this appointment could not reduce the tension and the archrivals found new topics to continue to blame each other. Fenerbahçe claimed that Galatasaray wanted privilege, not justice. On the other hand, Galatasaray declared that end of the match statements of Fenerbahçe's world famous coach Jose Mourinho were racist. In short, incidents that increase schadenfreude will continue to occur (e.g., Jose Mourinho's nose pinching incident) and it is expected that intense schadenfreude data from football supporters will likely be obtained by research conducted during the times of championships, staying in the relegation or derby periods.

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Authors' Contributions

The first author contributed to the conception and design, data collection, analysis and interpretation. The second author contributed to reviewing the conception and design, interpretation of the data, and critical review.

Declaration of Conflict Interest

There is no financial conflict of interest with any institution, organization, or person regarding our article, and there is no conflict of interest between the authors.

Ethics Statements

The required ethical approval for the study was received by Çankaya University Humanities and Social Sciences Scientific Research and Publication Ethics Committee with document number E-90705970-050.99-120694 dated 12.01.2023.

REFERENCES

Abell, L. & Brewer, G. (2018). Machiavellianism and schadenfreude in women's friendships. *Psychological Reports, 121*(5), 909-919.

Akdemir, P. & Erbay, V. (2023, 09 Mart). Bursaspor-Amedspor maçı: Dünün olayı değil... gazete duvaR. Retrieved March 22, 2023, from https://www.gazeteduvar.com.tr/bursaspor-amedspor-maci-dunun-olayi-degil-haber-1607316

Akpan, E. B. & Piate, R. C. (2023). Assessment of different methods of sampling techniques: The strengths and weakness. *Shared Seasoned International Journal of Topical Issues, 9*(1), 64-83.

Amani, D. (2019). Fan identification, brand community identification, and oppositional brand loyalty towards sponsors of a rival sports team: The mediating role of schadenfreude. *Journal of Business and Behavioural Entrepreneurship, 3*(2), 25-40.

Anadolu Ajansı (2021, 10 September). Başkent derbisi 40 yıl sonra 'alt ligde' oynanacak. Retrieved December 18, 2023, from https://www.aa.com.tr/tr/futbol/baskent-derbisi-40-yil-sonra-alt-ligde-oynanacak/2360961

Angell, R., Gorton, M., Bottomley, P., & White, J. (2016). Understanding fans' responses to the sponsor of a rival team. *European Sport Management Quarterly, 16(2),* 1-24.

Arslan, D. (2010, 20 September). (Goal.com özel) Türk futbol tarihinden beş olaylı maç. Retrieved January 04, 2024, from https://www.goal.com/tr/news/2556/editoryal/2010/09/20/1822099/goalcom-özel-türk-futbol-tarihinden-beş-olaylı-maç

Aydın, M. ve Taner, E. (2022). *Trabzonspor Anadolu devrimini nasıl başardı? TS tarihine damga vuran yıldızlar.* [Video]. https://www.youtube.com/watch?v=qk1FAINzWuE

Başel, H. (2009). Sivas'tan göç ve göç edenlerin sosyo–ekonomik nitelikleri – 1. *Sosyal Siyaset Konferansları Dergisi, 56*, 365-391.

BBC (2009, 28 May). Nigeria United fan kills rivals. Retrieved January 22, 2023, from http://news.bbc.co.uk/2/hi/africa/8072356.stm

BBC(2006, 26 August). A rivalry tied up in religion. Retrieved December 8, 2024, from http://news.bbc.co.uk/2/hi/uk_news/scotland/5289202.stm

Behrens, A., & Uhrich, S. (2020). Uniting a sport teams' global fan community: Prototypical behavior of satellite fans enhances local fans' attitudes and perceptions of groupness. European Sport Management Quarterly, 20(5), 598-617.

Bilir, P. & Sangün, L. (2014). Adana Demirspor ve Adanaspor futbol taraftarlarının şiddet eğilimleri . *Spor ve Performans Araştırmaları Dergisi, 5*(1), 56-65.

Boddy, C. R., Ladyshewsky, R. K., & Galvin, P. (2010). The influence of corporate psychopaths on corporate social responsibility and organizational commitment to employees. *Journal of Business Ethics, 97*(1), 1-19.

Bora, T. & Cantek, L. (2020). Ankara Futbolu: Memleket futbolunun kenar semti. Kebikeç, 9, 201-222. https://kebikecdergi.wordpress.com/wp-content/uploads/2012/07/19_bora-cantek.pdf

Brislin, R. W., Lonner, W. J. & Thorndike, R. M. (1973). *Cross-cultural research methods*. Wiley.

Byrne, B. M. (2022). *Structural equation modeling with AMOS basic concepts, applications, and programming* (2nd ed.). Routledge.

Çapık, C. (2014). Geçerlik ve güvenirlik çalışmalarında doğrulayıcı faktör analizinin kullanımı. *Anadolu Hemşirelik ve Sağlık Bilimleri Dergisi, 17*(3), 196-205.

Carter, R. L. (2006). Solutions for missing data in structural equation modeling. *Research & Practice in Assessment, Winter* (1), 4-7.

Chisari, F. (2004). 'The Cursed Cup': Italian responses to the 1985 Heysel Disaster. *Soccer and Society, 5*(2), 201-218.

Combs, D. J. Y., Powell, C. A. J., Schurtz, D. R., & Smith, R. H. (2009). Politics, schadenfreude, and ingroup identification: The sometimes happy thing about a poor economy and death. *Journal of Experimental Social Psychology, 45*(4), 635–646.

Crysel, L.C. & Webster, G.D. (2018). Schadenfreude and the spread of political misfortune. *PLoS ONE 13*(9), 1-27. https://doi.org/10.1371/journal.pone.0201754

Cumhuriyet (2015, 18 February). Şalgam suyundan köfteciye... İşte Süper Lig'in sponsorları. Retrieved November 17, 2023, from https://www.cumhuriyet.com.tr/haber/salgam-suyundan-kofteciye-iste-super-ligin-sponsorlari-216871

Dalakas, V., & Melancon, J. P. (2012). Fan identification, Schadenfreude toward hated rivals, and the mediating effects of Importance of Winning Index (IWIN). *Journal of Services Marketing, 26*(1), 51-59.

Edensor, T. & Millington, S. (2008). 'This is Our City': Branding football and local embeddedness, *Global Networks, 8*(2), 172–193.

Evans, D. & Norcliffe, G. (2016). Local identities in a global game: the social production of football space in Liverpool. *Journal of Sport & Tourism, 20*(3-4), 217-232.

Field, A. (2000). *Discovering statistics using SPSS for Windows.* Sage Publications.

FIFA (2023, 18 January). One Month On: 5 billion engaged with the FIFA World Cup Qatar 2022™. Retrieved April 14, 2023, from https://www.fifa.com/tournaments/mens/worldcup/qatar2022/news/one-month-on-5-billion-engaged-with-the-fifa-world-cup-qatar-2022-tm

Fotomaç (2012, 24 April). Bu rekabet çok farklı. Retrieved January 26, 2024, from https://www.fotomac.com.tr/eskisehirspor/2012/04/24/bu-rekabet-cok-farkli

Fotomaç (2021, 21 August). Ali Koç'tan 1 milyar TL. Retrieved October 11, 2023, from https://www.fotomac.com.tr/fenerbahce/2021/08/21/ali-koctan-1-milyar-tl

Fotomaç (2021, 6 May). Pınar Karşıyaka final aşkına parkede! Retrieved September 14, 2023, from https://www.fotomac.com.tr/basketbol/2021/05/06/pinar-karsiyaka-final-askina-parkede

Garcia, P. C., Castro, J. A. D. & Santos, J. M. S. (2007). The economic geography of football success: Empirical evidence from European cities. *Rivista di Diritto ed Economia Dello Sport, 3*(2), 67-88.

Gündüz, M. (2007). Toplumsal sorunları çözmede eğitime biçilen merkezi rol ve son dönem Osmanlı Aydınlarında eğitim düşüncesi. *Erdem, 16*(48), 21-54.

Güngör, İ. (2015, 31 March). İzmir'in Kan Davası: Karşıyaka - Göztepe Rekabeti. *ABC Spor*. Retrieved February 04, 2024, from https://www.abcspor.com/izmirin-kan-davasi-karsiyaka-goztepe-rekabeti/

Habertürk (2007, 6 December). Bursaspor, Beşiktaş'ı neden sevmez?. Retrieved July 10, 2023, from https://www.haberturk.com/spor/spor/haber/46654-bursaspor-besiktasi-neden-sevmez

Hair, J.F., Black, W.C., Babin, B.J., & Anderson, R.E. (2010). *Multivariate Data Analysis.* Prentice Hall.

Hogg, M. A. (2001). A Social identity theory of leadership. *Personality and Social Psychology Review, 5*(3), 184–200.

Hogg, M. A., & Reid, S. A. (2006). Social identity, self-categorization, and the communication of group norms. *Communication Theory, 16*(1), 7–30.

Hogg, M. A., Hardie, E. A., & Reynolds, K. J. (1995). Prototypical similarity, self-categorization, and depersonalized attraction: A perspective on group cohesiveness. *European Journal of Social Psychology*, *25*(2), 159-177.

Hoogland, C. E., Schurtz, D. R., Cooper, C. M., Combs, D. J. Y., Brown, E. G., & Smith, R. H. (2015). The joy of pain and the pain of joy: In-group identification predicts

schadenfreude and gluckschmerz following rival groups' fortunes. *Motivation and Emotion, 39*(2), 260–281.

Hox, J. & Bechger, T. (1998). An introduction to structural equation modeling. *Family Science Review, 11*, 354-373.

Huddy, L. (2001). From social to political identity: A critical examination of social identity theory. *Political Psychology, 22*(1), 127–156.

Hürriyet (2017, 9 May). Trabzonspor'u husumet faturası. Retrieved October 09, 2023, from https://www.hurriyet.com.tr/trabzonsporu-husumet-faturasi-40094176

İlhan, E. (2014). Sporda Şiddetin Ulaştığı Nokta; 17 Eylül 1967 Kayserispor-Sivasspor Karşılaşması. *KMÜ Sosyal ve Ekonomik Araştırmalar Dergisi, 16*(Özel Sayı I), 188-196.

İlkhaber (2023, 20 March). Sancak: Hedefimiz 3 yıl içinde şampiyonluk yaşamak. Retrieved May 25, 2023, https://www.ilkhaber-gazetesi.com/sancak-hedefimiz-3-yil-icinde-sampiyonluk-yasamak

İnalcık, H. (2007). *Fatih Devri üzerinde tetkikler ve vesikalar 1.* Türk Tarih Kurumu.

James, S., Kavanagh, P. S., Jonason, P. K., Chonody, J. M., & Scrutton, H. E. (2014). The dark triad, schadenfreude, and sensational interests: Dark personalities, dark emotions, and dark behaviors. *Personality and Individual Differences, 68*, 211–216.

Katz, M., Baker, T. A. & Du, H. (2020). Team identity, supporter club identity, and fan relationships: A Brand community network analysis of a soccer supporters club. *Journal of Sport Management, 34*(1), 9-21.

Kawarazaki, H., Mahmud, M., Sawada, Y., & Mai Seki, M. (2023). Haste makes no waste: Positive peer effects of classroom speed competition on learning. *Oxford Bulletin of Economics and Statistics, 85*(4), 755-772.

Keddie, P. (2018). *The passion: Football and the story of modern Turkey.* I.B. Tauris.

Kilduff, G. J., Elfenbein, H. A. & Staw, B. M. (2010). The psychology of rivalry: A relationally dependent analysis of competition. *The Academy of Management Journal, 53*(5), 943-969.

Korte, R. F. (2007). A review of social identity theory with implications for training and development. *Journal of European Industrial Training, 31*(3), 166–180.

Leach, C. W., Spears, R., Branscombe, N. R., & Doosje, B. (2003). Malicious pleasure: Schadenfreude at the suffering of another group. *Journal of Personality and Social Psychology, 84*(5), 932-943.

Li, X., McAllister, D. J., Ilıes, R. & Gloor, J. L. (2019). Schadenfreude: A counternormative observer response to workplace mistreatment. *Academy of Management, 44*(2), 360-376.

Milstein, N., Striet, Y., Lavidor, M., Anaki, D., & Gordon, I. (2022). Rivalry and performance: A systematic review and meta-analysis. *Organizational Psychology Review, 12*(3), 332-361.

Moisieiev, D., Dimitriu, R. & Jain, S. P. (2020). So happy for your loss: Consumer schadenfreude increases choice satisfaction. *Psychology and Marketing, 37*(4), 1525-1538.

Ouwerkerk, J. W., Van Dijk, W. W., Vonkeman, C. C., & Spears, R. (2018). When we enjoy bad news about other groups: A social identity approach to out-group schadenfreude. *Group Processes & Intergroup Relations, 21*(1), 214–232.

Pietraszkiewicz, A. & Chambliss, C. (2015). The link between depression and schadenfreude: Further evidence. *Psychological Reports: Mental & Physical Health, 117*(1), 181-187.

Reuters (2013, 3 May). Boca Juniors and River Plate historical background. Retrieved December 2, 2024, from https://www.reuters.com/article/sports/boca-juniors-and-river-plate-historical-background-idUSBRE9420SJ/

Roseman, I. J. & Steele, A. K. (2018). Concluding commentary: Schadenfreude, gluckschmerz, jealousy, and hate - What (and when, and why) are the emotions? *E*motion Review, *10*(4), 327-340.

Schrepp, M. (2020). On the usage of Cronbach's Alpha to measure reliability of UX Scales. *Journal of Usability Studies, 15*(4), 247-258.

Shamay-Tsoory, S. G., Ahronberg-Kirschenbaum, D. & Bauminger-Zviely, N. (2014). There is no joy like malicious joy: Schadenfreude in young children. *PLoS ONE, 9*(7), 1-7.

Sharapov, D. & Ross, J. M. (2023). Whom should a leader imitate? Using rivalry-based imitation to manage strategic risk in changing environments. *Strategic Management Journal 44*(1), 311-342.

Simon, D. C. (2017). The Anatomy of schadenfreude; or Montaigne's laughter. *Critical Inquiry, 43*(2), 250-280.

Sivas Ekspres (2024, 20 July). Sivaslılar göçmen kuşlar gibi gidiyor, işte rakam. Retrieved December 16, 2024, from https://www.sivasekspres.com/haber/sivaslilar-gocmen-kuslar-gibi-gidiyor-iste-rakam-51496.html

Smith, R. H., Powell, C. A., Combs, D. J., & Schurtz, D. R. (2009). Exploring the when and why of schadenfreude. *Social and Personality Psychology Compass, 3*(4), 530-546.

Sung, H., Mills, B. M., & Tainsky, S. (2017). From schadenfreude to mitfreude? Estimating viewership loss and rivalrous relationships in otherwise neutral markets. *Sport Management Review, 20*(2), 159-169.

Tajfel, H., & Turner, J. C. 1986. The social identity of intergroup behavior. In S. Worchel & W. G. Austin (Eds.), *Psychology of intergroup relations*: (pp. 7–24). Chicago: Nelson-Hall.

The Athletic (2023, 21 March). Derby days, Rome: Derby della Capitale. Retrieved November 30, 2024, from https://www.nytimes.com/athletic/4317699/2023/03/21/derby-days-rome-lazio-roma/

The Guardian (2021, 17 April). Kung-fu kicks and riot police: The day Maradona got Barça brawling. Retrieved December 14, 2024, from

https://www.theguardian.com/football/2021/apr/17/kung-fu-kicks-riot-police-maradona-barcelona-brawl-athletic-bilbao-copa-del-rey

TRT Haber (2022, 20 December). Karşıyaka'ya stat müjdesi. Retrieved January 19, 2023, https://www.trthaber.com/haber/spor/karsiyakaya-stat-mujdesi-732212.html

Tunç, S. (2011). *Trabzon'da futbolun tarihi: Mektepliler, münevverler, meraklılar.* İletişim Publication.

Tuncay, B. (2002). *Galatasaray Tarihi: Avrupa zaferleriyle unutulmaz yıldızlarıyla.* Yapı Kredi Publication.

Tyler, B.D., Cobbs, J., Nichols, B.S. & Dalakas, V. (2021). Schadenfreude, rivalry antecedents, and the role of perceived sincerity in sponsorship of sport rivalries. *Journal of Business Research, 124*(1), 708-719.

van Dijk W.W., Ouwerkerk J.W., Smith R.H. & Cikara M. (2015). The role of self-evaluation and envy in schadenfreude. *European Review of Social Psychology, 26*(1), 247-282.

van Dijk, W. W. & Ouwerkerk, J. W. (2014). *Schadenfreude: Understanding pleasure at the misfortune of others.* Cambridge University Press.

Weber, R., Brand, A., Niemann A. and Koch, F. (2020). Non-elite conceptions of Europe: Europe as a reference frame in English football fan discussions. *Journal of Contemporary European Research, 16*(3): 293-319. https://doi.org/10.30950/jcer.v16i3.1089

Wei, L. & Liu, B. (2020). Reactions to others' misfortune on social media: Effects of homophily and publicness on schadenfreude, empathy, and perceived deservingness. *Computers in Human Behavior, 102*, 1-13.

Xu, E., Huang, X., Jia, R., Xu, J., Liu, W., Graham, L., & Snape, E. (2020). The "evil pleasure": Abusive supervision and third-party observers' malicious reactions toward victims. *Organization Science, 31*(5), 1115–1137.

Yavuz, C. (2007, 14 December). Dostumun düşmanı düşmanımdır! Retrieved April 26, 2023, from https://www.odatv4.com/siyaset/dostumun-dusmani-dusmanimdir-1412071200-635

Yıldırım, Y. & Uçar, M. (2009). *Sıcağıyla acısıyla Adana futbolu.* İletişim Publication

Yip, J. A., Schweitzer, M. E., & Nurmohamed, S. (2018). Trash-talking: Competitive incivility motivates rivalry, performance, and unethical behavior. *Organizational Behavior and Human Decision Processes, 144*(2018), 125-144.

Yong, A. G. & Pearce, S. (2013). A beginner's guide to factor analysis: Focusing on exploratory factor analysis. *Tutorials in Quantitative Methods for Psychology, 9*(2), 79-94.

Yu, T. & Cannella, A. A. (2007). Rivalry between multinational enterprises: An event history approach. *Academy of Management Journal, 50*(3), 663-684.

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Pamukkale J Sport Sci, 16(1), 208-228, 2025 Research Article

Indonesian Version of the Short Mental Toughness Questionnaire (MTQ): Factor Structure and Measurement Invariance

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ABSTRACT

This study aims to evaluate the factor structure of the short version of the Mental Toughness Questionnaire (S-MTQ) in the Indonesian context and test measurement invariance based on gender (male vs. female) and status (athlete vs. non-athlete). A total of 710 people (M_{age} = 22.07 years; SD = 7.99) consisting of 490 (69.01%) males and 220 (30.99%) females; 476 (67.04%) athletes and 234 (32.96%) non-athletes were involved in the study. Confirmatory factor analysis (CFA) was used to evaluate the factor structure of the short MTQ. The results showed that the unidimensional models tested, MTQ-18 and MTQ-10, were unfit. Therefore, a revision was carried out by removing items that had low loading factor values. The results of the revised Indonesian version (MTQid-6) found CFI = .983, TLI = .969, RMSEA = .052, and SRMR = .024, which indicated that the MTQid-6 unidimensional model was very satisfactory. MTQid-6 has a loading factor category ranging from good to very good (λ = .50 to .74). This validity is strengthened by convergent validity results, which show that MTQid-6 has a significant correlation with MTI, PPI-A, and APSQ ($p < .001$). The reliability analysis results show high internal consistency values, namely α = .762, ω = .763. Invariance testing found invariance at the configural, metric, and scalar levels (ΔCFI ≤ -.01, ΔRMSEA ≤ .015). With these results, MTQid-6 can be used to measure MT, both in athletes and non-athletes, in both males and females in the Indonesian population.

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INTRODUCTION

Instruments used in scientific research are a crucial aspect (Kerlinger, 2006). When they are used to collect data whose validity and reliability are questionable, the data produced by the measuring instrument very likely have a high error content (Azwar, 2013). Concerning the assessment of the mental aspects of athletes, the problem in Indonesia is the instruments used for it (Putra et al., 2023). It was discovered that the development process was not explained in detail when the instrument was developed. Similarly, in applying external instruments, the adaptation of the language and testing process was not performed in an internationally recognized way (ITC, 2017; Hambleton & de Jong, 2003; Ohrbach et al., 2013). In other words, instruments that reveal aspects of mental toughness written in Indonesian are still very limited and separate the issues. To overcome this, it is urgent to adapt the language to the standardized or commonly used one so that the study of mental toughness in Indonesia becomes better and people can use instruments that are already in Indonesian without testing them first.

Mental toughness (MT) is understood in various ways (Stamatis et al., 2021). Up to now, it has been defined as a collection of values, attitudes, emotions, and cognitions attached to a person and affect him or her when responding to and assessing pressure, challenges, and difficulties he or she faces to achieve his or her goals (Gucciardi et al., 2008). Later, Gucciardi (2017) modernized the definition, and he wrote that mental toughness is "a state-like psychological resource that is purposeful, flexible, and efficient in nature for the enactment and maintenance of goal-directed pursuits." In general, mental toughness is considered a multidimensional construct. There are many qualities usually associated with it, including unwavering self-confidence, the ability to bounce back after defeat/failure (resilience), the ability to never give up, the ability to deal with difficulties and pressure effectively, and the ability to maintain concentration despite many experiences and potential disruption (Liew et al., 2019). Other experts also expressed the same thing. Clough and Strycharczyk (2012) write that MT is the quality that largely establishes how people deal effectively with challenges, stressors, and pressure irrespective of prevailing circumstances.

In MT research, the MTQ-48 (Clough et al., 2002) has become a very popular instrument and is widely used by researchers in the field (Gucciardi et al., 2012). Clough and colleagues developed MTQ-48 based on the Hardiness theory created by Kobasa (1979). Hardiness theory explains the personality characteristics of a person who is strong, stable, and

resistant to stress, which is characterized by three dominant dimensions: control, commitment, and challenge. Based on this theoretical basis, MTQ-48 was developed with four dimensions which are widely known as 4Cs, namely those consisting of commitment, challenge, control, and confidence (Clough et al., 2002). During its development, the psychometric properties of the MTQ-48 were widely criticized and debated (see debates in Gucciardi et al., 2012; Clough et al., 2012; Gucciardi et al., 2013). On the other hand, by researchers, the MTQ-48 is still often used to measure mental aspects in sports contexts (Crust & Azadi, 2010; Vaughan et al., 2018). That is why, Dagnall et al. (2019) and Papageorgiou et al. (2018) then retested the instrument more rigorously and produced more concise versions, namely the MTQ-10 and MTQ-18. Both the MTQ-48 and the short version of the MTQ included populations in Europe.

Apart from MTQ, several instruments have been recorded as having been created by experts. For example, instruments created by experts to measure MT in a sports context include the Mental Toughness Index (MTI; Gucciardi et al., 2014), Mental Toughness Questionnaire (MTQ; Cherry, 2005), Sport Mental Toughness Questionnaire (SMTQ; Sheard et al., 2009), and the Psychological Performance Inventory-Alternative (PPI-A; Golby et al., 2007). However, some instruments are specific to sports, such as cricket (Gucciardi & Gordon, 2009), volleyball (Tiwari & Sharma, 2007), and football (Gucciardi et al., 2009). Even though there are several similar instruments, MTQ is an instrument that scholars often use to reveal MT dimensions (Birch et al., 2019; Clough et al., 2002; Gucciardi et al., 2012). On the other hand, several studies show serious issues regarding the psychometric properties of the MTQ, and further testing is needed (Gucciardi et al., 2012; Vaughan et al., 2018).

To date, only limited testing of the short version of the MTQ outside its original language and culture has been carried out in Russian (Denovan et al., 2021) and found that it is psychometrically acceptable, but issues related to the factor structure still need to be addressed in future research. Facts in the field also show that MTQ is often directed at measuring the MT of athletes and non-athletes or male and female subjects. Psychometrically, if the two groups are compared (athletes vs non-athletes; male vs female), it is very important to measure invariance first on the instrument used (Chen, 2007). That is why Dagnall et al. (2019) tested the factor structure of the short version of the MTQ and conducted an invariance analysis based on gender. Vaughan et al. (2018) tested the MTQ and, in their research, carried out the analysis of variance based on athlete and non-athlete status. Kawabata et al. (2021), in their rigorous study of the MTQ, also used invariance based on gender and found that both

the short version of the MTQ and the very short version of the MTQ (MTQ-6) were valid measuring tools in measuring MT.

With the various issues surrounding the MTQ and the results of the latest studies, as stated above, we see that further testing is needed regarding the psychometric structure in language and cultural contexts other than the original. Different cultures and languages have different conceptions of MT. MT expression may vary between languages (Pennebaker et al., 2003). With this in mind, assessing the psychometric properties of an instrument translated beyond its original language is important to ensure that it is valid and reliable in measuring a broader population. For this reason, this study aims to evaluate the factor structure of the short version of the MTQ (MTQ-18 and MTQ-10) in the Indonesian context. In addition, the study also aims to test measurement invariance based on gender (male vs. female) and status (athlete vs. non-athlete).

METHODS

Participants

Participants were recruited online and offline using the convenience sampling method. The researchers distributed the filling link to colleagues in several sports study programs and sports coaches to pass on to athletes or students. Through this method, 653 participants participated in this study. For the offline method, the researchers distributed the instrument to athletes from the Student Education and Training Center (PPLP) Papua, Indonesia. Through this method, 104 people participated. A total of 757 people participated in this study, but 47 data had to be excluded after data screening due to careless responses and outliers. Therefore, the number of data analyzed further in this study is 710. There were 490 male participants (69.01%) and 220 (30.99%) female participants. Of these respondents, 476 (67.04%) athletes and 234 (32.96%) non-athletes. The age range of participants was between 13 and 60 years, with a mean age value of 22.07 years and a standard deviation of 7.99.

Data Collection Procedure

This research procedure was approved by the Health Research Ethics Committee Cenderawasih University, Number 065/KEPK-FKM UC. All respondents were asked to provide informed consent before participating in this study. Thus, the data received and analyzed are data that the respondent has approved. The researchers began this research by applying for permission from the MTQ instrument developer. After receiving permission to

carry out language adaptation and testing in the Indonesian context, they handed over the original MTQ to two English language experts to translate into Indonesian. The results of this synthesis stage were then submitted to three sports psychology experts, all of whom have doctoral-level education. The three experts were asked to assess the suitability of the substance of each item in the Indonesian version of the MTQ with the original version. The results from the three experts were then synthesized and submitted to an Indonesian language expert to check the readability level of the Indonesian version of the MTQ. After that, the researchers tested the readability level on three athletes at the junior high school level, three athletes at the high school level, and three sports students. At this stage, respondents were asked to give a rating from number 1 (which means the sentence is very difficult to understand) to number 5 (which means the sentence is very easy to understand) on each item in the Indonesian version of the MTQ. Items that receive an average score of 1 and 2 are considered to have a low readability level so improvements need to be made conversely, if the average item value is high then the item is considered to have a good readability level. They then submitted the final results of the Indonesian version of the MTQ instrument (MTQid) to a different English language expert from the initial stage to be translated back into the original language. After receiving the MTQid and MTQ back translation, the researchers then sent the two instruments to the MTQ developer to review and get input regarding the results of the language adaptation that had been done. After receiving input and being declared "OK" by the original developer, the researchers collected data from the Indonesian community. Data collection was carried out directly by researchers, and colleagues were asked for their help in distributing links to instrument testing to athletes or students.

Data Collection Tools

Mental Toughness Questionnaire (MTQ)

The instruments tested and validated in this study were the MTQ-18 (e.g., Even when under considerable pressure I usually remain calm)(Dagnall et al., 2019) and the MTQ-10 (e.g., I generally feel in control)(Papageorgiou et al., 2018). MTQ was developed to reveal a person's mental toughness. MTQ-18 has a value of CFI = 0.900, SRMR = 0.055, and RMSEA = 0.059 while MTQ-10 has a value of CFI = 0.950, SRMR = 0.037, and RMSEA = 0.055 (Dagnall et al., 2019). Alternative answers in the MTQ are in the form of a five-point Likert scale, ranging from strongly disagree, disagree, neither agree nor disagree, agree to strongly agree (1-5)(Dagnall et al., 2019; Papageorgiou et al., 2018). In MTQ-18, there are 9 items whose scoring method is

reversed, namely item numbers 2, 3, 6, 8, 9, 11, 12, 16, and 17, while in MTQ-10, there are 4 items, namely numbers 2, 3, 6, and 7. Initially, MTQ was viewed as multidimensional with dimensions known as 4/6C (Clough et al., 2002). However, in subsequent tests, the MTQ was considered more appropriate as unidimensional (Dagnall et al., 2019; Papageorgiou et al., 2018). A high MTQ score indicates that a person's MT is also high and vice versa.

Mental Toughness Index (MTI)

The MTI was developed by Gucciardi et al., (2014) to measure athletes' mental toughness. It contains eight items (e.g., I can find a positive in most situations.) and has alternative answers in the form of a continuum ranging from 1 (False, 100% of the time) to 7 (True, 100% of the time). The MTI has been adapted into Indonesian and has very good loading factor values (λ = .563 to .759) and excellent internal consistency reliability (CR = .864; α = .862; Putra, Kurdi, et al., 2024). Apart from that, the Indonesian version of MTI (MTIid) also has very satisfactory fit values, namely CFI = .967, TLI = .954, GFI = .966, SRMR = .034, and RMSEA = .069 (Putra, Kurdi, et al., 2024).

Psychological Performance Inventory-Alternative (PPI-A)

The PPI-A, which was developed by Golby et al. (2007) and has been adapted into the Indonesian version, will be used (Putra, Sutoro, et al., 2024). PPI-A was developed to measure athletes' mental toughness. It consists of four sub-scales, namely determination (e.g., The goals I've set for myself as a player keep me working hard.), self-belief (e.g., I lost my confidence very quickly), positive cognition (e.g., I can clear interfering emotions quickly and regain my focus), and visualization (e.g., I visualize working through challenging situations before competition). The Indonesian version of the PPI-A consists of nine items with alternative answers in the form of a Likert scale, ranging from almost never, seldom, sometimes, often to almost always (1-5). In the Indonesian version, PPI-Aid has very good loading factor values (λ = .563 to .759) and internal consistency α = .74 to 77. Apart from that, PPIid also has a very satisfactory fit value, namely CFI = .961; GFI = .969; TLI = .938; SRMR = .038; RMSEA = .057 (Putra, Sutoro, et al., 2024).

Athlete Psychological Strain Questionnaire (APSQ)

The APSQ developed by (Rice et al., 2019) aims to look at a person's mental health, especially in the context of sports. The APSQ has three subscales, namely self-regulation difficulties (e.g., I was irritable, angry, or aggressive), performance concerns (e.g., I worried

about life after sport), and externalized coping (e.g., I needed alcohol or other substances to relax). The three sub-scales are translated into 10 statements with alternative answers in a Likert scale ranging from none of the time, a little of the time, some of the time, most of the time to all of the time (1 to 5). The APSQ has been adapted into Indonesian, and the Indonesian version of the APSQ (APSQid) has very good loading factor values (λ = .53 – .72) and internal consistency reliability including excellent (ω = .819; α = .822; Putra, Rahayuni, et al., 2025). Apart from that, APSQid also has very satisfactory fit values, namely CFI = 0.950, TLI = 0.929, GFI = 0.959, SRMR = 0.044, RMSEA = 0.062 (Putra, Rahayuni, et al., 2025).

Data Analysis

Initial analysis was carried out to see the presence of careless responses and test normality. The normality test refers to the Skewness, Kurtosis, and Shapiro-Wilk values. After that, confirmatory factor analysis (CFA) was calculated using the maximum likelihood (ML) estimator. To assess the accuracy of the model tested (Indonesian version of MTQ), parameters such as chi-square ($\chi 2$), the comparative fit index (CFI), the Tucker-Lewis index (TLI), standardized root mean square residual (SRMR), and root mean squared error of approximation (RMSEA) was used. The following are the cut-off values used to assess model fit: CFI and TLI scores > .90 (Browne & Cudeck, 1992), SRMR scores ≤ .07 (Bagozzi, 2010), and RMSEA scores ≤ .08 (Browne & Cudeck, 1992). After the model was fit, the analysis continued looking at the factor loadings of each item in the MTQid in various samples. The factor loading criteria refer to the recommendations given by Comrey & Lee (1992); i.e., > .71 = excellent; > .63 = very good; > .55 = good; > .45 = fair; < .32 = poor). Reliability analysis was carried out to assess the internal consistency of the MTQid and the researchers used Cronbach's Alpha (α), McDonald's omega (ω), and item-total correlation (*r*ix). A multigroup CFA was conducted to explore four distinct types of measurement invariance across status (male vs. female; athlete vs. non-athlete; and age range of <18 vs. ≥18): configural, metric, scalar, and strict. In the configural invariance (M1), each group was allowed unrestricted estimation of all parameters. For the metric invariance (M2), the item factor loadings were equally constrained across groups. Scalar invariance (M3) involved constraining factor loadings and intercepts for all groups. In the strict invariance phase (M4), equality across groups was enforced for factor loadings, intercepts, and residual variances. Measurement invariance was considered not fulfilled if: ΔCFI ≥ -.01, ΔRMSEA ≥ .015 (Chen, 2007). Next, convergent validity was analyzed by correlating MTQid scores with MTI, PPI-A, and APSQ scores using Pearson's correlation

coefficient. It was hypothesized that the MTQid score would show a positive correlation with the MTI and PPI-A while the APSQ would have a negative correlation. The analysis in this research was carried out with the help of the JASP program version 0.18.1.0.

RESULTS

Initial and descriptive analysis

Initial analysis was conducted for data screening purposes, such as careless responding and data normality. Univariate normality analysis shows that the data are normally distributed (Table 1) but multivariate analysis shows a value of S-W = .945 ($p < .001$) which indicates that the assumption of multivariate normality is not met. Therefore, CFA analysis on the maximum likelihood (ML) estimator was carried out with bootstrapping (600 resamplings).

Table 1
Descriptive Result and Data Normality (n = 710)

	i1	i2	i3	i4	i5	i6	i7	i8	i9	i10	i11	i12	i13	i14	i15	i16	i17	i18	MTQ
M	2.96	3.88	3.90	3.28	2.78	4.02	4.09	3.62	2.46	2.46	2.60	4.40	3.25	2.74	2.95	3.09	4.25	3.40	63.48
SD	1.16	.936	.85	1.17	1.14	1.08	.93	.955	1.08	1.16	1.15	.81	1.06	1.14	1.11	1.11	.79	1.35	7.26
Sk	.19	-.60	-.43	-.19	.26	-.93	-.99	-.26	.52	.47	.44	-1.23	-.27	.291	.12	.01	-.81	-.39	-.08
Kr	-.79	.05	-.11	-.83	-.62	.17	.89	-.32	-.191	-.60	-.44	.90	-.30	-.63	-.62	-.58	.24	-.97	-.38
S-W	.91	.86	.86	.91	.91	.81	.82	.89	.89	.89	.90	.73	.904	.91	.91	.91	.80	.88	.99
Min	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	42.00
Max	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	83.00

Note: i = item number; M = Mean; SD = Standard deviation; Sk = Skewness; Kr = Kurtosis; S-W = Shapiro-Wilk; Min = Minimum; Max = Maximum

Confirmatory Factor Analysis

Confirmatory Factor Analysis (CFA) on two MTQ models (MTQ-18 and MTQ-10) showed that the model accuracy was not satisfactory (Table 2). The CFI, TLI, RMSEA, and SRMR values were far from being recommended. Apart from that, the results of the analysis also showed that nine items in the MTQ-18 and MTQ-10 had factor loadings below 0.32 (Table 3). On the other hand, items in MTQ-10 whose factor loading threshold is acceptable ($\lambda \geq 0.32$) are also part of MTQ-18. Therefore, the researchers collected items with a factor loading ≥ 0.32, with nine total items. The results of the CFA analysis on these nine items showed that the model did not fit (CFI = 0.779, TLI = 0.706, RMSEA = 0.120, and SRMR = 0.073). Therefore, the researchers carried out revisions by removing items with low factor loadings. After removing three items from the properties, the research results showed that the model was better and entered marginal fit. Considering that the model was still marginally fit, a covariance correlation was carried out based on the modification index (MI) value. The final results show

that the Indonesian version of the MTQ with six items has a value of CFI = .983, TLI = .969, RMSEA = .052, and SRMR = .024, which indicates a very satisfactory model fit (Table 2). The factor loading value is relatively high (Figure 1).

Table 2
Measurement Models of MTQ-18 and MTQ-10, and Revision of the Indonesian Version of Short MTQ

Model	df	χ^2	CFI	TLI	RMSEA [90%CI]	SRMR
MTQ-18						
Unidimensional (1)	135	1288.770	.510	.445	.110 [.104 - .115]	.105
MTQ-10						
Unidimensional (2)	35	331.452	.721	.642	.109 [.099 - .120]	.081
MTQ Indonesia (MTQid-6)						
Unidimensional (3)	8	23.363	.983	.969	.052 [.028 - .077]	.024

Note. df = degrees of freedom; $\chi 2$ = chi-square; CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation; CI = confidence interval; SRMR = standardized root mean residual

Table 3
Factor Loading MTQ-18 and MTQ-10

No. Item	MTQ-18			MTQ-10		
	Std. Error	p	λ	Std. Error	p	λ
i1	0.044	< .001	0.595	0.045	< .001	0.629
i2	0.040	< .001	0.344	0.040	< .001	0.357
i3	0.037	< .001	0.352	0.037	< .001	0.378
i4	0.045	< .001	0.560	0.047	< .001	0.540
i5	0.043	< .001	0.649	0.044	< .001	0.697
i6	0.047	< .001	0.202	0.047	< .001	0.166
i7	0.041	0.696	0.017			
i8	0.041	< .001	0.230	0.042	< .001	0.288
i9	0.045	< .001	0.307			
I10	0.046	< .001	0.479	0.047	< .001	0.493
i11	0.049	< .001	0.188			
i12	0.035	< .001	0.288			
i13	0.045	0.394	-0.036	0.046	0.655	0.019
i14	0.045	< .001	0.568			
i15	0.043	< .001	0.616	0.045	< .001	0.522
i16	0.046	< .001	0.310			
i17	0.034	< .001	0.365			
i18	0.057	0.001	-0.136			

Note. Std. = Standard; p = p-value; λ = loading factors

Invariance analysis

Multi-group CFA was performed to investigate measurement invariance based on gender differences (males vs. females) and status (athletes vs. non-athletes). Invariance testing uses four levels of measurement invariance: configural, metric, scalar, and strict. The results of measurement invariance based on gender show that there is measurement invariance at configural, metric, and scalar (ΔCFI ≤ -.01, ΔRMSEA ≤ .015). At the same time, at the strict level, the value obtained is greater than the threshold used so that it can be stated that at the strict level, there is no measurement invariance (Table 4). For invariance based on athlete vs. athlete status, non-athletes were found to have measurement invariance at the configural and metric levels, while for the scalar level, it was found to be ΔCFI = -.012 (ΔCFI ≥ -.01) and ΔRMSEA = 0.004 (ΔRMSEA ≤ .015). In other words, the invariance results are based on athlete vs. athlete groups; non-athlete occurs only at the configural and metric levels, while at the scalar and strict levels, the invariance is not fulfilled (Table 4). The same thing was found from the invariance analysis based on age (<18 vs. ≥18), namely that there was measurement invariance at the configural and metric levels, while for the scalar, it was found that ΔCFI = -0.018 (ΔCFI ≥ -.01) and ΔRMSEA = 0.010 (ΔRMSEA ≤ .015). In other words, invariance results based on age (<18 vs. ≥18) occur only at the configural and metric levels, while at the scalar and strict levels, the invariance is not fulfilled (Table 4).

Figure 1
MTQid-6 Unidimensional Model and Magnitude of Loading Factors

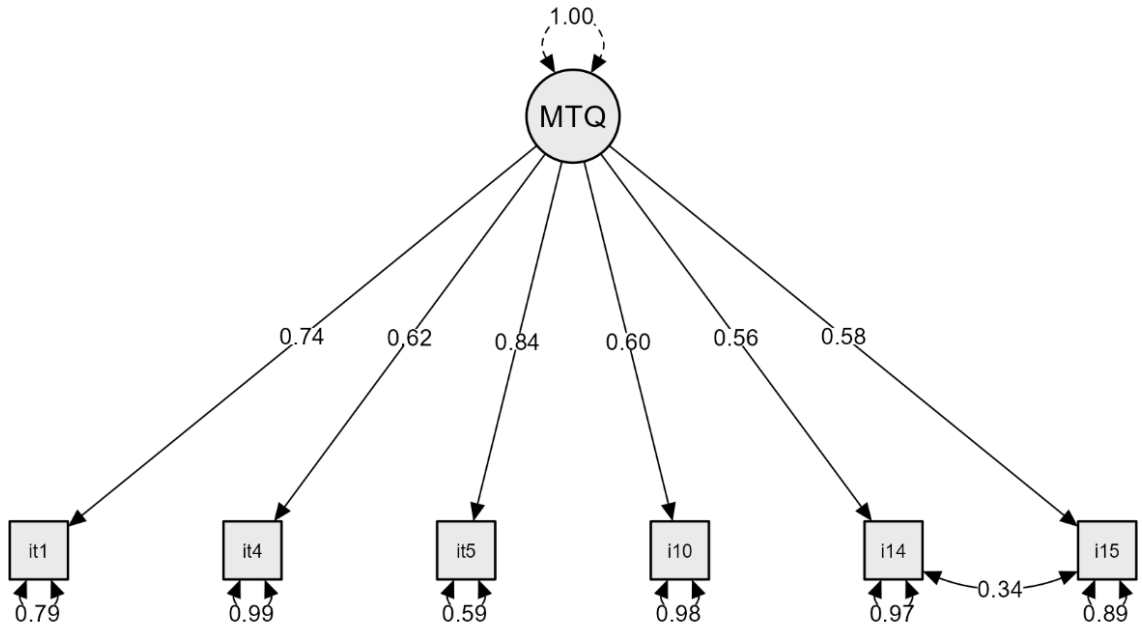

Table 4
Summary of Invariance Analysis by Gender, Athlete, and Age

Group and Invariance Level	Model fit		Model comparison	
	CFI	RMSEA	ΔCFI	ΔRMSEA
Gender (male vs. female)				
Configural (M1)	0.980	0.058	-	-
Metric (M2)	0.978	0.053	-0.002	-0.005
Scalar (M3)	0.968	0.057	-0.010	0.004
Strict (M4)	0.955	0.060	-0.013	0.003
Athlete (athlete vs. Non-athlete)				
Configural (M1)	0.963	0.078	-	-
Metric (M2)	0.963	0.068	0.000	-0.010
Scalar (M3)	0.951	0.070	-0.012	0.002
Strict (M4)	0.949	0.064	-0.002	-0.006
Age (<18 vs. ≥18)				
Configural (M1)	0.976	0.063	-	-
Metric (M2)	0.975	0.056	0.001	-0.007
Scalar (M3)	0.957	0.066	-0.018	0.010
Strict (M4)	0.957	0.059	0.000	-0.007

Validity and Reliability MTQid-6

Convergent validity analysis was carried out by correlating MTQid-6 scores with MTI, APSQ, and PPI-A, namely instruments that measure the construct of mental toughness. Convergent validity is achieved when a significant correlation exists between MTQid-6 with MTI, APSQ, and PPI-A. The results of the analysis indicate that there is a significant positive correlation between MTQid-6 and MTI (r = .234, p < .001; Table 4). The same thing was found with the APSQ: the value obtained was r = -.539, p < .001. MTQid-6 is statistically significant with all factors in the APSQ. The correlation between MTQid-6 and PPI-A shows a significant positive correlation (r = .224, p < .001). Only the visualization factor is not significant, while the other three factors in the PPI-A have significant correlation values (p < .001). These results indicate a correlation among the Indonesian version of the MTQ (MTQid-6) with the MTI, APSQ, and PPI-A. In other words, the convergent validity of MTQid-6 has been achieved. These results strengthen the findings in the CFA, which show that the loading factor value for each item in the Indonesian version of the MTQ ranges from .50 to .74, or in the fair to excellent category (Table 5).

The reliability test results using internal consistency with Cronbach's Alpha and McDonald's Omega, respectively, found scores of α = .762, and ω = .763 (Table 5). The item-total correlation coefficient value is also quite high. This indicates that MTQid-6 is reliable.

Table 5
Factor Loading, Internal Consistency, and Convergent Validity

Item	λ	*r*ix	α	ω	1	2	3	4	5	6	7	8	9	10	11
i1	.64	.684													
i4	.53	.639													
i5	.74	.738	.762	.763											
i10	.52	.620													
i14	.50	.678													
i15	.53	.694													
MTQid (1)					-										
MTI (2)					.234**	-									
SR (3)					-.466**	-.396**	-								
Per (4)					-.524**	-.266**	.632**	-							
EC (5)					-.287**	-.254**	.434**	.479**	-						
APSQ (6)					-.539**	-.375**	.880**	.890**	.668**	-					
Det (7)					.153**	.463**	-.231**	-.145	-.163**	-.218**	-				
SB (8)					.246**	.430**	-.331**	-.241	-.175**	-.314**	.485**	-			
PC (9)					.242**	.479**	-.290**	-.194	-.066	-.246**	.478**	.562**	-		
Vis (10)					.048	.435**	-.168**	-.055	-.076*	-.124**	.499**	.460**	.490**	-	
PPI-A (11)					.224**	.574**	-.325**	.203**	-.145**	-.286**	.760**	.786**	.836**	.767**	-

Note. i = item number; λ = loading factors; rix = item-total correlation; α = Cronbach's Alpha; ω = McDonald's omega; SR = self-regulation; Per = performance; EC = external coping; Det = determinant; SB = self-belief; PC = positive cognition; Vis = visualization; *p < .05; **p < .001

DISCUSSION

This study seeks to evaluate the factor structure of the short versions of the MTQ (MTQ-18 and MTQ-10) in the Indonesian context and test measurement invariance based on gender (male vs. female) and status (athlete vs. non-athlete). The results showed that the unidimensional model tested in MTQ-18 and MTQ-10 did not fit. Therefore, a revision was carried out by removing items that had low loading factor values. The results of the revised Indonesian version showed that the model was better than the previous one, although it was still in the marginal fit category. Therefore, modifications were carried out by carrying out covariance correlation, and the modification results for MTQid-6 found model robustness indices at CFI = .983, TLI = .969, RMSEA = .052, and SRMR = .024. These results indicate that the MTQid-6 unidimensional model is very satisfactory. The results found in this study are different from those found in previous studies (Dagnall et al., 2019; Papageorgiou et al., 2018), which showed that the MTQ-18 and MTQ-10 were suitable models. However, regarding whether MTQ is more appropriate as multidimensional or unidimensional, the results of this study are in line with previous studies which found MTQ to be a unidimensional model (Dagnall et al., 2019; Papageorgiou et al., 2018).

In terms of psychometric structure, the results of this study confirm previous studies which indicate that the 4/6Cs theoretical model that underlies the preparation of the MTQ is one of the issues in the psychometric properties of the MTQ and this is in line with what was found by Gucciardi et al., (2012) when testing the MTQ. In addition, research conducted by Birch et al. (2017) also strengthens previous findings, showing that the 4/6Cs model is less suitable for measuring MT in student-athletes. The research involved samples of athletes and students. Another similar study also revealed that the 4/6Cs theoretical model in elite athletes obtained poor fit data (Vaughan et al., 2018). With these facts, the findings in this study relatively find the same thing regarding the psychometric structure of the MTQ, namely that there are weaknesses in it so the model tends not to fit.

The reduction of the items in the MTQid to six items shows that only these six items have factor loading values in the Indonesian version. For items with a value of less than .32, the researchers removed them from the MTQid property. This follows the rule of thumb that it can still be acceptable (Comrey & Lee, 1992). A loading factor value above .32 indicates that the item is statistically significant in measuring the latent variable. This study identified nine items with a loading factor of less than .32 in the MTQid, namely item numbers 6, 7, 8, 9, 11, 12, 13, 16 and 18. Even though the nine items have been removed from the MTQid property,

the model is not yet fit, so three other items that have low loading factors, namely items number 2, 3, and 17, have been removed. even though it still fits marginally. It can be seen that the items are unfavorable and need to be reversed in scoring (Dagnall et al., 2019; Papageorgiou et al., 2018). None succeeded in having a high value, so all unfavorable items in the MTQid were excluded.

Referring to the classification of loading factor values from Comrey & Lee (1992), it can be stated that the Indonesian version of MTQ very short (MTQid-6) has a category range between good to very good. What was found in this study is in line with the findings of Kawabata et al. (2021), which shows that the very short MTQ (VS-MTQ) or 6-item version has a high loading factor value. However, if Kawabata and colleagues (2021) excluded reverse score items in the VS-MTQ because there were potential wording effects (Wang et al., 2015), this study did not do this, and the item exclusion relied on the loading factor value. Based on the loading factor values, the results of this study seem to find the same thing as Kawabata et al. (2021). Namely, unfavorable items do not pass the expected loading factor threshold ($\lambda \geq .50$). In other words, unfavorable items should be excluded from the model in this study. The above validity is strengthened by convergent validity results, which show that MTQid-6 has a significant correlation with MTI, PPI-A, and APSQ ($p < .001$).

The results of the MTQid-6 invariance test using the criteria from Chen (2007) ($\Delta CFI \geq -.01$, $\Delta RMSEA \geq .015$) can be stated that there is measurement invariance at the configural, metric, and scalar levels, while at the strict level, there is no measurement invariance. By referring to the criteria above, the results of this study are in line with previous studies that tested MTQ invariance and found that there was no significant reduction in model fit at the configural, metric, and scalar levels (Dagnall et al., 2019; Vaughan et al., 2018). In other words, this study confirms previous findings examining the MTQ. However, whereas previous studies only used gender groups (male vs. female), this study not only analyzed gender differences but also conducted analyses based on status (athlete vs. non-athlete groups) and age (<18 vs. ≥18).

The reliability analysis results show the values $\alpha = .762$, $\omega = .763$, and rix = .620 to .738. This indicates that the reliability of MTQid-6 is good. These results confirm the findings in the short version of the MTQ, which shows that the reliability of the MTQ found a value of $\alpha = .77$ (Papageorgiou et al., 2018). The MTQ reliability value, which is not very different, is also reported at .70 (Gucciardi et al., 2013). However, some researchers find the MTQ reliability

value above .80 (see, for example, Dagnall et al., 2019; Vaughan et al., 2018). Thus, the reliability of the MTQid-6 confirms the MTQ test results in studies.

In general, this research shows the importance of assessing the psychometric properties of an instrument translated into Indonesian to ensure that the measuring tool is valid and reliable for the target population. This study has carried out language and cultural adaptations by involving linguists and sports psychologists to address issues related to cultural and linguistic differences (Geisinger, 1994), connotations and expressions (Andayani et al., 2020), as well as linguistic gaps (Gjersing et al., 2010) that could weaken the validity of the scale (Denovan et al., 2021) have been strictly bypassed. Thus, the results of the evaluation of the MTQ factor structure found that MTQid-6 in the Indonesian context was considered valid and reliable for measuring MT in Indonesia, in athletes and non-athletes, and in males and females.

Limitations

Even though this study has attempted to carry out language adaptation and rigorous testing of psychometric properties and carry out invariance in two different groups (males vs. females; athletes vs. non-athletes), whereas previous studies only carried out invariance based on gender (Dagnall et al., 2019; Vaughan et al., 2018), but we consider there are three limitations to this study. First, although the athlete subjects involved were relatively large, this study did not classify athlete levels (e.g.: regional, national, and international). Second, the subject's age was not analyzed in more depthby classifying it between teenagers and adults. Third, this study only focuses on measuring mental-related dimensions and does not relate them to other constructs, for example, happiness in life (Dagnall et al., 2019; Wandik et al., 2024), grit and hardiness (Denovan et al., 2021), stress, depression and burnout (Kawabata et al., 2021; Gerber et al., 2018), religiosity and anxiety (Guntoro & Putra, 2022), physical capacity (Guntoro et al., 2023) and other psychological dimensions so that more in-depth analysis can be carried out such as structural equation modeling (SEM). By linking it with other variables and using SEM, it will be possible to explore more deeply the reliability of the MTQid-6 instrument and its contribution to the other constructs being investigated.

CONCLUSION

This study provides new insight concerning evaluating the short version MTQ factor structure (MTQ-18 and MTQ-10). Testing MTQ in the Indonesian context found a more concise MTQ, namely MTQ version 6 (MTQid-6). The MTQid-6 model fits the data and has good validity and reliability, so the MTQid-6 can be used to measure MT in athletes and non-

athletes, both men and women in Indonesia. Using valid and reliable measuring instruments to reveal MT, studies on MT, especially in Indonesia, will have more reliable data and results.

Based on these findings, we recommend that future studies consider the classification of athlete levels (e.g., regional, national, and international) and age levels (adolescents and adults) so that they can be analyzed in more depth regarding these categories. In addition, linking it with other relevant variables can be done to find more comprehensive results regarding the validity of MTQid-6 as an MT measurement tool for athletes and non-athletes in Indonesia.

PRACTICAL IMPLICATIONS

By successfully carrying out a psychometric structure evaluation of the short version of the MTQ, the researchers recommend trainers, students, and the public who want to study MT use the MTQid-6 as a data collection instrument. In addition, MTQid-6 can be used by practitioners in Indonesia to detect early MT conditions (athletes and non-athletes, males and females), which can then be used as initial information to provide support and improve the quality of MT. In other words, studies related to MT in Indonesia, either experimental, for example, providing MT training programs (Sutoro et al., 2023) or descriptive, can use MTQid-6 as a tool to measure the MT of research subjects.

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Authors' Contributions

The first, second, third, and tenth authors contributed to conceptualizing the research, research outline, and research method. The fourth, fifth, sixth, seventh, eighth, and ninth authors contributed to data collection and data analysis. The tenth, first, second, and third authors carried out critical interpretation of the final draft and finalization of the article.

Declaration of Conflict Interest

The authors have no conflicts of interest to report.

Ethics Statement

The protocol of the study was approved by the Health Research Ethics Committee, Faculty of Public Health, Universitas Cenderawasih with the number 065/KEPK-FKM UC issued on August 1, 2023. All respondents were requested to provide written informed consent before participating in this study.

REFERENCES

Andayani, T. M., Kristina, S. A., Endarti, D., Haris, R. N. H., & Rahmawati, A. (2020). Translation, Cultural Adaptation, and Validation of Short-Form 6D on the General Population in Indonesia. *Value in Health Regional Issues*, *21*, 205–210. https://doi.org/10.1016/j.vhri.2019.11.004

Azwar, S. (2013). *Reliabilitas dan validitas*. Pustaka Pelajar.

Bagozzi, R. P. (2010). Structural equation models are modelling tools with many ambiguities: Comments acknowledging the need for caution and humility in their use. *Journal of Consumer Psychology*, *20*(2), 208–214. https://doi.org/10.1016/j.jcps.2010.03.001

Birch, P. D. J., Crampton, S., Greenlees, I., Lowry, R., & Coffee, P. (2019). The Mental Toughness Questionniare-48: A Re-examination of Factorial Validity. *International Journal of Sport Psychology*, *48*(3), 331–355. https://doi.org/10.7352/IJSP.2017.48.331

Browne, M. W., & Cudeck, R. (1992). Alternative Ways of Assessing Model Fit. *Sociological Methods & Research*, *21*(2), 230–258. https://doi.org/10.1177/0049124192021002005

Chen, F. F. (2007). Sensitivity of goodness of fit indexes to lack of measurement invariance. *Structural Equation Modeling: A Multidisciplinary Journal*, *14*(3), 464–504. https://doi.org/10.1080/10705510701301834

Cherry, H. L. (2005). *Psychometric Analysis of an Inventory Assessing Mental Toughness* [University of Tennessee - Knoxville]. https://trace.tennessee.edu/utk_gradthes/588

Clough, P., Earle, K., & Sewell, D. (2002). Mental toughness: the concept and its measurement. In I. M. Cockerill (Ed.), *Solutions in sport psychology*. Cengage Learning, EMEA.

Clough, P. J., & Strycharczyk, D. (2012). *Developing Mental Toughness: Improving Performance, Wellbeing and Positive Behaviour in Others*. Kogan Page Limited.

Clough, Peter, Earle, K., Perry, J. L., & Crust, L. (2012). Comment on "Progressing measurement in mental toughness: A case example of the Mental Toughness Questionnaire 48" by Gucciardi, Hanton, and Mallett (2012). *Sport, Exercise, and Performance Psychology*, *1*(4), 283–287. https://doi.org/10.1037/a0029771

Comrey, A. L., & Lee, H. B. (1992). *A First Course in Factor Analysis*. Lawrence Erlbaum Associates, Inc.

Crust, L., & Azadi, K. (2010). Mental toughness and athletes' use of psychological strategies.

European Journal of Sport Science, *10*(1), 43–51. https://doi.org/10.1080/17461390903049972

Dagnall, N., Denovan, A., Papageorgiou, K. A., & Clough, P. J. (2019). Psychometric Assessment of Shortened Mental Toughness Questionnaires (MTQ): Factor Structure of the MTQ-18 and the MTQ-10. *Frontiers in Psychology*, *10*(1993), 1–12. https://doi.org/10.3389/fpsyg.2019.01933

Denovan, A., Dagnall, N., Hill-Artamonova, E., & Musienko, T. (2021). Mental toughness questionnaire (MTQ18): A Russian version. *National Security and Strategic Planning*, *2021*(3), 47–59. https://doi.org/10.37468/2307-1400-2021-3-47-59

Geisinger, K. F. (1994). Cross-Cultural Normative Assessment: Translation and Adaptation Issues Influencing the Normative Interpretation of Assessment Instruments. *Psychological Assessment*, *6*(4), 304–312. https://doi.org/10.1037/1040-3590.6.4.304

Gerber, M., Best, S., Meerstetter, F., Walter, M., Ludyga, S., Brand, S., Bianchi, R., Madigan, D. J., Isoard-Gautheur, S., & Gustafsson, H. (2018). Effects of stress and mental toughness on burnout and depressive symptoms: A prospective study with young elite athletes. *Journal of Science and Medicine in Sport*, *21*(12), 1200–1205. https://doi.org/10.1016/j.jsams.2018.05.018

Gjersing, L., Caplehorn, J. R., & Clausen, T. (2010). Cross-cultural adaptation of research instruments: Language, setting, time and statistical considerations. *BMC Medical Research Methodology*, *10*. https://doi.org/10.1186/1471-2288-10-13

Golby, J., Sheard, M., & van Wersch, A. (2007). Evaluating the Factor Structure of the Psychological Performance Inventory. *Perceptual and Motor Skills*, *105*(1), 309–325. https://doi.org/10.2466/pms.105.1.309-325

Gucciardi, D. F. (2017). Mental toughness: progress and prospects. *Current Opinion in Psychology*, *16*(16), 17–23. https://doi.org/10.1016/j.copsyc.2017.03.010

Gucciardi, D. F., & Gordon, S. (2009). Development and preliminary validation of the cricket mental toughness inventory (CMTI). *Journal of Sports Sciences*, *27*(12), 1293–1310. https://doi.org/10.1080/02640410903242306

Gucciardi, D. F., Gordon, S., & Dimmock, J. A. (2008). Towards an understanding of mental toughness in Australian football. *Journal of Applied Sport Psychology*, *20*(3), 261–281. https://doi.org/10.1080/10413200801998556

Gucciardi, D. F., Gordon, S., & Dimmock, J. A. (2009). Development and preliminary validation of a mental toughness inventory for Australian football. *Psychology of Sport and Exercise*, *10*(1), 201–209. https://doi.org/10.1016/j.psychsport.2008.07.011

Gucciardi, D. F., Hanton, S., Gordon, S., Mallett, C. J., & Temby, P. (2014). The Concept of Mental Toughness: Tests of Dimensionality, Nomological Network, and Traitness. *Journal of Personality*, *83*(1), 26–44. https://doi.org/10.1111/jopy.12079

Gucciardi, D. F., Hanton, S., & Mallett, C. J. (2012). Progressing measurement in mental

toughness: A case example of the Mental Toughness Questionnaire 48. *Sport, Exercise, and Performance Psychology*, *1*(3), 194–214. https://doi.org/10.1037/a0027190

Gucciardi, D. F., Hanton, S., & Mallett, C. J. (2013). Progressing measurement in mental toughness: A response to Clough, Earle, Perry, and Crust. *Sport, Exercise, and Performance Psychology*, *2*(3), 157–172. https://doi.org/10.1037/spy0000002

Guntoro, T. S., & Putra, M. F. P. (2022). Athletes' religiosity: How it plays a role in athletes' anxiety and life satisfaction. *HTS Teologiese Studies/Theological Studies*, *78*(1), a7802. https://doi.org/10.4102/hts.v78i1.7802

Guntoro, T. S., Sutoro, Putra, M. F. P., Kurdi, Németh, Z., & Setiawan, E. (2023). The role of anthropometry, physical, psychological and personality for elite athletes in competitive sports. *Pedagogy of Physical Culture and Sports*, *27*(4), 331–339. https://doi.org/10.15561/26649837.2023.0409

Hambleton, R. K., & de Jong, J. H. A. L. (2003). Advances in translating and adapting educational and psychological tests. *Language Testing*, *20*(2), 127–134. https://doi.org/10.1191/0265532203lt247xx

ITC. (2017). ITC Guidelines for Translating and Adapting Tests (Second Edition). *International Journal of Testing*, 15305058. https://doi.org/10.1080/15305058.2017.1398166

Kawabata, M., Pavey, T. G., & Coulter, T. J. (2021). Evolving the validity of a mental toughness measure: Refined versions of the Mental Toughness Questionnaire-48. *Stress and Health*, *37*(2), 378–391. https://doi.org/10.1002/smi.3004

Kerlinger, F. N. (2006). *Asas-asas penelitian behavioral*. Gadjah Mada Univeristy Press.

Kobasa, S. C. (1979). Stressful life events, personality, and health: An inquiry into hardiness. *Journal of Personality and Social Psychology*, *37*(1), 1–11. https://doi.org/10.1037/0022-3514.37.1.1

Liew, G. C., Kuan, G., Chin, N. S., & Hashim, H. A. (2019). Mental toughness in sport: Systematic review and future. *German Journal of Exercise and Sport Research*, *49*(4), 381–394. https://doi.org/10.1007/s12662-019-00603-3

Ohrbach, R., Bjorner, J., Metric, Q., Jezewski, M., John, M. T., & Lobbezoo, F. (2013). *Guidelines for establishing cultural equivalency of Instruments*. https://ubwp.buffalo.edu/

Papageorgiou, K. A., Malanchini, M., Denovan, A., Clough, P. J., Shakeshaft, N., Schofield, K., & Kovas, Y. (2018). Longitudinal associations between narcissism, mental toughness and school achievement. *Personality and Individual Differences*, *131*, 105–110. https://doi.org/10.1016/j.paid.2018.04.024

Pennebaker, J. W., Mehl, M. R., & Niederhoffer, K. G. (2003). Psychological Aspects of Natural Language Use: Our Words, Our Selves. *Annual Review of Psychology*, *54*, 547–577. https://doi.org/10.1146/annurev.psych.54.101601.145041

Putra, M. F. P., Kurdi, Syahruddin, S., Hasibuan, S., Sinulingga, A., Kamaruddin, I., Kristiyandaru, A., Mashud, Hariadi, I., Guntoro, T. S., Sutoro, S., Sinaga, E., Ibrahim,

Setiawan, E., Ridwan, M., Wanena, T., Hidayat, R. R., & Hariadi, I. (2024). An Indonesian Version of Mental Toughness Index: Testing Psychometric Properties in Athletes and Non-athletes. *Retos*, *55*, 816–824. https://doi.org/10.47197/retos.v55.106086

Putra, M. F. P., Rahayuni, K., Wanena, T., Larung, E. Y. P., Sinaga, E., Zainuri, A., Dwiariani, D. A., Numbery, G. K. I., Hidayat, R. R., & Wandik, Y. (2025). Psychometric Properties of the Athlete Psychological Strain Questionnaire (APSQ): Adapting and Validating Its Indonesian Version. *Sport and Tourism Central European Journal*, *8*(1), 1–10.

Putra, M. F. P., Sutoro, Guntoro, T. S., Sinaga, E., Wanena, T., Rahayuni, K., Jannah, M., Warni, W. E., Juriana, Priambodo, A., Tahki, K., Hariadi, I., Hidayat, R. R., & Wandik, Y. (2024). Cross-cultural adaptation of the psychological performance inventory-alternative (PPI-A) for the Indonesian context. *Retos*, *56*, 990–997. https://doi.org/10.47197/retos.v56.103765

Putra, M. F. P., Sutoro, & Sinaga, E. (2023). Mental atlet: Konstruk, pengukuran, dan arah penelitian ke depan. *Multilateral : Jurnal Pendidikan Jasmani Dan Olahraga*, *22*(1), 63–79. https://doi.org/10.20527/multilateral.v22i1.14785

Rice, S. M., Parker, A. G., Mawren, D., Clifton, P., Lloyd, M., Kountouris, A., Smith, B., Mcgorry, P. D., & Purcell, R. (2019). Preliminary psychometric validation of a brief screening tool for athlete mental health among male elite athletes: the Athlete Psychological Strain Questionnaire. *International Journal of Sport and Exercise Psychology*, *18*(1), 850–865. https://doi.org/10.1080/1612197X.2019.1611900

Sheard, M., Golby, J., & Van Wersch, A. (2009). Progress toward construct validation of the Sports Mental Toughness Questionnaire (SMTQ). *European Journal of Psychological Assessment*, *25*(3), 186–193. https://doi.org/10.1027/1015-5759.25.3.186

Sutoro, Guntoro, T. S., & Putra, M. F. P. (2023). Development and validation mental training model: Mental Toughness Training Circle (MTTC). *F1000Reserach*, *12*(169), 1–36. https://doi.org/10.12688/f1000research.129010.1

Stamatis, A., Morgan, G. B., Papadakis, Z., Mougios, V., Bogdanis, G., & Spinou, A. (2021). Cross-cultural invariance of the mental toughness index among American and Greek athletes. *Current Psychology*, *40*, 5793-5800.

Tiwari, S., & Sharma, J. (2007). *Development and Validation of Mental Toughness Questionnaire for Volleyball Players*. Annamali University, India.

Vaughan, R., Hanna, D., & Breslin, G. (2018). Psychometric properties of the Mental Toughness Questionnaire 48 (MTQ48) in elite, amateur and nonathletes. *Sport, Exercise, and Performance Psychology*, *7*(2), 128–140. https://doi.org/10.1037/spy0000114

Wandik, Y., Dina, Guntoro, T. S., Sutoro, Wambrauw, O. O. O., Abidjulu, C. F., Irab, S. P., Jembise, T. L., Wanena, T., Kmurawak, R. M. B., Rahayu, A. S., Manalu, J., Yektiningtyas, W., Gultom, M., Zainuri, A., J., N. J., Sinaga, E., Hidayat, R. R., Nurhidayah, D., … Putra, M. F. P. (2024). Interrelation of mental toughness, religiosity, and happiness of elite adolescent athletes based on gender, type of sport, and level of

education. *Retos*, *56*, 981–989. https://doi.org/10.47197/retos.v56.103469

Wang, W. C., Chen, H. F., & Jin, K. Y. (2015). Item Response Theory Models for Wording Effects in Mixed-Format Scales. *Educational and Psychological Measurement*, *75*(1), 157–178. https://doi.org/10.1177/0013164414528209

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Evaluation of Return to Sport and Anxiety in Injured Team Athletes: A Mixed Methods Study

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ABSTRACT

This study aimed to evaluate the return to sport and anxiety in athletes with anterior cruciate ligament injury. It was conducted using an exploratory sequential mixed design in mixed methods research. In the first phase of the study, 185 athletes (87 women and 98 men) with anterior cruciate ligament injuries were included in the quantitative dimension. In the qualitative dimension, semi-structured interviews were conducted with 18 athletes. In the quantitative and qualitative findings obtained, significant differences were obtained in terms of the return to sport and anxiety states of athletes with an anterior cruciate ligament injury in terms of the branch, league level, duration of return to sport, and age variables. Qualitative findings were used to support the results obtained from quantitative data. At this point, in the qualitative findings, the anxiety experienced by the athletes was very high. They emphasized that the change in the league level did not affect the process of return to sport. It was reported that athletes feared re-injury on return and were concerned that they would not be able to return to their previous performance. In other results related to qualitative findings, the importance of positive social support and physiotherapy support for injured athletes was emphasized. In their opinions about psychological support during the injury process, it was stated that psychological support is important for athletes in this process and that support should be obtained from expert sports psychologists, especially if needed.

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INTRODUCTION

Physical damage is caused by sports injuries, and psychological damage is suffered by injured athletes. Psychologically, sports injuries can seriously affect the athlete and hinder their abilities. The physical aspect of sports injuries is usually dealt with, while the psychological dimension is often left to the background. The psychology of the athlete's return to sport after injury is thought to be important, and at this point, research on the psychology of injury has begun (Brewer, 2009).

This research in the field of injury psychology has been conducted on athletes with different injuries and levels of play. It is seen that the psychological states of athletes during and after the injury process are examined. The theoretical foundations in this field emerged from the stress injury model created by Anderson and Williams. This model defines stress level as an important dimension of sports injuries. The relationship between stress in athletes' lives and injury rate has been discussed (Anderson & Williams, 1988). Stress is an important antecedent to injury and plays an important role in post-injury responses, rehabilitation, and return to sport. Athlete's psychological responses to injury, such as depression, suicidal ideation, anxiety, disordered eating and substance abuse, can trigger mental health problems. Athletes see seeking help in this process as a sign of weakness. Athletes feel that while they are trying to overcome physical problems, they should also be able to overcome psychological barriers. Injury is a process that has psychological as well as physical effects (Putukian, 2016). In the field of injury psychology, research has been conducted on athletes who have suffered many different types of injuries. It is known that anterior cruciate ligament injury is the most common type of injury encountered by athletes. Returning to sport after anterior cruciate ligament injury is a concern for athletes because the healing process is difficult and prolonged. Ardern et al.'s (2014) study reported that the main reasons athletes with anterior cruciate ligament injury could not return to sports were lack of confidence in the knee and fear of re-injury. Psychological readiness for return to sport supports return to sport before anterior cruciate ligament injury. It is important to understand the relationship between psychological factors and return to sport. It is important for the athlete to participate in physical rehabilitation after surgery and to have a good knee so that the athlete can return to sport. It is hypothesized that factors such as the cause, severity, type of injury, age, gender, ethnicity, and socioeconomic status of the athlete indirectly affect the return to sport. It is also emphasized that psychological factors have a significant impact on early recovery after anterior cruciate ligament injury (Clare et al., 2015).

The study aimed to examine in depth the return to sport and anxiety experienced by Turkish athletes during the injury process. The reason for the need for such a study is that there is no research on the anxiety and return to sports of injured Turkish athletes after injury. In this study, the data collection process was primarily carried out with quantitative research methods. Then, qualitative interviews were conducted to examine the research findings in more depth.

In this direction, whether there is a difference in terms of gender, time of return to sport, and level of play in terms of return to sport and anxiety status of injured athletes was examined primarily by quantitative method. Then, the results obtained from quantitative findings were aimed to be supported by qualitative research questions. In the study, the psychological conditions experienced by male and female athletes who are active in sports at different levels and in different branches in the process of returning to sports were examined.

METHODS

Research Design

The research design is an exploratory sequential mixed design, one of the mixed methods research designs. The purpose of using this design in the research is to explain the relationships between quantitative data in-depth with qualitative data. In the literature, the notation of exploratory sequential mixed design is NIC → nit (Creswell & Clark, 2020). The exploratory sequential mixed design is a useful design when qualitative data are needed to explain quantitative significant or surprising results. This study aimed to quantitatively examine the relationship between anxiety and return to sport in athletes with anterior cruciate ligament injury according to various variables. It is to reveal the reasons for the results obtained with the quantitative method in depth with qualitative ways. Therefore, exploratory sequential design was utilized. The research design, study group, data collection tools, collection, and analysis of data are presented separately for the quantitative and qualitative dimensions of the research.

Quantitative Dimension of the Research

Participants

The study population consisted of handball, volleyball, soccer, and basketball players with anterior cruciate ligament injuries living in different cities of Turkey. In the research, simple random method, one of the probability-based sampling methods was used (Creswell, 2020). Within the teams, 186 athletes (n=87 females, n=98 males) who had an anterior cruciate

ligament injury and returned to sports who voluntarily wanted to participate in the study participated in the study.

A total of 186 athletes with anterior cruciate ligament injuries, including 66 from the football branch, 44 from the volleyball branch, 38 from the basketball branch, and 37 from the handball branch, took part in the study. Among these athletes, 33 athletes at the Super League level, 39 at the 1st League level, 56 at the 2nd League level, and 57 at the Amateur League level participated. 53 athletes returned to sport between 1-6 months, 99 athletes who returned between 7-12 months, and 32 athletes who returned over 12 months.

Quantitative Data Collection Tools

The Return to Sport Scale (Webster et al., 2008) and the Sports Injury Anxiety Scale (Rex & Metzler., 2016) were used as data collection tools to evaluate athletes' return to sport and anxiety status with anterior cruciate ligament injury.

Validity and Reliability

Cronbach's Alpha value was found to be .84 in the reliability analysis of the Return to Sport After Anterior Cruciate Ligament Injury Scale. As a result of validity analyses, KMO and Bartlett's values were examined. As a result of Bartlett's test, $p = 0.00$ (<0.05) was found, and it was accepted that there was a relationship between the variables. KMO value was found to be .89

Reliability Analysis of Sports Injury Anxiety Scale Cronbach's Alpha value was found as .76. Confirmatory factor analysis was applied to check the structural validity of the anxiety scale. As a result of Bartlett's test, $P = 0.00$ (<0.05) was found, and it was accepted that there was a relationship between the variables. Kaiser Meyer Olkin (KMO) value was found as .82. It can be stated that both scales are valid and reliable.

Quantitative Data Analysis

The quantitative data collection process started on 11.03.2021 and was completed on 28.02.2022. Approval for the study was obtained from Anadolu University Scientific Research Publication Ethics Committee with Ethics Committee Decision No. 1/6 dated 31.03.2021.

Since competitions and training were suspended due to the Covid-19 pandemic, the scale application and qualitative interviews were conducted online. Confirmation of voluntary participation was obtained from each athlete, and the athletes were informed that they could leave the study at any time. IBM SPSS Statistics 26 package program and JASP 2021 program were used to analyze the research data. Normality analyses were conducted to determine

whether the data collected in the study were suitable for parametric or nonparametric tests. At this stage, skewness, kurtosis, Kolmogrov Smirnov values (for samples of 30 and above) and histograms of the data were examined. Parametric tests (Independent sample t-test, Anova and Manova) were applied to normally distributed data. Posthoc analyses were performed to determine the differences between the groups.

Qualitative Dimension of the Research

The qualitative dimension of this study, which was conducted with **an exploratory sequential mixed method design**, was aimed to reveal the opinions of athletes who had anterior cruciate ligament injuries about their return to sports and anxiety after injury.

Participants

Participant information in the qualitative dimension of the study varied in terms of gender, branch, league levels, psychological support, time of injury, and age of the injury. A total of 18 athletes, five women and 13 men, participated in semi-structured interviews. The study included three volleyballs, three handball, seven soccer, and five basketball branches. Considering the status of receiving psychological support, seven athletes received psychological support in this process.

Qualitative Data Collection Tool and Process

In qualitative data for the research, the semi-structured interview technique developed with evaluations of the data from the quantitative dimension was utilized. In preparing the semi-structured interview questions of the research, the findings that emerged after the analysis of the quantitative data and the literature on the subject were evaluated. The interview questions prepared by the researcher were reviewed with three faculty members who are experts in the field, and the interview questions were finalized. Pilot interviews were conducted with four athletes, reflecting the characteristics of the study group. As a result of the analysis of these interviews, some questions were reorganized. The updated interview questions were again shared with three expert instructors, and the interview form was finalized after the relevant feedback was received. The four pilot athletes interviewed were not included in the analysis. During the qualitative data collection process, appointments were made with the participants, and the interviews were conducted between September 28, 2022, and October 21, 2022, according to the determined interview schedule. Interviews ranged from approximately 17 minutes to a maximum of 55 minutes.

Analyzing Qualitative Data

A content analysis technique was used to analyze the study's qualitative data. Content analysis is defined as categorizing the data into categories by coding for an in-depth understanding of the data obtained by conducting interviews with people who voluntarily participated in the research and creating themes and sub-themes by revealing the relationships between these categories (Patton, 2002; Saldana, 2022). The data were coded by dividing them into the smallest meaningful parts within the scope of content analysis, then categories were created with these codes, and themes were reached by organizing the categories. The third researcher proceeded with the same process. Inter-coder reliability was ensured by comparing the coding, categories, and themes of the two researchers at the last stage. In this study, which utilized an exploratory sequential design, qualitative data were analyzed after quantitative data analysis. Quantitative and qualitative data were associated, evaluated, and interpreted.

RESULTS

In this section, the research findings are presented in accordance with the research problems. For this purpose, the findings obtained from quantitative data are presented first, followed by those obtained from qualitative data. Finally, quantitative and qualitative data were correlated and presented as a whole.

Findings on Quantitative Dimension

The study presented analyses related to the quantitative dimension of return to sport and anxiety. The independent sample t-test, conducted according to the gender variable given in Table 1, determined that there was no significant difference in the return to sport status of female and male athletes with anterior cruciate ligament injury (p >.05).

Table 1
Independent Sample T-Test of Anterior Cruciate Ligament Injury Return to Sport According to Gender Variable

	Gender	n	$\bar{X}$	Ss	t	p
Injury Return to Sport Scale	Female	87	64.32	25.89	-1.802	.073
	Male	98	71.48	27.88	-1.810	

According to the results of the ANOVA test presented in Table 2, p <.05 significant difference was found in the analysis of the Return to Sport Scale in terms of branch, league level, duration (intensity) of return to sport, and age variables. In the post hoc analyses conducted to determine the differences between the groups, when the differences in the branches were examined, differences were found in football-volleyball branches, volleyball-

basketball branches, and volleyball-handball branches. When the differences at the league level were analyzed, differences were found between Super League - amateur league, 1st league- amateur league, 2nd league- 1st league. When the differences were analyzed in terms of the duration of return to sports, differences were found between (1-6) months- 12 months and over and (7-12) months- (1-6) months. When the differences in the age variable were analyzed, a difference was found between 26-30 years of age and 31 years of age.

Table 2
One-Way Analysis of Variance (ANOVA) Test of Anterior Cruciate Ligament Injury Return to Sport According to Branch, League Level, and Return to Sport Time and Age Variables

ACL Scale		n	$\bar{X}$	Ss	F	p
Branch	Football	66	70.44	25.62	5.865	.001*
	Volleyball	44	54.02	29.01		
	Basketball	38	74.55	24.02		
	Handball	37	74.11	25.37		
League Level	Super League	33	74.94	22.13	7.719	.001*
	1st League	40	80.85	23.53		
	2nd League	56	63.23	24.43		
	Amateur League	56	58.70	30.13		
Return to Sport Duration	1-6 month	53	77.66	24.82	4.899	.008*
	7-12 month	100	64.88	27.42		
	12 months +	32	62.41	26.62		
Age	15-20 age	32	70.72	32.65	2.770	.043*
	21-26 age	54	67.96	25.05		
	26-30 age	48	75.17	28.70		
	31 yaş +	31	60.00	22.09		

Note. *: p<0.05

As a result of the independent sample t-test given in Table 3, significant differences (p<.05) were found in the sub-dimensions of suffering anxiety and loss of social support of the Sports Injury Anxiety Scale of female and male athletes who had anterior cruciate ligament injuries.

Table 3
Independent Sample T-Test of Sports Injury Anxiety Status of Athletes with Anterior Cruciate Ligament Injury According to Gender Variable

Anxiety Scale Sub Dimensions	Gender	n	$\bar{X}$	Ss	t	p
Anxiety of losing talent	Female	87	6.67	2.59	.032	.974
	Male	98	6.65	3.07		
Anxiety about being perceived as weak	Female	87	4.78	2.06	-1.567	.119
	Male	98	5.32	2.51		
Anxiety of suffering	Female	87	10.93	2.77	2.159	.032*
	Male	98	10.03	2.88		
Anxiety of disappointment	Female	87	8.13	3.78	.649	.517
	Male	98	7.78	3.56		
Loss of social support	Female	98	6.13	3.06	-3.254	.001*
	Male	87	7.81	3.84		
Anxiety of re-injury	Female	87	13.67	3.62	1.086	.279
	Male	98	13.05	4.03		

Note. *: p<0.05

According to the results of the MANOVA test presented in Table 4, a significant difference (p <0.05) was found in the sub-dimensions of anxiety of losing ability and anxiety of losing social support in terms of the branch variable of sports injury anxiety status of athletes who had anterior cruciate ligament injury. In the post-hoc analyses conducted to determine the differences between the groups, a difference was found in football-handball and volleyball-handball branches in the sub-dimensions of anxiety about losing one's ability. In the sub-dimensions of losing social support, differences were found in football-volleyball, football-basketball, and football-handball branches.

There was no significant difference (p >0.05) in the sub-dimensions of sports injury anxiety in terms of the league-level variable of the sports injury anxiety status of athletes with anterior cruciate ligament injury. A significant difference (p <0.05) was found in the sub-dimensions of pain anxiety, disappointment anxiety, and re-injury anxiety in terms of the time of return to sports in terms of the sports injury anxiety status of athletes with anterior cruciate ligament injury. In the post hoc analyses conducted to determine the differences between the groups, a difference was found between 1-6 months and 7-12 months in the sub-dimensions of anxiety about losing one's ability. There was a difference between 1-6 months and 7-12 months and between 7-12 months and 12 months and above in disappointment anxiety. There was a difference between 1-6 months and 7-12 months in the re-injury anxiety sub-dimension. A significant difference (p <0.05) was found in the sub-dimensions of anxiety about being perceived as weak and losing social support in terms of age variable in the sports injury anxiety status of athletes with anterior cruciate ligament injury. In the post hoc analyses conducted to determine the differences between the groups, a difference was found between the ages 21-26 and 26-30 in the anxiety of being perceived as weak and between the ages 21-26 and 26-30 in the sub-dimension of losing social support.

Table 4
Multiple Analysis of Variance (MANOVA) Test of Sports Injury Anxiety Status of Athletes with Anterior Cruciate Ligament Injury According to Branch, League Level, Return to Sports, and Age Variables

Sport Injury Anxiety Scale Sub-Dimensions		Pillai's Trace	*F*	sd	p
Branch	Anxiety of losing talent	.28	4.482	3	.005*
	Anxiety about being perceived as weak		.105		.957
	Anxiety of suffering		1.366		.255
	Anxiety of disappointment		1782		.152
	Loss of social support		9.101		.001*
	Anxiety of re-injury		.437		.727

Note. *: p <0.05

Table 4 (Continued)

Sport Injury Anxiety Scale Sub-Dimensions		Pillai's Trace	*F*	sd	p
League Level	Anxiety of losing talent	.86	2.173	3	.093
	Anxiety about being perceived as weak		.396		.756
	Anxiety of suffering		1.204		.310
	Anxiety of disappointment		.360		.782
	Loss of social support		.675		.568
	Anxiety of re-injury		.905		.440
Return to Sport Duration	Anxiety of losing talent	.13	2.856	2	.060
	Anxiety about being perceived as weak		1.373		.256
	Anxiety of suffering		3.081		.048*
	Anxiety of disappointment		4.485		.013*
	Loss of social support		2.442		.090
	Anxiety of re-injury		8.689		.001*
Age	Anxiety of losing talent	.15	.660	3	.578
	Anxiety about being perceived as weak		3.708		.013*
	Anxiety of suffering		2.470		.063
	Anxiety of disappointment		2.427		.067
	Loss of social support		3.483		.017*
	Anxiety of re-injury		2.208		.089

Note. *: p <0.05

Findings on Qualitative Dimension

The findings related to the qualitative dimension were formed as a result of semi-structured interviews with injured athletes. As a result of the analysis of the data obtained from these interviews, the findings were presented under seven themes. These themes are;

- Injury-anxiety relationship
- Injury and its relationship with league-level
- Return to sports process and injury
- Social support and injury
- Assessment of psychological support in injury
- Coping techniques and injury relationship
- Benefits of injury

The opinions of the injured athletes about the relationship between injury and anxiety are categorized in terms of category and code in Table 5. According to the results, the anxiety they experienced during the injury process was expressed under two categories: Cognitive anxiety and situational anxiety. In these categories, athletes frequently stated that they experienced anxiety and fear during and after the injury.

Table 5
Injured Athletes' Views on The Relationship Between Injury and Anxiety.

Theme	*Category*	*Code*	*f*	*Opinions*
Relationship between Injury and Anxiety	Cognitive Anxiety	Anxiety and Fear	19	*Participant V3's views; 'I was scared, I was very scared, when I was injured, it didn't seem so difficult, I didn't think it was something that couldn't be solved, but I was very scared because I couldn't use anything in the choice of surgery, I was worried, I was very scared.'*
		Failure to perform at the same level	13	
		Re-injury anxiety	9	
		Failure to return	5	
		Lack of confidence	4	
			50	
	Situational Anxiety	The Covid-19 process	4	*Participant F7's views; 'the thing that affected me psychologically the most was walking with a stick... I felt as if people's eyes were always on me, which made me psychologically very low.' The pandemic was also continuing during the period when I had surgery, I was completely at home because the pandemic was continuing, so the negativities of staying at home were reflected, that is, it had negative effects on my psychology.*
		Walking with a stick	4	
		Physiotherapy process (separate from the team)	4	
		Anxiety about the Future Surgery	4	
			4	
			16	

Three different categories were formed in the opinions of injured athletes about their current level of play and their ability to reach the same level on their return and are presented in Table 6. The categories were concerns about returning to sport after injury, lost opportunities, and positive perspective. It was found that the athletes' concerns about returning to the league level were related to whether they could reach their previous performance. Therefore, athletes preferred to play in the same or a lower league.

Table 6
Injured Athletes' Opinions About the League Level

Theme	**Category**	**Code**	**f**	**Opinions**
Relationship with injury and league level	Concerns about return	Concerns about achieving previous performance	9	*H4's views were as follows: 'You know, will I be able to provide the old performance because when you have a leg, even your running is affected and it is very difficult to recover again, I thought, of course, I thought if it would not be like before...'*
		Preference to stay in the same league or lower league	7	
		Playing in lower leagues due to fear	5	
			21	
	Lost opportunities	Not included in the national team	5	*H5's views; 'At the same time, I am a national athlete, so it was even more difficult for me, will I ever make the national team again?*
		Replacement by another player	2	
		Financial decline	2	
			9	
	Positive outlook	I knew I'd get my old performance back	9	*H6's opinion; 'being aware of these things, such as working continuously in the off-season, created awareness, so I was not worried that I would not be able to return again, because when I returned, I returned well, it was completely gone from my mind.'*
			9	

In Table 7, four different categories were formed about how injured athletes stayed away from sports. These categories were expressed as emotional reactions, physical reactions, return process, and time of injury in returning to sport after injury. It was stated that the athletes did not have much concern about the time of return to sports after the injury and whether the time was long or short was psychologically very long, but that this process was not psychologically very easy. It was emphasized that the time and age they experienced the injury were important.

In Table 8, the importance of support during the injury process was emphasized many times by the athletes. In this sense, it is of great importance that the club, coach, teammates and social environment support the athlete in this process. In this direction, the opinions received from the athletes were defined in three different categories: positive social support, physiotherapy support and its importance and lack of support.

Table 7
Injured Athletes' Opinions About the Period They Stayed Away From Sports

Theme	Category	Code	f	Opinions
Return to sport and injury	Emotional responses	Fear of experiencing the same processes again	8	*V1's views; '...I mean, I was crying in the room every night, my friends were there, they were going away and I was being treated, so I wanted to quit, I didn't want to go through this again and go through the same things again.*
		Staying away from sports	6	
		Crying	4	
		Desire to quit	3	
		Feeling alone	2	
			23	
	Physical responses	Pain	10	*F7's views; '....I could walk as much as possible with crutches, psychologically it was really a very difficult process for me'.*
		Ache	9	
		Trying to be cautious and controlled	6	
		Crutch walking	2	
			27	
	Return process	Time is not important to make healthy returns	12	*Participant B16's views are as follows; '...no, the right time is the right place, be careful, there is no need to rush, I always acted in a motivation. I always acted in anticipation of the right moment. I had to.'*
		Prolonged duration has affected	5	
		The effect of being at the beginning or end of the season	1	
			18	
	When the injury occurred	Injury at an early age made recovery easy.	9	*Participant H4's views; 'I was very young. Doctors were always saying that the growth of your height would be something, it might stop, you know, you are too young, the physical structure of the body is not fully established.'*
		Injury at a young age had a negative effect	6	
		Age has no effect	4	
		Muscles are in the developmental stage and cannot be fully diagnosed	2	
			21	

In Table 9, seven of the 18 injured athletes received psychological support before or during this process and continued during the injury process. Three athletes stated that they received support from a sports psychologist and that this support was beneficial and contributed positively to the athlete's return. Four athletes received psychiatric support; however, it was observed that it was not as effective as a sports psychologist. At this point, it is thought that sports psychologists are seriously important for athletes. It is thought that supporting athletes psychologically and physically will enable them to realize the return to sport in a healthier way.

In the category given in Table 10, it was stated that some coping practices were performed mentally during the recovery process of injured athletes and that these were beneficial.

Table 8
Injured Athletes' Views on the Support They Received During Their Return to Sport

Theme	Category	Code	f	Opinions
Social support and injury	Positive social support	Giving or receiving support from the injured athlete	24	*F7's opinion; 'The support of my coaches who knew me was positive, they treated me as if I had never come back from injury... my family and friends have always supported me in this process...'*
		Family-friends support	15	
		Teammate support	12	
		Coaching support	11	*Participant F9's opinion is as follows: 'If it wasn't for my family, I wouldn't have returned anyway, especially my mother...'*
		Social Support		
		Psychologically relaxed	11	
			73	
	Physiotherapy support	Physiotherapy is very important	14	*Participant F13's views; 'I don't think it is possible to return without a physiotherapist, even if you return, there is a very high chance of re-injury...'*
		Physiotherapist support	10	
			24	
	Lack of support	Negotiate low contracts with the club	6	*V1's views; 'injured... injured and injured... with an eye. For example, when a team called me and told me the price, but you were injured last year, you were wounded, so they looked at me like this is too much. I saw myself inadequate, I mean I saw myself incomplete, you know, this is a bad thing, you get a stigma, you are already injured!.*
		I never got any support from my coach	2	
		Being seen as injured and deficient	2	
			10	

Table 9
Injured Athletes' Views on Psychological Support

Theme	Category	Code	f	Opinions
Assessment of psychological support in injury	Importance of psychological support and reasons for seeking support	Support is important and must be received	14	*Participant V2's views; 'It was a great relief, I mean it was the first time I had experienced something like this, it was my first injury and as I said, I thought it would never happen to me, my return to the field was quicker, thanks to my psychologist, I think I recovered with her help.'*
		Due to Covid-19	1	
		Feeling alone and incomplete	1	
		Because of anxiety	1	
		Frustration and fear	1	
		Anger	1	
			19	
	Psychological support needs	I did not receive support	9	*F8's views; 'I would definitely recommend it... some people may not need it, for example, I didn't need it at all the first time, but it depends on the situation of the person at that moment, if there is a doubt or fear, I think they should definitely take it.'*
		If my club had psychological support, I would take it	5	
		To be taken when needed	4	
			18	
	Practices with psychologist	Imagination	3	*V2's opinion is as follows; '...he supported me a lot with videos showing how the athlete was injured and how he came back. or when an athlete could not do something, he supported me a lot with videos showing that he could do it with more than one thought or willingly'*
		Video monitoring	1	
		Try to think positive	1	
			5	

Table 10
Athletes' Opinions on Coping Techniques for Injury

Theme	Category	Code	f	Opinions
Coping techniques and injury relationship	Coping with injury practices	Talking to yourself	10	*Participant H6's views; 'I would definitely dream about it. You know, I would come back again, I would play at this level again, even higher than this level, and I would always think about the matches I played well while I was sleeping.*
		Video monitoring	10	
		Imagination	10	
		Stopping thinking	4	
		Staying away	2	
		Positive thinking	1	
		Goal setting	2	
			39	

DISCUSSION

In the results related to quantitative and qualitative findings, a significant difference ($p < 0.05$) was found in the sub-dimensions of anxiety of losing ability and anxiety of losing social support in terms of the branch variable in sports injury anxiety states. Qualitative findings: In the feedback received about the psychological state of injured athletes, it was determined that the anxiety experienced by the athletes was very high. They stated that athletes from all branches experience anxiety and fear in this process, especially anxiety about reaching their old performance/losing their ability, anxiety about re-injury, anxiety about not being able to return, and lack of confidence in their knee and themselves when they return (Table 5). It is

seen that the qualitative research findings at this point support the results obtained with the quantitative method. It is seen that similar studies conducted in the literature support these results.

When quantitative studies are examined in the literature, Kabak and Çelik (2022) examined the differences between injury anxiety in terms of the branch variable of sports injury anxiety in terms of team and individual sports branches. They found a significant difference in the sub-dimensions of the sports injury anxiety scale. In their research findings, Saki and Çankaya (2022) found that there was a low level of positive relationship between the sub-dimensions of sports injury anxiety level of soccer players. In the research findings of Ünver et al. (2020), when the sports injury anxiety scores of athletes were compared according to branches, a significant difference was found in the sub-dimensions of the sports injury anxiety scale. Tanyeri (2019) examined the differences between branches and injury anxiety and found a significant difference in the sub-dimension of 'disappointment anxiety'.

In qualitative research findings; Russel et al. (2024) suggest that re-injury anxiety and perceived ability limitations are psychological constructs that differ between those who return to sport and those who do not, and therefore, may be points of intervention to increase the probability of return to sport. Aydoğan et al. (2022) stated that athletes who experienced serious sports injuries felt blamed, impatience, perceiving the injury as serious, fear of not being able to show the same performance, and pressure to return to training. Şahin and Türksoy (2017) examined the opinions of football players with anterior cruciate ligament injury about the feelings, thoughts, and behaviors they experienced during the treatment process; it was revealed that the athletes were generally anxious, impatient, and impetuous about recovery, feared re-injury in this process and performed some movements uncontrollably with this fear. Tomalski (2013) reported that athletes experience fear of re-injury and have concerns about reaching their previous performance. Tjong et al. (2013) stated that athletes who returned to sports experienced fear upon returning; however, as they struggled with this fear, they gained self-confidence, and these fears decreased.

In the results related to quantitative and qualitative findings (Table 2 and Table 4), no significant difference ($p > 0.05$) was found in the sub-dimensions of sports injury anxiety in terms of the league-level variable. In the athletes' opinions about the league-level, it was determined that there were concerns about whether they would be able to reach their former performance again (Table 6). It was stated that the athletes were not concerned about whether there was a change in the league level. Concerns were expressed about missing opportunities with the national team or being replaced by other players. It is seen that qualitative findings

support the quantitative findings. It was found that the change in the league level of the athletes did not differ.

Similar quantitative studies supporting these results in the literature are as follows: Piussi et al. (2022) found that depression symptoms were more severe in professional athletes compared to recreational athletes. There was no difference in anxiety symptoms between professional and amateur athletes. Kayhan et al. (2019) did not find a statistical difference between injury anxiety levels in female athletes according to the analyses conducted according to sports levels (amateur-professional). In this case, it was stated that there was no difference in the injury anxiety of female athletes whether they were doing sports at amateur or professional level.

As for qualitative research, Trainor (2018) stated that athletes have concerns about losing and regaining their abilities. Athletes reported feeling guilty about being away from their team and felt pressure to prove themselves and regain their pre-injury skills when they returned to the sport. Tjong et al. (2013) defined those who could not return to pre-injury sports level as delayers and unconfident. Athletes who returned to their pre-injury activity levels reported being self-motivated, competitive, team-oriented, and self-aware. Evans et al. (2012) identified the replacement of semi-professional and professional team athletes by other players after injury as a stressor.

In the results related to quantitative and qualitative findings, a significant difference ($p<0.05$) was found in the sub-dimensions of suffering, disappointment and re-injury anxiety regarding the duration of return to sports. A significant difference ($p <.05$) was found in terms of branch, league level, and duration (severity) of return to sports (Tables 2 and 4). The athletes stated that they experienced fear of experiencing the same processes again, pain and suffering, and anxiety of re-injury in the process of returning to sports. It was stated that it is important to make a healthy return rather than a long or short period in the process of returning to sports. It was also emphasized that the time of injury is important in return (Table 7). The studies supporting these results in the literature are as follows;

Quantitative studies supporting these results in the literature are as follows: Injury severity is associated with increased stress and anxiety. Considering the psychological status of injury-prone athletes (Quan et al., 2025). Güler (2022) found that there was a relationship between the duration of injury and the sub-dimensions of injury anxiety. It was found that 'anxiety about losing social support' and 'anxiety about re-injury' increased in those with a longer duration of injury. Alshetıwı (2022) found that the level of anxiety in athletes with injury histories differed significantly, and the duration of injury was one of the factors that

increased this level of anxiety. Namlı and Buzdağlı (2020) found a statistically significant difference in the sub-dimensions of 'anxiety of disappointment' and 'anxiety of losing social support' in the duration of staying away from sports after injury. Williams (2019) found a statistically significant difference in the anxiety experienced between athletes less than 3 months away from sports and those with 3 months or more. It has been found that the longer an athlete is unable to participate in their sport, the more stress and anxiety they are likely to experience.

As for qualitative research; Clement et al. (2015) stated that the fear of injury increases in direct proportion to the length of time athletes stay away from sports. Athletes stated that they were concerned about the time to return to sport. Evans et al. (2012) found that the severity of the injury and the loss of time during the injury process affect the demands on the athlete during and after the injury process. Missed opportunities, important competitions, and games at the onset of injury are the most important stressors for athletes. At the same time, the inability to sign a contract due to the injury coinciding with the contract time and the uncertainty about it was defined as the stress factor that affected the athlete the most in this process. According to Podlog and Eklund (2009), athletes' time pressure and constraints to return to specific competitions and competitions affect their goals and expectations during the injury process.

In the qualitative findings, the importance of positive social support and physiotherapy support in this process was emphasized in the opinions received from the athletes about the relationship between social support and injury. It was emphasized that receiving or giving support from an injured person or the support of the social environment and the coach is important in returning (Table 8). The studies supporting these findings in the literature are as follows;

Yao et al. (2025) stated that the athletes did not receive social support from their clubs during the injury process and this situation led to insecurity. The importance of providing psychological support to athletes in this process was emphasized. Trainor (2018) stated that it would benefit athletes to receive social support from people who have had previous injuries and experience. They stated that social support can be meaningful and valuable as it comes from people with similar experiences. Clement et al. (2015) stated that injured athletes seek social support from important people in this process, especially from their coaches. It was emphasized that social support is necessary and important in recovery. Podlog et al. (2015) emphasized that athletes need support to increase their confidence in social support during

the injury process and to eliminate their concerns about the injury and that this support is important.

In the results related to qualitative findings, according to the opinions obtained from the evaluations related to psychological support in injury, it was stated that psychological support is important for athletes in this process and that support should be obtained from expert sports psychologists in case of need (Table 9). It has been stated that in addition to the athlete's physically healthy return, psychologically healthy return can be ensured with such support. The studies supporting these findings in the literature are as follows;

Truong et al. (2025) It has been emphasized that social support strategies and therapeutic applications will positively affect the motivation of athletes after sports-related knee injuries. Tranaeus et al. (2024) rehabilitation process may affect the cognitive, emotional, and behavioral reactions of the athlete. Social support, awareness, acceptance-based practices, and cognitive-behavior-based intervention programs reduce negative reactions and contribute positively to the return process. Afacan and Demir (2022) conducted a study with Turkish professional athletes at the Turkish Super League level. They found that soccer players need psychosocial (mental) support in areas such as concentration, motivation, self-confidence, and fear. According to Brewer (2009), psychological interventions can contribute to the prevention of sports injuries. Stress management and social support interventions were found to be effective in reducing the occurrence of sports injuries. Psychological interventions, biofeedback, relaxation/dreaming, goal setting, self-talk, relaxation, imagery, and goal setting have been applied to treat injured athletes.

In the results related to qualitative findings, according to the opinions about coping during the injury process, it was stated that some coping techniques (self-talk, imagination, watching videos, etc.) that athletes apply to themselves to cope with the injury in this process are beneficial in the recovery process (Table 10). The studies supporting these findings in the literature are as follows;

It is recommended to apply psychological techniques known as motor imagery in this process to reduce the loss of strength and anxiety of re-injury in athletes with acute injury and for the healthy development of the athlete (Mc Neil et al.,2025 & Liu et al.,2024). Estepp (2013) found that athletes most frequently use goal setting, communication, and time management**.** In Maddison's (2006) study, it was reported that athletes who participated in a stress management intervention lost less time due to injury at the end of the season than athletes who did not participate. It supports the suggestion that a stress management program is effective in preventing further time lost due to injury for athletes with a risky injury profile.

Cassidy (2006) suggests that athletes should be referred to a sports psychology counselor who is knowledgeable in relaxation techniques, imagery techniques and cognitive restructuring. Noh (2005) believes that identifying coping strategies is beneficial for reducing stress.

CONCLUSION

As a result of this research, the psychological conditions experienced by injured athletes after injury were analyzed with quantitative and qualitative methods. In line with the data and opinions received from the athletes, it was emphasized that the injury process negatively affects the athlete both physically and psychologically. With both quantitative and qualitative data, it was determined that athletes at all levels (Super League, 1st League, 2nd League, and amateur League) need psychological support.

At this point, scientific studies have shown that athletes should receive some psychological support as well as physical support in this process. In this process, it should not be ignored that the athlete needs to return to sports healthily. It is recommended that the athlete, physiotherapist, and coach communicate together during the injury process. The physiotherapist has great importance in supporting and motivating the athlete. Another person who is effective and important in this process is the athlete's coach. The more support the coach provides to the athlete in this process, the more it will positively affect their return to sport. The coach should be aware of this issue and, if necessary, seek support from experts in the field of sports psychology. King et al. (2023) The most important role that coaches play during rehabilitation is to provide social support to the injured athlete.

If the athlete needs it, getting support from a sports psychologist in this process is recommended. This has been the opinion of some athletes. I needed psychological support during the injury process, but I could not get it. The athlete must be mentally ready to return to sport. Newton et al. (2024) When the rehabilitation process is carried out with sports psychology specialists, it can make the athlete's rehabilitation process more comfortable. For an athlete who has suffered an anterior cruciate ligament injury, the re-injury anxiety affects the return to sport, so it is important to follow up on these processes for return. Anxiety, fear, or psychological concerns experienced by athletes should be evaluated (Grinberg, 2023).

As a result, psychologically supporting and motivating the injured athlete will help to speed up his/her comeback process. The attitudes and behaviors of the family, friends, social environment, physiotherapist, and coach will ensure that the athlete's return process will be positive.

PRACTICAL IMPLICATIONS

Maddison (2006) stated that stress management interventions are adequate to prevent time loss in injury. Forsdyke (2020) stated that athletes with more social support spend the rehabilitation process with less anxiety and have more self-confidence in returning to sport. Brewer et al, (1991) stated that practices such as relaxation, imagery, self-talk, goal setting are useful in the rehabilitation process. It is argued that psychological skill applications may be beneficial in injury rehabilitation (Scherzer et al., 2001., Brewer, 2009). It is recommended that coaches support this process, a social support network should be provided before the season, and relaxation, imagery, and cognitive studies should be carried out with a sports psychologist (Cassidy, 2006). It is seen that the results of our research support these findings in some respects.

In addition to physical follow-up of athletes after injury, psychological follow-up is recommended. Especially after severe injury, the athletes expressed that they experienced serious anxiety in the process of returning to sports. In this process, the support of the coach and club managers is important. Again, the support of teammates and family is important for athletes' return process. It will take a certain amount of time for the athlete to regain self-confidence, so it should not be forgotten that the athlete needs support in this process. The athlete may feel that he/she is not valued by the club, or he/she is worried about returning to his/her old career. Club managers should make the athlete feel their support. If the club or the athlete has the opportunity, getting support from a sports psychologist in this process is strongly recommended.

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Authors' Contributions

First author carried out the writing of the theoretical part of the article and the data collection process. Second author analyzed the qualitative data and took part in the qualitative discussion. Third author analysis of quantitative data and quantitative discussion are included in the conclusion**.**

Declaration of Conflict Interest

No potential conflict of interest was reported by the author(s).

Ethics Statement

Approval for the study was obtained from Anadolu University Health Sciences Scientific Research Publication Ethics Committee with the Ethics Committee Decision No. 1/6 dated 31.03.2021.

REFERENCES

Afacan, E. & Demir., M. (2022). Profesyonel futbolcuların psikososyal (mental) destek gereksinimlerinin araştırılması. *Akdeniz Spor Bilimleri Dergisi*, 5(1), 403-413. https://doi.org/10.38021/asbid.1203609

Alshetıwı, H. M. (2022). *Amatör futbolcularda sakatlanma kaygı düzeylerinin bazı değişkenlere göre incelenmesi.* Yüksek Lisans Tezi. İstanbul: İstanbul Gelişim Üniversitesi, Lisansüstü Eğitim Enstitüsü.

Anderson, M. B. & Williams, J. M. (1988). A model of stress and athletic injury: Prediction and prevention. *Journal of Sport and Exercise Psyhology*, 10 (3), 294-306. https://doi.org/10.1123/jsep.10.3.294

Ardern, C. L., Österberg. A., Tagesson. S., Gauffin. H., Webster. K. E., & Kvis. T. J. (2014). The impact of psychological readiness to return to sport and recreational activities after anterior cruciate ligament reconstruction. Br J Sports Med, 48 (22), 1613-1619. https://doi.org/10.1136/bjsports-2014-093842

Aydoğan, Z., Kerkez, F. I., Can, S. & Manav, G. (2022). Spor yaralanmalarının psikolojik etkilerinin değerlendirilmesi. *Akdeniz Spor Bilimleri Dergisi*, 5(2), 278-290. https://doi.org/10.38021/asbid.1122253

Brewer, B. W., Van Raalte, J. L & Linder, D.E. (1991) Role of the sport psychologist in treating injured athletes: A survey of sports medicine providers. Journal of Applied Sport Psychology, 3(2), 183-190. https://psycnet.apa.org/doi/10.1080/10413209108406443

Brewer, B. W. (2009). Injury prevention and rehabilitation. Sport Psychology. International. Brewer. B.W (Editor), *Handbook of sports medicine and science sport psychology* (s. 75-87). Blackwell publishing.

Cassidy, C. M. (2006). *Understanding sport injury anxiety*. Sport psychology and counseling. Athletic therapy today. Human Kinetics, 11(4), 57-58.

Clare, L., Joanna Kvist, & Kate E. (2015). Psychological aspects of anterior cruciate ligament injuries. *Operative Techniques in Sports Medicine*, 24 (1), 77-83. https://doi.org/10.1053/j.otsm.2015.09.006

Creswell, J., Plano Clark. V. (2020). *Karma yöntem araştırmaları tasarımı ve yürütülmesi*. (Çev: Y. Dede ve S.B. Demir). Ankara: Anı yayıncılık.

Clement, D., Arvinen-Barrow. M., & Fetty.T. (2015). Psychosocial responses during different phases of sport-injury rehabilitation: A qualitative study. Journal of Athletic Training, 50(1), 95–104. https://doi.org/10.4085/1062-6050-49.3.52

Evans, L., Wadey, R., Hanton, S., & Mitchell, I. (2012). Stressors experienced by injured athletes, Journal of Sports Sciences, 30(9), 917-927. https://doi.org/10.1080/02640414.2012.682078

Estepp, M. K. (2013). *NCAA Division I athletic trainers' perceptions and use of psychological skills during injury rehabilitation.* Master's Thesis, Konoxville: University of Tennessee.

Forsdyke. D.M. (2020). Psychosocial factors and return to sport outcomes in football: A mixed methods approach. Degree of Doctor of Philosophy. London: York St John University.

Golafshani, N. (2003). Understanding reliability and validity in qualitative research. *The Qualitative Report,* 8(4), 597-606. https://doi.org/10.46743/2160-3715/2003.1870

Güler, Y.E. (2022). Hentbolcularda yaralanma kaygısı düzeyinin farklı değişkenler açısından incelenmesi. *Spor Eğitim Dergisi*, 6 (2). 99-108. https://doi.org/10.55238/seder.1147358

Grinberg. A. (2023). Re-injury Fear and Anxiety Following Anterior Cruciate Ligament Injury. Let's Get Our Constructs Straight!. JOSPT Open Published Online: October 27, 2(1) Pages4-7. https://doi.org/10.2519/josptopen.2023.0807

Kabak, S. & Çelik, A. (2022). Spor alanı ile ilgili özel yetenek sınavına girecek olan bireylerin branşlarına göre spor yaralanma kaygı düzeylerinin incelenmesi. *Akdeniz Spor Bilimleri Dergisi*, 5(1), 444-454. https://doi.org/10.38021/asbid.1206245

Kayhan, R. F., Yapıcı, A. & Üstün, D.Ü. (2019). Kadın sporcuların yaralanma kaygılarının çeşitli değişkenlere göre incelenmesi. *Sportif Bakış: Spor ve Eğitim Bilimleri Dergisi*, 6 (1), 276-287. https://doi.org/10.33468/sbsebd.109

Kirk, J. & Miller, M. L. (1986). *Reliability and validity in qualitative research.* Sage Publications, Thousand Oaks, CA.

King, J., Burgess, T. L., Hendricks, C., & Carson, F. (2023). The coach's role during an athlete's rehabilitation following sports injury: A scoping review. *International Journal of Sports Science & Coaching*, 18(3), 928-944. https://psycnet.apa.org/doi/10.1177/17479541221150694

Liu, S., & Noh, Y. E. (2024). The effectiveness and applicability of mindfulness intervention in psychological adaptation after sports injury: a systematic review. Australian Journal of Psychology, 76(1). https://doi.org/10.1080/00049530.2024.2357627

Maddison, R. (2006). *Sport related injury: Prediction, prevention, and rehabilitation. A psychological approach.* Doctor of Phılosophy Thesis. New Zealand: University of Auckland.

McNeil D. G, Lindsay R. S., Worn R., Spittle, M., & Gabbett T. J. (2025). Could Motor Imagery Training Provide a Novel Load Management Solution for Athletes? Recommendations for Sport Medicine and Performance Practitioners. *Sports Health. 17*(1):156-163. https://doi.org/10.1177/19417381241297161

Mills, G. E. (2003). *Action research. A guide for the teacher researcher*. Upper Saddle River, NJ: Pearson Education, Inc.

Miles, M, B., & Huberman, A. M. (1994). Qualitative data analysis: An expanded Sourcebook. (2nd ed). Thousand Oaks, CA: Sage

Namlı, S. & Buzdağlı, Y. (2020). Aktif sporcuların yaralanma sonrası kaygı düzeylerinin incelenmesi. *Gazi Beden Eğitimi ve Spor Bilimleri Dergisi*, 25(4), 469-480.

Newton, C., & Chu, T. L. (Alan). (2024). Rehabilitation Profiling for Injured Elite Athletes: A Case Study with Implications for Rehabilitation, Recovery, and Return-to-Sport Transitions. *Journal of Sport Psychology in Action*, 16(1), 5–17. https://doi.org/10.1080/21520704.2024.2359699

Noh, Y. E. (2005). *Psychosocıal intervention for the prevention of injury in dance.* Doctor of Phılosophy Thesis. Melbourne: Vıctorıa University.

Patton. M. Q. (2002). Qualitative research and evaluation methods (3rd ed.). Thousand Oaks, CA: Sage Publications.

Patton, M. Q. (2014). Qualitative Research & Evaluation Method. Sage Publication.Page: 520

Putukian, M. (2016). The psychological response to injury in student athletes: a narrative review with a focus on mental health. Br J Sports Med, 50, 145–148. https://doi.org/10.1136/bjsports-2015-095586

Podlog, L., Eklund, R. C. (2009). High-level athletes' perceptions of success in returning to sport following injury. *Psychology of Sport and Exercise*, 10, 535–544. https://psycnet.apa.org/doi/10.1016/j.psychsport.2009.02.003

Podlog, L., Banham, S. M., Wadey, R., & Hannon. J. C. (2015). Psychological readiness to return to competitive sport following injury: A Qualitative Study. *The Sport Psychologist,* 29, 1-14. https://psycnet.apa.org/doi/10.1123/tsp.2014-0063

Piussi, R., Berghdal, T., Sundemo, D., Grassi, A., Zaffagnini, S., Sansone, M., Samuelsson, K., & Senorski. E.H. (2022). Self reported symptoms of depression and anxiety after ACL Injury. *The Orthopaedic Journal of Sports Medicine,*10(1),1-9. https://doi.org/10.1177/23259671211066493

Rex. C. C & Metzler. J. N. (2016). Development of the sport injury anxiety scale. *Measurement in Physical Education and Exercise Science*, 20(3), 146-158. https://psycnet.apa.org/doi/10.1080/1091367X.2016.1188818

Saki, U & Çankaya, S. (2022). Üniversite oyunlarına katılan futbolcularda spor yaralanması kaygı düzeyi ile çok alanlı kararlılık arasındaki ilişkinin incelenmesi. *Spor Bilimleri Araştırmaları Dergisi, 7*(2), 498-514. https://doi.org/10.25307/jssr.1120485

Saldana, J. (2022). *Nitel araştırmacılar için kodlama el kitabı*. (Çev: A. Tüfekçi., S.N. Şad). Ankara: Pegem Akademi.

Scherzer, C. B., Brewer, B. W., Cornelius, A. E., Van Raalte, J. L., Petitpas, A. J., Sklar, J. H., Pohlman, M. H., Krushell, R. J., & Ditmar. T. D. (2001). Psychological skills and adherence to rehabilitation after reconstruction of the anterior cruciate ligament. *J Sport Rehabil, 10*, 165-172.

Russel. H.C., Arendt. E.A., Wiese Bjornstal.D.M. (2024) Psychological Responses During Latter Rehabilitation and Return to Sport After Anterior Cruciate Ligament Reconstruction Surgery. *J Athl Train. 59* (6): 627–632. https://doi.org/10.4085/1062-6050-0058.23

Şahin, M. & Türksoy, A. (2017). Ön çapraz bağ yaralanması geçiren futbolcuların psikolojik sağlamlıklarının İncelemesi üzerine nitel bir araştırma. *The Journal of Social Science*, *16*, 51-65. http://dx.doi.org/10.16990/SOBIDER.3870

Tanyeri, L. (2019). Farklı branş sporcularında yaralanma kaygısının incelenmesi. *Uluslararası Toplum Araştırmaları Dergisi*, 9 (13), 577-591. https://doi.org/10.26466/opus.588668

Tomalski, J. L. (2013). *The relatıonshıp between coping and sport injury anxıety among college athletes*. Degree Master of Science. North Carolina: The University of North Carolina.

Tjong, V. K., Murnaghan, L., Nyhof-Young, J. M., & Ogilvie-Harris, D. J. (2013). A qualitative investigation of the decision to return to sport after anterior cruciate ligament reconstruction. *The American Journal of Sports Medicine*, *20*(10),1-7. https://doi.org/10.1177/0363546513508762

Trainor, L. R. (2018). *The rebalancing act: Women's experiences of psychological well-being during serious sport injury*. Degree of Master of Arts. Vancover: The University of British Columbia.

Tranaeus. U., Gledhill. A., Johnson. U., Podlog.L., Wadey. R., Bjornstal. D.W., & Ivarsson. A. (2024). 50 Years of Research on the Psychology of Sport Injury: A Consensus Statement. *Sports Medicine 54:*1733–1748. https://doi.org/10.1007/s40279-024-02045-w

Truong, L. K., Mosewich, A. D., Miciak, M., Losciale, J. M., Li, L. C., & Whittaker, J. L. (2025). Social support and therapeutic relationships intertwine to influence exercisebehavior in people with sport-related knee injuries. *Physıotherapy Theory And Practıce* Vol. 41, No. 1, 139–152. https://doi.org/10.1080/09593985.2024.2315520

Unver, Ş., Şimşek E., Islamoğlu I. & Arslan H. (2020). Universite takımlarında yer alan sporcuların yaralanma kaygı düzeylerinin Iincelenmesi. *Beden Eğitimi ve Spor Bilimleri Dergisi,* 14(3), 400-410.

Webster, K.E., Feller, J.A., Lambros, C. (2008). Development and preliminary validation of a scale to measure the psychological impact of returning to sport following anterior cruciate ligament reconstruction surgery. *Phys Ther Sport*, *9*(1), 9–15. https://doi.org/10.1016/j.ptsp.2007.09.003

Williams, D. M. (2019). *Pshychological health of injured college athletes. Master of Arts in Psychology,* Houston: Houston Baptist University.

Quan, G., Xiao, H. & Chen, Y. Exploring the mechanisms influencing psychological adaptation in athletes in high-risk sports: a moderated mediation model. *Sci Rep* 15, 2259 (2025). https://doi.org/10.1038/s41598-025-86432-x

Yao, Z., Al-Hashimy, H. N. H., & Yao, J. (2025). Psychosocial impact and rehabilitation strategies for basketball-related injuries: SEM-PLS analysis. *WORK*, 0(0). https://doi.org/10.1177/10519815241300290

Yıldırım, A & Şimşek, H. (2006). *Nitel araştırma yöntemleri*. Ankara: Seçkin Yayıncılık.

https://doi.org/10.54141/psbd.1595606

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Pamukkale J Sport Sci, 16(1), 253-270, 2025 Review

The Impact of Foam Rolling on Recovery and Performance Components (ROM, Strength, Jump, Agility): A Systematic Review

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ABSTRACT

Foam rolling has emerged as one of the most popular recovery methods in recent years. This study aims to evaluate the effects of foam rolling on the recovery process and various performance parameters in athletes and healthy active individuals. This research is a systematic review that analyzes randomized controlled trials published in English between January 2014 and March 2024, accessed through electronic databases such as PubMed, Scopus, and EBSCO SportDiscuss with Full Text. The keywords used in the search include "foam rolling," "foam roller," "foam rolling massage," and "myofascial release." The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were utilized to guide the research process and the preparation of the report. According to the inclusion and exclusion criteria, 14 articles were included in this review. The findings suggest that foam rolling accelerates recovery after injuries, facilitates the overall recovery process, and generally enhances performance. On the other hand, there is no definitive evidence indicating adverse effects on performance. Foam rolling may help mitigate declines in muscle performance, particularly in terms of physical attributes such as strength, power, and agility, and reduce perceived pain and effort following intense exercise. However, due to the heterogeneity of the study samples, further research focusing specifically on sports-related applications is recommended.

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INTRODUCTION

The health benefits of physical activity are well established. However, intense exercise can lead to immediate and delayed physiological changes, placing significant stress on the musculoskeletal system and resulting in muscle fatigue, reduced mobility, and exercise-induced muscle damage (Harrison et al., 2024). Exercise-induced muscle damage is characterized by increased muscle soreness, impaired muscle function, and loss of strength (Jiaming & Rahimi, 2021). Particularly in sports that require high technical demands and repetitive movements, effective management of the recovery process after training and competition is crucial. Various recovery methods used in this process are broadly classified into active and passive recovery strategies (Bishop et al., 2008).

Among active recovery methods, dynamic stretching, massage, electrical stimulation, cold-water immersion, low-intensity aerobic exercises, sauna, whole-body cryotherapy, and foam rolling (FR) techniques are commonly utilized (Dutta et al., 2023; Rahimi et al., 2020; Rey et al., 2019). FR is a widely used active recovery method, particularly among athletes, aiming to reduce muscle stiffness, enhance range of motion (ROM), and alleviate muscle tension by applying pressure to soft tissue (Jo et al., 2018; Konrad et al., 2022). Recent research suggests that FR not only accelerates recovery but also improves key physical performance parameters such as ROM, muscle strength, flexibility, agility, and jump performance (MacDonald et al., 2014; Nakamura et al., 2021).

By utilizing body weight, FR facilitates the release of muscle tension. Athletes roll a firm foam cylinder back and forth over their muscles, applying pressure to soft tissues (Beardsley & Škarabot, 2015). Due to their shapes and sizes, foam rollers allow for covering a large surface area while applying appropriate pressure. Variations such as spiked, knobbed, and vibrating foam rollers are believed to provide more sensitive and deeper effects (Michalak et al., 2024). Although comprehensive studies on the effectiveness and precise mechanisms of FR are lacking, various morphological and physiological mechanisms may contribute to accelerated recovery (Aboodarda et al., 2015).

The physiological mechanisms underlying FR's role in recovery are multifaceted. FR is believed to enhance blood circulation in muscle tissue, facilitating the removal of metabolic waste and increasing oxygen supply (Okamoto et al., 2014). Additionally, it has been suggested that FR improves proprioception and neuromuscular function, contributing to enhanced muscle performance. Furthermore, FR has been reported to increase

parasympathetic nervous system activity, promoting muscle relaxation and reducing perceived muscle soreness (Beardsley & Škarabot, 2015). Recent studies indicate that FR reduces arterial stiffness and improves vascular function, potentially accelerating muscle repair and recovery (Kiyono et al., 2020).

The use of FR in post-exercise recovery has gained increasing popularity among athletes. Studies have investigated its effectiveness in team sports (e.g., soccer, basketball), endurance sports (e.g., long-distance running, cycling), and strength-based disciplines (e.g., weightlifting, CrossFit). However, there are conflicting findings in the literature regarding the effectiveness of FR in different sports. Recent studies have demonstrated the positive effects of FR on performance parameters, including range of motion (ROM), muscle pain, and strength. A study investigating the acute effect of foam rolling on eccentrically induced muscle damage showed that a 90-second foam rolling (FR) session, applied 48 hours after exercise, significantly reduced muscle soreness and improved muscle strength (Nakamura et al., 2021). Similarly, another recently study stressed that FR not only reduced muscle pain but also improved joint proprioception and decreased strength loss after eccentric exercises (Naderi et al., 2020). MacDonald et al., (2014) reported that FR performed after exercise-induced muscle damage (EIMD) increased knee joint ROM compared to a control group. Likewise, FR applied to the hamstring muscles significantly increased ankle joint ROM (Halperin et al., 2014). Another study demonstrated significant improvements in muscle performance tests, including power, speed, strength, and agility, when FR was incorporated into a warm-up protocol (Peacock et al., 2014). Romero Moraleda et al., (2017) observed that maximum voluntary contraction in the rectus femoris muscle improved following FR treatment compared to manual therapy techniques such as neurodynamic mobilization. A review by Wiewelhove et al. (2019) reported a trend toward improved sprint performance following FR. Conversely, some contradictory findings were present in previously scientific studies. MacDonald et al., (2013) found no beneficial effects on muscle performance when measuring maximum voluntary contraction. A study involving twenty-six healthy college students found no effect of FR on isometric strength compared to plank exercises (Healey et al., 2013). A study by Halperin et al. (2014) found no significant differences between FR and static stretching as recovery tools. Recovery from high-intensity exercise is crucial for regaining previous performance levels. A review of the current literature reveals the positive effects of FR on maintaining physical performance and perceived levels.

Due to the contradictory findings in the current literature and the limited number of randomized controlled trials examining the effects on athletes and healthy active individuals, it is essential to examine variables such as application duration, intensity, and methodological differences in more detail to better understand the role of FR in different sports. This situation necessitates a further systematic review of the effect of FR.

In this context, the present systematic review aims to evaluate the effects of FR on recovery processes and various physical performance parameters, including muscle strength, range of motion (ROM), agility, flexibility, and jumping performance, in athletes and physically active individuals. In this review, "*performance*" refers specifically to measurable physical attributes such as muscle strength, range of motion (ROM), flexibility, agility, and jump performance**.** These components were selected based on the most commonly reported outcome measures across the included randomized controlled trials. A comprehensive review of the current literature findings and an examination of the role of FR in recovery may provide valuable insights for its application in sports science.

METHODS

Study Design

A systematic review was conducted to discuss the findings of studies examining the effects of foam rolling (FR) on athletes and healthy active individuals, and to establish a fundamental guide for using foam rolling as a recovery strategy in athletes. This study was carried out in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2015). A schematic representation of the systematic review is shown in Figure 1. Ethical approval was not required for this study.

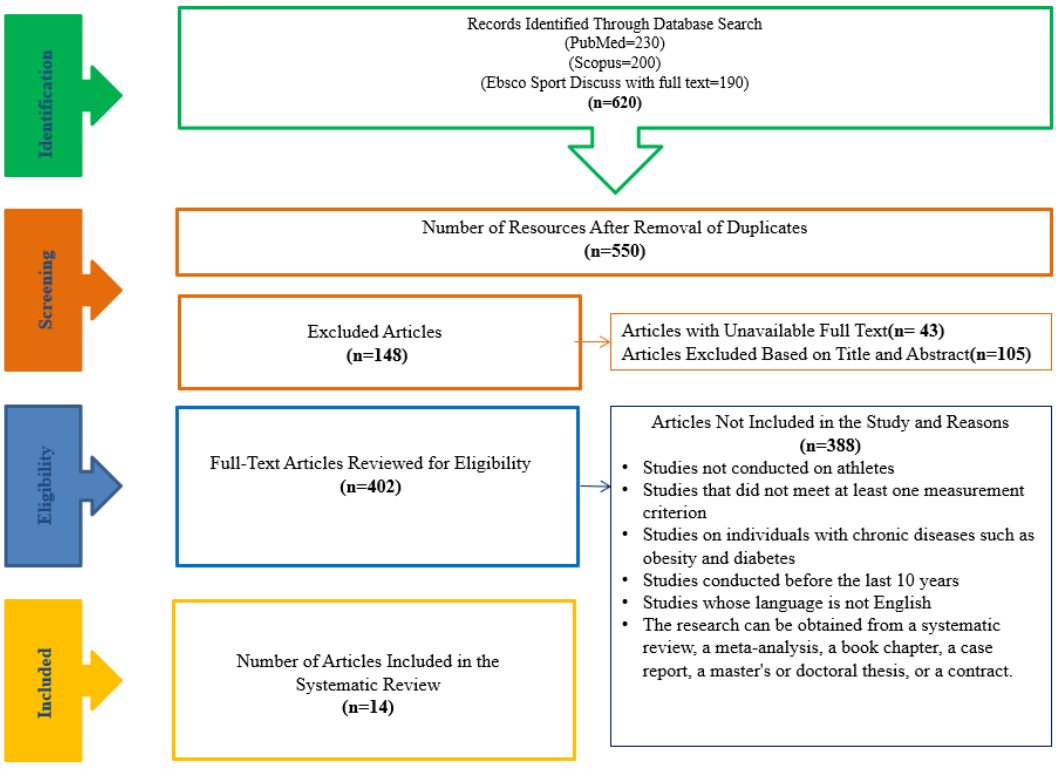
Search Strategy

This present study is a systematic review conducted by searching electronic databases (PubMed, Scopus, Ebsco SPORTDiscuss with Full Text) for English randomized controlled studies from January 2014 to March 2024. Keywords such as “foam rolling,” “foam roller,” “foam rolling massage,” and “myofascial release” were used in the review. Boolean search principles (e.g., “foam rolling OR foam roller AND sport OR performance OR exercise”) were applied. Articles related to athletes' recovery processes and performance were screened, and full-text articles were evaluated based on inclusion criteria for sampling.

Study Selection

The data were evaluated outlined in the PRISMA guidelines (Figure 1), in accordance with the inclusion criteria. The selection of studies was based on the following inclusion and exclusion criteria; i) Inclusion Criteria: The present systematic review included randomized controlled trials that investigated any combination of treatments involving foam rolling (FR) on athletes (e.g., foam rolling combined with stretching) or trials that included another treatment as a control condition (e.g., stretching). Studies involving active, healthy individuals who did not specifically identify as athletes were also included. There were no restrictions regarding gender, ethnicity, or race. Only studies published in the last ten years, in English, and conducted as randomized controlled trials were included. Additionally, studies had to include at least one common outcome measurement, which was determined as "jump-power performance"; ii) Exclusion Criteria: Studies published more than ten years ago, those not written in English, non-randomized controlled trials, reviews, book chapters, conference abstracts, studies not conducted on athletes, studies involving individuals with chronic illnesses, studies for which full text could not be accessed, articles with mismatched titles and abstracts, and duplicated articles were excluded. Studies that did not assess the common outcome measurement were also excluded.

Figure 1
PRISMA Flow Diagram of the study (Moher et al., 2015)



Data Analysis

The quality of the included studies was assessed using the Physiotherapy Evidence Database (PEDro) scale, which has demonstrated high reliability and validity for this purpose (Verhagen et al., 1998). The version of the scale adapted from a recent review by Sarmento et al. (2018) was used. All ten quality criteria were rated on a three-level scale: Yes = 2 points, Maybe = 1 point, No = 0 points. Total scores ranged from 0 to 20. Two researchers conducted Independent assessments. In case of discrepancies, these were resolved through a consensus discussion with a third senior researcher. The data quality evaluation scores of the included studies are shown in Table 1.

RESULTS

Initial Search Results

A total of 620 references were initially obtained. After applying the research criteria, 14 studies were selected for inclusion). The number of participants and their characteristics, the exercise and recovery protocols used in the studies, the tests applied, and the results obtained are summarized in Table 3. Each article was screened and evaluated based on its title, abstract, and full text for eligibility. A total of 402 articles were subjected to further screening and evaluation. After excluding studies published more than ten years ago, those that were not randomized controlled trials, those not written in English, and studies excluded for various reasons (e.g., not involving athletes), 14 articles were included in the study (Figure 1).

Participant Characteristics

The characteristics of the study participants, the exercise protocols used, and the main results obtained from the included studies are explained in Table 2. The participants in the included studies were healthy, active individuals with a background in certain sports. Their ages typically ranged from 20 to 35 years, with one study involving participants under the age of 18. None of the participants had chronic conditions such as obesity or diabetes. Additionally, individuals with a history of smoking, medication and steroid use, or musculoskeletal disorders were excluded. A total of 410 participants across 14 studies were included in the review. Since some studies did not specify gender, the exact number of males and females is not precise. No distinctions were made based on gender, religion, language, or race in the selection of participants.

Table 1
Data Quality Assessment Scores Given to Studies

Author, Year	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Total Score
Rahimi et al., 2020	1	2	1	2	2	2	2	2	2	0	16
Rey, E. et al., 2019	2	2	1	2	2	1	2	2	2	0	16
Nakamura et al., 2023	2	2	1	2	2	2	2	2	2	0	17
Giovanelli et al., 2018	2	2	1	2	2	1	2	2	2	0	16
Healey et al., 2013	2	2	1	2	2	2	2	2	0	1	16
Pearcey et al., 2015	2	1	1	2	2	2	2	2	1	2	17
Romero-Franco et al., 2019	2	2	1	2	2	2	2	2	2	0	17
Ko´zlenia et al., 2022	2	2	1	2	2	2	2	2	2	2	19
Oliveira et al., 2023	2	0	2	2	2	2	2	2	2	0	16
Romero-Moraleda et al., 2019	2	2	2	2	2	2	2	1	2	2	19
Lin et al., 2020	1	2	1	2	2	2	2	2	2	0	16
Akarsu et al., 2022	2	2	1	2	1	2	2	2	0	2	16
Wang et al., 2022	2	2	1	2	2	2	2	2	2	0	17
Chen et al., 2021	1	2	1	2	2	2	2	2	2	0	16

Note. Q: Question

Recovery Protocols

The recovery protocols are summarized in Table 2. In some studies, a control group was used for comparison with FR-based recovery. Control groups used methods such as passive recovery, static stretching, planking, dynamic stretching, and recovery with percussive devices (PVPD). Some studies employed a crossover design, where groups alternated according to specific rules and applied each recovery method used in the study. While the duration of the FR protocols varied across studies, they were applied rotationally to specific muscle groups within a defined rest and application time. In some studies, vibrational FR and double FR were used.

Tests and Measurements Performed in Studies

The studies included in the review measured various parameters, including jump performance, agility, sprint, perceived effort, flexibility, muscle pain, total quality recovery, range of motion (ROM), tissue stiffness, strength, proprioception, and sport-specific metrics. For jump performance, tests such as squat jump, vertical jump, counter movement jump (CMJ), drop jump, and squat jump via EXER were used. Agility was assessed using the PRO agility test and the T-test. For anaerobic power, the repeated sprint test was used, while aerobic capacity was measured through the Yo-Yo intermittent recovery test level 2 (YYIRT-L2). Perceived effort was measured with the Borg CR-10 Test and general fatigue scale. Flexibility was assessed using the Thomas test, Ely test, and sit-and-reach test. Pain was measured using the Visual Analog Scale (VAS), pressure pain threshold, and palpation. Perceptual

measurements were taken using the Hooper Index (HI) and total quality recovery (TQR). Tissue stiffness was measured using a myometer, and joint range of motion was assessed with ROM tests.

Table 2
Summary of data From Articles Included in the Review

Author/Year	Characteristics	Recovery Protocol	Tests	Study Results
Rahimi et al., 2020	Iran (U-23) Futsal, 6 d/w, 90 min/day training, 19 years, M, n=16 (FR 8; CG 8)	FR: 15 min post-match (3 sets x 40 sec x 20 sec rest/exercise); lower extremities.	SJT - PRO Agility Test - HI – RST YYIRTL2- Borg CR-10 Scale - KL	Anaerobic Power (SJT); FR ↑ Blood lactate removal FR ↑ Perceptual indices of the FR methıd. ↑ On the performance indicators of FR ↔
Rey et al., 2019	Elite football, 5d/wk training, 22-30 years n=18 (FR: 9; CG: 9)	FR: 20 min post-match (2 sets x 45 sec x 15 sec rest/exercise); CG: PT	TQR –VAS –Sit&Reach test, CMJ -5m and 10m Sprint Test, T Test	CMJ, in both groups T Test, in CG ↓ FR, T-Test performance ↑ Flexibility in both groups ↔
Nakamura et al., 2023	Mean age 22, M, n=15	FR+SS, SS+FR, FRvibration+SS, SS+ FRvibration, passive recovery, respectively.	Knee flexion ROM; PPT -Tissue stiffness ; CMJ	Knee flexion ROM in all conditions ↑ Tissue hardness in all conditions ↓ Max. Iso. contraction after FR+SS ↓ Adding vibration to FR ↔
Giovanelli et al., 2018	Mean age: 26, active healthy students	1 min SMFR for each muscle on eight muscle groups	Treadmill test, Squat, CMJ test(EXER), Borg CR-10 scale	Post-exercise Cr, in the next 3 hours ↑ Pos-exercise ↓ Max power during, after and 3 hours after CMJ ↑
Healey et al., 2013	Mean age 21, active healthy students, n=26 (13M, 13F)	FR: Muscle groups for 30 sec CG: Planking	Palpation Pain, General Fatigue, Borg CR-10 test, Vertical jump test, Isometric strength - Agility test	No difference was seen between the groups in all 4 athletic tests. Higher level in men in all athletic tests Pain, fatigue, effort in both groups Pain; more fatigue ↑
Pearcey et al., 2015	Healthy active M, n=8	FR: 20 min (45 sec x 15 sec rest/exercise)	Quadriceps pressure pain threshold, Sprint test -power T-Test Squat 70% 1RM	FR, quadriceps pressure pain threshold ↑ Significant effects ranged from small to large for sprint duration, power, and dynamic strength-endurance.
Romero Franco et al., 2019	Age 18-25; athlete; n=30 (18M, 12F; FR: 15, CG:15)	Post-run FR: 6 min (45 sec x 15 sec rest/exercise) ; lower extremity	DiF, KE, DiE, ADF ROM, Diz propioception - CMJ	EG, 0 min and 10 min ADF and CMJ compared to baseline ↑
Ko´zlenia et al., 2022	Age 20-25; amateur athlete; n=30 (14M, 16F; FR:15, CG:15)	Post-warm-up FR: 15 sec per lower extremity muscle group and 20 reps CG: warm-up	SJ, CMJ, DJ	FR: All jump test parameters ↑
Oliveira et al., 2023	Age 25-35; experienced athlete; M; n=39 (FR=13 SG=13 PD=13)	After HIFT FR: 20 min (2 sets x 45 sec x 15 sec rest/exercise) SS: 20 min (45 sec x 15 sec rest/exercise) PD: 20 min passive sitting	FS, VAS, TQR, Sit-Reach Test (Flexibility), CMJ Test, T-Test	Strength and flexibility; none returned to baseline ↑ Deteriorations at 24 hours in all groups. FR; perceptions of superior recovery

Table 2 (Continued)

Author/Year	Characteristics	Recovery Protocol	Tests	Study Results
Moraleda et al., 2019	Mean age 22; active individual; n=38 (32M,6F)	Post-Squat NVFR: Regular FR VFR Group: Vibration FR	VAS, CMJ, PAKF, PAKE Dif ROM	VFR; VAS ↑ VFR; PKE ROM ↓
Cheng Lin et al., 2020	Age 20-30; badminton athlete n=40(25 M, 15 F; DS: 20; DS+VFR:20)	Post-training DS: Dynamic warm-up exercise, VFR: vibration FR for 20 seconds for each muscle group	DIF, DIE ROM, Mymeter (stiffness), Flexibility ely test CMJ Agility Test	DS: DS; DiF ROM, CMJ, Agility ↑ Quadriceps and gastrocnemius muscle stiffness ↓ DS + VFR: DiE ROM ↑ Quadriceps muscle stiffness ↓
Akarsu et al., 2022	Taekwondo athletes with at least three years of experience, average age 16; n=21	Running, Running+ SS, Running+ FR conditions	CMJ	No difference between running and SE. Statistically significant differences between running and FR and FR and SE
Wang et al., 2022	Mean age 20; tennis player; n=27	VFR: 7 min vibrating foam roller, PVPD: 7 min vibrating percussion device CG: 7 min sitting	CMJ, DJ, HT, 2,5 m Lateral Acceleration test, Y-Balance Test	VFR: CMJ and HT results and reactive strength index (RSI) according to CG ↑
Chen et al., 2021	Mean age 20; taekwondo athlete; M; n=15	GW: 5 min running + 5 min sitting + 5 min DS, GW+VFR: 5 min running + 3 sets of VR, GW + double VFR	Flexibility Test, CMJ, Agility Test, HT, Kick Speed Frequency	HT in GS+VR vs. GS ↑ GS + VR and GS + double VR, kick frequency ↑ GS + VR and GS + double VR did not significantly improve flexibility and CMJ asymmetry performance.

Note. d/w: days/week, M: male, F: female, FR: foam rolling, CG: control group, PT: passive recovery, SS: static stretching, FR: Foam Rolling; VFR: vibrating foam rolling, CMJ: counter movement jump, ROM: range of motion, SMFR: Self-myofascial foam rolling, Rc: running cost, RM: maximum repetition, KF: knee flexion, HE: hip extension, KE: knee extension, ADF: ankle dorsiflexion, PR: passive rest, HIFT: high-intensity functional training, NVFR: non-vibrating foam roller, VFR: vibrating foam roller, PAHF: passive active hip flexion, PAHE: passive active hip extension, DW: dynamic warm-up, PVPD: vibrating percussion device, GW: general warm-up, SJT: Squat Jump Test, HI: Hooper Index, RST: Repeated Sprint Test, YYIRTL2: Yo-Yo Intermittent Recovery Test, KL: Blood lactate level, TQR: Total quality improvement, VAS: Visual analog scale, PPT: Pain pressure threshold, -SJ: Squat Jump, DJ: Falling Jump, FS:Sensory scale, HT: Hexagon test

DISCUSSION

Given the widespread use of foam rolling (FR) in sports performance, this study aimed to determine the recovery effects of FR on various performance parameters such as jump performance, muscle strength, flexibility, agility, and range of motion (ROM) in athletes and healthy active individuals. A review of the literature revealed that a study by Schroeder and Best (2015) reported unclear outcomes regarding the use of FR as a pre-exercise recovery strategy. Similarly, a study by McKenney et al. (2013) found only a few practical and beneficial outcomes. Beardsley and Škarabot (2015) conducted a more in-depth review of FR use, finding conflicting results regarding its effects on flexibility, strength development, sports performance, and delayed-onset muscle soreness (DOMS). Given the time that has elapsed since these studies were published and their focus on different populations, the present

systematic review aimed to provide a comprehensive analysis of the effects of FR on specific physical performance variables in athletes. Our findings are particularly significant given the widespread application of FR methods in sports performance.

The results of our study suggest that FR may facilitate post-exercise recovery and improve key performance parameters such as ROM, muscle strength, flexibility, agility, and jump performance. Additionally, there is no clear evidence indicating a negative impact of FR on performance. Various differences in recovery protocols, participant characteristics, study designs, FR duration and intensity, timing of post-exercise assessments, and individual differences within athletic populations highlight the importance of considering these factors.

The effects of FR may vary across different sports disciplines due to the specific physiological and biomechanical demands of each activity. Research suggests that endurance athletes (e.g., long-distance runners and cyclists) primarily benefit from FR in terms of maintaining ROM and reducing muscle soreness, likely due to its effects on circulation and myofascial relaxation (Okamoto et al., 2014). In contrast, strength-based athletes (e.g., weightlifters and CrossFit participants) exhibit mixed responses; some studies report improvements in power output, while others find no significant difference compared to static stretching or other recovery methods (MacDonald et al., 2013). Furthermore, team sport athletes engaged in high-intensity intermittent efforts (e.g., soccer and basketball players) appear to benefit from FR by enhancing recovery between matches and reducing perceived muscle soreness (Rey et al., 2019). However, inconsistencies remain regarding its effects on explosive power and agility, emphasizing the need for sport-specific research.

When examining the effects of FR on ROM values, significant improvements in ankle dorsiflexion ROM were observed compared to passive recovery methods. However, no superiority was noted when compared to static stretching methods. While dynamic stretching increased ROM values, adding vibration FR to dynamic stretching had no additional effect. The observed increase in ROM may be related to various factors, including tissue flexibility, temperature, perfusion, fatigue, and the reorganization of tissue fibers (Gajdosik, 2001; Madding et al., 1987; McHugh & Cosgrave, 2010; Wepple & Magnusson, 2010). The short duration of the included studies means that long-term effects could not be evaluated, preventing any definitive conclusions regarding the long-term benefits of FR on ROM or flexibility. Additionally, it is worth noting that a variety of methods were employed to assess ROM, including goniometry, inclinometers, isokinetic dynamometry, and sit-and-reach tests. Measurement errors during testing may have contributed to the observed positive effects.

In line with the reviewed studies, the effects of FR on various sports performance parameters have been clearly outlined. Regarding jump power performance, in the commonly used countermovement jump (CMJ) test, eight studies reported statistically significant improvements with FR, two studies found negative effects, and four studies reported no effect. It was determined that FR application was superior to passive recovery in terms of CMJ performance but showed no difference compared to static stretching. Additionally, no significant difference was found when compared to plank exercises. However, a notable gender difference was observed, with men achieving higher values in all performance tests than women. Vibrating FR was found to provide similar benefits to non-vibrating FR but did not demonstrate superiority. The variability in protocols used across studies made it difficult to consolidate the data into a common conclusion.

Regarding the effects of FR on agility, no significant difference was found compared to passive recovery. Similarly, no significant difference was observed when compared to plank exercise recovery methods. However, a gender difference was again noted, with men outperforming women in all performance tests. When examining T-test scores, Rey et al. (2019) reported that FR minimized potential performance declines compared to passive recovery, while Pearcey et al. (2015) reported positive effects of FR. In contrast, De Oliveira et al. (2023) stated that FR did not provide superiority over other methods. The activation of proprioceptors through FR may enhance muscle contraction and response speed. The contradictory findings regarding agility may be explained by the hypothesis that muscle tone and stiffness negatively affect agility test performance (Alonso-Calvete et al., 2022).

Adding vibration resistance training (VRT) to dynamic stretching did not provide additional benefits compared to dynamic stretching alone; however, it showed significant improvements when incorporated into general warm-up protocols. When repeated sprint tests were examined, no significant impact of FR on performance was observed; however, it did not cause a decline in performance either. In the absence of FR, muscle soreness was found to affect all performance measures negatively. In terms of strength, Healey et al. (2013) found no difference between different applications but reported gender differences, with men performing better in all measurements. Nakamura et al. (2023) observed a decrease in maximal isometric contraction torque when static stretching was applied alongside FR.

In flexibility assessments, FR was not found to be superior to other recovery protocols. This may be because the force applied to muscles through FR may not be sufficient to improve flexibility. However, some studies suggest that FR has positive effects on flexibility (Aune et

al., 2019; Guillot et al., 2019; Junker et al., 2015, 2019; Kiyono et al., 2020). The benefits of FR on flexibility are primarily associated with acute neural responses, with optimal results observed two minutes after application and effects diminishing within approximately 30 to 60 minutes.

When considering the effects of FR on all parameters, although many studies support its benefits, inconsistencies in the literature can be attributed to several factors. In terms of application duration and frequency, short-duration FR applications (<120 seconds/muscle group) typically provide acute improvements in ROM, whereas longer durations (>5 minutes/muscle group) may be more effective in reducing muscle soreness and accelerating recovery (Healey et al., 2013; Nakamura et al., 2021). However, there is no consensus in the literature regarding the optimal duration of FR. Regarding the timing of performance measurements in studies, assessments conducted immediately after exercise may not fully reflect the effects of FR, as its benefits for reducing muscle soreness and promoting relaxation typically become more pronounced within 24–48 hours (Wiewelhove et al., 2019). This variation may explain why some studies report no significant impact of FR on performance parameters.

Individual factors such as being a professional or amateur athlete, gender, age, and training level can influence the effects of FR. Elite athletes may benefit less from FR due to their already well-developed recovery mechanisms, whereas amateur or recreational athletes may experience more noticeable improvements (Beardsley & Škarabot, 2015). Additionally, the response to FR may be related to an individual's baseline muscle stiffness and flexibility. Female athletes generally have greater joint range of motion (ROM), suggesting that FR may be more effective in increasing ROM in women (Chen et al., 2021). In contrast, male athletes may derive greater benefits from FR in terms of reducing muscle stiffness and managing pain (Konrad et al., 2022). Studies have also reported that in older individuals, FR has more pronounced effects on increasing blood circulation and reducing muscle stiffness (Kiyono et al., 2020).

Comparative studies of FR with static stretching, dynamic stretching, and passive recovery methods have yielded conflicting findings. However, FR is more effective than passive recovery in maintaining ROM and reducing muscle soreness (Wiewelhove et al., 2019). Therefore, FR is recommended as a more advantageous recovery strategy compared to complete rest. Some studies suggest that FR is more effective than static stretching in enhancing ROM and flexibility, while others report no significant difference between the two

methods (Halperin et al., 2014). The combination of FR with dynamic stretching has been reported to lead to greater improvements in performance parameters (Chen et al., 2021).

Recent studies have also compared FR with cryotherapy and percussion therapy, such as massage guns. While FR has been found effective in reducing muscle stiffness and increasing ROM, percussion therapy may be more advantageous for deep tissue relaxation (De Oliveira et al., 2023). These comparisons suggest that FR may be more effective when combined with other recovery methods.

Limitations

This systematic review may be subject to some bias, as it only included studies published in English and sourced research from limited databases. Different exercise protocols were employed across the included studies, utilizing various treatments, application durations, and measurement methods, resulting in varying outcomes. This situation hinders the clarity of the findings. Furthermore, due to the heterogeneity of studies, it is difficult to determine the correct application of FR in physical sports training. Therefore, the study's results should be viewed from this perspective.

CONCLUSION

The results of this systematic review suggest that FR accelerates recovery after injury, facilitates post-exercise recovery, generally enhances performance, and does not hurt performance. FR may also alleviate decreases in muscle performance and reduce perceived pain and effort following intense exercise. The findings indicate that FR does not negatively affect athletic performance. This suggests that FR is a recovery tool rather than a performance enhancer. Therefore, FR seems to be a suitable method for use during or before warm-up. Some studies recommend its use in combination with dynamic stretching (DS) and active warm-up (Lin et al., 2020; Chen et al., 2021). Due to the heterogeneity of methods across studies, there is no consensus on the optimal FR protocol. Sufficient high-quality evidence is lacking to draw definitive conclusions. Future research should focus on replicating methods and using larger sample sizes. The current literature provides some evidence for the use of FR in the athletic population, but limitations should be considered before integrating these methods.

PRACTICAL IMPLICATIONS

This study was to determine whether foam rolling affects performance when used as a recovery method. Foam rolling can be used as a recovery method before or during a warm-up in athletes and healthy active individuals.

Authors' Contributions

This study was conducted with the contributions of three authors. The study design was carried out by the first author, with contributions from the second and third authors. Data collection was conducted by the first and second authors. Statistical analysis was performed jointly by the first and second authors. The manuscript was prepared by all three authors.

Declaration of Conflict Interest

There is no conflict of interest or gain in the article**.**

Ethics Statement

This review was conducted in accordance with academic ethical standards. All sources were properly cited, and no data manipulation or plagiarism occurred. Approval of the ethics committee is not required for this article.

REFERENCES

Aboodarda, S. J., Spence, A. J., & Button, D. C. (2015). Pain pressure threshold of a muscle tender spot increases following local and non-local rolling massage. *BMC Musculoskeletal Disorders, 16*, 265. https://doi.org/10.1186/s12891-015-0729-5

Akarsu, M., Kurhan, C. O., İlbak, İ., Altuntop, R., Gönç, M., Stojanović, S., & Purenovic-Ivanović, T. (2022). Acute effects of self-myofascial release through foam roller and static stretching methods on vertical jump performance of taekwondo players. *Journal of Pharmaceutical Negative Results, 13*(S06), 2226–2230. https://doi.org/10.47750/pnr.2022.13.S06.289

Alonso-Calvete, A., Lorenzo-Martínez, M., Padrón-Cabo, A., Pérez-Ferreirós, A., Kalén, A., Abelairas-Gómez, C., & Rey, E. (2022). Does vibration foam roller influence performance and recovery? A systematic review and meta-analysis. *Sports Medicine - Open, 8*(1), 32. https://doi.org/10.1186/s40798-022-00421-2

Aune, A. A., Bishop, C., Turner, A. N., Papadopoulos, K., Budd, S., Richardson, M., & Maloney, S. J. (2019). Acute and chronic effects of foam rolling vs eccentric exercise on ROM and force output of the plantar flexors. *Journal of Sports Sciences, 37*(1), 138–145. https://doi.org/10.1080/02640414.2018.1486000

Beardsley, C., & Škarabot, J. (2015). Effects of self-myofascial release: A systematic review.

Journal of Bodywork and Movement Therapies, 19(4), 747-758. https://doi.org/10.1016/j.jbmt.2015.08.007

Bishop, P. A., Jones, E., & Woods, A. K. (2008). Recovery: Post-exercise strategies and applications. *Sports Medicine, 38*(6), 415-431. https://doi.org/10.2165/00007256-200838060-00003

Chen, C. H., Nosaka, K., Chen, H. L., Lin, M. J., Tseng, W. C., & Chen, T. C. (2021). Effects of foam rolling on range of motion, muscle stiffness, and muscle strength. *European Journal of Applied Physiology, 121*(1), 59-69. https://doi.org/10.1007/s00421-020-04469-y

De Oliveira, F., Paz, G. A., Corrêa Neto, V. G., Alvarenga, R., Marques Neto, S. R., Willardson, J. M., & Miranda, H. (2023). Effects of different recovery modalities on delayed onset muscle soreness, recovery perceptions, and performance following a bout of high-intensity functional training. *International Journal of Environmental Research and Public Health, 20*, 3461. https://doi.org/10.3390/ijerph20043461

Dutta, P., Saha, D., & Mahato, A. K. (2023). Foam rolling and its effectiveness in sports recovery: A review. *Journal of Sports Sciences, 41*(5), 512-525. https://doi.org/10.1080/02640414.2023.2169910

Gajdosik, R. L. (2001). Passive extensibility of skeletal muscle: Review of the literature with clinical implications. *Clinical Biomechanics, 16*(2), 87-101. https://doi.org/10.1016/s0268-0033(00)00061-9

Giovanelli, N., Vaccari, F., Floreani, M., Rejc, E., Copetti, J., Garra, M., Biasutti, L., & Lazzer, S. (2018). Short-term effects of rolling massage on energy cost of running and power of the lower limbs. *International Journal of Sports Physiology and Performance, 13*(10), 1337-1343. https://doi.org/10.1123/ijspp.2018-0142

Guillot, A., Kerautret, Y., Queyrel, F., Schobb, W., & Di Rienzo, F. (2019). Foam rolling and joint distraction with elastic band training performed for 5–7 weeks respectively improve lower limb flexibility. *Journal of Sports Science & Medicine, 18*(1), 160.

Halperin, I., Aboodarda, S. J., Button, D. C., Andersen, L. L., & Behm, D. G. (2014). Roller massager improves range of motion of plantar flexor muscles without subsequent decreases in force parameters. *International Journal of Sports Physical Therapy, 9*(1), 92-102.

Harrison, D. C., Smith, J. A., & Brown, K. (2024). The physiological adaptations to foam rolling: A meta-analysis. *Journal of Strength and Conditioning Research, 38*(3), 455-472. https://doi.org/10.1519/JSC.0000000000004567

Healey, K. C., Hatfield, D. L., Blanpied, P., Dorfman, L. R., & Riebe, D. (2013). The effects of myofascial release with foam rolling on performance. *Journal of Strength and Conditioning Research, 28*(1), 61-68. https://doi.org/10.1519/JSC.0b013e3182956569

Jiaming, Y., & Rahimi, M. H. (2021). Creatine supplementation effect on recovery following exercise-induced muscle damage: A systematic review and meta-analysis of

randomized controlled trials. *Journal of Food Biochemistry, 45*(10), e13916. https://doi.org/10.1111/jfbc.13916

Jo, E., Juache, G., Sarussam, A., & Kim, D. H. (2018). Acute effects of self-myofascial release using a foam roller on flexibility and muscle performance. *Journal of Sports Medicine and Physical Fitness, 58*(7-8), 993-1000. https://doi.org/10.23736/S0022-4707.18.08497-5

Junker, D., & Stöggl, T. (2019). The training effects of foam rolling on core strength endurance, balance, muscle performance and range of motion: A randomized controlled trial. *Journal of Sports Science and Medicine, 18*, 229.

Junker, D. H., & Stöggl, T. L. (2015). The foam roll as a tool to improve hamstring flexibility. *Journal of Strength and Conditioning Research, 29*(12), 3480–3485. https://doi.org/10.1519/JSC.0000000000001007

Kiyono, R., Onuma, R., Yasaka, K., Sato, S., Yahata, K., & Nakamura, M. (2020). Effects of 5-week foam rolling intervention on range of motion and muscle stiffness. *Journal of Strength and Conditioning Research*. https://doi.org/10.1519/JSC.0000000000003757

Koźlenia, D., & Domaradzki, J. (2022). Acute effect of short intensive self-myofascial release on jump performance in amateur athletes: A randomized cross-over study. *International Journal of Environmental Research and Public Health, 19*(24), 16816. https://doi.org/10.3390/ijerph192416816

Konrad, A., Nakamura, M., Tilp, M., Donti, O., & Behm, D. G. (2022). Foam rolling training effects on range of motion: A systematic review and meta-analysis. *Sports Medicine, 52*(10), 2523-2535. https://doi.org/10.1007/s40279-022-01699-8

Lin, W. C., Lee, C. L., & Chang, N. J. (2020). Acute effects of dynamic stretching followed by vibration foam rolling on sports performance of badminton athletes. *Journal of Sports Science & Medicine, 19*(2), 420-428.

Macdonald, G. Z., Button, D. C., Drinkwater, E. J., & Behm, D. G. (2014). Foam rolling as a recovery tool after an intense bout of physical activity. *Medicine and Science in Sports and Exercise, 46*(1), 131-142.

MacDonald, G. Z., Penney, M. D., Mullaley, M. E., Cuconato, A. L., Drake, C. D., Behm, D. G., & Button, D. C. (2013). An acute bout of self-myofascial release increases range of motion without a subsequent decrease in muscle activation or force. *Journal of Strength and Conditioning Research, 27*(3), 812-821. https://doi.org/10.1519/JSC.0b013e31825c2bc1

Madding, S. W., Wong, J. G., Hallum, A., & Medeiros, J. (1987). Effect of duration of passive stretch on hip abduction range of motion. The Journal of orthopaedic and sports physical therapy, 8(8), 409–416. https://doi.org/10.2519/jospt.1987.8.8.409

McHugh, M. P., & Cosgrave, C. H. (2010). To stretch or not to stretch: The role of stretching in injury prevention and performance. *Scandinavian Journal of Medicine & Science in Sports, 20*(2), 169-181. https://doi.org/10.1111/j.1600-0838.2009.01058.x

McKenney, K., Elder, A. S., Elder, C., & Hutchins, A. (2013). Myofascial release as a treatment for orthopaedic conditions: A systematic review. *Journal of Athletic Training, 48*(4), 522-527. https://doi.org/10.4085/1062-6050-48.4.08

Michalak, B., Kopiczko, A., Gajda, R., & Adamczyk, J. G. (2024). Recovery effect of self-myofascial release treatment using different types of foam rollers. *Scientific Reports, 14*(1), 15762. https://doi.org/10.1038/s41598-024-66577-x

Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., Shekelle, P., & Stewart, L. A. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Systematic Reviews, 4*(1), 1-9. https://doi.org/10.1186/2046-4053-4-1

Naderi, A., Rezvani, M. H., & Degens, H. (2020). Foam rolling and muscle and joint proprioception after exercise-induced muscle damage. *Journal of Athletic Training, 55*(1), 58–64. https://doi.org/10.4085/1062-6050-459-18

Nakamura, M., Konrad, A., Yasaka, K., Kiyono, R., Onuma, R., Yahata, K., et al. (2021). The acute effect of foam rolling on eccentrically-induced muscle damage. *International Journal of Environmental Research and Public Health, 18*(1), 75–79. https://doi.org/10.3390/ijerph18010075

Nakamura, M., Konrad, A., Kasahara, K., Yoshida, R., Murakami, Y., Sato, S., Aizawa, K., Koizumi, R., & Wilke, J. (2023). The combined effect of static stretching and foam rolling with or without vibration on the range of motion, muscle performance, and tissue hardness of the knee extensor. *Journal of Strength and Conditioning Research, 37*(2), 322-327. https://doi.org/10.1519/JSC.0000000000004263

Okamoto, T., Masuhara, M., & Ikuta, K. (2014). Acute effects of self-myofascial release using a foam roller on arterial function. *Journal of Strength and Conditioning Research, 28*(1), 69-73. https://doi.org/10.1519/JSC.0b013e31829480f5

Peacock, C. A., Krein, D. D., Silver, T. A., Sanders, G. J., & von Carlowitz, K. P. A. (2014). An acute bout of self-myofascial release in the form of foam rolling improves performance testing. *International Journal of Exercise Science, 7*(3), 202-211.

Pearcey, G. E., Bradbury-Squires, D. J., Kawamoto, J. E., Drinkwater, E. J., Behm, D. G., & Button, D. C. (2015). Foam rolling for delayed-onset muscle soreness and recovery of dynamic performance measures. *Journal of Athletic Training, 50*(1), 5-13. https://doi.org/10.4085/1062-6050-50.1.01

Rahimi, A., Amani-Shalamzari, S., & Clemente, F. M. (2020). The effects of foam roll on perceptual and performance recovery during a futsal tournament. *Physiology & Behavior, 223*, 112981. https://doi.org/10.1016/j.physbeh.2020.112981

Rey, E., Padrón-Cabo, A., Costa, P. B., & Barcala-Furelos, R. (2019). Effects of foam rolling as a recovery tool in professional soccer players. *Journal of Strength and Conditioning Research, 33*(8), 2194-2201. https://doi.org/10.1519/JSC.0000000000002277

Romero-Franco, N., Romero-Franco, J., & Jiménez-Reyes, P. (2019). Jogging and practical-

duration foam-rolling exercises and range of motion, proprioception, and vertical jump in athletes. *Journal of Athletic Training, 54*(11), 1171-1178. https://doi.org/10.4085/1062-6050-474-18

Romero-Moraleda, B., González-García, J., Cuéllar-Rayo, Á., Balsalobre-Fernández, C., Muñoz-García, D., & Morencos, E. (2019). Effects of vibration and non-vibration foam rolling on recovery after exercise with induced muscle damage. *Journal of Sports Science & Medicine, 18*(1), 172-180.

Romero-Moraleda, B., La Touche, R., Lerma-Lara, S., Ferrer-Peña, R., Paredes, V., Peinado, A. B., & Muñoz-García, D. (2017). Neurodynamic mobilization and foam rolling improved delayed-onset muscle soreness in a healthy adult population: A randomized controlled clinical trial. *PeerJ, 5*, e3908.

Sarmento, H., Clemente, F. M., Harper, L. D., Costa, I. T. D., Owen, A., & Figueiredo, A. J. (2018). Small sided games in soccer–a systematic review. *International journal of performance analysis in sport*, *18*(5), 693-749.

Schroeder, A. N., & Best, T. M. (2015). Is self-myofascial release an effective preexercise and recovery strategy? A literature review. *Current Sports Medicine Reports, 14*(3), 200-208. https://doi.org/10.1249/JSR.0000000000000148

Sherry, W. M., Wong, J. G., Hallum, A., & Medeiros, J. M. (1987). *Journal of Orthopaedic & Sports Physical Therapy, 8*(8), 409-416.

Verhagen, A. P., de Vet, H. C., de Bie, R. A., et al. (1998). The Delphi list: A criteria list for quality assessment of randomized clinical trials for conducting systematic reviews developed by Delphi consensus. *Journal of Clinical Epidemiology, 51*(22), 1235-1241. https://doi.org/10.1016/S0895-4356(98)00131-0

Wang, F., Zhang, Z., Li, C., Zhu, D., Hu, Y., & Fu, H. (2022). Acute effects of vibration foam rolling and local vibration during warm-up on athletic performance in tennis players. *PLoS ONE, 17*(5), e0268515. https://doi.org/10.1371/journal.pone.0268515

Weppler, C. H., & Magnusson, S. P. (2010). Increasing muscle extensibility: A matter of increasing length or modifying sensation? *Physical Therapy, 90*(3), 438-449.

Wiewelhove, T., Döweling, A., Schneider, C., Hottenrott, L., Meyer, T., Kellmann, M., Pfeiffer, M., & Ferrauti, A. (2019). A meta-analysis of the effects of foam rolling on performance and recovery. *Frontiers in Physiology, 10*, 376. https://doi.org/10.3389/fphys.2019.0037