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Research Article

'Why Do People Participate in Long-Distance Running': Serious Leisure Experiences of Long-Distance Runners in Terms of Self-Determination Theory

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ABSTRACT

This study aimed to examine the experiences of individuals who perform long-distance running as a serious leisure activity within the framework of the Self-Determination Theory. According to the theoretical framework, the aim was to understand how participation in a serious leisure activity affects the basic psychological needs of autonomy, competence, and relatedness. In this phenomenological study, runners were observed in their own serious leisure area. The semi-structured interview technique was used in the study. Interviews were conducted with 15 women and 21 men, a total of 36 recreational long-distance runners, who participated in running groups in Ankara, Turkey. As a result of the participants' opinions and observations, themes were formed according to the basic concepts of autonomy, competence, and relatedness within the framework of the Self-Determination Theory. According to the opinions of participants, the effects of participation in long-distance running on the relatedness need were more prominent than other psychological needs. This study reveals that as a serious leisure activity, long-distance running provides participants with a sense of success, psychological relief, and happiness by satisfying different levels of the basic psychological needs of the participants.

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INTRODUCTION

Today, the need for leisure activities among individuals is increasing. The reason for this need is the desire to spend time in an area that is stripped of business and daily problems. Some leisure activities contribute to social life by developing interpersonal relationships. Given the personal and social benefits to individuals, leisure has profound meanings (Iwasaki, 2017).

The existence of physical, psychological, and social benefits of physical activity, such as leisure activities, was proven in many studies (Fox, 1999; Hayosh, 2017; Joseph & Southcott, 2018; Legg et al., 2017; Patterson & Pegg, 2009; Penedo & Dahn, 2005). Running as a leisure activity appears to create intense pleasure and embodied empowerment (Allen-Collinson, 2023). It has also been observed that affective interactions and performance measures can produce quite pleasurable emotions during the running experience (Jackman et al., 2023).

Nowadays, attracting attention to physical activity on social media is very easy (Cavallo et al., 2012). The number of people interested in physical activity for leisure is increasing day by day. Social media effectively directs the public and has highlighted long-distance running as an increasing trend in recent years (Norman & Pickering, 2019).

Long-distance running is very popular in Turkey in recent years through running groups. Due to this popularity, research is increasing (Çalışkan & Ardahan, 2022; Çetin & Özman, 2019; Pekel et al., 2022; Şallı, 2020; Yıldız, 2023). The high rate of access to social media helps to bring recreational long-distance runners together. These groups are attractive because of some factors, such as being organized weekly, open to everyone, and offering a social environment to make new friends.

Long-distance running events are organized on certain dates every year and are open to everyone (Runzy, n.d.). Participation conditions may vary depending on the distance, and there is also a participation fee. Marathons are held in many cities in the country and many places worldwide (UTMB, n.d.). The Istanbul Marathon had around 45,000 participants in the 42K and 15K categories in 2023 (GSM IBB, n.d.). Tokyo, Boston, London, Berlin, Chicago, and New York are the largest and most renowned marathons in the world (World Marathon Majors, n.d.). Many international racing events are held with tens of thousands of people. Regular participation in these events without any financial reward is interesting to leisure researchers (Fairer-Wessels, 2013; Hallmann & Wicker, 2012; Lamont et al., 2014; Shipway & Jones, 2007).

Leisure is defined as free or unobligated time (Leitner & Leitner, 2012) without work or performing other life-sustaining functions. The most agreed-upon meaning is that leisure is the antithesis of work (Gurbuz & Henderson, 2013). Serious leisure is the systematic pursuit of a core activity that is fulfilling. Participants find a social identity by expressing these special skills and experiences (Green & Jones, 2005). According to Stebbins (1982), who revealed the serious leisure perspective, motivation is the key to sustaining the activity.

The leisure consists of casual, project-based, and serious pursuits (Hartel, 2013). Casual leisure is defined as a short-term, satisfying activity that doesn't need preparation or special training (Gould et al., 2008). Casual leisure involves pure entertainment and satisfaction (Stebbins, 1997). Project-based leisure is short-term, uncomplicated, one-off, or rare creative activities (Stebbins, 2005). These leisure activities require skill and planning. Project-based leisure doesn't fall within the scope of serious leisure and is not expected to develop in this direction (Bailey & Fernando, 2012).

In the literature, the positive effects of serious leisure activity participation on participants are noteworthy (Chen, 2014; Heo et al., 2018; Shipway & Jones, 2007). In recent studies, the experiences of serious leisure runners have been examined in different ways. However, motivations for participation in serious leisure activities, subjective well-being, and participant characteristics are among the topics examined (Qiu et al., 2020a; Qiu et al., 2020b; Tian et al., 2020). Serious leisure activity leads to improvement and orients knowledge, skills, and experience to the activity. Six distinctive features differentiate serious leisure from other leisure types are the need to persevere, follow a leisure career, significant personal effort, several durable benefits, unique and complex ethos and social world, and a distinctive identity (Stebbins, 2018).

Serious leisure is cited as having increasing importance for leisure and is a way in which an activity can turn into a career. Individuals can turn their hobbies into careers due to their sense of devotion. Amateurs can become professionals. In fact, the emergence of some professions stems from dedication to them as leisure activities (Stebbins, 2018). Motivation is of great importance for this dedication. Neulinger (1981) has shown that intrinsic, extrinsic, and both intrinsic and extrinsic motivations are effective in participation in leisure activities in the leisure paradigm. Neulinger's (1981) leisure paradigm is similar to Self-Determination Theory in terms of the effect of intrinsic and extrinsic motivation on autonomy in individuals.

Self-determination theory (SDT) focuses on individuals' internalizing their external motivation, ensuring autonomy in their daily lives and, thus, self-regulation of their behaviors. The social-contextual environment positively influences psychological well-being and

motivation through the satisfaction of three basic needs (Ryan & Deci, 2000), which are autonomy, competence, and relatedness. Autonomy is a person's need to control the course of their life. Competence means the need to be effective in dealing with the environment. Relatedness is defined as close, compassionate relationships with others (Deci & Ryan, 2012). The theory accepts these basic psychological needs as universal (Hennessey et al., 2015). According to the SDT, there is a continuum from non-self-determined to self-determined. Moving from extrinsic motivation to intrinsic motivation, the fulfillment of basic needs' needs increases (Ryan & Deci, 2000). People tend to develop psychologically and act to overcome obstacles (Deci & Ryan, 2002).

Autonomy, competence, and relatedness are the basic needs of a social being. These basic needs in the SDT can be fulfilled through intrinsic motivation for serious leisure physical activity. Various studies have demonstrated that meeting basic psychological needs through physical activity has positive effects on individuals (Lee & Ewert, 2019; McDonough & Crocker, 2007; Owen et al., 2014; Teixeira et al., 2012). While there are studies in the literature examining the effects of serious leisure activity on individuals with self-determination theory, there are also studies that reveal the positive gains of regular leisure physical activities on participants. Some of these studies are seen in the paragraph below.

Lee and Ewert (2019) examined the associations between serious leisure and quality of motivation in line with the SDT among rock climbers. They have seen that motivation has positive effects on commitment, identity development, and achievement. Koçak (2016) found out that the reasons for cycling were to be healthier, stronger, happier, and overcome daily stress according to participants. Robinson et al. (2014) examined how a group of novice marathon runners entered the social world of a long-distance running community in their study. As a result, novice runners who worked with the club integrated with the values and behaviors of the social community. Fairer-Wessels (2013) examined motivation among serious leisure participants competing in the Comrades Marathon, one of South Africa's major sports events. In the research, the participants strongly identified with the activity and formed an identity. Shipway and Holloway (2010) proposed that adopting a healthy lifestyle approach with long-distance running, sports, and leisure activities contributed to both health and quality of life. In addition to studies aimed at understanding the motivations of serious leisure long-distance runners, it is understood that participants who participate in different sports activities, such as cycling and rock climbing, continue their activities with various motivational factors. This can be for reasons such as being healthy and feeling good, or it can provide results such as creating an identity and being part of a community. It is understood

from the studies that participation in regular physical activity in leisure provides positive psychological contributions to individuals and can also enable them to create a social environment.

The SDT is seen as functional in examining the physical, psychological, and social benefits provided by serious leisure physical activity for participants (Moustaka et al., 2010). The theoretical framework of the study is to discover the extent to which basic needs such as autonomy, competence, and relatedness are satisfied in individuals who run long distances as a serious leisure activity. Despite the popularity of the topic in Turkey, there is very little in-depth research available in the literature. Besides, it examines the motivations of runners within the framework of SDT. The original value to examine the strong connection between serious leisure participation and SDT in long-distance runners whose members of different running groups in Ankara, Turkey. Thus, the aim of the study was to examine the experiences of serious leisure long-distance runners within the framework of the SDT. The purpose was to understand how participation in a serious leisure activity affects individuals' basic psychological needs.

METHODS

Participants

The study group was determined according to the maximum variation sampling method, which was chosen to include differences between participants, such as running distances or socio-cultural environments. Interviews were conducted with 36 recreational long-distance runners between the ages of 21 and 48, including 15 women and 21 men. Participants ran at least twice a week with running groups in Ankara (Table 1).

For research, connections were established with running groups in Ankara via social media. Running groups post their weekly events on their social media accounts. A direct message was sent to the running groups' Instagram accounts, and the person who manages the account was contacted. Information about the research was provided. In line with their acceptance and invitation, to their weekly events one-on-one communication was established with the participants there. Participation in the study was based on volunteerism. Before the study, permission was obtained from the Ethics Committee of Ankara University (2019, No. 122).

Data collection continued until data saturation was reached. Five different groups of individuals were included in the study, and they were identified with nicknames. All were educated and had good jobs. The running experiences of recreational long-distance runners

ranged from 3 months to 24 years. They had participated in at least two long-distance running events.

Table 1
Characteristics of Participants (n = 36)

Name	Age	Education	Occupation	Running experience	Weekly training	Weekly distance /km	Races
Selin	32	Graduated	Civil Servant	6 months	2-3 days	20 km	21K 42K
Merve	38	Graduated	Teacher	4 years	4 days	60 km	15K 38K 42K 50K 55K
Zeynep	28	Graduated	Representative	3 months	2-3 days	25 km	5K 11K
Fatma	27	Graduated	Engineer	16 years	3 days	30-40 km	11K 13K 42K 42K
Buket	34	Graduated	Civil Servant	7 months	3 days	20 km	9K 10K 10K 21K
Hatice	35	Graduated	Banker	5 months	3 days	10 km	9K 10K
Demet	48	PhD	Lecturer	2 years	3 days	20 km	7K 10K 10K 10K
Seda	28	Graduated	Physiotherapist	11 months	2-3 days	10 km	15K 21K
Nil	36	Postgrad	Student	4 years	2-3 days	10-15 km	10K 10K 10K 21K 21K
Mina	27	Postgrad	Student	1,5 years	4 days	20 km	23K 38K
Elif	25	Graduated	Psychologist	1 year	2 days	20 km	21K 21K 21K
Leyla	36	Graduated	Administrator	2 years	3 days	40 km	38K 42K
Gizem	23	Undergrad	Student	4 years	3 days	30 km	21K 21K 30K 63K
Beren	21	Undergrad	Student	6 months	2 days	10-15 km	4K 5K 5K
Duru	26	Graduated	Nurse	3 years	4 days	50 km	15K 42K
Can	30	Postgrad	IT Expert	3 years	3 days	30 km	15K 15K 21K 42K 42K
Poyraz	34	Graduated	Project Expert	5 years	4 days	70 km	15K 21K 21K 42K 42K
Mert	30	Postgrad	Student	1 year	3-4 days	40 km	15K 21K 23K 42K 50K
Hasan	35	Graduated	Officer	3 years	4 days	30-40 km	15K 21K 21K 35K 63K
Remzi	38	Graduated	Civil Servant	18 years	3 days	25 km	5K 11K
Yusuf	35	Graduated	Inspector	2,5 years	5-6 days	120-140 km	21K 37K 42K 55K 63K
Adem	34	Postgrad	Civil Servant	1 year	3-4 days	80-100 km	21K 23K 55K 119K
Tayfun	38	Postgrad	Civil Servant	3 years	6 days	10-12 km	5K 11K
Mustafa	30	Postgrad	Engineer	8 months	2 days	15 km	5K 5K 5K 5K 12K
Murat	38	Postgrad	Pharmacist	3 years	3 days	30 km	21K 38K
Selim	44	Postgrad	Pilot	20 years	3 days	45 km	38K 38K 42K
Sinan	34	PhD	Engineer	5 years	2 days	30 km	15K 21K 21K 42K
Osman	31	Graduated	Engineer	1,5 years	4 days	55 km	21K 21K 37K 38K 42K
Kadir	36	Graduated	Craftsman	24 years	7 days	100-120 km	250K 250K 250K 250K
Ali	34	Postgrad	Human Resources	4 years	6 days	80 km	42K 42K 42K 42K
Orhan	47	Postgrad	Engineer	4 years	2 days	30 km	21K 21K 42K 70K 74K
Furkan	38	Postgrad	Engineer	4 years	2 days	25 km	35K 38K 38K 63K
Arda	27	Graduated	Football player	1,5 years	2 days	10-15 km	5K 5K 11K
Sabri	30	PhD	Psychologist	1 year	3 days	15 km	15K 21K
Cemil	27	Postgrad	Engineer	3 years	3 days	30 km	21K 21K 21K

Procedures

The research was designed using a qualitative approach. A phenomenological approach was adopted to observe individuals' experiences (Creswell and Poth, 2016).

Phenomenology was selected as the most appropriate design to answer the question: "Could participation in long-distance running as a serious leisure activity contribute to meeting the basic psychological needs of individuals of autonomy, competence, and relatedness?" The phenomenology pattern was based on the interpretative paradigm (Merriam & Tisdell, 2015).

In the research, interviews were conducted to assess the experiences of participants and to examine their perspectives in detail (Merriam & Tisdell, 2015). The semi-structured interview technique was used in the study. While preparing interview questions, opinions of two experts working in the recreation field were obtained and some studies on the subject were examined (Chatzisarantis & Hagger, 2009; Fairer-Wessels, 2013; Lamont et al., 2014; McDonough & Crocker, 2007; Öztürk & Koca, 2017; Robinson et al., 2014; Shipway & Holloway, 2010; Shipway & Jones, 2007). Interview questions were prepared to determine autonomy, competence, and relatedness and were classified according to the theoretical framework. In the study, participants were asked nine semi-structured and personal information form questions. Examples of some questions on the interview form are "How would you describe a good runner?" and "What does running mean to you?" Interviews were conducted before or after events. Appointments were made with the contact through social media, and preliminary information was given about the research. After connecting with groups, data were collected during running group activities over six months. The first author of the study conducted the interviews. Interviews lasted 26 minutes on average and were recorded, while observations and field notes were made. Field notes were taken during the running groups' weekly activity days and during the times when there were no interviews. These observations, included in the field notes, took place both in the running areas and in meeting areas, such as cafes, where they spent time before and after the run. Participants also signed an informed consent form for the research.

Participants attended long-distance running practice every week as a leisure activity. They did not neglect their activity even in winter (persevere). It was observed that the participants trained at least 2 days a week, and for some, this frequency could be 6 to 7 days (significant personal effort). They had the opportunity to create a career with the progress of their performance over time. It is understood that despite having a profession, they entered special preparation processes for race events held outside the city they live in, and after each one, they set new goals and prepared (follow a leisure career). To achieve this career, they worked hard and strived to improve their skills. They had their own social environment in the running groups, and their values were reflected in this social environment. The fact that they acted together with the running groups they were a part of during these processes, the

identities they created belonging to the culture of their own running group (unique and complex ethos and social world), and the values they had as a long-distance runner and the identity they created attracted attention (distinctive identity). All this provided them with an attractive social and personal identity. It is thought that the participants' desire to run for a lifetime stems from all those benefits they felt (several durable benefits). Due to these features, they meet the six criteria for serious leisure (Stebbins, 2018). All of these were mentioned in the researcher's notes during the data collection process. The study was designed to include participants who had participated in at least two long-distance running events and were part of a running group. However, during the research process, it was clearly understood that they had the characteristics of serious leisure participants.

Statistical Analyses

After the first author transcribed interview records, the data were analyzed with the thematic analysis method (Braun & Clarke, 2006). For thematic analysis, firstly, transcripts and field notes were organized, then initial codes were generated by hand, and after that, codes were combined with similar codes. After the first author completed the coding process, the next step was to review potential themes and define and name them (Braun & Clarke, 2012). Regular meetings were held with the second author during the process of uncovering themes. In addition to the main themes determined by the research, sub-themes are included among the findings. This is necessary for research with psychological aspects because more detailed, in-depth, and versatile results can be obtained; thus, thematic analysis was used (Doğusan & Koçak, 2021). The confidentiality principle was followed while collecting and storing all personal information. The names of individuals were kept secret, and code names were used during data analysis. The names seen in Table 1, which contain participant information, are not the names of the participants but code names. Field notes were used to double-check the codes and themes.

Some strategies were used to provide internal validity for the research. Data triangulation, adequate and appropriate participation in the data collection, researcher credentials, and expert examination strategies were used (Merriam & Tisdell, 2015). Data triangulation attempts to provide validity through the combination of observations, interviews, and field notes. A wider range of diversity was achieved by interviewing members of five different groups. The first author met with the study group for approximately six months during the data collection period, on weekly running activity days, in the areas where they held their running activities, and in café-style venues where they spent time before

and/or after the activity. Since the second author is an expert in her field, the first author and the second author regularly met to check the quality and consistency of the data with the expert examination.

External validity is related to the extent to which the results are applicable to different situations, which is related to the generalizability of the research. In qualitative research, understanding a specific situation in depth is important. To ensure external validity, the maximum diversity sampling method, which is one of the non-random purpose sampling, was chosen in our study. The validity and reliability of the research was ensured by these credibility strategies.

RESULTS

In the study, individuals who chose long-distance running as serious leisure activity provided similar opinions. As a result of the participants' opinions and observations made, themes were created according to the basic concepts of autonomy, competence, and relatedness within the framework of the SDT. The analysis results had three main themes.

Autonomous Decisions: Running as a Part of Life

The first theme examined the participants' autonomous decisions regarding running. This theme was formed because of the answers to the questions aimed at understanding the autonomous decision-making of the participants during the individual interviews.

Running responsibility

Participants emphasized that running is a responsibility in their lives to be healthy. They stated that they want to run throughout their lives and that it is a good thing for them to do. The participants made statements about running being a part of their lives. About the place of the running in her life:

> *"Running has an important place in my life; for example, I come here on Wednesday evenings. Sometimes I couldn't date my boyfriend, or I couldn't spend time with my family because I come running. For example, no one can wake up early on Sunday mornings, but we go running around Lake Eymir at 8:00 a.m. (Seda)"*

Fatma said about the importance of running: *"Running has a very important place in my life, as important as family or friends."* Leyla expressed her discomfort when she could not take part in running activities:

> *"I look at the videos and photos of my runner friends from social media pages. I sometimes ask myself why I'm not there. This is what happens at events when I couldn't go. It would*

be nice to go. I'm uncomfortable when I can't take part in training. I don't like to be absent."

For runners, serious leisure qualities such as perseverance and pursuing a leisure career are considered noteworthy.

Running for self-improvement

It was observed that the participants wanted to improve themselves until they could perform at their best, in line with their autonomous decisions. When the participants were asked about their expectations from running, the answer was "to improve myself". Poyraz stated that goals should be realistic as an amateur:

"The expectation of amateur athletes like us may be to develop within our own limits. You can display very good performances, but since you are not training and nourished like an athlete, the only goal can be set by your own development."

Elif explained her progress in running:

"For me 5K was a dream and 10K or 21K was impossible. I ran 21K three times. I ran 15K four times. It's not enough anymore and now my goal is to run a marathon in Amsterdam in October. In fact, I want to spend a little more time on planning the marathon."

The participants wanted to develop themselves to meet their autonomy needs without external expectations, pressure, or obligations. Participants stated that running is an area where they can improve themselves. The marathon event is a part of their lives, and they participate in marathon events due to their desire and enjoyment. Still, women participants especially hesitated to identify themselves as runners.

"I've been running for one and half years. I've been describing myself as a runner for the last six months because I've realized that I love it. I saw the improvement in myself. My training became more regular. I'm a developing runner. (Mina)"

"Am I runner? I don't know. It means sport for me, being healthier, staying away from negative things and relaxing. I competed in four marathon events. I always try to exceed my previous performance. I'm trying to improve myself. (Buket)"

Although the participants see running as a part of their lives, they hesitate to define themselves as long-distance runners.

Fun runners

Participants frequently expressed the phrase "I run because I enjoy it" regarding their expectations from running. In this sub-theme, what is meant by fun is that they continue their

running activity with their own autonomous decisions without any financial expectations in a professional way. They seem to have achieved a career from a serious leisure perspective, but this is seen as a career they enjoy rather than a career with financial rewards. The participants need to see running as a pleasure. Adem expressed his enjoyment while running:

> "Especially I love running together with people, people having fun while running… I also enjoy the training I do when I train with them. They think I have fun running too. I don't get bored running in the forest for three hours thanks to them. If the person next to me can run for three hours by having fun, laughing, telling jokes, if he can do this, then it's pleasant for me."

About the reason for running: "First, we run to be healthy. To feel good, it seems like you are free of weight, and when you run like that, you get relief mentally. You can get rid of your troubles (Nil)." About the happiness that running brings: "People say that they see the expression of happiness on my face when I run. They understand that I love doing this (Demet)."

Most of the participants ran for fun, and they did not want to participate in an activity with a materialistic aim. They also emphasized that they want running to be a platform that meets their autonomy needs but not to become a tool of necessity or oppression.

Need for Competence: Changing Meaning of Leisure

This theme was created based on questions directed to runners to reveal their perceptions of competence. An attempt was made to understand what characteristics the participants use to define a good runner and whether they believe they have these characteristics.

Being a Model Runner

When the participants were asked how they wanted an outsider to see them, they said they wanted to be seen as exemplary runners. Ali thinks that people who look from outside should take them as an example:

> "As far as I can see from my environment, there are two kinds of perspectives. Someone says, "Why do you run? What does it mean, and especially why are you running in this cold?" There is also a group that says, "How nice! I wish I could run too." I think they should be envious; after all, we are doing a physical activity, so winning a medal is not very important."

They stated that it is important to create running awareness for a healthy life. Mert stated that he wanted to set an example for people:

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"I would like them to see us as people who can run with the right form. I wish I could run like that. After all, we are not professional runners, there are mistakes we make. I would like to be a good example by running with the right technique. Others may see it that way."

Mert both wants to set an example for people and hesitates between professionalism and amateurism. He was not sure that he ran with the right technique, which revealed questions about his perception of competence.

Although the participants generally hesitate in their perception of competence regarding professionalism and amateurism, they think that they have the competence to be an example of healthy living as leisure runners. As people running for health, they can meet their competence needs by taking a stance against other people.

Pushing Boundaries: Goals and Achievements

When asked to talk about the process of a running race, the participants first talked about their training and nutrition regimens during the preparation process, and psychologically convincing themselves that they could do it. For the participants, doing something good for themselves, setting a goal, and succeeding in the end, even if they had difficulties on the way, meant a lot. This is directly related to meeting their competence needs by seeing themselves succeeding through running.

According to participants, the most important thing in a marathon event is completing the route in a good time. They need to improve the time they ran before, even for one second, and that they push their boundaries to do the best they can, giving them a sense of success and happiness at the end of the route. Orhan expressed these feelings as follows:

"The feeling after finishing never changes. It is great pain, the pain you feel while running, fatigue, boredom, but the feeling of great accomplishment after two hours comes after it ends. You have accomplished something very difficult. It is good to have achieved something that few people in the world do, and something that many cannot do."

Feeling that they have achieved something that most people cannot achieve in the world, setting a goal and reaching it, completing the route despite all the difficulties, and physical and psychological suffering show that the participants meet their competence needs with long-distance running events.

About a marathon event process:

"There are times when I suffer on the route, but I came there for a purpose, so I need to finish it in a healthy way. When I get here, it's simple that I'm going to experience it and finish it and then go home. I don't say 'why am I here, why am I running, damn it'. Finishing it doesn't matter, but I will. Then there is happiness and fatigue. (Gizem)"

About the racing process:

"It was fun, and it was nice to see the finish line. You see that you have accomplished something, and you have done something for yourself. You get a medal, and you experience something like this in your life. You take that medal and put it in your room, and you remember it. Running is one of the points where I have lived life to the full. (Seda)"

"You're dealing with something in life. You're doing something for yourself. For your health, to make yourself happy. There has been a target set and you've made it. Life is important in such things, these things make people happy, or life is empty and has no meaning. (Zeynep)"

Nil explained how it affected people through running discipline:

I find those who run outside are very cool. It's cool. Those who see me can be envious because I have two children, I am currently writing a doctoral thesis, one of my children had a serious illness and I was running at that time. I was creating a space for myself. I see that people admire it, they say, you gave yourself space, you did well.

The participants believe a marathon is an easy way to set a goal and see what they have accomplished. Significant personal effort and several durable benefits are important for runners.

The Relaxing Effect of Running

For the question of how running made them feel, the participants used the expression "relieved" most. Participants stated that running had a relaxing effect on them, relieving them from daily stress. The relationship between relaxation and the need for competence mentioned in this sub-theme is a sense of competence that comes with the disappearance of the feeling of inadequacy they feel due to the negative emotions they experience in daily life, rather than the competence they feel on the running field. They associated this relaxing effect with the happiness hormone, therapy, and meditation. They emphasized being healthy and fit most for the physical effect of running. They stated that staying healthy had a relaxing effect on them

throughout their lives. About the relationship between running and happiness, Merve said the following about the happiness she felt during the run:

"I am very happy when I run, I love running, but I love after running the most because there is an incredible psychological relief after the run is over. For example, if I am little bored at the beginning of the run, I will think that it wasn't that important after the run is over. You're getting rid of an incredible toxin, and the happiness hormone is secreted when people run."

In daily life, the runners turned negative feelings about their perceptions of competence when they experience stress by focusing only on the run-in leisure and meeting their competence needs. They emphasized that running has a significant impact on happiness.

Relatedness: Reconstruction of the Social Environment

Team support

The participants explained that their friendship with their running group friends was reinforced by attending racing events in other cities and spending much time together. Adem said the following about his friends waiting for him at the finish line:

"The last long distance I ran was valuable to me. There was a problem with my right knee, and I could not move anymore. Knowing that I had friends at the end made me finish about 30K on foot. If I didn't know they were waiting, I wouldn't be able to walk. It is a different feeling to know that someone is waiting there, I don't remember being so emotional in a long time, it was 120K running."

Leyla said about the influence on her motivation from her teammates:

"I'm not tired when running is over. When I come to the end, there is more energy. My motivation rises. At the end, it can be even more pleasant when my friends are waiting for me."

"The running group motivates friends. It may seem very difficult to wake up at 7:00 a.m. on a Sunday morning, but you can be motivated that you will go to breakfast together and have coffee with them after running finishes. Apart from running, sometimes we also spend time with some of the team members. We also have friends who help training. (Mina)"

The participants emphasized that this bond, which was established on a voluntary basis only without any expectations between them, is very pure and real. Here on runners, the distinctive identity and unique and complex ethos feature of serious leisure seen. The runners

fulfilled their relatedness needs in the running social environment. It is seen that the participants have social world in the distinctive features of serious leisure.

Social runners

Participants used "social runner" when describing themselves as runners and mentioned contributions to sports tourism during their out-of-town trips for running events. Buket said about friendship in the running group:

"I've started to realize the things that I was troubled about were very insignificant. I'm happy now. We are together at least three-four days of the week, then we drink coffee, eat, sometimes we are involved in other plans. I'm having fun, doing sport, and relaxing. We have friends from different professions, and we have a lot in common."

Leyla explained the effect of social media on their connections with other running groups, which is an important sharing place for running groups:

"I follow other running groups on social media. I have friends from there. When we meet in the run we chat. I didn't join those groups, but as far as I can see from the outside, they're nice and they've formed a bond."

As well as Leyla, who has her group in a separate place, Elif expressed the social media influence as follows:

"I'm also uncomfortable when I miss training because they use social media a lot, when I see their photos, I say I wish I were there."

The runners considered the groups were important for socialization and psychological relief.

Cemil discussed a different dimension of running. He explained the steps he took to touch others' lives, collect donations by running, and deliver them to those in need.

"For example, you run for an autism foundation, there is a shirt for it. At some point when you run, you see children with autism, and you feel you are doing something very beautiful at that moment."

According to the participants, meeting the need for relatedness stands out more than the other psychological needs. The participants touched on the issue of relatedness in many points about their running experiences.

DISCUSSION

McDonough and Crocker (2007) revealed that if the psychological needs of autonomy, competence, and relatedness are met, the participants experience self-determined types of motivation and obtain more positive results. The study shows the importance of all three needs in activity motivation for adults.

Ryan et al. (2010) found that non-work activities (such as leisure, personal care, and household chores) were associated with higher positive effects and lower relative negative effects compared to negative effects in work activities. These two correlations mediate the fulfillment of the basic psychological needs of autonomy, competence, and relatedness. According to our findings, meeting the basic psychological needs of autonomy, competence, and relatedness through long-distance running as a serious leisure activity provided participants with many positive gains.

Autonomy

Participants emphasized that long-distance running is a leisure activity that will help increase exercise participation and physical activity participation and has the potential to be accessible and fun. According to Sands and Wehmeyer (1996), autonomy means that a person is free in their decisions without coercion. For the participants, running is an act of pleasure, and it turns into an activity with materialistic purposes if this fact changes.

Fairer-Wessels (2013) found that participants strongly identified with the activity and formed an identity. In our study, there are some gaps in defining themselves as runners, but they meet their need for autonomy by creating a special space for themselves.

In parallel with our research, Gui et al. (2019) found that if autonomy, competence, and relatedness, basic psychological needs, especially the need for autonomy, are met, it contributes to the effective well-being of people during leisure in general. Patterson and Pegg (2009) found that participation in serious leisure activities had increased effects on the development of trust, skills, and self-esteem.

Competence

According to the findings obtained from the research, the participants emphasized that running is a responsibility to be healthy in their lives. Similar to the results of our research, Koçak (2016) found that cycling caused participants to be healthier, stronger, happier, and overcome daily stress. Similar to the findings of our study, Shipway and Holloway (2010) stated that long-distance running is an integral part of an active and healthy lifestyle. Like our

study, long-distance running research revealed that participants strongly link to the activity. The fact that they constitute an example for society as people who adopt a healthy lifestyle ensures that their competence needs are met.

The answer to questions about their expectations from running was "to be able to improve myself". They talked about the continuity of development thanks to introducing new goals as previous goals were achieved. Like the findings of our study, Lee and Ewert (2019) stated that intrinsic motivation has positive personal and social effects on loyalty, identity development, and acquisition. They wanted to improve themselves in line with their inner motivation without any external expectations, pressure, or necessity.

Relatedness

According to the SDT, being in contact with the social environment, feeling a sense of belonging, and the desire to establish relationships comprise the relatedness needs of individuals (Deci & Ryan, 2012). Relatedness in the SDT occurs when the individual establishes satisfying and supportive social relationships (Deci et al., 1996). Robinson et al. (2014) revealed that novice runners who joined the long-distance running community and who worked with the club integrated with the values and behaviors in the community's social life. In our study, the participants stated that their social environment was shaped around the running group. They meet their needs for relatedness with the social environment they acquire through running. Yet, their social environment is limited to the running team due to the time they devote to the running group.

Sivan et al. (2019) saw that psychological reasons were the most prominent in a study that examined the reasons for participating in serious leisure activities. In parallel with our study, the relatedness need is more prominent than other psychological needs. Participants touched on the issue of relatedness at many points from the start to the end of the interview about running.

Limitations

The research was conducted with participants over 18 who participated in different types of long-distance running race events. Considering that there are running groups in many cities in Turkey, the research was limited to participants in running groups in Ankara. In addition, interviews were conducted with participants who participated in the event at least two days a week and at least two long-distance running race events due to the serious leisure activity. The research group was limited to those who volunteered to participate in the study.

CONCLUSION

As a serious leisure activity, long-distance running provides participants with a sense of success, psychological relief, and happiness by satisfying the basic needs in the SDTs of autonomy, competence, and relatedness. External motivation sources, such as social media and friends which are effective when starting to run, transformed into intrinsic motivation as a result of happiness and relaxation felt during running. Despite being a serious leisure participant and not receiving any financial gain from running, participants had a negative perception of competence, but their belief that they would develop themselves made running an important part of their lives. According to the participants' opinions, the effects of participation in long-distance running on relatedness needs were more prominent than other psychological needs. As a result, the basic psychological needs of autonomy, competence and relatedness in the SDT can be met at different levels with long-distance running as a serious leisure activity. Meeting basic psychological needs with long-distance running, a serious leisure activity, can provide positive benefits for individuals. For this reason, all individuals must be directed to active serious leisure activities where they can achieve positive gains.

To sum up, as a serious leisure activity, long-distance running provides participants with a sense of success, psychological relief, and happiness by satisfying their basic needs within the framework of the SDT.

Recommendations include performing more in-depth studies about the psychological benefits of physical activity in serious leisure. Since this research was conducted only with recreational long-distance runners in Ankara, more extensive research can be conducted nationwide. Research can be conducted to determine the psychological benefits of physical activity with different serious leisure activity participants and whether the effects of participation in serious leisure physical activity vary according to age groups, such as children or older individuals.

PRACTICAL IMPLICATIONS

Suggestions for implementation include campaigns organized on social media to raise awareness among families about physical activity as a serious leisure activity. Participation in physical activity as a serious leisure activity can be considered as a country and sports policy, and steps can be taken to provide individuals with leisure education from an early age. Running groups engaged in serious leisure physical activity can be encouraged and supported

in the context of efforts to popularize the sport in society. As a sports policy, programs can be developed for professional athletes and serious leisure physical activity participants.

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Authors' Contribution

The second author has given the design of the manuscript, the first author, to data collecting. All authors analyzed and interpreted the data. The first author drafted the manuscript, and the second author revised it critically. All authors read and approved the final version of the manuscript.

Declaration of Conflict Interest

No potential conflict of interest was reported by the authors.

Ethics Statement

This study was reviewed and approved by Ankara University Ethics Committee (21.03.2019, No. 122).

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The Role of Performance Metrics in Estimating Market Values of Footballers in Europe's Top Five Leagues

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ABSTRACT

The transfer economy in football is a multi-billion-dollar industry, where accurate valuation of players is crucial for clubs' financial sustainability and competitive success. This study investigates the role of performance metrics in estimating the market values of football players in Europe's top five leagues (Spain's La Liga, France's Ligue 1, England's Premier League, Italy's Serie A, and Germany's Bundesliga). The study collected 28 performance metrics (e.g., goals, shots per game, assists, and pass success percentage) for 1508 players from the Whoscored platform. Additionally, the players' positions and the leagues they play in were also included as features. These data were combined with market values from the Transfermarkt platform, resulting in a comprehensive dataset. Two main analytical methods were employed: regression and classification. In the regression analysis, seven models (Adaboost, Decision Tree, Gradient Boosting, K Nearest Neighbors, Random Forest, Ridge Regression, and Support Vector Machine) predicted players' market values. The highest accuracy was achieved with the Random Forest algorithm (R-squared: 0.90). In the classification analysis, players' market values were categorized into four classes (low, lower-mid, upper-mid, and high), and their class memberships were predicted based on performance metrics. The CNN algorithm achieved the highest accuracy, with a success rate of 97%. The results indicate that performance metrics significantly contribute to estimating football players' market values, and models based on these metrics can assist clubs in making more informed, data-driven decisions during transfers.

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INTRODUCTION

Football, a sport with roots in ancient civilizations, attained its modern form in 19th-century England. The establishment of the Football Association in 1863 marked the beginning of standardized rules, which soon spread globally (Murray, 1994). The rapid globalization of football transformed it into the world's most popular sport in a short period. Today, football plays a significant role in bringing together millions of people from diverse cultures and fostering social and cultural bonds (Goldblatt, 2006).

Beyond being a mere sport, football is a force that shapes social dynamics and unites communities. Major tournaments enhance feelings of friendship and competition among nations. Football's impact on the masses is evident in the deserted streets on match days, the packed stadiums, and the millions of viewers in front of screens. Consequently, football is not just a sporting event but a social phenomenon (Giulianotti, 1999).

The economic dimension of football has undergone dramatic changes over time. While football was considered an amateur sport at the beginning of the 20th century, it has since evolved into a multi-billion-dollar industry. The formation of professional leagues and the sale of television broadcast rights significantly increased the economic value of football. Since the 1990s, football clubs have gained substantial financial power through sponsorship deals, ticket sales, merchandise, and media rights.

Enormous expenditures made by clubs mark the football transfer market to enhance their competitive edge. According to the Deloitte Football Money League (2024) report, the total annual revenue of European football reached €10.5 billion for the 2023/24 season (Deloitte, 2024). This figure illustrates that football is not just a sport but a colossal economic sector. This growth has enhanced football's integration with the media, advertising, and entertainment industries, boosting its economic potential.

In recent years, the astronomical amounts spent on football transfers have become evident, exemplified by Neymar's 2017 transfer to Paris Saint-Germain for €222 million (Bida & Mirzoyan, 2023). Such high-profile transfers attract the attention of clubs' fans and the media. However, these expenditures also raise concerns about clubs' financial sustainability.

The substantial transfer expenditures and financial management issues faced by football clubs have led some to bankruptcy. For instance, in 2012, Glasgow Rangers went into administration due to financial troubles and were demoted to lower leagues (BBC Sport, 2012). Similarly, in 2015, Parma FC in Italy went bankrupt due to a financial crisis and was relegated to Serie D (Gazzetta dello Sport, 2015).

Clubs' financial challenges are not solely due to poor financial management. Many clubs experienced revenue losses during the COVID-19 pandemic, forcing them to cut player salaries and suspend infrastructure projects (Deloitte, 2021). This situation highlights the need for clubs to adopt more careful and strategic transfer policies to ensure financial sustainability.

Player scouting is one of clubs' most crucial tools to discover talented players and strengthen their squads. The scouting process involves analyzing players' performance data to assess their future potential. Performance metrics are used to objectively measure a player's effectiveness and contribution on the field (Mann et al., 2017). These metrics include various statistics such as shooting percentage, pass accuracy, and dribbling success rate.

Scouting platforms play a significant role in providing clubs with player performance data. Platforms like Wyscout and Scout7 offer detailed performance data for thousands of players worldwide. Clubs pay annual subscription fees to access these comprehensive databases (Hudl, 2019). These investments help clubs to make accurate player transfers and minimize financial risks.

Performance metrics are paramount to maximize returns from high-cost transfers. Performance data objective assesse a player's effectiveness and contribution to the team. These data allow coaches and club managers to monitor players' development and make necessary tactical adjustments (Carling et al. et al., 2005). For high-cost transfers to be successful, a player must be talentednd fit into the team's playing style and minimize injury risks. Performance metrics play a critical role in monitoring and managing these factors. Clubs aim to continuously monitor players' performance to maximize returns on their investments (Morgans et al., 2014).

Artificial Intelligence (AI) is increasingly being utilized in the football world. Football teams use AI technologies to analyze player performance, develop tactical strategies, and reduce injury risks. AI-based analysis systems provide coaches valuable insights by examining player movements and team formations in detail during matches. Another significant application of AI in football is player scouting and transfer strategies. AI algorithms analyze the performance data of players worldwide and provide clubs with information on potential transfer targets. This enables clubs to make more informed and data-driven transfer decisions. Additionally, AI technologies are used in injury prediction and prevention systems, making significant contributions to maintaining players' health and performance (Pariath et al., 2018).

This study aims to provide a scientific approach to determining the market values of football players. Through this approach, the goal is to develop an artificial intelligence model that can predict market values based on the future performance of players. This model aims

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to establish an objective, impartial, and reliable authority in market value determination, thereby contributing to accurate pricing in the football economy, where significant financial transactions occur. Unlike platforms like Transfermarkt, which often rely on subjective inputs such as user votes and expert opinions, this model offers a fully data-driven approach that ensures greater objectivity and precision. The model provides a more comprehensive and detailed valuation by integrating a wide array of performance metrics. Additionally, its ability to forecast future player performance allows clubs to plan their transfer strategies more effectively. In this way, the model will assist clubs in making more informed decisions during transfer processes and support their financial sustainability.

In this study, data collected from 1508 football players playing in the five major European leagues (Spain's La Liga, France's Ligue 1, England's Premier League, Italy's Serie A, and Germany's Bundesliga) and compiled at the end of the 2023-2024 season, from the websites Whoscored and Transfermarkt were analyzed.

A unique dataset was created by collecting 28 different performance metrics, the positions played, and the leagues from WhoScored for each player, while the market value data was gathered from Transfermarkt. Two main processes were performed on this dataset: regression and classification. While predicting the market values of football players based on their performance metrics, the dataset was split into 80% for training and 20% for testing during the regression analyses, whereas k-fold validation with k=5 was employed for the classification tasks. Among seven different regression models, the Random Forest Regression algorithm achieved the highest accuracy, with an R-squared value of 0.90. In the classification tasks, the players were first categorized into four different classes based on their market values, and then their class membership was predicted based on their performance metrics. Among ten different classification algorithms, the highest accuracy was achieved by the CNN algorithm, with a success rate of 97%.

The results indicate that regression and classification models can successfully determine and classify football players' market values. Therefore, it has been demonstrated that a decision support system that can assist football clubs in determining the appropriate transfer fees during the transfer process can be developed using both regression and classification-based artificial intelligence models.

The successful results obtained by the models underscore the importance of performance metrics in determining player market values. These models allow clubs to make more informed decisions about player selection and transfers. Additionally, they contribute to the efficient allocation of transfer expenditures, supporting clubs' financial sustainability.

In recent literature, several studies have explored the prediction of football players' market values using performance metrics and machine learning techniques. The study by Li et al. (2023) explores the use of machine learning models to assess the market values of football players. The research develops two models examining the relationships between players' key characteristics, on-field performance, and salaries. The study by Al-Asadi and Taşdemir (2022) investigates the application of machine learning techniques to predict the market values of football players using FIFA video game data. The research evaluates the effectiveness of various regression models, with the Random Forest algorithm showing the highest accuracy in predicting player market values. The study by Leifheit and Follert (2023) presents a financial valuation approach for football players from a club's perspective, focusing on future payment streams and using the income approach combined with Monte Carlo simulations. The study by Inan and Cavas (2021) develops an artificial neural network (ANN) model to estimate the market values of football players in the Turkish Super League, using performance metrics such as minutes played, goals scored, and passing accuracy. The study by Herm et al. (2014) explores the accuracy and evaluation attributes of an online community (specifically, Transfermarkt.de) in estimating the market values of professional soccer players. The study by Arrul et al. (2022) investigates the application of a neural network model to predict the market values of football players using data from FIFA 19. The study by Behravan and Razavi (2021) introduces a novel machine-learning approach for estimating football players' market values using the FIFA 20 dataset. The study by Kologlu et al. (2018) applies multiple linear regression to estimate the market values of football players in forward positions, using physical and performance factors from the 2017-2018 season. Lee et al. (2022) study proposes an optimized LightGBM model using Bayesian hyperparameter optimization to predict football players' market values. Aydemir et al. (2022) study proposes a machine-learning ensemble approach to predict football players' transfer values. The study by Franceschi et al. provides a systematic review of empirical research aimed at identifying the factors influencing football players' market valuations (Franceschi, 2024). The studies encountered in the literature on predicting football players' market values using artificial intelligence techniques have been listed above. A detailed comparison of each study with our work is provided in the discussions section.

METHODS

This section describes the dataset employed in the study, the algorithms used, and the metrics utilized to evaluate the data derived from these algorithms.

Dataset

The dataset used in this study contains performance data and market values for 1508 football players playing in the top five European leagues, with 28 different performance metrics included. Additionally, the dataset includes information on the players' positions and the leagues they play. The performance data, league information, and positions of the players were individually collected from the Whoscored platform. Subsequently, the market value of each player was obtained from the Transfermarkt platform. (Whoscored, 2024; Transfermarkt, 2024). This approach resulted in a comprehensive dataset on players in Europe's major leagues. The independent and dependent variables included in the dataset are presented in Table 1. The minimum and maximum value ranges for each variable are also shown in the same table.

Table 1
The Features Within the Dataset and Their Value Ranges

Variables Type	Features	Min – Max Range
	Age	16-40
	Minutes played	173-3060
	The number of matches started in the first 11	0-34
	Number of matches in which he was substituted	0-24
	Total goals	0-33
	Total assists	0-12
	Yellow card	0-16
	Red card	0-3
	Pass success percentage	46.1-95.5
Independent Variables	Aerial duels won per game	0-6.8
	Man of the match	0-9
	Shots per game	0-4.5
	Dribbles per game	0-3.6
	Fouled per game	0-2.9
	Offsides per game	0-1.5
	Dispossessed per game	0-2.9
	Bad control per game	0-3.8
	Tackles per game	0-4.6
	Interceptions per game	0-2.4
	Fouls per game	0-2.7
	Offside won per game	0-1.7
	Clearances per game	0-6
	Outfielder block per game	0-1.6
	Own goals	0-2
	Key passes per game	0-3.7
Independent Variables	Passes per game	3.1-106
	Crosses per game	0-2.9
	Long balls per game	0-15.2
	Through balls per game	0-0.6
	League	Categorical
	Position	Categorical
Dependent Variables	Market Value (€)	0-180000000

Scaling The Features in the Dataset

Min-Max Scaling is a widely used method in data normalization. This technique normalizes data by rescaling each value in a dataset to a specified range. Min-Max Scaling is particularly beneficial in machine learning models, where it helps make data points on different scales comparable. The method rescales each data point based on the minimum and maximum values in the dataset, so all data falls within a specified range (typically [0, 1]). Mathematically, for a data point x, Min-Max Scaling is expressed as:

$$x' = \frac{x - x_{min}}{x_{max} - x_{min}}$$

In this formula, x' represents the scaled value, x is the original value, x_{min} is the minimum value in the dataset, and x_{max} is the maximum value. This method enables the effective processing of different variables, particularly those measured in different units or scales, by machine learning algorithms (Jain et al., 2000).

Min-Max Scaling ensures that all data in the dataset falls within a specified range, making it particularly effective in gradient-based optimization algorithms and rule-based learning methods (Han et al., 2011). However, a major limitation of Min-Max Scaling is that if new values fall outside the range of the original minimum and maximum values, the scaled values may fall outside the [0, 1] range. Therefore, Min-Max Scaling works best when the same minimum and maximum values are used for both the training and test datasets.

Model Selection

In this study, the regression analyses were performed using the following algorithms: Adaboost, Decision Tree, Gradient Boosting, K Nearest Neighbors, Random Forest, Ridge Regression, and Support Vector Machine. For classification tasks, various algorithms were tested, including RandomForestClassifier, GaussianNB, SVC, KNN, GradientBoostingClassifier, XGBClassifier, AdaBoostClassifier, LogisticRegression, MLPClassifier, and CNN, with extensive hyperparameter tuning via GridSearchCV. This section explains the Random Forest and Gradient Boosting algorithms, which achieved the highest performance in the regression analysis, the CNN algorithm, which yielded the best results in the classification tasks.

Random Forest

Random Forest is another ensemble learning method widely used for classification and regression tasks. Unlike Gradient Boosting, which builds trees sequentially, Random Forest constructs many decision trees simultaneously during training and aggregates their results.

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This technique helps reduce overfitting and improves the model's generalization ability. The prediction for a new input x in a Random Forest is the average of the predictions from all individual trees:

$$\tilde{y} = \frac{1}{N} \sum_{i=1}^{N} T_i(x)$$

Where $T_i(x)$ represents the prediction from the i-th tree in the forest, and N is the total number of trees. Each tree in the Random Forest is built using a bootstrap sample of the data, and at each split, a random subset of features is selected. This process introduces randomness into the model, which helps variance and avoid overfitting (Breiman, 2001). The construction of each tree involves recursively splitting the data at points that maximize the reduction in a loss function, such as mean squared error for regression tasks.

This study applied the Random Forest algorithm to the same dataset of football players' performance metrics. The model demonstrated strong predictive power, making it a valuable tool for estimating market values. The inherent capability of Random Forest to handle many features and capture non-linear relationships contributed to its success in this context. The aggregated results from multiple trees provided a robust and stable prediction, enhancing the reliability of the model (Liaw & Wiener, 2002).

Gradient Boosting

Gradient Boosting is a powerful machine learning technique that builds an ensemble of weak learners, typically decision trees, to create a strong predictive model. The core idea of Gradient Boosting is to add trees to the model, each correcting the errors of the previous trees. This process can be mathematically expressed as follows: Given a dataset (X, y), where X represents the input features and y the target variable, the goal is to minimize a loss function $L(y, \tilde{y})$ over the predictions $\tilde{y}$.

Initially, the model starts with a simple prediction, such as the mean of y:

$$\tilde{y}_0 = mean(y)$$

In each subsequent iteration m, a new tree $h_m(X)$ is trained to fit the negative gradient of the loss function with respect to the current model prediction:

$$T_{i,m} = -\left[\frac{\partial L(yi, \tilde{y}i)}{\partial \tilde{y}_i}\right]_{\tilde{y}_i - \tilde{y}_{i,m-1}}$$

The model is then updated as follows:

$$\tilde{y}_m = \tilde{y}_{m-1} + \lambda h_m(X)$$

Here, λ is the learning rate that controls the contribution of each tree. This iterative process continues until the model's performance no longer improves significantly on a validation set. Gradient Boosting has been shown to be highly effective in various predictive tasks due to its ability to capture complex patterns in the data (Friedman, 2001).

Convolutional Neural Networks (CNN)

Convolutional Neural Networks (CNNs) are a class of deep learning algorithms particularly well-suited for tasks involving image and spatial data analysis, but they have also been successfully applied to various other classification problems. A CNN consists of multiple layers, including convolutional layers, pooling layers, and fully connected layers. The convolutional layers apply a series of filters (or kernels) that slide across the input data, detecting local patterns and features. Mathematically, the convolution operation performed by the filters can be expressed as:

$$S(i,j) = (I * K)(i,j) \sum_m \sum_n I(m,n).K(i-m,j-n)$$

Where $S(i,j)$ is the output feature map, I is the input matrix, and K is the convolutional kernel. This operation allows the CNN to automatically and hierarchically learn spatial hierarchies of features from the input data.

In classification tasks, the output from the convolutional and pooling layers is typically passed through fully connected layers, which interpret the learned features and make predictions. The final layer of the CNN usually uses a softmax function to produce a probability distribution over the possible classes. The CNN's parameters, including the filter weights, are learned during training through backpropagation and gradient descent optimization. This architecture enables CNNs to achieve high accuracy in various classification tasks, making them a powerful tool for machine learning (LeCun et al., 1998; Goodfellow et al., 2016).

Evaluation of the models

In this study, the performance of the regression models was evaluated using the R^2, MSE (Mean Squared Error), and RMSE (Root Mean Squared Error) metrics, while the performance of the classification models was assessed using the accuracy, precision, recall, F1-score, and support metrics.

R-Squared (R²)

R-squared is a statistical measure represents the proportion of the variance for a dependent variable explained by an independent variable or variables in a regression model. It is often used to evaluate the goodness of fit of a regression model. The value of R² ranges from 0 to 1, where 0 indicates that the model explains none of the variability of the response data around its mean, and 1 indicates that the model explains all the variability. The R² value can be calculated using the following formula:

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(y_i - \tilde{y}_i)^2}{\sum_{i=1}^{n}(y_i - \tilde{y})^2}$$

In this formula, y_i represents the observed values, $\tilde{y}_i$ represents the predicted values, and $\tilde{y}$ is the mean of the observed values (Draper & Smith, 1998). R² is a key metric because it provides an indication of how well the model's predictions match the actual data.

Mean Squared Error (MSE)

Mean Squared Error (MSE) is a common measure of the quality of an estimator—it is always non-negative, and values closer to zero are better. MSE is the average of the squares of the errors—that is, the average squared difference between the estimated values and the actual value. The formula for MSE is given by:

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(y_i - \tilde{y}_i)^2$$

In the formula above, n is the number of observations, y_i is the actual value, and $\tilde{y}_i$ is the predicted value (Montgomery et al., 2012). MSE is particularly useful because it penalizes larger errors more severely than smaller ones, making it a sensitive measure of prediction accuracy.

Root Mean Squared Error (RMSE)

Root Mean Squared Error (RMSE) is the square root of the Mean Squared Error. It is used to measure the differences between values predicted by a model and the values observed. RMSE is a good measure of how accurately the model predicts the response and is the standard deviation of the prediction errors (residuals). The formula for RMSE is:

$$MSE = \frac{1}{n}\sqrt{\sum_{i=1}^{n}(y_i - \tilde{y}_i)^2}$$

In the formula above, n is the number of observations, y_i is the actual value, and $i\tilde{y}_i$ is the predicted value (Chai & Draxler, 2014). RMSE is widely used because it gives an easily

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interpretable measure of model accuracy in the same units as the data, and it is more sensitive to outliers than MSE.

Accuracy

Accuracy is one of the most used metrics for evaluating the performance of a classification model. It represents the ratio of correctly predicted instances to the total number of instances. Mathematically, the accuracy metric is defined as:

$$Accuracy: \frac{TP + TN}{TP + TN + FP + FN}$$

In this formula, TP (True Positives) denotes the instances correctly classified as positive, TN (True Negatives) represents the instances correctly classified as negative, FP (False Positives) refers to the instances incorrectly classified as positive, and FN (False Negatives) represents the instances incorrectly classified as negative. Accuracy provides a general measure of how well the classification model performs overall, but it can be misleading in cases of class imbalance (Fawcett, 2006; Sokolova & Lapalme, 2009).

Precision

Precision is a performance metric that indicates how many instances predicted by a classification model are positive. Precision is critical when assessing a model's ability to minimize false positives. Mathematically, the precision metric is defined as:

$$Precision = \frac{TP}{TP + FP}$$

In this formula, TP (True Positives) represents the instances correctly classified as positive, while FP (False Positives) refers to the instances incorrectly classified as positive. Precision plays a critical role in measuring the reliability of a classification model's otmispositic predictions, especially in imbalanced datasets (Powers, 2011; Sokolova & Lapalme, 2009).

Recall

Recall is a performance metric that indicates how effectively a classification model can identify positive instances. It is particularly important for assessing the model's ability to minimize the number of false negatives. Mathematically, the recall metric is defined as:

$$Recall = \frac{TP}{TP + FN}$$

In this formula, TP (True Positives) represents the instances correctly classified as positive, while FN (False Negatives) refers to the instances incorrectly classified as negative, meaning the positive instances that the model missed. Recall plays a critical role, especially in

imbalanced datasets, for measuring how well the model can capture all instances of the positive class (Sokolova & Lapalme, 2009; Manning et al., 2008).

F1-Score

The F1-score is a performance metric defined as the harmonic mean of precision and recall. It balances precision and recall, ensuring that both metrics are considered. This is particularly important in imbalanced datasets or when the model needs to balance false positives and negatives. Mathematically, the F1-score is expressed as:

$$F1 - score = 2 * \frac{precision * recall}{precision + recall}$$

In this formula, precision represents the proportion of true positives among the instances predicted as positive, while recall indicates how well the model identifies all positive instances. The F1-score is recognized as a critical metric for balancing the disparity between precision and recall and for evaluating the model's overall performance (Powers, 2011; Sokolova & Lapalme, 2009).

RESULTS

In this study, two different methods, regression and classification, were applied to the original dataset collected. In the regression analysis, the dependent variable, Market Value, was predicted using other independent attributes. In the classification analysis, the football players in the dataset were categorized into different classes based on their market values. Subsequently, the cost classes of the players were predicted using the independent variables.

Regression Analysis

In this study, seven different regression models (Adaboost, Decision Tree, Gradient Boosting, K Nearest Neighbors, Random Forest, Ridge Regression, and Support Vector Machine) were initially applied to the raw dataset. Due to the unsatisfactory accuracy of the results from these procedures, the dataset was first adjusted using the standard scaling method. Subsequently, a correlation analysis was conducted to identify and remove features unrelated with the dependent variable. Figure 1 shows features with the highest positive and negative correlations with the dependent variable, Market Value.

Figure 1
Top 10 Positive and Negative Correlations with Market Value
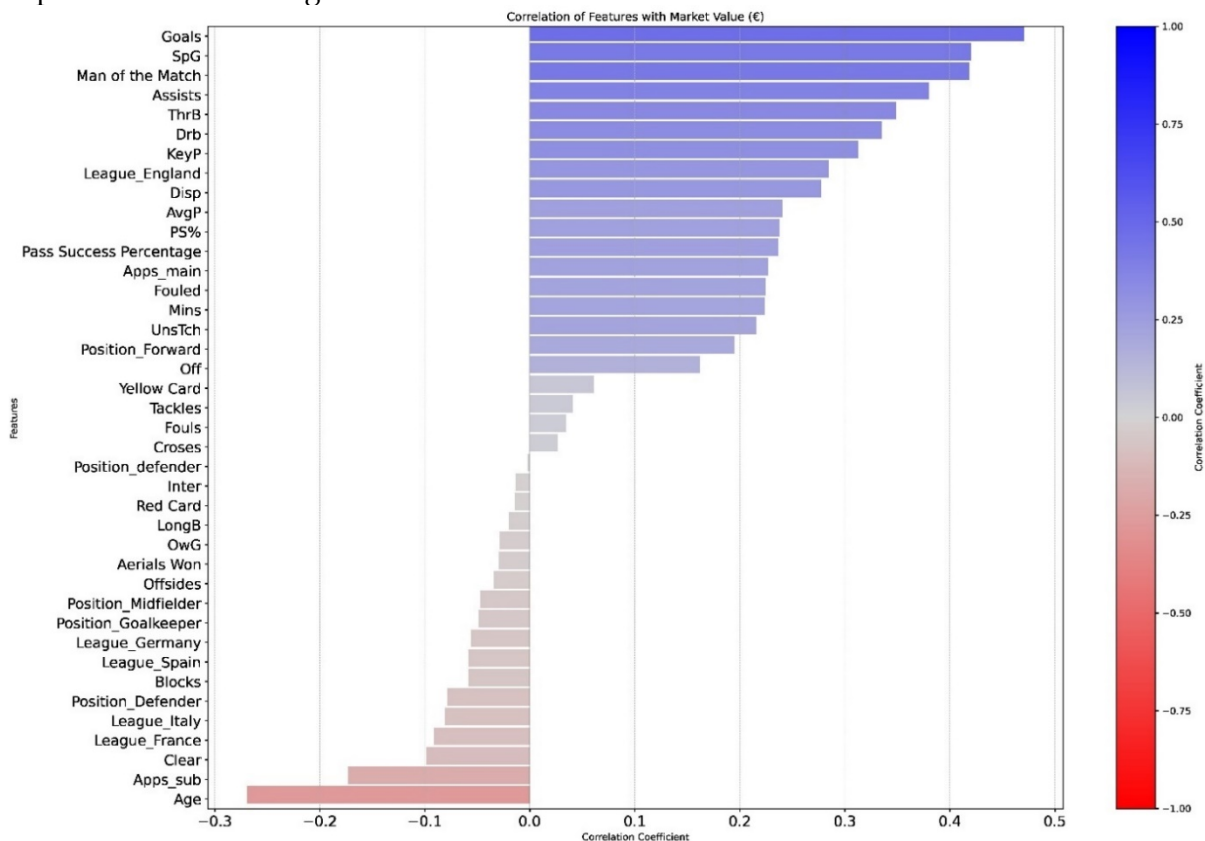
According to the correlation analysis performed, the independent variables with the highest positive correlations with the dependent variable, market value, are as follows: Total goals (Goals), shots per game (SpG), man of the match, assists, through balls per game (ThrB), sribbles per game (Drb), key passes per game (KeyP), being in the Premier League (League_England), dispossessed per game (Disp), AvgP, passes per game (PS%), pass success percentage, top 11 (Apss_main), fouled, playing time (Mins), turnover per game (UnsTch), forward (Position_Forward), off, age, number of matches in which he was substituted (Apps_sub), clearances per game (Clear).

The independent variables with the highest negative correlations with the dependent variable, market value, are as follows: Yellow card, tackles, fouls, interceptions per game (Inter), red card, long balls per game (LongB), own goals (OwG), aerial duels won per game (Aerials Won), offsides per game (Offsides), midfielder (Position_Midfielder), goalkeeper (Position_Goalkeeper), being in the Germany League (League_Germany), Being in the Spain League (League_Spain), outfielder block per game (Blocks), defender (Position_Defender), being in the Italy League (League_Italy), being in the France League (League_France).

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Following the correlation analysis, the attributes with the highest positive and negative correlations with the dependent variable were retained in the dataset, while the remaining attributes were removed. With the refined dataset, the dependent variable, Market Value, was predicted using the following algorithms: Adaboost, Decision Tree, Gradient Boosting, K Nearest Neighbors, Random Forest, Ridge Regression, and Support Vector Machine. The Random Forest and Gradient Boosting algorithms obtained the most successful results. Therefore, the data and results pertaining to these algorithms are presented. In this study, we opted not to use traditional reference groups for the League and Position variables due to their overall weak explanatory power. Only League_England and Position_Forward demonstrated a meaningful correlation with the target variable, while other leagues and positions showed weaker or insignificant effects on market value.

The hyperparameters used while running the Random Forest and Gradient Boosting algorithms were fine-tuned to maximize the performance of each algorithm. The most successful hyperparameter values obtained are shown in Table 2.

Table 2

The Best Hyperparameter Values Obtained for the Machine Learning Algorithms Used

Algorithms	Trained Hypermeters	Best Hypermeters Values
Gradient Boosting	'n_estimators' : [50, 75, 100], 'max_depth': [2, 4, 8], 'min_samples_split' : [1,2,4], 'min_samples_leaf' : [1,2 ,8], 'learning_rate' : [0.05, 0.1 , 0.5, 1]	learning_rate': 0.05, 'max_depth': 4, 'min_samples_leaf': 8, 'min_samples_split': 4, 'n_estimators': 100
Random Forest	'n_estimators' : [50,100,200], 'max_depth': [2, 4, 8, 16], 'min_samples_split' : [2,3,4], 'min_samples_leaf' : [2,3,4,8]	max_depth': 16, 'min_samples_leaf': 4, 'min_samples_split': 4, 'n_estimators': 50

Table 3 presents the training and testing graphs, prediction error distributions, and validation graphs for the Random Forest and Gradient Boosting algorithms, which were trained to predict the market values of football players in the top five European leagues using machine learning. A linear plot is expected in the training and testing graphs for successful training. Although the Random Forest algorithm's test and training graphs do not show a clear linear line, it can be said that there is no significant deviation. In the error distribution graphs, distributions with minimal variation are expected. When examining the error distribution graphs for the Gradient Boosting and Random Forest algorithms, it is observed that the errors are concentrated around zero. In the prediction and accuracy graphs, the blue lines represent the actual values, while the orange lines represent the values predicted by the model. In this

graph, the desired outcome is the overlap of these two different colored lines. The graph obtained from the Gradient Boosting algorithm ishows that the blue and orange lines overlap.

Table 3
Various Performance Graphs Obtained From Random Forest and Gradient Boosting Algorithms

Alg.	Real Values & Prediction	Fault Distribution	Predicting Values
Random Forest			
Gradient Boosting			
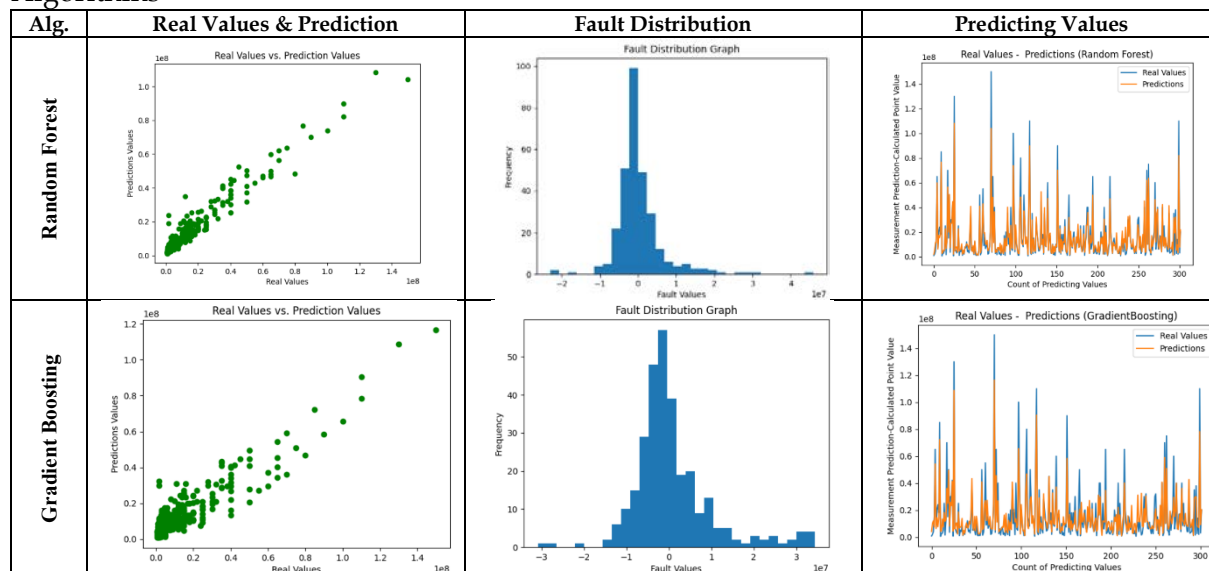
Table 4 shows the metric values obtained from Gradient boosting and random forest algorithms. The metrics obtained from the Gradient Boosting and Random Forest regression models provide significant insights into the models' performance and accuracy in predicting football players' market values.

Table 4
Various Performance Metrics Obtained From the Algorithms Used

Algorithms	R-Squared	MSE	RMSE
Random Forest	0.9040082175222088	43761946912597.55	6615281.317721684
Gradient Boosting	0.80772276818793	87657774383008.19	9362573.064228026

Classification Analysis

In this study, classification processes were conducted following the regression procedures on the original dataset. The subsequent sections provide information on the reasons for performing classification, how the classes were created, and the metric values obtained from these procedures.

The market value has been converted to categorical named "Low", "Lower-Mid", "Upper-Mid" and "High". Converting a continuous target into a categorical one can significantly influence predictive models' effectiveness and applicability. Predictive models typically predict a quantity when dealing with continuous variables, thus framing the problem

as a regression. Conversely, if the target variable is categorical, the task transforms into a classification aimed at predicting discrete labels. In predictive modeling, the characterization of the target variable crucially defines the analytical strategy—whether one might pursue regression or classification methodologies (Gareth et al., 2013). The conversion of continuous variables into categorical variables is driven by several considerations that enhance the interpretability and applicability of the analytical outcomes:

- o *Interpretability:* Categorical outcomes simplify interpreting the model's results, making the predictions more intuitive and actionable (Hastie et al., 2009).

- o *Handling Non-linear Relationships:* Classification algorithms can effectively manage complex, non-linear relationships that linear regression might fail to capture, thus potentially improving model performance (Breiman, 2001).

- o *Dealing with Skewed Data:* Continuous data that are heavily skewed may adversely affect model performance, especially if certain statistical assumptions (e.g., normality) are violated. Categorization can mitigate such issues (George et al., 2005).

- o *Robustness and Performance:* Models built on categorized data are often more robust and simpler to validate across different subpopulations, thus enhancing the model's generalizability and utility (Breiman, 2001).

The transformation from continuous to categorical variables should adhere to sound methodological principles. The categorization process must ensure that critical information is not obscured and the resulting categories are substantively meaningful (Agresti, 2012).

In feature selection, correlation and ANOVA tests have been widely used in machine learning. The correlation between a feature and the target value can vary widely depending on the nature of the data and the specific problem. There isn't a specific threshold for a "good" correlation value that applies universally, but understanding the correlation's strength can help us select feature and understand the underlying relationships in the data. With correlation, +1 indicates a perfect positive correlation, -1 indicates a perfect negative correlation, and 0 indicates no linear correlation. It can be said that if an absolute value of correlation is near 1, then the relationship between the feature and the target value is high, but this also raises concerns about potential overfitting if the model is overly reliant on them.

On the other hand, when it comes to ANOVA tests, the F-values and p-values help identify the features that have a statistically significant relationship with the target variable. Of course, there are neither "good" values for F-values or p-values. However, these values can

be very helpful in understanding the data characteristics and the desired level of confidence in the results.

The F-value represents the variance ratio between the groups (between-group variability) to the variance within the groups (within-group variability). A higher F-value indicates that the group means are significantly different, suggesting a stronger relationship between the feature and the target variable. Thus, it can be said that higher F-values are better. The p-value indicates the probability that the observed data could have occurred by chance under the null hypothesis, which in the context of ANOVA, there are no differences among group means. A low p-value suggests that the observed data are unlikely under the null hypothesis and that there is a statistically significant effect. Typically, a p-value less than 0.05 is considered statistically significant, meaning there is less than a 5% probability that the difference among the group means occurred by chance. However, this threshold can be adjusted if we want to be more confident and reduce the chance of false positives, adopting a more stringent level like 0.01.

Table 5 displays the F-Values and P-Values from the ANOVA tests and the correlation values between features and the target variable. The table is sorted based on the F-Value. A p-value threshold of 0.01 was chosen, along with high F-values, to provide a more stringent criterion for statistical significance. This reduces the likelihood of false positives, enhances confidence in the results, and aligns with rigorous scientific standards. Additionally, a correlation threshold 0.20 was determined to ensure strong relationships between features and the target variable. Consequently, the features 'Goals', 'League_England', 'Age', 'ThrB', 'Man of the Match', 'SpG', 'Assists', 'Drb', 'KeyP', 'AvgP', 'Disp', 'PS%', 'Pass Success Percentage', 'Apps_main', 'Mins', 'Fouled' and 'UnsTch' were selected for our model.

Table 5
F-Values and P-Values From the ANOVA Tests

Feature	F-Value	P-Value	Correlation
Goals	6.921477	1.016068e-56	0.470555
League_England	6.203801	3.669312e-49	0.284496
Age	5.659184	2.187875e-43	-0.269271
ThrB	5.258585	3.975027e-39	0.348716
Man of the Match	5.230734	7.862186e-39	0.418369
SpG	5.198296	1.739901e-38	0.420393
Assists	4.270797	1.172761e-28	0.380256
Drb	3.327598	6.652129e-19	0.335281
KeyP	3.251458	3.875351e-18	0.312894
AvgP	2.815660	7.337121e-14	0.240314
Disp	2.750623	3.058217e-13	0.277440

Table 5 *(Continued)*

Feature	F-Value	P-Value	Correlation
PS%	2.705459	8.177499e-13	0.237691
Pass Success Percentage	2.687372	1.210252e-12	0.236792
Apps_main	2.450002	1.860794e-10	0.227125
Mins	2.379942	7.874275e-10	0.223510
Fouled	2.283613	5.513421e-09	0.224452
Feature	F-Value	P-Value	Correlation
League_Spain	2.067382	3.631018e-07	-0.058138
UnsTch	1.880720	1.058149e-05	0.215552
Position_Forward	1.853433	1.694458e-05	0.194655
Off	1.768668	7.026165e-05	0.162074
League_Italy	1.636212	5.666960e-04	-0.080680
Apps_sub	1.629456	6.273308e-04	-0.173085
Tackles	1.401693	1.404777e-02	0.040936
League_Germany	1.369985	2.050243e-02	-0.056099
Yellow Card	1.354213	2.460770e-02	0.060769
League_France	1.337613	2.969716e-02	-0.091227
Position_Defender	1.223311	9.606589e-02	-0.078811
Fouls	1.103788	2.563111e-01	0.034875
Inter	1.064114	3.342108e-01	-0.013796
Position_Midfielder	1.034925	3.982358e-01	-0.047409
Blocks	0.993588	4.957139e-01	-0.058723
Red Card	0.941609	6.219149e-01	-0.014327
OwG	0.931666	6.455674e-01	-0.028492
Clear	0.926909	6.567548e-01	-0.098732
Offsides	0.846132	8.250200e-01	-0.034334
Croses	0.789850	9.076117e-01	0.026532
Aerials Won	0.729231	9.616859e-01	-0.029563
LongB	0.702325	9.759380e-01	-0.020089
Position_Goalkeeper	0.671243	9.868230e-01	-0.048497

The classification model has been tested using various algorithms, including RandomForestClassifier, GaussianNB, SVC, KNN, GradientBoostingClassifier, XGBClassifier, AdaBoostClassifier, LogisticRegression, MLPClassifier, and CNN, with extensive hyperparameter tuning via GridSearchCV. The best performance was achieved with the CNN model, which attained an accuracy of 97%. Other algorithms did not surpass an accuracy of 80%. Table 6 outlines the layer architecture of the CNN model. Sixteen features were selected for the model, necessitating multiple convolutional layers to capture complex hierarchical features. BatchNormalization layers stabilize the model and accelerate training, MaxPooling layers reduce spatial dimensions and computational load, and Dropout layers prevent overfitting. These architectural choices collectively create a powerful and efficient model that

accurately classifyies data with the selected 16 features. Table 7 displays the metric values for the classification process performed using the CNN model. Figure 2 shows the confusion matrix for the classification process performed using the CNN model.

Table 6
Layer Architecture and Parameters of the CNN Model for Classification Task

Layer (type)	Output Shape	Param #
conv1d_3 (Conv1D)	(None, 17, 64)	192
batch_normalization_3	(Batch (None, 17, 64))	256
max_pooling1d_3	(MaxPooling1 (None, 8, 64)	0
conv1d_4	(Conv1D) (None, 8, 64)	8256
batch_normalization_4	(Batch (None, 8, 64)	256
max_pooling1d_4	(MaxPooling1 (None, 4, 64)	0
conv1d_5	(Conv1D) (None, 4, 32)	4128
batch_normalization_5	(Batch (None, 4, 32)	128
max_pooling1d_5	(MaxPooling1 (None, 2, 32)	0
flatten_1	(Flatten) (None, 64)	0
dense_3	(Dense) (None, 256)	16640
dropout_2	(Dropout) (None, 256)	0
dense_4	(Dense) (None, 128)	32896
dropout_3	(Dropout) (None, 128)	0
dense_5	(Dense) (None, 4)	516

Total params: 63.288
Trainable params: 62.948
Non-trainable params: 320

Table 7
The Metrics for the CNN Model

	Precision	Recall	F1- Score	Support
0	0.97	0.98	0.98	386
1	0.99	0.95	0.97	418
2	0.96	0.97	0.96	346
3	0.97	0.98	0.98	358
Accuracy			0.97	1508
Macro Avg.	0.97	0.97	0.97	1508
Weighted Avg.	0.97	0.97	0.97	1508

Note. Test Accuracy: 0.9728116989135742

Figure 2
The Confusion Matrix of the Proposed CNN Model
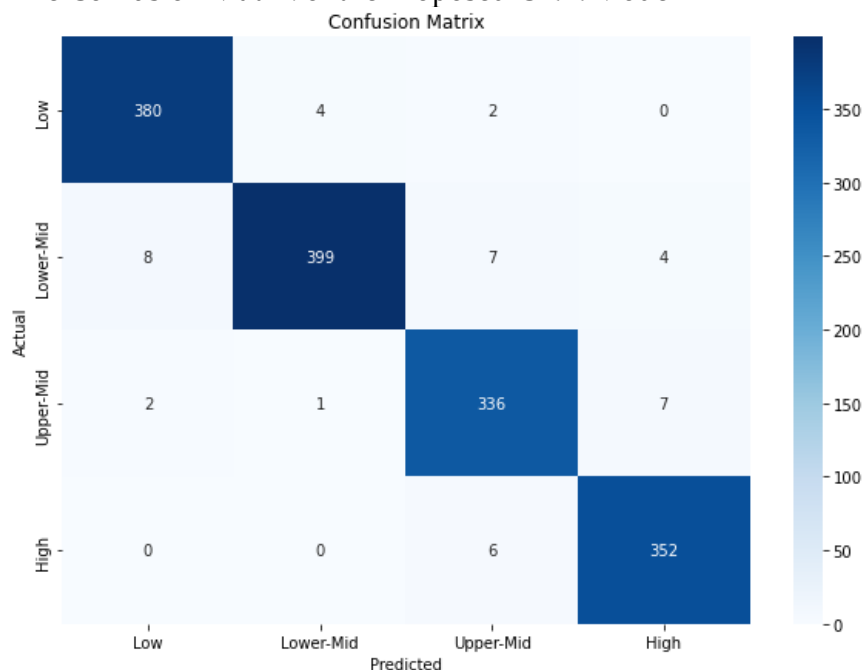
DISCUSSION

This study has demonstrated the significant role of performance metrics in estimating the market values of football players in Europe's top five leagues.

In this study, the highest R-squared value for determining football player market value using regression analysis was 0.90 with the Random Forest algorithm. When examining the performance of the Random Forest model, the Mean Squared Error (MSE) was found to be 43761946912597.55. Although this value appears to be extremely high, it is understandable given that the dataset is in Euros and has a wide range of player values. Football players' market values can vary from a few hundred thousand Euros to hundreds of millions of Euros. This broad range leads to substantial prediction errors. The Root Mean Squared Error (RMSE) was calculated to be 6615281.31. Since RMSE is the square root of MSE, it represents the error in the same unit, indicating that the model's predictions deviate from the actual market values by an average of approximately 6.9 million Euros. This error margin is acceptable considering the natural variability in football players' market values. The model's R-squared (R^2) value was determined to be 0.90, indicating that the model explains 90% of the variance in the dependent variable (market value), which signifies a strong performance.

The obtained R^2 value indicates that the overall performance and accuracy of the models provide reliable results in predicting football players' market values. Despite the high MSE and RMSE values, which are expected due to the nature of the dataset and the wide range

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of market values, the strong R2 value demonstrates the models' effectiveness in capturing the underlying patterns in the data.

Random Forest emerged as the most successful algorithm in regression analysis due to its ensemble learning approach, which combines multiple decision trees to improve predictive accuracy and control overfitting. Each decision tree in the Random Forest is trained on a random subset of the data, allowing the model to capture a wide range of patterns and relationships within the dataset. This method is particularly effective in handling complex, non-linear interactions between features, making it more robust against noise in the data. In contrast, other algorithms like Ridge Regression and Support Vector Machines struggled to achieve similar accuracy due to their linear assumptions and sensitivity to outliers, which limited their ability to model the intricate patterns in the data.

In this study, the highest accuracy rate for determining football player market value using a classification process was 97% with the CNN algorithm. The metrics obtained from the classification process using the CNN model indicate a very high performance. The average precision, recall, and F1-score of 0.96 to 0.99 were calculated based on the class. These values demonstrate the model's high accuracy in positive predictions (precision) and its effectiveness in positive classification (recall).

An F1-score of 0.96 to 0.98 show a good balance between precision and recall, indicating strong overall performance of the model. The average support value of 1509 signifies that there are enough data points in each class, ensuring the reliability of the results. Additionally, a test accuracy of 97% suggests that the model has a high general accuracy and can correctly classify most of the examples in the dataset. These metrics indicate that the CNN model performs effectively and reliably in the classification task, and it also highlights the model's high generalizability.

In the classification tasks, the Convolutional Neural Network (CNN) outperformed other models due to its ability to automatically and hierarchically extract features from the input data, mpartinly when dealing with spatial or grid-like structures. CNNs are designed to capture local patterns through convolutional layers, which is especially advantageous when the data has underlying spatial dependencies or complex feature interactions. This allows the CNN to effectively differentiate between classes, even in the presence of noisy or irrelevant data. On the other hand, traditional models like Logistic Regression or even other machine learning algorithms such as RandomForestClassifier and SVC struggled because they either could not automatically learn feature representations or were less effective in capturing the complex relationships within the data.

In our analysis, we observed negative correlations between spcifcertaic defensive metrics, such as interceptions per game, aerial duels won per game, clearances per game, and players' market values. Although these metrics are typically seen as indicators of strong defensive performance, their negative correlation with market value can be explained by several factors upon closer examination.

First, it is important to consider the positional differences in football. Players who excel in these defensive statistics are typically defenders and, in some cases, defensive midfielders. Historically, these positions tend to have lower market values compared to attacking players, who contribute directly to goal-scoring opportunities. For example, forwards and attacking midfielders who accumulate goals, assists, and key passes are generally valued more highly by clubs due to their perceived direct impact on match outcomes. This disparity in market value between positions can explain why metrics strongly associated with defenders, such as clearances and aerial duels, show negative correlations with market value. The underlying logic is not that these players are less valuable but rather that their market value is shaped by their positional role and perceived importance in modern football.

Secondly, league-level differences also play a role. The Premier League, for instance, is known for its more physically demanding style of play, where defensive contributions such as aerial duels and clearances might be more prominent compared to other leagues like La Liga or Serie A, which may emphasize technical skills and ball control. The overall market value of players in the Premier League is typically higher due to the financial strength of clubs in this league. However, as these defensive metrics are less valued in attacking players, it may result in a negative correlation between these statistics and market value, particularly when aggregated across different leagues. In conclusion, while these defensive metrics are undoubtedly crucial to a team's overall success, their impact on individual market values is mediated by positional roles and league-specific dynamics. Future research could benefit from applying normalization techniques to better capture the true relationship between player performance and market value across various contexts.

This study's primary aim is to estimate football players' global market values based on their performance data. Accordingly, the objective is to analyze the impact of performance metrics on individual player valuations from a global perspective. Our study focuses not on examining differences between leagues or positions, but rather on developing a general market valuation model applicable to all football players.

While normalization by league and position could offer a more nuanced analysis, it would shift the study's focus towards localized market dynamics, which falls outside the scope

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of this study. The central goal of this research is to provide a global assessment, offering a broader perspective on player valuation in the world of football. Normalization based on league and position would be more suited for studies analyzing local differences. However, this approach does not align with the purpose of the porposed study, which aims to estimate market values from a universal perspective.

Furthermore, estimating global market values based on performance data aims to offer clubs a general guide for their transfer strategies. Emphasizing league and position-based differences would require specific models for each club or league, which would narrow the scope of our study and weaken its general applicability. Therefore, we believe that normalization according to league and position averages falls outside the scope and purpose of this research.

The results of the regression and classification models offer insights into various aspects, such as football performance, the transfer market, and football club economics, providing a foundation for practical applications in club management and strategic transfers.

Performance metrics provide an objective way to measure players' impact on the field. In this study, metrics such as the number of goals, shots per game, assists, man of the match and age were found to have high correlations with players' market values. These findings underscore the importance of adopting a more analytical approach in evaluating player performance. Coaches and technical directors can use these metrics to better analyze players' contributions on the field and make strategic decisions.

The findings of this study can directly influence decision-making processes in the football transfer market. Player transfers are critical for clubs' success, and mistakes in these processes can lead to significant financial losses. Our study has shown that regression and classification models based on performance metrics can accurately predict player market values. This encourages clubs to adopt more precise and data-driven approaches in their transfer decisions.

Football economics is vital for clubs' financial health and sustainability. Transfer expenditures constitute a large portion of clubs' budgets, and poor transfer policies can lead to financial crises. Our study has demonstrated that performance data can be effectively used to estimate players' market values. This can help clubs make more informed decisions during transfers and utilize their financial resources more efficiently.

Clubs' economic sustainability is critical for maintaining their long-term success. Since many clubs experienced revenue losses during the COVID-19 pandemic, cost-effective transfer strategies have become even more important. This study provides valuable insights that can

help clubs optimize their transfer expenditures and reduce financial risks. Prediction models based on performance metrics can enable clubs to make more strategic player selections, supporting their financial sustainability.

Various studies have employed machine learning and statistical modeling techniques to estimate the market values of football players. While some of these studies share similarities in methods and findings with our work, distinct differences set our research apart.

Li et al. (2023) focused on using machine learning models to predict football players' market values, primarily using player salaries as proxies. In contrast, our research directly estimates market values by incorporating additional variables such as position and league information into a broader dataset and by comparing the performance of different machine learning models to provide a more comprehensive approach. This distinction highlights our contribution to achieving more accurate predictions.

Al-Asadi and Tasdemir (2022) utilized FIFA video game data to estimate player market values. Our approach differs by using real-world performance data and including additional variables like league and position. Furthermore, we compare multiple machine learning models and optimize them to enhance predictive accuracy, making our study more applicable to real-world scenarios.

Leifheit and Follert (2023) introduced a financial valuation model that focuses on players' subjective and future-oriented value based on payment streams. Our study diverges by directly predicting market values using a variety of machine learning models, incorporating real-world performance data such as position and league, and offering a more practical and data-driven model for market value prediction.

Inan and Cavas (2021) applied an artificial neural network (ANN) to estimate market values in the Turkish Super League. While their study provides valuable insights into ANN application, our research is distinguished using a broader range of machine learning models and additional variables like league and position data. We also emphasize model optimization to enhance accuracy, providing a more comprehensive approach.

Herm et al. (2014) examined crowd-sourced evaluations of soccer players' market values, highlighting external popularity metrics and talent-related factors. Our research, however, leverages advanced machine learning models and systematically incorporates performance metrics and additional variables, resulting in a more objective and data-driven prediction model.

Arrul et al. (2022) focused on a neural network model using FIFA 19 data. In contrast, our research incorporates real-world performance data and additional variables like league

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and position. We also compare and optimize multiple machine learning models, offering a more comprehensive approach to player valuation.

Behravan and Razavi (2021) emphasized a hybrid machine learning model using APSO-clustering combined with PSO-SVR based on video game data. Our study expands on this by using real-world data and incorporating additional variables. We apply multiple machine learning models in a real-world context, optimizing them to enhance accuracy and practical application in professional football.

Koloğlu et al. (2018) employed multiple linear regression to assess market values, particularly for forward positions. While their study provides insights into influential factors, our research differs by using a broader range of machine learning models, including ensemble methods, and incorporating variables like league and position data for a more dynamic approach.

Lee et al. (2022) introduced an optimized LightGBM model with Bayesian hyperparameter optimization. While their study focuses on optimizing a single model, our research compares multiple models and incorporates additional variables like league and position data, providing a more versatile approach to predicting market values.

Aydemir et al. (2022) used a machine learning ensemble approach with diverse data sources to predict transfer values. Our research extends this by incorporating additional variables like league and position data and comparing multiple models optimized for real-world scenarios, offering a more adaptable and robust framework.

Franceschi et al. (2024) systematically reviewed the factors affecting market valuations, focusing on a general framework. Our research, however, employs advanced machine learning models, incorporates specific variables like position and league data, and compares a greater variety of models, setting our work apart as a significant contribution to more accurate predictions. Compared to these studies, the original contributions of our work include:

- o *Multiple Model Comparison:* We compared various machine learning models to identify the best-performing ones in predicting market values.
- o *Use of Ensemble Methods:* We developed more robust predictive models by reducing noise and improving accuracy through ensemble methods.
- o *Hyperparameter Optimization:* Optimizing the models' hyperparameters significantly enhanced their predictive accuracy.

These aspects demonstrate that our study makes a significant contribution to the literature, representing an important step toward more accurate estimation of football players' market values.

One of study's major limitations is the data collection challenge. Specifically, no existing platform provides all the necessary information, making the process complex. The authors meticulously collected data for approximately 1,500 players, including performance, league, and position information. Despite being time-consuming and labor-intensive, this process was carried out with great care to ensure reliability and validity.

Based on our findings, we recommend that future research focus on expanding the dataset to include a broader range of leagues, seasons, and player groups. Utilizing larger and more diverse datasets could improve generalizability and provide a more comprehensive understanding of the factors influencing player market values.

In conclusion, this study highlights the importance of performance metrics in estimating football players' market values and provides a pathway for clubs to make more informed and data-driven decisions in the transfer process. These findings can make significant contributions to future research and practice in football economics and club management.

Limitations

While this study provides valuable insights into the role of performance metrics in estimating the market values of football players in Europe's top five leagues, certain limitations should be acknowledged.

- o Dataset Scope: The dataset includes performance metrics and market values for 1508 players from a single season. This focus on a specific timeframe limits the generalizability of the findings to other seasons or leagues outside the top five in Europe.

- o Market Value Subjectivity: Market values were obtained from the Transfermarkt platform, which partially relies on subjective inputs such as expert opinions and user votes. While these values are widely recognized, they may not fully capture market dynamics or fluctuations influenced by factors like recent transfers or injuries.

- o Exclusion of External Variables: Non-performance-related factors such as player endorsements, media popularity, and off-field behavior, which can significantly impact market values, were not included in the model. Incorporating such variables could enhance the model's accuracy.

o Model-Specific Biases: The machine learning algorithms used (e.g., Random Forest and CNN) have inherent assumptions and biases, which might influence the results. Different algorithms or approaches could yield varying outcomes.

o Resource Constraints: Due to practical limitations, the study did not incorporate a longitudinal analysis to observe changes in market values over time, which might offer deeper insights into player valuation dynamics.

Despite these limitations, the study provides a robust framework for future research to refine and expand upon these findings. Incorporating larger, more diverse datasets and additional variables could further enhance the predictive accuracy and applicability of the proposed models.

CONCLUSION

This study has demonstrated the significant role of performance metrics in estimating the market values of football players in Europe's top five leagues. The findings suggest that football clubs can make more informed decisions during transfer processes when performance data is used accurately and effectively. Specifically, the high correlations between metrics such as the number of goals, shots per game, assists, man of the match, and age with player market values emphasize the importance of adopting a more analytical and data-driven approach in player evaluations.

Moreover, the high accuracy rates of the regression and classification models used in this study provide a valuable foundation for future research in football economics and club management. Prediction models based on performance metrics can help clubs optimize their transfer expenditures and ensure financial sustainability. In this context, our findings support football clubs in making strategic decisions that enhance the efficient use of financial resources, thereby aiding in their long-term success and sustainability.

PRACTICAL IMPLICATIONS

This study has significant practical implications for football clubs, analysts, and stakeholders in the transfer market. It demonstrates that integrating performance metrics into machine learning models provides a robust framework for estimating football players' market values. By adopting these models, clubs can make more informed, data-driven decisions during transfer negotiations, effectively reducing the risks of overpayment or undervaluation.

Identifying players whose performance metrics align closely with their market values allows clubs to optimize their transfer budgets. This approach is particularly beneficial for

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ensuring financial sustainability, especially for clubs with limited resources or those recovering from economic disruptions, such as the COVID-19 pandemic. Furthermore, metrics such as goals, assists, and passing accuracy offer an objective foundation for evaluating players' contributions, minimizing reliance on subjective assessments and biases. This improvement enhances the fairness and accuracy of talent evaluations.

The insights from this study also have the potential to revolutionize scouting processes. Clubs can prioritize performance metrics that show the strongest correlation with market value, enabling them to identify high-potential talent more effectively. Beyond football, the methodology proposed in this study could be adapted for other sports, such as basketball or baseball, or even extended to industries where performance metrics influence valuation, such as corporate talent assessments.

Although these implications are promising, their practical implementation requires access to comprehensive performance datasets and expertise in machine learning. Collaboration between football clubs and analytics providers will be essential to address these challenges, ensuring the proposed models achieve their maximum potential impact.

Authors' Contributions

Both authors have equally contributed to all stages of this research. This includes the conception and design of the study, data collection, analysis and interpretation of the data, as well as the drafting and revision of the manuscript. Both authors read and approved the final manuscript.

Declaration of Conflict Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Ethics Statement

This study was conducted using publicly available online data pertaining to football players' performance metrics and market values. No experiments or tests involving human participants were carried out. Therefore, ethical approval from an ethics committee was not required for this research.

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Research Article

The Relationship Between Leisure Satisfaction and University Adjustment in University Students in the Context of Dropout Theory

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ABSTRACT

The aim of this study is to examine the relationship between leisure satisfaction and adjustment to university life among students. The study included students studying at Akdeniz University Central Campus in Antalya. The sample group consisted of 111 male (mean age = 21.982±2.753) and 139 female (mean age = 21.640±4.462) students who participated voluntarily. The convenience sampling technique was used to reach the sample. The Leisure Satisfaction Scale, the University Adjustment Scale, and the personal information form were used to collect the data. As a result of the analysis, two significant canonical correlations were and the significant contributions of the variables to these canonical functions are at a .45 significance level. The results showed that as psychological, educational, social, physical, and aesthetic satisfaction in the leisure satisfaction dataset increased, students' institutional and personal-emotional adjustment to the university also increased. In addition, it was determined that as relaxation, aesthetic, educational, physical, and psychological satisfaction in the leisure satisfaction data set increased, students' social adjustment also increased. According to the findings of the study, it is recommended that universities should increase leisure time activities and improve physical conditions to ensure students' adaptation to the university.

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INTRODUCTION

The concept of leisure has been an indispensable part of human life since ancient times. From the earliest ages, people have engaged in painting, music, and various sports activities during their leisure time (Ağaoğlu et al., 2005). Today, leisure is not only defined as a sense of freedom (Kuo et al., 2021) but also recognized as a critical life domain shaping the health and well-being of society (Denovan & Macaskill, 2017). Nash considers recreation to best way of expressing intrinsic drives (Canadian Parks/Recreation Association, 1995). Leisure satisfaction refers to the positive and pleasant feelings individuals experience as a result of engaging in leisure activities, representing a state of immediate gratification (Çakıroğlu, 1998). Positive leisure experiences are associated with well-being (Mansfield et al., 2020) and stress reduction (Chun et al., 2012). Young people learn to socialize through leisure activities by gaining meaningful and positive experiences (Granzin & Haggard, 2000). On the other hand, the literature suggests that not enjoying leisure activities can increase substance and internet use among adolescents (Wang, 2019; Weybright et al., 2015). These definitions reveal that recreation has both individual and social functions (Tekin et al., 2009). Current research highlights the significant role of leisure activities for youth in coping with stress (Park & Kim, 2018), fostering positive youth development (Bruner et al., 2017, p. 212), and supporting mental health (Hall et al., 2016). While Meyer and Brightbill describe recreation as a social force (Scholl et al., 1999), Butler emphasizes its effectiveness as a tool for avoiding harmful habits and promoting social cohesion (Shaw, 2000). Like cultural and artistic activities, leisure plays an important role in society, enhancing individuals' health and well-being (Khasnabis et al., 2010). The positive emotions derived from leisure activities point to leisure satisfaction. Ngai (2005) underscores the vital role of access to leisure in making individuals more socially harmonious.

For these reasons, university adaptation is a significant factor in students' career and social lives. Adapting to university life is considered a challenging period (İkiz & Mete-Otlu, 2015; Özkan & Yılmaz, 2010). During this difficult time, students' participation in leisure activities and sharing positive emotions influence their adaptation to university life. Sevinç and Gizir (2014) noted that adverse experiences in social relationships, utilization of sports facilities, and leisure activities negatively affect students' adaptation to university life. Participation in leisure activities at university can alleviate the stress caused by this challenging process. Universities offer various opportunities for students to engage in leisure

activities. The satisfaction students derive from these opportunities constitutes the concept of leisure satisfaction. Through the leisure opportunities they provide, universities offer students an educational environment and opportunities for socialization, relaxation, renewal, acquiring new hobbies, and learning new skills. Leisure activities are essential for students to learn university norms and develop a sense of belonging through socialization. Indeed, Zheng and Zheng (2023) note that leisure activities facilitate the adaptation process during the university transition by providing social support. Recreational activities enhance individuals' quality of life through physical, environmental, relaxation, educational, social, and psychological benefits (Bammel & Burrus-Bammel, 1996; Bright, 2000; Ho, 2008; Hung, 2012). These activities help individuals experience happiness, escape the troubles of daily life, and avoid harmful habits (Toker, 2021). Nash associates happy individuals with recreation, emphasizing that creative, exploratory, and meaningful activities occur in a satisfying life (Nash, 1960). Leisure activities positively affect individuals by ensuring mental and emotional balance (Karaküçük & Gürbüz, 2007). Ağan (2000) emphasizes the need for recreation and sports activities among university students. These features suggest that satisfaction derived from leisure activities plays a role in university adaptation.

Universities are institutions that fulfill educational functions and places where individuals develop themselves multidimensionally and lay the foundations of their professional lives. Kokotieieva et al. (2023) highlight that a student's professional development begins at university. University education is a significant tool for individuals to access various economic opportunities and enhance their cultural and social capital. A study examining the adaptation of first- and second-year students to university life found that 32.9% of students experienced adaptation problems (Değer & Çiftçi, 2020). Failure to adapt to university life, despite possessing the knowledge to enter a program, may lead individuals to drop out of education, causing psychological issues due to uncertainty about their future and posing a societal problem due to the potential loss of qualified labor. The transition to university is a phase where students adapt from familiar norms of their previous environments to new norms (Tinto, 1975). Failure to complete this transition phase often results in students leaving university. Addressing university adaptation problems is crucial for ensuring the continuity of students' educational lives, contributing to both individual and societal welfare. Leisure activities are important during this transition phase as they allow students to observe and experience the norms of university life. Therefore, examining the relationship between leisure satisfaction and university adaptation in detail is essential.

Studies in the literature have often evaluated university adaptation from the perspective of students' problems and expectations regarding university (İkiz & Mete-Otlu, 2015; Özkan & Yılmaz, 2010). However, research examining university adaptation from the perspective of leisure satisfaction appears to be scarce. In their study on students' leisure satisfaction, Sönmez and Gürbüz (2022) found a relationship between satisfaction derived from participation in leisure activities and university adaptation. This finding is important for our study. However, we believe that analyzing the multidimensional relationships between these two variable sets and evaluating them in a holistic context will add depth to the research findings. As it identifies the most significant combinations (canonical variables) for both data sets, canonical correlation analysis is more robust than other correlation analyses. Its ability to focus on the entire data structure provides more comprehensive insights, offering valuable clues for administrators and experts in determining the types of activities and events to be organized for university adaptation. Our study is expected to contribute to the literature by examining the relationship between students' leisure satisfaction and university adaptation in more depth and evaluating it within Tinto's Student Dropout Model framework.

Theoretical Framework

When the theoretical foundations of adjustment to university life are examined, it is seen that the theories of dropout model (Tinto, 1975), student attrition model (Bean, 1980) and student involvement model (Astin, 1984) stand out. Our study has been handled within the framework of the dropout model developed by Tinto. According to Tinto, universities are social systems, and the process of adaptation to a university consists of a series of stages. A student must go through separation, transition, and integration stages to adapt to the university. The separation stage, refers to the separation of the student from the family and friend environment from the order of high school life.

The transition phase is when students get used to the norms of their new environment after the familiar norms of their old environment. The integration stage is the final stage in which students feel that they belong to the university. According to Tinto (1975, 1982, 1987), students are more likely to stay and graduate if they are academically and socially integrated into the institution. Integration into the academic community means that the more connected a student feels with and supported by peers and faculty, the higher the degree of engagement in university life, both in and out of the classroom (Tinto, 2005). Tinto (2017a, 2017b) suggests that three factors determine students' adjustment to university in their first academic years.

Students' personal and psychological characteristics, academic factors (related to pedagogy and counseling), social and relational factors. Tinto emphasizes that students' interactions with peers and lecturers, especially in the first academic years, support the increase of their belonging to the university. In a study conducted by Gedik (2018), it is stated that school engagement is positively affected as the satisfaction obtained from leisure time increases. In this sense, leisure time activities are functional in establishing and reinforcing peer relationships. In conclusion, leisure time activities play a major role in improving individuals' mental and physical health, increasing social cohesion and individual happiness. University students' participation in leisure time activities has an important effect on facilitating the adaptation process to university life. Accordingly, the study has two parameters: adjustment to university life and leisure time satisfaction. In order to determine the relationship between these two parameters, the research hypothesis was determined as "H_1: There is a significant relationship between the subdimensions of leisure satisfaction (psychological, educational, social, physical, relaxation, aesthetics) and the subdimensions of university adjustment (personal-emotional, social, institutional)."

METHODS

Research Design

This study was designed with a quantitative research method in the context of the functionalist paradigm, which is widely preferred in the field of sports sciences (Köse et al., 2021). The relational research model was used to determine the relationship between leisure satisfaction and university adjustment in university students. In correlational research, the relationship between two or more variables is examined, and it is aimed to understand the interaction of these variables with each other (Büyüköztürk et al., 2022). Canonical correlation analysis allows the relationship of two different quantitative variables or their effect on each other to be observed by interpreting the correlation coefficient (R^2; Fraenkel et al., 2012). In this study, canonical correlation analysis was used for relational survey research.

Canonical correlation is used to analyze the multidimensional relationship between two sets of variables. When addressing concepts with multiple sub-dimensions, such as leisure satisfaction and university adjustment, this method examines relationships between individual variables and reveals the holistic relationship between two sets of variables. While commonly used correlation analyses in the literature typically explore relationships between individual variable pairs, canonical correlation focuses on the entire data structure, providing

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more comprehensive insights. For instance, some dimensions of leisure satisfaction, such as physical satisfaction, may be more influential in personal-emotional adjustment to university than other sub-dimensions. Canonical correlation analysis offers the advantage of simultaneously examining how different sub-dimensions are interrelated, considering this multidimensional structure, which sets it apart from other methods.

Participants

The study population consists of students at Akdeniz University. The sample of the study consisted of 111 (Mage = 21.982±2.753) male and 139 (Mage = 21.640±4.462) female students studying at Akdeniz University, totaling 250 (Mage = 21.792±3.796) participants. The convenience sampling technique was used in the study, one of the non-probability sampling methods. This technique is used in cases where the researcher has difficulty with random or systematic sampling (Fraenkel et al., 2012). The participating students were asked whether they attended activities organized at the university (e.g., hobby courses, artistic and sports events, social and cultural activities). Among those who participated in these activities, volunteers were included in the study. Initially, it was planned to collect the data face-to-face; however, following the earthquakes on February 6, 2023, centered in Pazarcık and Elbistan, Kahramanmaraş, which caused devastating damage in 11 provinces, universities switched to remote education. Consequently, 157 data points were collected online.

Data Collection Tools

In the study, the researcher used a personal information form to obtain demographic information about age, gender, and frequency of participation in leisure time activities, and two scales were used.

University Adjustment Scale (UAS)

The University Adjustment Scale was developed by Tuhanioğlu and Gizir (2020). The University Adjustment Scale consists of 45 items in total and consists of four dimensions: institutional adjustment (10 items), academic adjustment (12 items), personal/emotional adjustment (10 items), and social adjustment (13 items). The "academic adjustment" factor in the scale refers to the ability and satisfaction of students to effectively fulfill their academic obligations in the department or program they are studying. "Social adjustment", one of the scale factors, can be defined as the ability of students to interact harmoniously with their social environment at the university and develop their relationships. Social adjustment helps

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students to meet their social needs, establish friendships, and interact with individuals from different cultures. emotional "Personal-emotional adjustment" factor refers to students' emotional states (joyful, sad, anxious, happy, stressed, etc.). The "institutional fit" factor refers to student's satisfaction with the sense of belonging they feel towards the institution.

Leisure Satisfaction Scale (LSS)

The scale was developed by Beard and Ragheb (1980), and its short form was adapted to Turkish culture by Gökçe and Orhan (2011). Cronbach's α for the overall total is .90, for the educational sub-dimension α is .77, for the relaxation sub-dimension α is .80, for the psychological sub-dimension α is .77, for the social sub-dimension α is .76, for the physiological sub-dimension α is .79 and for the aesthetic sub-dimension α is .79. In order to test the test-retest reliability of the scale, an intraclass correlation test was conducted. The test result was found to vary between .59 and .75. No significant difference was found in the difference analysis between the two applications (p>.05). Köse et al. (2024), the validity evidence for the leisure time satisfaction scale is as follows: $\chi 2/df$=14.42; CFI = .97; NFI = .97; NNFI = .98; RMSEA (90 % CI) = .076 (.073-.078); SRMR = .053. In addition, in the study conducted by Köse et al. (2024) for construct validity, the measurement invariance of the leisure time satisfaction scale according to gender, age or marital status was tested and it was determined that the measurement tool provided at least the metric invariance criterion for all three variables.

Data Collection Procedure

The data collection process was initiated after the approval of Akdeniz University Ethics Ethics Committee. The data collection phase was carried out voluntarily. Permission was obtained from the participants, and they were informed about the purpose of the study. Before data collection, participants were informed that the anonymity and confidentiality of their answers would always be protected.

Statistical Analyses

Before starting the canonical correlation study, the basic assumptions regarding the analysis were tested to minimize the problems that may occur during the analysis phase. These assumptions are the detection of missing and extreme values, univariate and multivariate normality and linearity, sample size, multicollinearity, and homogeneity. In this context, extreme and missing values data are organized, and assumptions of multivariate normality

and linearity, defined as essentially elliptical, were accepted. According to Rosenthal and Rosnow (2008), Skewness and kurtosis values vary between -1 and +1. These values were checked to test univariate normality and found to be eligible. The Kolmogorv-Simirnow test results showed significant significance in all sub-dimensions of the leisure time satisfaction and university adjustment scale (p = .000).

Finally, the problem of multicollinearity among the data was tested. When the analysis results were analyzed, it was found that VIF values were <1, CI values were <13, and Tolerance value was high (it is close to 1). Belsley (1991) states there is no multicollinearity problem when the VIF value is below 10 and the CI value is under 30. The tolerance value is calculated as 1-R^2, and a larger tolerance value means a smaller VIF value (Mertler & Vannatta, 2005). The obtained results show that there is no multicollinearity problem among the variables. Then, the homogeneity of variances was tested with the Box M test, and it was found that variance and covariance matrices were homogeneous. IBM SPSS 23 program was used in the process of conducting these analyses.

RESULTS

The results of the Wilks, Hotellings, Roys and Pillais tests, which show the statistical significance of the canonical model obtained according to the findings obtained as a result of the canonical correlation analysis, were analyzed. Wilks λ test is based on these significance tests in canonical correlation analysis (Sherry & Henson, 2005). Therefore, the F value obtained from Wilks λ test is taken as basis in this study. The significance tests in Table 1 show that the canonical model is significant (Wilks λ = .74756, $F_{(18, 682.14)}$ = 4.10576, P = .000). In line with the obtained results, it was determined that there is a significant relationship between leisure satisfaction and university adjustment. In canonical correlation analysis studies, it is also recommended to consider the effect size "1- λ". This value is considered to consider the possibility of the number "n" affecting the significance of the model. This study used the "1-λ" value to calculate the inverse effect size (1 - .74756 = 0.25244). As a result, the shared variance between leisure satisfaction and university adjustment was 25.244%.

In order to determine the significance of canonical functions, the eigenvalues of canonical functions should be examined (Sherry & Henson, 2005). The canonical functions and their eigenvalues are presented in Table 13. While the correlation value for the first canonical correlation is .17307, the correlation value for the second canonical function is .07134, and the correlation value for the third canonical function is .02655.

Figure 1

Common Variance Between Leisure Satisfaction and University Adjustment
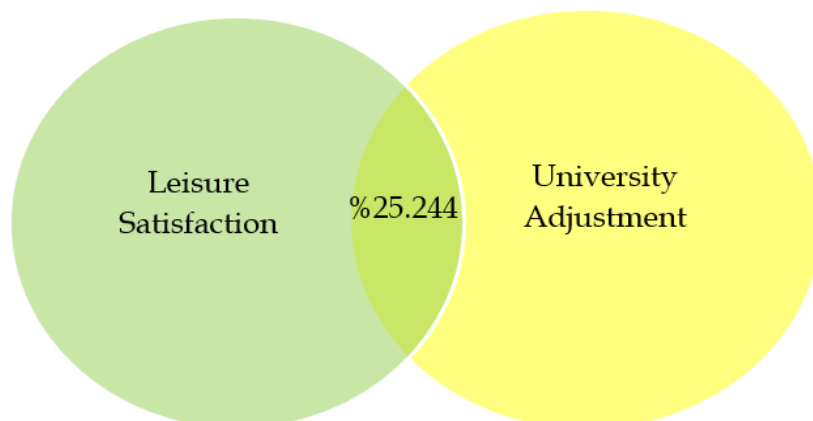
Table 1

Multivaried Significance Tests

Test	Value	Approximate F.	Hypothesis sd.	Error sd	Significance of F.
Pillais	.27095	4.02098	18.00	729.00	.000
Hotellings	.31337	4.17252	18.00	719.00	.000
Wilks	.74756	4.10576	18.00	682.14	.000
Roys	.17307				

As seen in Table 2, the highest correlation between canonical variables belongs to the first canonical function. When the first function is excluded from the analysis, the significance of the canonical correlation and the common variance shared by the remaining canonical functions are determined. With dimension reduction analysis, the line columns of the table are examined for each canonical function, and it is seen that the canonical correlation coefficient decreases when it reaches the bottom line of the table, and usually, the relationship between the canonical variables in this last canonical function is not significant (Sherry & Henson, 2005). When we examined the variables of leisure satisfaction and university adjustment, it was determined that the first two canonical functions were significant in the relationship between the data sets. In line with the results obtained, it was determined that there is a significant relationship between leisure satisfaction and university adjustment.

Table 2
Eigen Values and Canonical Correlation

Root No.	Eigen Value	Percentage(%)	Cumulative Percantage(%)	Cannonical Coralelation	Squared Cannonical Coralelation
1	.20929	66.78486	66.78486	.41601	.17307
2	.07682	24.51262	91.29747	.26709	.07134
3	.02727	8.70253	100.00000	.16293	.02655

In Table 3, the canonical model consisting of the cumulative values of the three canonical functions is significant (Wilks's λ = .74756, F(18, 682.14) = 4.10576, p = .000). Considering the cumulative value of the first and third canonical function, the shared variance of leisure satisfaction and university adjustment was found to be 25.244% [1-λ = .74756]. The second canonical function (2 to 2), which remained after the first canonical function was removed, showed that the relationship between leisure satisfaction and university adjustment data sets was also significant (Wilks's λ = .90401, F(10, 484) = 2.50480, p =.006). The shared common variance was 9.599% [1-λ = .90401]. In other words, it is the 1st and 2nd canonical functions that contribute the most to the relationship between leisure satisfaction and motivation. The 3rd canonical function is not reported because it is not significant.

Table 3
Dimension Reduction Analysis

Root	Wilks λ	F	Hypothesis sd	Error sd	Significance Level of F
1 to 3	.74756	4.10576	18.00	682.14	.000
2 to 2	.90401	2.50480	10.00	484.00	.006
3 to 3	.97345	1.65674	4.00	243.00	.161

Another important issue to be addressed in canonical correlation analysis is the extent to which the variables in the data sets contribute to the relationship between canonical variables. The standardized coefficients and structural coefficients of canonical functions guide finding the answer to this question. A comprehensive analysis of the relationship between two variables is made using these coefficients. In this study, the extent to which the psychological, educational, social, physical, relaxation, and aesthetic dimensions in the leisure satisfaction data set and the personal-emotional, social, and institutional adjustment variables

in the university adjustment data set contribute to the relationship between canonical variables was determined. For this purpose, the standardized coefficients and structural coefficients of the first and second canonical functions between canonical variables were examined. The findings are presented in Table 4. In the presentation of the findings, the standardized coefficient values and structural coefficient values of the canonical functions are included in addition to the common variance value shared by the variables in the leisure satisfaction and university adjustment data sets. The "H^2" value in the table is obtained by summing the shared variance values of the variables in the first and second canonical functions of the variables in the leisure satisfaction and university adjustment data sets and gives the amount of the common variance that these variables share with the data set in the canonical model. A value of .45 is taken as a reference to evaluate the importance of the variance the variables share with the data set they are in. This criterion is used to determine whether the contribution of the variables to this data set is significant. If a variable's Rc and H^2 values are above .45, it can be said that this variable makes a significant contribution to the data set. The acceptance of the criterion above .45 comes from factor analysis. In factor analysis, items with factor loadings higher than .45 are considered very good items (Sherry & Henson, 2005). The canonical functions obtained from canonical correlation analysis, the signs (+, -) of the variables that contribute (significantly contribute) to the data set above .45 give information about the direction of the relationship between these variables. Variables with the same signs have a similar relationship.

According to the findings in Table 4, in the first canonical function, it was determined that the contributions of psychological, educational, social, physical, aesthetic, and physical variables to the leisure satisfaction data set were above .45. These variables were found to contribute more to the leisure satisfaction dataset than the relaxation variable. In addition, the first canonical function determined that personal-emotional harmony and institutional harmony variables contributed more than the social harmony variable in the university adjustment data set. When the Rc^2 value is evaluated, it is seen that the value calculated for the first canonical function is .17307. This value reveals that the common variance shared between the two data sets is 17.307%.

Table 4

Canonical Analysis of Canonical Functions 1 and 2 for the Relationship Between LSS and UAS Data Sets

Variables	1st Canonical Function			2nd Canonical Function			
	Standardized Coefficients	Structural Coefficients (Rc)	Square of Structural Coefficients (Rc²)	Standardized Coefficients	Structural Coefficients (Rc)	Square of Structural Coefficients (Rc²)	Communality Coefficient (H²)
Psychological	0.02684	0.74849	.56023	.20404	-0.48876	.23888	0.79911
Educational	-0.3365	0.71558	.51205	-0.96212	-0.56886	.32360	0.83565
Social	0.8082	0.80187	.64299	1.44293	-0.42496	.18059	0.82358
Physical	1.24084	0.86328	.74525	0.23328	-0.49997	.24997	0.99522
Relaxation	-0.5405	0.42943	.18441	-0.81468	-0.77344	.59820	0.78261
Aesthetics	-0.5055	0.52711	.27784	-0.89699	-0.72701	.52854	0.80638
R$_c$²			.17307			.07134	
Personal-Emotional	0.70284	.91322	.83397	-0.46478	-0.2135	.04558	0.87955
Social	-0.0436	0.06921	.00479	-0.91429	-0.81617	.66613	0.67092
Institutional	0.46462	0.77734	.60425	0.62742	0.24633	.06082	0.66507

Note. Variables that contribute most to canonical functions

The variables belonging to both data sets in the first canonical function are positive. Based on this information, for the first canonical function in Table 4, it can be stated that as the psychological, educational, social, physical, and aesthetic satisfaction scores in the satisfaction data set increase, the personal-emotional fit and institutional fit in the university fit data set increase.

When the second function was analyzed, it was determined that the variables that contributed the most to the leisure time satisfaction data set were relaxation, aesthetic, educational, physical, and psychological satisfaction, respectively. Social cohesion contributes the most to the university fit data set. The standard variance value shared between both data sets for the second canonical function was found to be 7.134%. The variables in both data sets are similar for the second canonical function. This indicates that as relaxation, aesthetic, educational, physical and psychological satisfaction in the leisure satisfaction dataset increases, social adjustment in the university adjustment dataset also increases.

Figure 2 presents the structural coefficients of the first canonical function, and Figure 3 presents the structural coefficients of the second canonical function and the canonical

correlation coefficients between the leisure satisfaction (LSS) and university adjustment (UAS) datasets.

Figure 2
Structural and Canonical Correlation Value of the 1st Canonical Function between Leisure Satisfaction and University Adjustment
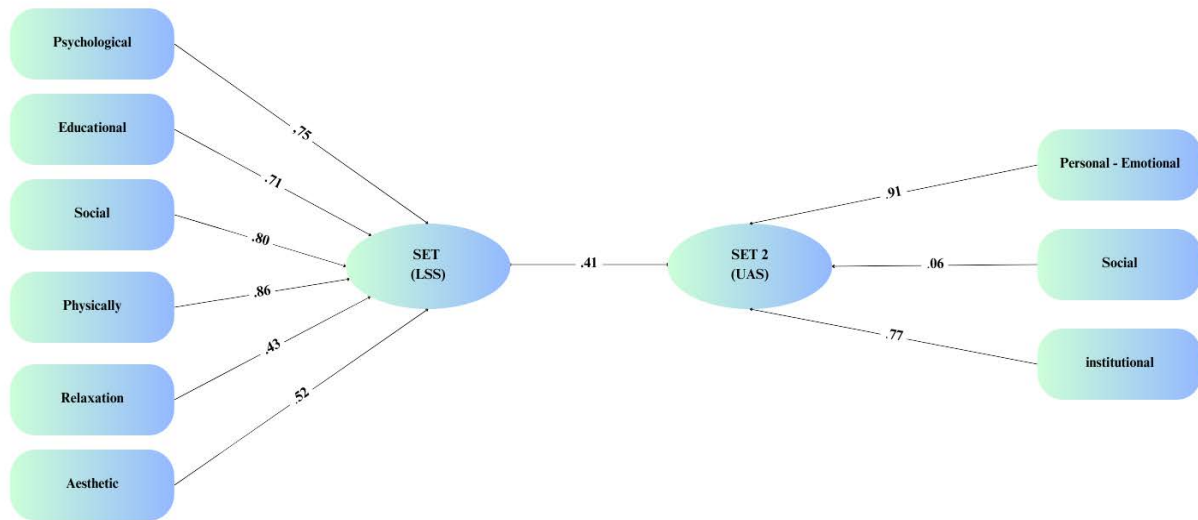
Figure 3
Structural and Canonical Correlation Value of the 2nd Canonical Function between Leisure Satisfaction and University Adjustment
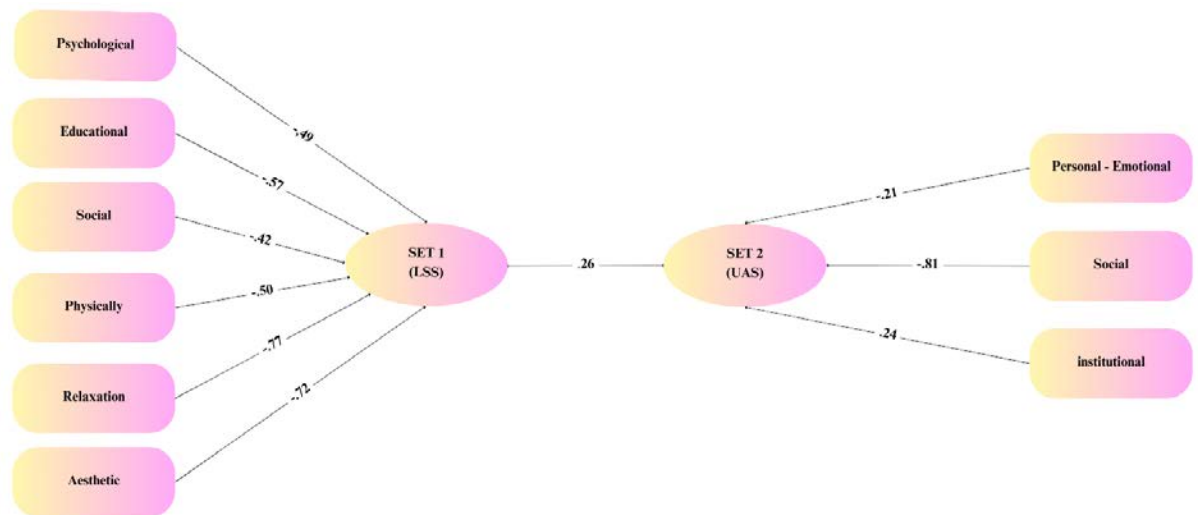
DISCUSSION

The fact that there is no comprehensive research in the literature on which sub-dimension of leisure satisfaction is a determinant in university students' adaptation to university makes it difficult to discuss the findings of this study. The primary purpose of our study is to understand in an exploratory context which sub-dimensions of leisure satisfaction

are more determinative in personal-emotional, social, and institutional adjustment to university life. The relationships between the sub-dimensions of these two variables and the possible reasons for these relationships will be discussed in detail. The discussion will also be placed in the context of Tinto's dropout theory.

The research findings revealed that the sub-factors that contributed the strongest to the leisure satisfaction dataset were physical, social, and psychological satisfaction. It is quite understandable that university students who participate in hobby classes, in particular, achieve the most physical satisfaction through classes involving physical activity. The fact that hobby classes were conducted with students from different faculties may have increased their social interactions with others and hence their social satisfaction. It is understandable that this process also affects psychological satisfaction, and that psychological satisfaction is one of the highest satisfactions experienced through these activities. In a study conducted by Köse (2021), the benefits of structured activities for prisoners were discussed. The research findings reveal that individuals engaged in social interaction feel better psychologically. Leisure activities are one of the most powerful socialization tools closely related to psychological well-being. At the same time, among the findings, people who physically benefit from leisure time activities feel better psychologically. Therefore, considering that university students obtained physical, psychological, and social satisfaction from the activities they participated in and the interrelationships of each satisfaction, it is possible that the psychological and social satisfaction of those who achieved physical satisfaction indirectly increased. Considering this interrelated relationship of the sub-dimensions, it is understandable that relaxation contributes more to the first canonical function than aesthetic and educational satisfaction. It was determined that the sub-dimensions that contributed the most to the 1st canonical function in the adaptation of university students participating in leisure activities to the university were Personal-Emotional and Institutional adjustment. Considering that individuals who participate in leisure time activities increase their personal-emotional adjustment by achieving success in regulating their emotions and the relationship between the satisfaction obtained from participation in leisure time activities and the frequency of participation, it is understandable that the student comes to the institution more often and increases institutional adjustment.

Considering the canonical relationships, it was determined that psychological satisfaction in the leisure satisfaction data set was positively related to personal-emotional adjustment and institutional adjustment in the university adjustment data set. Psychological

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satisfaction emerges as a result of the fact that leisure activities are engaging to the individual and give a sense of confidence and success. Personal-emotional adjustment is related to students' control of their negative emotions. The psychological satisfaction obtained from leisure time activities will likely help students to achieve personal-emotional adjustment to the university by helping the emotional regulations experienced by students during the university adjustment process. Siyahtaş and Donuk (2021) reported that university students' feelings of loneliness decreased with increased leisure time satisfaction. In a study conducted in 2023, students stated that they had adjustment problems but overcame them thanks to social support, positive perspective and social activities (Eryılmaz et al., 2023). In a study conducted by Öztürk (2020) with new university students, it was found that the stress perceived by students when they started university was high, negatively affecting university adaptation. From this point of view, it is thought that the relaxation and social adaptation of new students can be increased by account considering the suggestions to increase the satisfaction of new students in their leisure time. Psychological satisfaction is thought to be positively related to personal-emotional satisfaction because it can reduce the perceived stress level. Research findings show that as psychological satisfaction increases, institutional adaptation also increases. Institutional adaptation means that the student feels a sense of belonging to the university. Since students who participate in leisure activities at the university meet other students, expand their social networks, adapt to new norms, and receive acceptance and attention from other students, it is understandable that students who achieve psychological satisfaction increase their institutional cohesion. In the literature, there are studies emphasizing that leisure time activities increase the frequency of students coming to school (Eccles et al., 2003) and reduce drop-outs (Mahoney, 2000). A similar study by Karahan et al. (2005) supports our findings by revealing that students who actively participate in socio-cultural activities have fewer adjustment problems than students who do not. Sönmez and Gürbüz (2022) evaluated the satisfaction obtained from leisure time as a factor that supports students' adaptation to a new socio-cultural environment and self-improvement during the university process.

Educational satisfaction and personal-emotional adjustment are other canonical relationships. Research findings reveal that as the educational satisfaction obtained from leisure time activities has increased, students' personal-emotional adjustment has increased. Educational satisfaction refers to the satisfaction obtained from trying new things, getting to know oneself, and learning new things about other people. Participating in an activity of

interest as a leisure time activity can provide a break from the monotony of daily life. In addition, the self-confidence of the student who increases their intellectual equipment by acquiring new knowledge through leisure time activities will also improve. It is thought that the increase in knowledge can be decisive in coping with problems and providing students with another perspective to manage their personal-emotional situations better. Köse (2021) reveals that inmates who acquire new knowledge and experience through leisure time activities feel better psychologically, their self-confidence and self-esteem increase, and they are better able to cope with the problems they experience. This finding provides important support that students who experience educational satisfaction can learn to look at life from a different perspective and support them in regulating their personal-emotional state during their university adaptation process. Students whose perspectives change are likely to change their emotional states towards the difficulties in life, which is positively related to their adjustment to university. Another variable associated with educational satisfaction is institutional adjustment. Research findings show that as educational satisfaction increases, institutional adjustment increases. Universities are educational institutions that offer environments where students can learn new things during their free time at university. In this case, it is understandable that educational satisfaction contributes positively to students thinking that they have found what they hoped for at the university, are satisfied with their choice of university, and thus feel a sense of belonging.

Another important finding of our study is the relationship between social satisfaction, institutional adjustment and personal-emotional adjustment. According to the study's findings, it is shown that students' personal-emotional adjustment increases with their satisfaction with social satisfaction. Social satisfaction refers to individuals' friendships, communication, and interactions with other individuals. Therefore, it is understandable that a person increases whose social satisfaction increases is satisfied with the institution adapts to the institution, and increases personal-emotional adjustment. Increased social satisfaction is also positively related to increased personal-emotional adjustment. The findings show that people with increased social satisfaction have increased personal-emotional adjustment. It is also understandable that individuals who make new friends, interact with their social environment and have social network support decrease their feelings of loneliness etc. during the adaptation process to university and are more successful in personal-emotional adjustment. In a study conducted by Hadi et al. (2021), it was found that high leisure time satisfaction of individuals supports them to maintain their positive mood. Akhan and Demir

(2020), in their experimental study, emphasize that university adaptation programs prepared with creative drama activities will facilitate students' adaptation to university. In the study, one group received orientation training with creative drama activities, while the other group received an orientation program without drama activities. According to the data, it was found that students who participated in the adaptation program accompanied by drama had a higher level of adaptation to university (Akhan & Demir, 2020).

Physical satisfaction refers to the satisfaction received as a result of thinking that leisure time activity improves physical fitness, helps to stay healthy, and makes one feel refreshed. In our study, it is found that physical satisfaction obtained from leisure time increases organizational adaptation. In parallel with this finding of our study, Kim and Song (2021) found a statistical relationship between physical activity level and adjustment to university life and that physical activity may positively affect adjustment to university life. In this respect, it is thought that students feeling physically healthy and energetic within the opportunities provided by the university may facilitate their adaptation to the institution.

Aesthetic satisfaction describes the satisfaction obtained from the cleanliness and well-groomedness of the place where the individual performs leisure activities. In our study, it was found that as aesthetic satisfaction increases, personal-emotional adjustment increases. Participating in leisure time activities in an aesthetically attractive, well-maintained, and clean environment can increase individuals' motivation to participate, reduce their anxiety, and help them feel satisfied with themselves. In addition, a beautiful environment can provide an unforgettable experience and make activities more meaningful. Individuals who find their lives more meaningful will likely be more emotionally positive and more satisfied with life. Therefore, this relationship between aesthetic satisfaction and personal-emotional adjustment seems understandable. Among our findings, as aesthetic satisfaction increases, organizational adjustment also increases. Participating in leisure activities in a beautiful, well-maintained, and clean environment strengthens individuals' connection with their environment and sense of belonging. Therefore, it is expected that the relationship between aesthetic satisfaction and institutional adjustment is positive. In order to have aesthetic satisfaction, the university should have physical facilities.

In the 2nd canonical function, we can explain the relationship between aesthetic satisfaction and social cohesion as follows: 1-Fresh, clean, interesting, and beautiful environments where leisure activities occur can increase individuals' willingness to interact socially. People prefer to be in an aesthetically pleasing environment and such environments

can provide a platform for individuals to socialize and create a common interest among individuals. For example, an art gallery, park, or sports center can enable individuals to communicate with each other and develop a sense of community (Pretty et al., 2005). Al-Qaisy (2010) argues in his study that the university physical facilities (such as cleanliness, number of facilities, and quality of facilities) increase students' adjustment to the university.

Another finding not explained in the first function but included in the second canonical function is that social adjustment increases as relaxation satisfaction increases. Individuals do not feel like strangers in an environment where they feel comfortable and relaxed and can easily make friends. Therefore, it is understandable that social adjustment increases as the relaxation satisfaction obtained from leisure increases. It has been determined that students who have positive attitudes towards leisure time activities obtain satisfaction from leisure time activities, which contributes to their social well-being (Kim et al., 2015). In addition, the second function found that as the psychological, educational, aesthetic, physical, and relaxation satisfaction obtained from leisure activities increased, social adjustment to the university increased. Considering that these types of satisfaction are the dimensions of leisure satisfaction that support each other, the positive relationship with individuals' social adjustment seems understandable.

Considering all our findings, it is possible to state that leisure time satisfaction is generally effective in adjusting to university. For example, a study conducted by Gedik (2018), it was a study conducted by Gedik (2018) found that students who achieved physical and psychological satisfaction in their free time increased their commitment to the school. Astin (1984) argues that students' success in their courses positively affects their participation (adjustment) to university. In this context, Sarı and Kaya (2016) state a positive relationship between educational, social, physiological, psychological, and aesthetic satisfaction, which are the sub-dimensions of leisure satisfaction and academic achievement. From this point of view, it can be said that one of the practical factors in students' adjustment to university is leisure time satisfaction, and the grade point average of students who are satisfied in their leisure time may increase. In the literature, studies are emphasizing that academic achievement and social support are related to adjustment to university life (Perera & DiGiacomo, 2015; Yalım, 2007). As it is seen, it is stated that the academic achievement and social support of students who participate in leisure time activities and provide satisfaction are improved, and therefore their commitment to school increases. It is possible that the satisfaction obtained from the activities at the university may be is related to the institutional belonging to the university. Many studies

have shown that there is a relationship between leisure time satisfaction and frequency of participation (Choi & Yoo, 2017), and it can be said that increasing the frequency of participation in leisure time activities will positively affect belonging to the context, social environment, and institution.

In Tinto's three-phase model, the beginning of the adjustment process to university, in which students leave the care of their families and gain autonomy, refers to the separation phase. This phase may cause students to experience personal-emotional problems. For students who experience emotional problems during the separation phase, the adjustment process, which Tinto refers to as the transition process, becomes difficult, and this may even lead to a decrease in academic achievement and radical decisions such as leaving the university. The transition phase, which is the second stage in Tinto's model, is defined as a necessary process for a healthy adjustment to university. When the research findings are considered in the context of Tinto's theory, leisure time activities play a key role in students' adjustment to university at this stage. The transition phase of students who are satisfied with leisure time activities at university is completed healthily and the emotional problems experienced by students in the first phase gradually decrease. Thus, students can quickly adapt to university life. Considering the individual and social benefits, leisure time activities are thought to contribute positively to the transition phase and facilitate the integration phase. Considering the positive relationship between satisfaction from leisure time activities and adjustment to university life, the study's findings are consistent with Tinto's theoretical structure.

Limitations

This study is limited to students studying at Akdeniz University Central Campus. The methodological limitation of the research is that it consists of data collection tools, and the data is collected by "sampling methods with known probability". Another limitation of the study can be expressed as follows. All the scales used in the study are self-report scales. This may cause participants to give socially desirable responses rather than honest feedback about themselves. This may negatively affect the validity of the scales used in the study (Van de Mortel, 2008). Also, the Kahramanmaraş-based earthquake that occurred during the data collection process and the transition of universities to distance education may have caused bias in the results by affecting students' participation and answering behaviors.

CONCLUSION

Leisure satisfaction refers to a positive and pleasant feeling obtained from a leisure activity. This study aims to reveal the importance of satisfaction obtained from leisure time activities in adjustment to university life, which has institutional, personal-emotional, and social dimensions. When the results were analyzed, it was determined that the sub-dimensions that contributed the most to the first canonical function were psychological, educational, social, physical, and aesthetic satisfaction, respectively. These results reveal that university students derive the most psychological, educational, and social satisfaction from their leisure activities. The sub-dimensions that contribute the most to the university adjustment data set are personal-emotional adjustment and institutional adjustment. This result shows that university students who participate in leisure activities experience the most personal-emotional adjustment and theoretical adjustment. In addition, there are strong relationships between psychological, educational, social, physical, and aesthetic satisfaction obtained from leisure time and personal-emotional adjustment and theoretical adjustment. These findings suggest that university students' satisfaction with leisure activities is critical in understanding their adjustment to university. In particular, the fact that psychological, educational, and social satisfaction is strongly related to personal-emotional and institutional adjustment suggests that leisure effectively increases students' overall life balance and sense of belonging beyond individual well-being and academic achievement. These results emphasize that planning and promoting leisure time activities at universities can critically contribute to students' adjustment processes.

PRACTICAL IMPLICATIONS

We can express the theoretical implications of our study as follows: Studies on the motivational dimensions of participation in leisure activities will allow us to understand better students' leisure satisfaction and how this satisfaction affects their adjustment processes. In particular, the types of activities students derive satisfaction from and the motivations behind these activities can be investigated. Therefore, through qualitative interviews, a study can be planned on which activities students are more satisfied with and why they choose them. In addition, the study's data were obtained from only one campus, so the effects of leisure satisfaction on college adjustment in different cultural and demographic groups should be addressed in future studies. The results of such a study may reveal possible differences

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between students' leisure satisfaction and adjustment processes in different socio-cultural contexts.

The practical implications of our research results can be expressed as follows: The study's findings reveal that students' leisure time estimates increase their university adjustment. Therefore, universities can organize programs encouraging social activities and provide physical facilities, sports facilities, event spaces, and social centers to increase student participation. Such practices will support both the personal-emotional and social adjustment of students. In addition, adjustment programs that include leisure time activities can be prepared to support the adaptation process of new students. Universities can offer counseling services to increase students' satisfaction with leisure activities. Finally, it is seen that aesthetic adaptation is effective in university adjustment. In this context, universities should emphasize aesthetically enhancing physical spaces and providing students with relaxing and aesthetically satisfying environments. In addition, new activities and programs can be developed in line with the demands and needs of students.

Authors' Contribution

The first author contributed to writing–original draft, data curation resources and the second author contributed validation, review & editing. Both authors contributed to formal analysis and methodology.

Declaration of Conflict Interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethics Statement

Permissions were obtained from the Akdeniz University Ethics Committee (E-55578142-050.01.04-564427, Date: 25/01/2023) for the conduct of the study, the participants were given detailed information about the purpose of the study and how it would be conducted, it was stated that the study would be conducted on the basis of confidentiality and that they could withdraw from the study at any time.

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Research Article

Effects of Recreational Swimming on Blood Pressure and Lower Extremity Muscle Strength of Older Adults With Elevated Blood Pressure: A Sample of Altınova Beachgoers

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ABSTRACT

This study aimed to investigate the effects of recreational swimming (RS) on blood pressure (BP) and lower extremity muscle strength (LEMS) in older adults with elevated blood pressure (EBP). A total of 44 elderly people, 21 men (x̄age=70.6 years, sd= 1.07; body mass index (BMI)=27.4 kg/m2, sd=0.67) and 23 women (x̄age=70.2 years, sd=1.15; BMI=28.6 kg/m2, sd=0.92) participated in the study. Participants were reached by snowball sampling method. Data were collected using a semi-automated BP monitor and Chair Stand Test. Analyses were performed using mixed-design ANOVA with a significance level of $p<.05$. There was a significant difference between groups [$F_{(2,84)}=16.59$, $p<.001$, $\eta^2p=.028$] and times [$F_{(2,84)}=3.55$, $p<.033$, $\eta^2p=.080$] in systolic blood pressure (SBP). There was significant difference between groups [$F_{(1,42)}=24.48$, $p<.001$, $\eta^2p=.368$] in diastolic blood pressure (DBP). There was a statistically significant difference between groups [$F_{(1,42)}=28.68$, $p<.001$, $\eta^2p=.041$] in mean blood pressure (MBP). There was a statistically significant difference between groups and times [$F_{(1,42)}=4.2$, $p<.046$, $\eta^2p=.96$; $F_{(1,84)}=87.1$, $p<.001$, $\eta^2p=.96$, respectively] in LEMS. There was a significant difference between times [$F_{(2,84)}=26.6$, $p<.001$, $\eta^2p=.1$] in BMI. There was a statistically significant difference between groups, time and group*time interaction [$F_{(1,42)}=18.53$, $p<.001$, $\eta^2p=.03$; $F_{(2,84)}=29.35$, $p<.001$, $\eta^2p=.04$; $F_{(2,84)}=4.59$, $p<.013$, $\eta^2p=.099$, respectively] in rating of perceived exertion. RS in a blue ecological environment is thought to provide positive improvements in BP and LEMS values of older adults with EBP and to have a cumulative effect on metabolic safety and the quality of the aging process

INTRODUCTION

In Turkey, the proportion of the elderly population in the total population is 10.2%; the rate of chronic diseases such as hypertension, diabetes, stroke, paralysis, musculoskeletal, asthma, etc. is 78.7%; the rate of those who do not exercise regularly is 81.7%; the rate of falls in the last year is 24.0%; the rate of those who have functional difficulties is 27.1%, and the rate of those who have difficulty in carrying and holding is 29.7% (Türkiye İstatistik Kurumu, 2023).

The World Health Organization (WHO) states that 68% of deaths each year occur as a result of non-communicable (chronic) diseases (WHO, 2014). Over 1.3 billion people worldwide are thought to suffer from hypertension and this condition is more common in elder people (Picon et al., 2013).

Studies have shown that the prevalence of hypertension is higher among men until the age of 50 and following this age. Women are more likely to have it, especially after menopause (Cunha et al., 2021). It is also reported that hypertension complicates the living conditions of more than half of people aged 60-69 years and about three-quarters of people aged 70 years and older (Huang et al., 2013). Hypertension (HT) is a systemic disease characterized by persistent high blood pressure and is an important health problem due to its widespread prevalence in the population (Bahar, 2024; Türkiye Endokrinoloji ve Metabolizma Derneği, 2022).

The 2017 American College of Cardiology/American Heart Association (ACC/AHA) classifies blood pressure into four levels: Normal BP, elevated BP, Stage 1 hypertension, and Stage 2 hypertension, respectively (SBP/DBP ranges by classification level are <120 and <80 , 120-129 and <80, 130-139 or 80-89, ≥140 or ≥ 90, respectively). In addition, the office recommends that SBP/DBP values ≥140/90 mm Hg be considered as the reference point for the definition of hypertension (ACC/AHA, 2018; Muntner et al., 2019).

The report of the Turkish Society of Endocrinology and Metabolism (2022) stated that ≥4 days a week, moderate intensity, 30-60 minutes of dynamic activities have a positive effect on weight control, stress management and cardiovascular system (Türkiye Endokrinoloji ve Metabolizma Derneği, 2022). Research has shown that a -10 mm Hg change in SBP can reduce the risk of progression to major cardiovascular disease by 20%, coronary heart disease by 17%, stroke by 27%, heart failure by 28% and overall mortality by 13% (Ettehad et al., 2016). Igarashi and Yoshie Nogami's (2018) 14 Meta-analysis study results showed that regular aqua exercises positively affected on blood pressure (SBP-8.4 mmHg; DBP-3.3 mmHg). In

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a similar direction Sarmento et al. (2020) reported that in a systematic meta-analysis of 44 articles on the Web of Science, SPORTDiscus, MEDLINE, and PubMed databases that recreational football reduces BP and resting heart rate, increases bone mineral density, and acts as a stimulus for osteogenesis. It has been reported that brisk walking can reduce the risk of acute cardiovascular events in elderly patients with essential hypertension (He et al., 2018). In a meta-analysis of 23 articles, Huang et al. (2013) reported that regular aerobic exercise provided significant reductions of 3.9% and 4.5% in both SBP (-5.39 ± 1.21 mmHg, p<.0001) and DBP (-3.68 ± 0.83 mmHg, p<.0001) in sedentary older adults, respectively.

Although the benefits of physical activity and recreational sports are known, significant restrictions such as movement difficulties caused by aging, a sense of withdrawal to safe areas in health, social prejudices or diseases that have formed in society toward old age may limit the participation of the elderly population in exercise programmes (Marques et al., 2019; Kendall et al., 2014) It is thought that one of the means of overcoming these limitations will be swimming activities in the natural marine environment, which can be expressed as recreational and green exercise.

Aquatic exercise has recently become an alternative exercise programme for fitness and rehabilitation purposes (Delavatti et al., 2015). The conditions of seawater not only reduce the effect of body weight on joints and the likelihood of injury or falls (Lord et al., 2006) but can also provide multifaceted benefits to the cardiovascular system and muscle strength by creating non-mechanical resistance to exercise in water.

The fact that the sea has a different ambiance than land exercise and the effect of its biophysical characteristics may provide some advantages (Assis et al., 2006). However, the advantages and disadvantages of the marine environment for the hemodynamic safety of the elderly should be known in detail. For example, the intensity of water exercises decreases with increasing water depth (Barbosa et al., 2009).

Lower limb muscle groups are exposed to more resistance than upper limb muscle groups in exercises performed in the vertical position (Kim et al., 2015) and blood pressure values are higher in the aquatic environment than on land. Shallow water decreases buoyancy

In post-menopausal women (~74 years), 24 weeks of swimming exercise had a positive effect on blood pressure (BP) and muscle strength in terms of group*time interaction, respectively (systolic BP=Δ-9 mm Hg; diastolic BP=Δ- 9 mm Hg; muscle strength= Δ3 kg, P<0.05; Wong et al., 2019). Cunha et al. (2021) investigated the effects of resistance, cycling, and water-based exercise on blood pressure in older adults with hypertension and reported a

significant decrease in systolic blood pressure values only in the water-based exercise group (WE = Δ-4.6 mmHg; $p <.05$).

12 weeks of swimming exercise decreased systolic blood pressure from 131 ±3 mm Hg to 122 ±4 mm Hg in healthy adults (60 ±2) over 50 years of age with stage 1 hypertension and not taking medication (Nualnim et al., 2012). It was also reported that a 10-week swimming exercise program resulted in significant reductions in resting heart rate (81 ± 4 to 71 ± 3 beats/min; $P <0.01$) and systolic blood pressure (150 ± 5 to 144 ± 4 mmHg; $P <0.05$). An indicator of cardiovascular adaptation in adults [48 ± 2 years (mean ± SEM)] with stage 1 or 2 essential hypertension (Tanaka et al., 1997).

Interacting with the natural environment, such as green spaces (woodlands, urban parks) or blue spaces (aquatic environments such as rivers, lakes or the sea), has been shown to promote physical activity, improve mental health, reduce the propensity for illness and disease, and increase life expectancy. Living near blue areas, visiting blue areas, exercising in green and blue areas and incidental contact with blue areas (e.g. daily commuting from blue areas) are positively associated with health and well-being (Gascon et al., 2017; White et al., 2020).

Knowing about the functional living opportunities provided by seawater and at the same time generating scientific data by investigating the suitability of this exercise environment for the hemodynamic safety of the elderly will help the purposeful design of exercise programmes. Obtaining scientific norms for changes in blood pressure and LEMS values of the elderly belonging to different geographical clusters living in coastal areas and exercising in the marine environment is vital for research and application processes.

This study is thought to contribute to the creation of appropriate exercise protocols in terms of hemodynamic safety of elderly adults living in different geographies in terms of BP and lower extremity muscle strength values obtained due to swimming conditions and effects in the sea. It is assumed that there will be a significant effect on SBP, DBP, lower extremity muscle strength and body mass index values between groups, between times and depending on the group*time interaction. It is thought that there is a need for comparative practices and norm values specific to geriatric communities with different codes, including leisure time and psycho-social benefits. This study aimed to investigate the effect of a total four session of modified moderate intensity swimming exercise on blood pressure and lower extremity strength in elderly adults.

METHODS

Participants

This study was conducted in the summer of 2023 with older adults using Altinova Sand Island beach. The reasons for choosing this beach were that the residents living around it were mostly older adults, it was possible to walk to and from the beach and water safety (there was a wave breaker and the depth of a large area was at chest level), the average sea water temperature during the application period was 30-32 Co (651710 Thermometer Seawater). The water depth was 1.4-1.6 m in a large area and it was suitable for water recreation. To form the sample of the study, male and female visitors aged 65 years and older who visited the beach for five days were contacted through snowball sampling and 47 participants, 23 males and 24 females who met all the criteria below were invited to participate in the study. Three male participants (criteria 5 and 8) and one female participant (criterion 4) were excluded on the grounds of risk (Figure 1). For participation, the ability to swim freestyle and backstroke in rough form on the water surface was required.

Figure 1
Flowchart of the Study
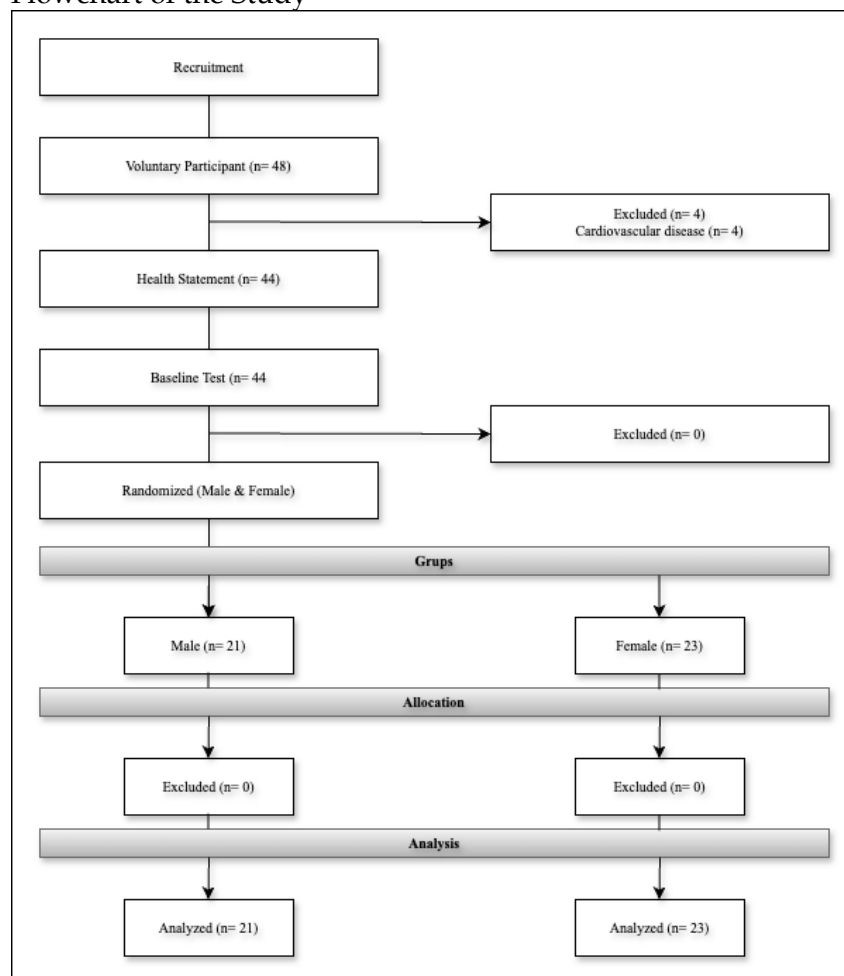
Current studies on exercise in hypertension show that 18-20 participants per group provides and adequate sample size. For this study, the sample size and the ratio of groups to each other were calculated based on the literature (He et al., 2018; Sohn et al., 2007).

Participant criterias are; 1) 65 years and older, 2) not participating in an exercise program in the last six months, 3) elevated blood pressure (lower than mean 130/ 80 mmhg sbp/dbp), 4) body mass index (bmi) less than 34kg/m2, 5) non-smoker, 6) be independent living persons, 7) ability to move independently and perform daily activities, 8) no medical contraindications for testing and practice in terms of physical fitness, 9) having no problems with verbal communication and 10) the lack of cognitive constraints every participant received comprehensive information regarding every phase of the research was clearly stated that they could leave the study at any time. Participants were informed about the consent form declaring their voluntary participation and asked to sign it. The research was ethically approved by the ethics committee of Eskisehir Technical University, Science and Engineering Sciences Scientific Research and Publication Ethics Committee (2023/E-87.914.409-050.03.04-2.300.029.618/) and was conducted in accordance with the recommendations of the Declaration of Helsinki. Table 1 shows the groups, measurements and application protocol.

Table 1
Research Model

Groups	Pretest	Intervention-1	Midtest	Intervention-2	Posttest
Male (N=21)	SBP	Beachgoers' recreational	SBP	Beachgoers' recreational	SBP
	DBP	swimming	DBP	swimming,	DBP
	MBP				
	30secCST	21 sesions	30secCST	21 sessions	30secCST
	BMI		BMI		BMI
	RPE		RPE		RPE
Female (N=23)	SBP	Beachgoers' recreational	SBP	Beachgoers' recreational	SBP
	DBP	Swimming	DBP	Swimming,	DBP
	MBP				
	30secCST	21 sessions	30secCST	21 sessions	30secCST
	BMI		BMI		BMI
	RPE		RPE		RPE

Note. SBP: Systolic Blood Pressure (mmHg); DBP: Diastolic Blood Pressure; (mmHg); MBP: Mean Blood Pressure; 30secCST: 30-Second Chair Stand Test; BMI: Body Mass Index; RPE: Rating of Perceived Exertion

Procedures

Participants were divided into two groups male and female. The application was carried out for four sessions per week, for a total of 42 sessions. The exercises were performed in the sea environment with a water temperature of 31-32°C in a safe area determined as 6x20 m and at a depth where each participant was positioned at chest level. All practices were performed under the supervision of two swimming specialty students. Swimming sessions started at 07:30 in the morning. Ten minutes before the start of the practice, blood pressure measurements were taken and recorded by a nurse from the staff of Ayvalık Municipality according to the order in which all participants arrived at the beach. The sessions consisted of 10 min warm-up (5 min flexibility on land, 5 min warm-up in water); 30 min recreational swimming and resistance exercise [(swimming, 3x6 min + 2 min rest), 2 sets of resistance exercise/ 2 min rest between sets, 8x 30sec active/30sec passive, fixed point and forward east jump)] and 10 min active rest.

Data Collection Tools

Hemodynamic Measurements

Participants were instructed not to smoke, drink tea or coffee, take caffeine, preferably not to eat, and not to talk during the measurement (at least 30 min). SBP and DBP measurements were taken in the sitting position using a semi-automated blood pressure (BP) monitor (Omron 705CP; Matsusaka, Japan), which is internationally validated according to the Eighth Report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Arterial Pressure (James et al., 2014). All BP measurements were performed between 07.00 and 07.30 in the morning. BP measurements were performed on the participant's bilateral arm for the first two sessions and when there was a difference between the measurements, subsequent measurements were performed on the arm with the higher value. After 10 minutes of rest, the participants' BP readings were recorded in a seated position in a chair with both feet on the floor, palm open, arm at heart level and at least two measurements were taken at a time and the mean values were recorded. All BP measurements were performed according to the American Heart Association guidelines. (Tanaka et al.,1997). Mean arterial blood pressure (MABP) was calculated using the following formula: MABP = SBP + (2 x DBP) /3 (Rmirez-Valez et al., 2020).

30-Second Chair Stand Test (30 sec. CST)

Evaluation of lower body strength. The examination subect is seated on a chair that is 43 cm high, the proper height. At the level of the chest, the arms are crossed. The goal is to complete as many right lifts (rpt) out of the chair in 30 seconds or less. (Rikli & Jones., 2013).

Body Mass Index

Height and weight measurements of the participants were performed using a SECA measuring device (model 764). Body Mass Index (BMI) values were calculated based on these data (underweight <18.5 kg/m2; normal 18.5-24.9 kg/m2; overweight 25-29.9 kg/m2; obesity> 30 kg/m2) (WHO, 2013).

Rating of Perceived Exertion

In this study, we applied the Rating of Perceived Exertion (RPE) scale developed by Borg (1998) and adapted by Foster et al. (2001), which is based on the idea of estimating the level of difficulty caused by the physical activity load with a specific rating method (Borg, 1998; Foster et al., 2001). Participants were briefed about the scale and encouraged to dry off immediately after exercise and rest sitting on the beach. Thirty minutes after each exercise session, they were asked to answer "How was your workout?". Two sessions of trials were conducted before the study. The participants' Rating of Perceived Exertion for the entire session was recorded numerically according to the same scale (Foster et al., 2001). The 42 sessions were divided into 3 blocks of 14 sessions and each block's RPE values were analyzed.

Data Analysis

The normality of the data was tested with the Kolmogorov-Smirnov test and the homogeneity of the variances was tested with skewness, kurtosis and Levene's test. After it was determined that the data were normally distributed, it was decided to perform parametric analyses. The assumption of sphericity was tested with Mauchly's W test and their conformity to normal distribution was checked with the Shapiro-Wilk test. For variables that do not meet the assumption of sphericity, the correction of the degrees of freedom was made depending on the Epsilon (ε) value and the Greenhouse-Geisser correction was applied (if $\varepsilon<0.75$). Hemodynamic measurements, 30 sec. CST, BMI and RPE data were analyzed by mixed design ANOVA for male and female groups, time differences and group-time interactions. P value <0.05 was considered statistically significant. Group and time comparisons of data were compared using the Bonferroni post hoc test. Partial eta squared ($\eta^2 p$) was calculated to determine the effect size of repeated measures ANOVA (Cohen, 1988; Schober, et al., 2018). Cohen's d effect sizes of the measures were calculated to determine

the magnitude of pairwise comparisons over time and between groups. The significance of the effect sizes was determined as Cohen's d insignificant (<0.2), small (≥0.2), medium (≥0.5), and large (≥0.8; Cohen, 1988; Schober et al., 2018). Statistical analyses were performed using R Studio (version 4.2.1) and IBM SPSS software (version 2022).

RESULTS

The mean age of male participants before the intervention (n = 21) was 70.6 years (sd = 1.07), mean height 172.9 (sd = 1.02), mean body weight 81.9 (sd = 2.45), and mean body mass index 27.4 (sd = 0.67). The mean age of female participants (n = 23) was 70.2 years (sd = 1.15), mean height 161.5 (sd = 1.28), mean body weight 73.1 (sd = 2.25) and mean body mass index 28.6 (sd = 0.92). Table 2 show the distribution of the male and female participants's tests results for SBP, DBP, MBP,30sec CST, BMI and RPE.

Table 2
Distribution of the Participants Pre-Mid-Posttests Statistical Results of SBP, DBP, MBP, 30sec CST, BMI and RPE

Variable	MG						FMG					
	Pre		Mid		Post		Pre		Mid		Post	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
SBP	131.8	9.1	128.8	8.9	127.7	4.5	120.7	11	118.3	11.7	119.4	8.2
DBP	77.7	7.6	76.9	5.5	76.6	4.7	67.6	7.3	67.2	8.2	67.4	7.1
MBP	95.7	6.2	94.1	5.4	93.5	4.3	85.1	7.3	84.3	7.9	84.7	6.6
30sec	12.3	2.4	14.2	2.9	14.5	3.2	10.6	2.3	12.5	2.5	12.9	2.9
BMI	27.4	3	27.1	3	26.5	2.7	28.1	4.4	27.8	4.2	27.5	4.1
RPE	4.6	0.6	4.1	0.34	4.2	0.5	5.3	0.6	5	0.63	4.6	0.56

Note. MG: Male Group; FMG: Female Group; SBP: Systolic Blood Pressure; DBP: Dyastolic Blood Pressure; MBP: Mean Blood Pressure; 30secCST: 30-Second Chair Stand Test; BMI: Body Mass Index; RPE: Rating of Percieved Exertion

Mixed Design ANOVA Results of SBP

Mauchly's W assumption was met regarding time and group*time interaction (Mauchly's W = 0.990, p>0.05). There was a significant difference between groups [$F_{(2,84)}$ = 16.59, p<.001, η^2p = .028] and a significant difference across the three time points [$F_{(2,84)}$ = 3.55, p<.033, η^2p = .080] in SBP. There was no statistically significant interaction between groups*time (p > .05; Table 3).

Mixed design ANOVA results of DBP

Mauchly's W assumption was not met regarding time and group*time interaction (Mauchly's W = .692, p<.001). Therefore, Greenhouse-Gaiser effect values were taken into consideration. In this context, when Table 8 was analyzed, there was a statistically significant difference between the groups in the two-way ANOVA performed for DBP values [F (1,42) = 24.48, p<.001, η^2p = .368]. There was not statistically significant difference between times* interaction between groups*time (p>.05; Table 3).

Mixed design ANOVA results of MBP

Mauchly's W assumption was not met regarding time and group*time interaction (Mauchly'sW = .808, p<.013). Therefore, Greenhouse-Gaiser effect values were taken into consideration. Table 11 ANOVA results of MBP values showed a statistically significant distinction existed between groups [F (1,42) = 28.68, p<.001, η^2p = .041], while no statistically significant interaction difference between times and group*time (p > .082; Table 3).

Mixed Design ANOVA Results of 30sec CST

Mauchly's W assumption was not met regarding time and group*time interaction (Mauchly's W = .607, p<.001). Therefore, Greenhouse-Gaiser effect values were taken into consideration. In this context, when Table 13 is examined, it is seen that in the two-way ANOVA conducted for 30 sec. CST values, between groups and time, respectively there was a statistically significant difference [F (1,42) = 4.2, p<.046, η^2p = .96; F (1,84) = 87.1, p<.001, η^2p = .96]. No statistically significant difference was found between groups*time interaction (p > .05; Table 3).

Table 3
Mixed Design ANOVA Results of SBP, DBP, MBP,30sec CST, BMI and RPE

Variables		Sum of Sq	df	MS	F	p	η^2P	O. Power[a]
SBP	**Group**	3272.75	1	3272.75	16.591	**0.001*****	0.28	0.978
	Time	209.819	2	104.909	3.553	**0.033***	0.08	0.646
	G*T	49.455	2	24.727	0.837	0.44	0.02	0.189
DBP	**Group**	3073.342	1	3073.34	24.48	**0.001*****	0.368	0.998
	Time	10.493	2	5.247	0.538	0.586	0.013	0.136
	G*T	4.675	2	2.337	0.24	0.787	0.006	0.087
MBP	**Group**	3125.154	1	3125.15	28.68	**0.001*****	0.41	0.999
	Time	44.986	1.7	26.81	2.7	0.082	0.06	0.525
	G*T	16.427	1.7	9.79	0.995	0.363	0.02	0.218

Table 3 (Continued)

Variables		Sum of Sq	df	MS	F	p	η^2_P	O. Power[a]
30sec	**Group**	90.04	1	90.04	4.2	**0.046***	0.96	0.518
	Time	132.87	1.4	92.56	87.1	**0.001***	0.675	1
	G*T	0.03	1.4	0.021	0.02	0.949	0.001	0.053
BMI	**Group**	6.34	1	6.34	0.464	0.5	0.011	0.102
	Time	11.1	1.7	6.44	26.6	**0.001***	0.388	1
	G*T	0.409	1.7	0.237	0.98	0.369	0.023	0.215
RPE	**Group**	13.21	1	13.21	18.53	**0.001***	0.03	0.988
	Time	6.75	2	3.37	29.35	**0.001***	0.04	1
	G*T	1.05	2	0.528	4.59	**0.013***	0.99	0.764

Notes. Sum of Sq: Sum of Squares; M.S: Mean Squares; O. Power[a]: Observed Power; G*P, Group*Time; *: p<0.05, ***: p<0.001

Mixed design ANOVA results of BMI

Mauchly's W assumption was not met regarding time and group*time interaction (Mauchly's W = .839, p < .027). Therefore, Greenhouse-Gaiser effect values were taken into consideration. In this context, there was a significant difference across the three time points [F (2,84) = 26.6, p<.001, η^2_P = .1] in BMI. There was not statistically significant between groups*interaction between groups * time (p > .05; Table 3).

Mixed design ANOVA results of RPE

Mauchly's W data are considered since the assumption of sphericity is met (Mauchly's W = .993, P > .872). In this context, A statistically significant distinction existed between groups, time and group*time interaction respectively [F (1,42) = 18.53, p < .001, η^2_P = .03; F (2,84) = 29.35, p < .001, η^2_P = .04; F (2,84) = 4.59, p<.013, η^2_P = .099] in RPE (Table 3).

Table 4
Groups * Time Post Hoc Results of SBP and DBP

Variables			Mean Difference	SE	p_{bonf}
SBP	M1	FM1	11.1	2.8	**0.002***
		FM2	13.5	2.8	**0.001***
		FM3	12.4	2.8	**0.001***
	M2	FM1	8.1	2.8	0.064***
		FM2	9.7	2.8	**0.004***
		FM3	9.5	2.8	**0.016***
	M3	FM2	9.4	2.8	**0.015***
		FM3	9.3	2.8	0.054
	FM2	M1	-13.5	2.8	**0.001***
		M2	-10.4	2.8	**0.004***
		M3	-9.4	2.8	**0.015***

Table 4 (Continued)

Variables			Mean Difference	SE	p_{bonf}
DBP	M1	FM1	10.1	2.1	**0.001*****
		FM2	10.4	2.1	**0.001*****
		FM3	10.2	2.1	**0.001*****
	M2	FM1	9.3	2.1	**0.001*****
		FM2	9.7	2.1	**0.001*****
		FM3	9.5	2.1	**0.001*****
	M3	FM1	9	2.1	**0.001*****
		FM2	9.3	2.1	**0.001*****
		FM3	9.2	2.1	**0.001*****

Note. M1: Male pretest; M2: Male midtest; M3: Male posttest; FM1: Female pretest; FM2: Female midtest: FM3, Female posttest, *: p<0.05, ***: p<0.001

*Groups * Time Post Hoc Results of SBP*

Table 4 showed a statistically notable distinction between the SBP pretest values of male participants and the pretest, midtest and posttest values of female participants (p < .001). There was a considerable distinction between the SBP midtest values of male participants and the midtest and posttest values of female participants, respectively (p. < .004, p < .016). There was a considerable distinction between the SBP posttest values of male participants and the midtest values of female participants, respectively (p < .015). There was a considerable distinction between the pre-test, mid-test and post-test values of female participants and male participants respectively, (p < .001, p < .004, p < .015). There was a statistically significant difference in SBP between men and women at all three measurements.

*Groups * Time Post Hoc Results of DBP*

ANOVA was applied to determine which groups the difference was a statistically significant difference was observed F (5) = 12.78; p<.001). In this context, the Bonferoni Post-hoc test was performed to determine between which groups the difference was between. Table 9 showed that a statistically significant difference was observed. In DBP between men and women at all three measurement points (p < .001; Table 4).

*Groups * Time Post Hoc Results of 30 sec CST*

Table 5 shows a statistically significant difference between male participants' 30 sec. CST midtest and female participants' 30 sec. CST pretest and between male participants' 30 sec. CST posttest and female participants' 30 sec. CST pretest (p<.001).

Table 5
Group and Time Post- Hoc Results of 30 sec. CST and RPE

Variables	Male	Female	Mean Difference	SE	p$_{bonf}$
30sec CST	M2	FM1	3.62	0.834	**0.001*****
	M3	FM1	3.91	0.834	**0.001*****
RPE	M1	FM1	-0.687	0.169	**0.001*****
	M2	FM1	-1.146	0.169	**0.001*****
		FM2	-0.82	0.169	**0.001*****
	M3	FM1	-1.075	0.169	**0.001*****
		FM2	-0.749	0.169	**0.001*****
	FM1	FM3	0.683	0.169	**0.001*****

Note. 30secCST: 30sec Chair Stand Test; BMI: Body Mass Index; RPE: Ratio of Percieved Exertion, ***: p<0.001

*Groups * Time Post Hoc Results of RPE*

Table 5 shows a statistically meaningful variation in the male participants' RPE pretest and female participants' RPE and female participants' RPE pretest; between male participants' RPE midtest and female participants' RPE pre- midtest; between male participants' RPE posttest and female participants' RPE pre- midtest. A statistically significant difference between female participants' RPE posttest (p < .001).

DISCUSSION

There is strong evidence that swimming positively effects on the BP of older adults. In this context research has shown that a -10 mmHg change in SBP can reduce the risk of progression to major cardiovascular disease by 20%, (Ettehad et al., 2016). Igarashi and Yoshie Nogami's (2018) 14 Meta-analysis study showed that regular aqua exercises positively affected BP. In a similar direction Sarmento et al. (2020) reported that in a systematic meta-analysis of 44 articles in Web of Science, SPORTDiscus, MEDLINE, and PubMed databases that recreational football reduces blood pressure.

It has been reported that brisk walking can reduce the risk of acute cardiovascular events in elderly patients with essential hypertension (He et al., 2018). In a meta-analysis of 23 articles, Huang et al. (2013) reported that regular aerobic exercise provided significant reductions in SBP and DBP (p <. 0001, p <. 0001) in sedentary older adults, respectively. In post-menopausal women (~74 years), 24 weeks of swimming (SWM) exercise had a positive effect on blood pressure (BP) and muscle strength in terms of group*time interaction (P < 0.05) (Wong et al., 2019).

Cunha et al. (2021) investigated the effects of resistance, cycling, and water-based exercise on blood pressure in older adults with hypertension and reported a significant decrease in SBP values only in the water-based exercise group (p <. 05). 12 weeks of swimming exercise decreased systolic blood pressure from 131 ±3 mm Hg to 122 ± 4 mm Hg in healthy adults (60 ± 2) over 50 years of age with stage 1 hypertension and not taking medication (Nualnim et al., 2012).

It was reported that 12 weeks of aquatic strength training significantly increased the maximal power of knee extensors by 20% in the right and left legs and knee flexors by 33% in both legs. In addition, 10 weeks of progressive resistance-type water training resulted in a 7% increase in the 60° s1 isokinetic torque of knee flexors and extensors in healthy women (Gusi et al.,2006) Meta-analyses show that there is a significant increase in hand grip strength, isometric peak torque (60°-s-1) of knee extension and flexion, and that exercises performed on land and in water provide similar muscle strength gains (Prado et al., 2022).

This study showed that recreational swimming in the sea, referred to as a blue exercise environment, contributes positively to blood pressure (BP) and lower limb muscle groups, which cumulatively affect the well-being of older adults. Decreased levels of noradrenaline and inhibition of sympathetic activity due to the effects of exercise; decreased circulating levels of angiotensin II, adenosine, endothelin and their receptors in the central nervous system may effect on blood pressure. Again, the improvement in exercise capacity increases baroreflex sensitivity and the stabilizing effect on the autonomic nervous system, the vasodilator effect of prostaglandins and nitric oxide released during exercise, positive changes in blood lipid levels, body fat and increase in metabolic rate with the effect of seawater temperature can be counted among the reasons. In addition, contribution to endothelium-related vasodilation by increasing the basal level of plasma nitrates, decrease in vascular tone and peripheral resistance in the sea, exercise-induced changes in blood volume and volume-regulating hormones may have a positive effect on blood pressure. Again, the fact that seawater is denser than air means that the resistance in the water increases the frequency of muscle stimulation depending on the speed of the movement. In addition, jumping movements with forward movement in the water cause neural and structural improvements in quadriceps and hamstring muscle strength suggesting that it provides positive development in lower extremity muscle groups. The partial resistance of the water movements (partial effect of the waves on the other participants), and the participants' initial 30-second sit-stand test values were quite low, suggesting that muscle strength.

CONCLUSION

The study's findings demonstrate that recreational semi-structured swimming exercise significantly reduces systolic, diastolic and mean blood pressure in older adults with stage-1 hypertension and is a potent modifier in preventing and controlling hypertension-related cardiovascular risks. In cases where lowering blood pressure is the main goal, aerobic swimming is considered one of the appropriate methods to achieve this goal. In this study, it is seen that the resistance created by seawater against calisthenic movements at the chest level provides significant increases in guadriceps and hamstring muscle strength. This situation can contribute to an increase in the activities of daily living of older adults.

As a result, it can be concluded that the incidence of injury is significantly lower in swimmers compared to endurance exercises such as running and cycling. It can be concluded that recreational swimming, which is purposefully organized by considering hemodynamic safety parameters, is a potentially useful alternative to land exercise for older adults. These findings also suggest that recreational swimming offers special conditions for obese patients, those with exercise-induced asthma or orthopedic injuries.

PRACTICAL IMPLICATIONS

The implementation process of the research provided an autotelic flow in a semi-structured manner that did not ignore the participants' daily marine activity habits and expectations. The course of the participants' daily blood pressure measurements and their well-being on that day was monitored. The use of sea shoes to prevent the sea floor from damaging the feet during the activity and the use of pasta for balance were relaxing elements for safe exercise.

Adaptation to the activities applied in each part of the session improved progressively. The participants' ability to perform the skills increased with cognitive and neuromuscular adaptation. Particularly health and safety concerns about participation in the study decreased. Partial high blood pressure and leg muscle strength data in the interim test strengthened the continuity of participation. The study raised public awareness about the effectiveness of exercise in coping with health problems of older adults.

Considering that 78.7% of the elderly population in Turkey has chronic (chronic) diseases such as blood pressure, diabetes, asthma, etc., it is thought that the results of the research will contribute to establishing norm values, creating a basis for new exercise modules

to laboratories or clinics and it is vital to make it more visible in public spaces with widespread practices.

The possible disadvantages of high-volume RT in institutionalized elderly patients need to be considered, particularly in light of the significant changes in hemodynamic parameters that occur during and right after the session. Numerous elements, such as hydrostatic pressure, diving, and the water's high heat conductivity, affect how the body reacts to swimming. While running and swimming have identical cardiac output levels, swimming results in a more significant mean arterial blood pressure. These variables should be considered when organizing interventions for special populations. In addition to body mass index, other variables related to body composition should be investigated concerning blood pressure. The oxygen saturation of the participants can be investigated as a variable. Increasing the number of participants in the study and conducting studies with control groups should be considered.

Acknowledgements

Authors' Contribution

All processes of this research from the beginning to the end are single-authored.

Declaration of Conflict Interest

There is no conflict of interest in this research.

Ethics Statement

The research was ethically approved by the ethics committee of Eskisehir Technical University, Science and Engineering Sciences Scientific Research and Publication Ethics Committee (2023/E-87.914.409-050.03.04-2.300.029.618/) and was conducted in accordance with the recommendations of the Declaration of Helsinki.

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Research Article

Investigating the Association of Ankle Dorsiflexion Range With Y Balance Test, Single Leg Hop for Distance and Body Composition in Collegiate Athletes

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ABSTRACT

Ankle sprains are prevalent among athletes, and decreased ankle dorsiflexion range of motion (ADROM) can contribute to these injuries. Various tests like the Y Balance Test (YBT), Single Leg Hop for Distance (SLHD), Weight-Bearing Lunge Test (WBLT), and Body Mass Index (BMI) are used to evaluate ankle function. The primary purpose of this study was to find out the correlation between ADROM and SLHD, WBLT, YBT, and BMI. Fifty-two collegiate athletes were recruited after eliminating athletes with a history of injuries to the lower extremities. The study discovered strong positive correlations between YBT anterior reach, ADROM ($r = 0.72$, $p<0.001$), and WBLT ($r = 0.64$, $p<0.001$). ADROM and WBLT were found through regression analysis to be significant predictors of YBT performance, particularly in the anterior reach direction. While body composition measures like BMI and total fat did not significantly correlate with YBT scores, SLHD did show a moderate correlation with YBT performance. These results imply that improving weight-bearing lunge capacity and ankle dorsiflexion may help male collegiate athletes achieve better dynamic balance. Including specific exercises to and strengthen WBLT and ADROM capacities in training regimens may lower the possibility of lower extremity injuries.

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INTRODUCTION

Ankle sprains are the most common musculoskeletal injury in athletes and the general population (Hodgkins & Wessling, 2021; Hootman et al., 2007). Decreased ankle dorsiflexion range of motion (ADROM) has a significant role in causing ankle injuries (Drewes et al., 2009; Irving et al., 2006). Therefore, the ankle joint requires extra attention from physiotherapists, strength and conditioning coaches, and other health professionals working with athletes to understand better the performance characteristics of the ankles and how they are associated with improved balance and jumping. Ankle function can be measured by assessing the range of motion and performing various functional tests. ADROM is often measured by practitioners in the off-season or during pre-participation examinations. Methods that require measuring ADROM in weight-bearing are used more because they reflect lower extremity function during activity (Hoch et al., 2011; Terada et al., 2014). The Weight-Bearing Lunge Test (WBLT) involves performing a forward lunge in a tandem walk and is becoming increasingly accepted (Bennell et al., 1998). Two common functional tests utilized to check ankle joints are the Y Balance Test (YBT) and Single Leg Hop for Distance (SLHD), which help analyze dynamic balance and ankle function (Ageberg & Cronström, 2018; Hartley et al., 2018). Body Mass Index (BMI) is another potentially modified clinical outcome predictor of lower limb injury risk, along with reduced ADROM (Doan et al., 2010; Jespersen et al., 2014). The risk of injury is significantly higher for overweight players (Tyler et al., 2006; Yard & Comstock, 2011). Moreover, a better understanding of using a dynamic balance assessment (YBT), SLHD, and BMI, and the possible associations with reduced ADROM may help coaches and practitioners develop individualized interventions for improving sports performance and reducing ankle injury risk.

Leg asymmetries in the anterior direction of YBT have been associated with a greater than two-fold increase in the risk of lower extremity injury (Smith et al., 2015). Evidence suggests a connection between ankle instability and impaired performance on the SLHD test (Hartley et al., 2018). An increased risk of ankle injury in athletes and chronic ankle instability has been demonstrated to be correlated with BMI (Gribble et al., 2016; Hershkovich et al., 2015). Previous research has not comprehensively examined these variables combined and focused on Indian athletes. Therefore, the associations among these factors in the context of Indian athletes remain underexplored and warrant further investigation to provide relevant insights and applications for this population.

A study of 35 healthy people indicated that limited dorsiflexion may impact dynamic balance, especially in the anterior direction, as the WBLT strongly predicted 28% of the variance in the anterior reach distance (r = 0.53; Hoch et al., 2011). Thirty-one rugby players' dynamic balance, jump performance, and landing patterns were examined in a different study. Significant positive associations were discovered between Counter Movement Jump (CMJ; r = 0.72) and the composite score of the YBT (r = 0.51) and SLHD. Moderate relationships were found in the posterolateral, posteromedial, and composite directions between the SLHD and the YBT. Based on playing position and limb dominance, 58 amateur male rugby players' YBT scores, ADROM, single-leg drop jump (SLDJ), and SLHD scores were compared and correlated. ADROM was connected with SLHD and YBT scores only in the backs, not forward rugby players. The information gap in the current literature remains inconclusive as to whether only the YBT scores in the anterior direction are linked to ADROM or if other YBT directions are also correlated. Additionally, there is a disparity in the correlation between ADROM, SLHD, and dynamic balance across player positions in rugby, as backs demonstrated stronger associations than forwards. This inconsistency raises doubts about the strength of the relationship between ADROM, YBT, and SLHD, suggesting the need for further research to clarify these associations and their implications for athletic performance and injury risk.

To the authors' knowledge, no study has yet been conducted to examine the relationship between an athlete's dynamic balance, ADROM, SLHD, and body composition. Therefore, this study aimed to determine how ankle dorsiflexion range, body composition measurement, and dynamic balance are related. It is hypothesized that ADROM significantly correlates with both the dynamic balance (YBT) in all directions and SLHD. Additionally, these correlations are contingent upon body composition.

METHODS

Participants

A power analysis was conducted to determine the appropriate sample size for this study, ensuring sufficient statistical power to detect meaningful effects (Overmoyer & Reiser, 2015). Fifty-two male collegiate athletes (age: 19.62 ± 1.54 years, height: 170.54 ± 11.17 cm, mass: 60.92 ± 8.84) represented at the university level were recruited. Athletes with a history of ankle sprains, surgery of the lower extremities, self-reported impairments in the foot and ankle, and vestibular disorders were excluded. The Institutional Ethics Committee of Suresh Gyan Vihar University (Approval number: 217/SG 23/02/2024) approved the experimental

methodology for this study, which adhered to the Declaration of Helsinki. Written informed consent was obtained, and each participant received complete information about the testing procedures. Participants were scheduled for a single testing session at the facility.

Data Collection Tools

The Omron Karada Scan HBF-224 was used for the BIA measurements in order to determine body composition. A universal goniometer was used to measure ADROM. The YBT was conducted using the Y junction, marked on the ground with securely affixed tape.

Data Collection Procedure

A cross-sectional design was utilized to identify the association between the results of the WBLT, ADROM, and YBT performance (normalized reach distance at maximal reach in each direction) and body composition analysis. Participants were instructed to limit their exercise to regular everyday activities the day before and the day of the test and to refrain from performing strenuous exercises for their back and lower limbs 48 hours before the visit. The assessments were conducted sequentially to ensure consistency and reduce the impact of fatigue or other confounding variables. First, the participant's height and weight were measured, followed by the assessment of body composition using Bioelectrical Impedance Analysis (BIA). Once these baseline measurements were taken, the evaluation of ADROM was carried out. Afterward, participants underwent the YBT to assess dynamic balance. Lastly, SLHD was performed.

Anthropometric Measurement

Upon arrival and confirmation of eligibility, participants were introduced to the testing protocol, followed by an assessment of their body weight and height. The height was measured in centimeters with a precision of 0.5 cm using a vertically placed rigid ruler fastened with a stable base. The weight was measured in kilograms with an accuracy of 0.1 kg using a mechanical scale. The Controller of Legal Metrology (Weights & Measures), India, officially verified the scale employed. Limb length was measured using a conventional tape measure. The starting point was the anterior superior iliac spine, and the endpoint was the center of the medial malleolus. This measurement was conducted while the participants were lying supine on a plinth. To determine leg dominance, participants were asked, "If you would shoot a ball on a target, which leg would you use to shoot the ball?" (van Melick et al., 2017). The BIA measurements were conducted using the Omron Karada Scan HBF-224 to assess body

composition. Before the BIA measurement, each participant wore minimum clothing, removed metal jewelry, and rested supine for five minutes to equilibrate bodily fluids.

Range of Motion Measurement

ADROM was determined by two measures: utilizing a universal goniometer and WBLT. Goniometer measurements were taken with the individual actively moving the joint in the dorsiflexion in supine (Norkin, 2016). The goniometer has moderate reliability, with intra-class correlation coefficient (ICC) scores of 0.55–0.61. A single examiner performed all measurements of ankle dorsiflexion range of motion (ADROM) to minimize inter-examiner variability (Worsley et al., 2018). The joint position was sustained for 5–10 seconds while a measurement was collected. An average range of three trials was included in the study. To assess their maximum weight-bearing dorsiflexion range, the subjects completed the WBLT (Vicenzino et al., 2006). The subjects completed three practice trials on each limb, flexing their knee to the wall while maintaining a firm test heel placement on the floor. During the test, stability was maintained by placing the opposing extremity behind the test foot. The great toe's distance from the wall, measured in centimeters, was defined as the furthest the foot could be positioned without the heel lifting off the floor and the knee still being able to make contact with the wall. Following three practice trials, three trials were recorded, and an average of three was utilized in the study.

Y balance test

YBT was completed in three directions: anterior, posteromedial, and posterolateral (Plisky et al., 2006). The Y junction, indicated on the ground by tape measures fastened in an inextensible manner, was where the distal side of the athlete's great toe touched. The participants used their dominant and non-dominant legs to reach all three directions. For the trial to be deemed correct, the participant had to keep their hands always on their hips, gently brush the measuring tape at the furthest distance without redirecting their weight onto the reaching foot, and return to a single-leg standing position for a minimum of two seconds. An average of three testing trials in each direction was considered for analysis. Scores were calculated by dividing the average reach distance (in cm) by each participant's leg length. To obtain the composite, the average reach in each of the three directions was divided by three leg lengths, and the outcome was then multiplied by 100%. Composite reach distance (%) = Sum of the 3 reach directions / 3 times the limb length * 100.

Single Leg Hop for Distance

The participants executed SLHD, as outlined by Daniel et al. (1988). This jump is executed with one leg to achieve the greatest possible horizontal distance (Daniel, 1988). During this activity, the arms are positioned behind the body, and participants must wear athletic footwear. Three trials of the single-leg hop for distance were conducted, and the average of the three trials was analyzed.

Statistical Analyses

Statistical analysis was performed using SPSS v26.0, Armonk, New York. Outcomes were analyzed for a normal distribution using the Kolmogorov-Smirnov test. Pearson correlation test was applied to find the correlation between YBT, ADROM (Goniometer), WBLT, SLHD, and body composition. A linear regression analysis was run to find the correlation between a criterion variable and a set of predictors. Probability of Type I error < 0.05 was accepted as the level of significance.

RESULTS

The normality test results indicated that the data followed a normal distribution ($p > 0.5$). Table 1 represents the demographic characteristics of the participants.

Table 1
Demographic Characteristics

Demographic Characteristics	Mean ± SD
Age (years)	19.62 ± 1.54
Height (cm)	170 ± 11.17
Weight (kg)	60.92 ± 8.84
BMI (kg/m2)	20.41 ± 2.59
Skeletal muscle mass (%)	31.55 ± 3.41
Total fat (%)	19.58 ± 5.48

Table 2 displays the mean and standard deviation (SD) values for ankle range, WBLT, and YBT measures while comparing the dominant leg (DL) and non-dominant leg (NDL). The non-dominant leg consistently exhibits higher mean values than the dominant leg across all metrics. Nevertheless, the disparities are typically minor, and the standard deviations imply a certain degree of overlap, indicating that the discrepancies may not be significant.

Table 3 presents the outcomes of the Pearson correlation analysis between the ankle dorsiflexion ROM measured by goniometer, WBLT, measurements from the YBT, body composition metrics, and SLHD. Strong positive correlations were present between YBT anterior reach with WBLT ($r = 0.64$, $p < 0.001$) and ankle dorsiflexion ROM ($r = 0.72$, $p < 0.001$). A moderately significant positive correlation is observed between YBT composite score

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with WBLT (r = 0.43, p <0.05) and ankle dorsiflexion ROM (r = 0.37, p<0.05). The associations observed in the posteromedial and posterolateral reaches in the Y Balance Test (YBT) are weaker and less reliable. Weak and non-significant associations between WBLT ankle dorsiflexion ROM and body composition parameters (BMI, skeletal muscle mass, and total fat) and SLHD are seen.

Table 2
Ankle Dorsiflexion ROM, WBLT, and Y Balance Test Scores for Dominant and Non-Dominant Legs

Tests	Mean ± SD	
	Dominant Leg	Non-Dominant Leg
Ankle DF ROM (degrees)	14.10 ± 3.12	14.63 ± 2.99
WBLT (cm)	10.96 ± 1.66	11.65 ± 1.63
Anterior reach YBT (%)	77.55 ± 7.63	81.08 ± 7.01
Posterolateral reach YBT (%)	104.70 ± 9.25	107.72 ± 8.63
Posteromedial reach YBT (%)	101.33 ± 8.31	103.98 ± 9.67
Composite Score (%)	94.53 ± 6.36	97.60 ± 6.34

Table 3
Result of Pearson Correlation Between WBLT, Ankle Dorsiflexion ROM with YBT, Body Composition, and SLHD

Tests			WBLT		Ankle Dorsiflexion ROM	
			DL	NDL	DL	NDL
Y Balance Test	Anterior	DL	r = 0.64 p <0.001*	r = 0.59 p<0.001*	r = 0.72 p<0.001*	r = 0.68 p<0.001*
		NDL	r = 0.57 p<0.001*	r = 0.60 p<0.001*	r =0.66 p<0.001*	r=0.62 p<0.001*
	Posteromedial	DL	r = 0.39 p<0.05*	r = 0.36 p<0.05*	r = 0.22 p = 0.10	r = 0.23 p = 0.10
		NDL	r = 0.33 p<0.05*	r = 0.37 p<0.05*	r = 0.10 p = 0.46	r = 0.20 p = 0.16
	Posterolateral	DL	r = 0.11 p = 0.94	r = 0.44 p = 0.76	r = 0.03 p = 0.83	r = 0.03 p = 0.80
		NDL	r = 0.14 p = 0.30	r = 0.20 p = 0.16	r = 0.04 p = 0.76	r = 0.04 p = 0.75
	Composite Score	DL	r = 0.43 p<0.05*	r = 0.42 p<0.05*	r = 0.37 p<0.05*	r = 0.35 p<0.05*
		NDL	r = 0.44 p<0.05*	r = 0.50 p<0.001*	r = 0.28 p<0.05*	r = 0.31 p<0.05*
Body Composition	BMI		r = -0.23 p = 0.09	r = -0.24 p = 0.08	r = -0.98 p = 0.49	r = -0.10 p = 0.47
	Skeletal Muscle Mass		r = 0.26 p = 0.06	r = 0.17 p = 0.22	r = 0.22 p = 0.10	r = 0.19 p = 0.17
	Total Fat		r = -0.18 p = 0.20	r = -.020 p = 0.14	r = -0.98 p = 0.49	r = -0.10 p = 0.47
SLHD	DL		r = 0.09 p = 0.49	r = 0.09 p = 0.51	r = 0.25 p = 0.70	r = 0.20 p = 0.14
	NDL		r = 0.15 p = 0.28	r = 0.16 p = 0.25	r = 0.23 p = 0.09	r = 0.19 p = 0.17

Note. *: statistically significant; Ant– Anterior, PM- Posteromedial, PL- Posterolateral, CS- Composite Score, DL- Dominant Leg, NDL– Non-Dominant Leg, WBLT- Weight Bearing Lunge Test, SLHD- Single Leg Hop for Distance, ROM- Range of Motion, BMI- Body Mass Index

Table 4 presents the findings of a linear regression analysis conducted to predict YBT performance based on many independent variables. WBLT indicates a strong positive association (r = 0.64 for DL and r = 0.60 for NDL) with high adjusted R² values (0.40 and 0.35, respectively), indicating a meaningful predictor with p-values <0.001. SLHD exhibits a moderate association (r = 0.35 for DL and r = 0.34 for NDL) with lower adjusted R² values (0.10 and 0.12, respectively) and significant p-values <0.05. Ankle ROM displays the strongest correlation (r = 0.72 for DL and r = 0.62 for NDL) and the highest adjusted R² values (0.51 and 0.38, respectively), being the most significant predictor with p-values <0.001. The analysis suggests the importance of WBLT, SLHD, and Ankle ROM in predicting YBT performance. However, Total Fat and BMI do not significantly contribute to the prediction models.

Table 4
Variables Included in Linear Regression Analysis for Predicting YBT Performance

Dependent Variable	Independent Variable	Correlation coefficient	Adjusted R2	Degree of freedoms	F stats	p-value
Ant-YBT (%) (DL)	WBLT	0.64	0.40	(1,50)	34.34	<0.001*
	SLHD	0.35	0.10	(1,50)	6.86	<0.05*
	Ankle ROM	0.72	0.51	(1,50)	54.98	<0.001*
	Total Fat	0.06	-0.16	(1,50)	0.18	0.67
	BMI	0.11	-0.01	(1,50)	0.63	0.42
	Skeletal Muscle Mass	0.30	0.08	(1,50)	4.84	<0.05*
Ant-YBT (%) (NDL)	WBLT	0.60	0.35	(1,50)	28.28	<0.001*
	SLHD	0.34	0.12	(1,50)	6.60	<0.05*
	Ankle ROM	0.62	0.38	(1,50)	31.33	<0.001*
	Total Fat	0.06	-0.01	(1,50)	0.18	0.67
	BMI	0.09	-0.01	(1,50)	0.46	0.50
	Skeletal Muscle Mass	0.27	0.05	(1,50)	3.86	<0.05*
CS-YBT (%) (DL)	WBLT	0.43	0.17	(1,50)	11.24	<0.05*
	SLHD	0.40	0.14	(1,50)	9.18	<0.05*
	Ankle ROM	0.37	0.12	(1,50)	8.12	<0.05*
	Total Fat	0.23	0.03	(1,50)	2.76	0.10
	BMI	0.26	0.05	(1,50)	3.58	0.06
	Skeletal Muscle Mass	0.18	0.01	(1,50)	1.58	0.22
CS- YBT (%) (NDL)	WBLT	0.50	0.23	(1,50)	16.62	<0.001*
	SLHD	0.40	0.15	(1,50)	9.88	<0.05*
	Ankle ROM	0.30	0.07	(1,50)	5.24	<0.05*
	Total Fat	0.21	0.05	(1,50)	2.34	0.13
	BMI	0.24	0.04	(1,50)	3.10	0.08
	Skeletal Muscle Mass	0.08	-0.01	(1,50)	0.33	0.57

Note. *: statistically significant, Ant– Anterior, PM- Posteromedial, PL- Posterolateral, CS- Composite Score, DL-Dominant Leg, NDL– Non-Dominant Leg, WBLT- Weight Bearing Lunge Test, SLHD- Single Leg Hop for Distance, ROM- Range of Motion, BMI- Body Mass Index

DISCUSSION

This study's main finding is that the ADROM, WBLT, and SLHD significantly influence the variability in YBT performance. Furthermore, ADROM was a predictor for the anterior direction, as commonly claimed, but also for the composite score. The findings partially support the hypothesis that ADROM strongly predicts YBT performance in all directions. The Y-Test reach scores are closely aligned with those of other research (Overmoyer & Reiser, 2013). The bilateral averages for ADROM, WBLT, and SLHD measurements were within the anticipated ranges for healthy and physically active people (Hoch et al., 2011; Kang, Lee, et al., 2015; Myers et al., 2014; Olszewski et al., 2024). A slight asymmetry was observed in this population during assessments, which aligns with findings from earlier studies (Daneshjoo et al., 2013; Knapik et al., 1991; Plisky et al., 2006).

Based on our study, we found that the ADROM was a strong predictor for both anterior reach and the composite score. Multiple studies have recognized that ADROM can be used to predict the ability to move forward (Gabriner et al., 2015; Kang, Kim, et al., 2015). There have been few studies that have found the association between ADROM and composite scores (Olszewski et al., 2024; Rafagnin et al., 2023). Consistent with previous research, we also discovered a weak but significant correlation between PM performance and WBLT (Nelson et al., 2021; Olszewski et al., 2024). Variations in administered testing protocols and sample characteristics may have caused the discrepancy between the results of the studies. It has been suggested that insufficient ADROM may lead to difficulties regulating the body's center of mass over the base of support, which can complicate balance maintenance during reach movements. Regression analysis was employed to look at the relationships between YBT performance scores (dependent variables: Anterior-YBT and CS-YBT for both dominant and non-dominant legs) and various independent variables, including WBLT, SLHD, ROM, Total Fat, BMI, and Skeletal Muscle Mass. With moderate to strong correlations and significant p-values, WBLT (35% variance) and Ankle ROM (38% variance) were the best predictors of YBT performance for both the dominant and non-dominant legs. A previous investigation that supported our findings discovered that ADROM was responsible for an estimated 28% of the variation in anterior reach (Hartley et al., 2018). Anterior reach distance variation was explained by a 31% variance of ADROM in a prior study involving participants with chronic ankle instability (Basnett et al., 2013). Additionally, results showed a slight (9% variance) correlation with the composite scores, which is less than the variance (17%) in the current study. The composite score's calculation method, which considers reaching distances in all

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three test directions, may have contributed to the low clinical relevance of these measure relationships. Contrary to our findings, a study discovered that lower composite scores were linked to higher ADROM values (Chimera & Larson, 2020). The observed disparity could potentially stem from variations in sample sizes and the absence of regression model segmentation based on reach direction. Consistent with previous findings, our study also observed that ADROM deficit did not significantly affect hopping performance (Jatmiko et al., 2023). This can be because other joints may have adjusted to compensate for the decreased dorsiflexion during SLHD. There is a statistically significant positive correlation between SLHD and the anterior reach and composite scores of YBT for both the dominant and non-dominant legs. The correlations are moderate, and a small but significant amount of the variance in YBT performance can be explained by SLHD: SLHD accounts for 10% (DL) and 12% (NDL) of the variance for anterior YBT. SLHD accounts for 14% (DL) and 15% (NDL) of the variance for composite score YBT. Previous studies using the YBT and power by countermovement jump and SLHD tests showed similar results illustrating the relationship between energy and dynamic balance. (Booysen et al., 2015; Wilczyński et al., 2021)

Body weight is a strong predictor among the many variables that may affect dynamic balance, and obesity is strongly linked to reduced mobility, increased postural sway, and falls (Ganesan et al., 2018). Our findings suggest a lack of significant correlation between total Fat and BMI, with the YBT performance. These study's findings were consistent with another investigation that evaluated the relationship between 149 collegiate students' YBT performance and BMI. The study shows no correlation between BMI and the YBT's normalized reach values for both limbs. (Suvarna et al., 2021) The present study's findings are inconsistent with previous research that has demonstrated a strong correlation between a higher BMI and poor performance on the YBT (Ewais et al., 2024). This discrepancy could be because this study primarily involved participants with normal BMI, which may limit the ability to detect significant correlations, as individuals within this range often experience fewer balance-related impairments. In contrast, studies that find a strong correlation typically include populations with a wider comprehensive range of BMI values, including those classified as overweight or obese, where the effects of increased body mass on balance are more pronounced. Also, methodological differences can influence outcomes, such as testing protocols and the specific populations studied.

Limitations

The study only included collegiate male athletes, so generalizing the findings to other demographic groups like females or athletes with particular injuries can not be generalized. The study's cross-sectional design collects data at a single point, making establishing a relationship between the variables difficult. Studies with a longitudinal design would be required to identify causal relationships and monitor changes over time. Future research should diversify the sample to include female athletes, non-athletes, and different age groups to ensure broader applicability of the findings. Data accuracy and relevance can be increased using advanced technology measurement tools.

CONCLUSION

Strong predictors of YBT performance include ADROM and WBLT, especially for the anterior reach direction. A noteworthy, although weaker, correlation exists between SLHD and YBT performance. Metrics of body composition like total fat and BMI do not substantially correlate or predict YBT performance. These results imply that increasing weight-bearing lunge capacity and ankle dorsiflexion range of motion may improve dynamic balance as assessed by the YBT in male collegiate athletes.

PRACTICAL IMPLICATIONS

The results of this study have critical applications for improving athletes' performance and training. Improving ADROM and WBLT capacities should be the priority for coaches and athletic trainers to improve dynamic balance, especially in the anterior direction. Performance can be improved, and specific deficiencies can be addressed with tailored training programs based on individual assessments of ADROM, WBLT, and SLHD.

Acknowledgments

Authors' Contribution

In this paragraph, it should be explained in meaningful sentences which author made what contributions in all processes from the beginning to the end of the research.

Declaration of Conflict Interest

The authors have no conflict of interest to declare.

Ethics Statement

The Institutional Ethics Committee of Suresh Gyan Vihar University, Jaipur, Rajasthan, India, approved the study (Approval number: 217/SG 23/02/2024).

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Research Article

Effectiveness of Badminton Physical Program on Mental Capacities in Healthy Older Adults

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ABSTRACT

Older people suffer from reduced mental and cognitive parameters such as executive function, working memory and cognitive flexibility. However, information about how racquet sports can improve mental skills in older adults requires greater analysis and research. To verify the effects of badminton physical program on cognitive function in older adults. We sought to examine the beneficial effects of badminton physical programs on multi-cognitive domains among healthy older adults. Specific cognitive functions were measured using the Stroop Test, the Digit Span Test, and the Mini-Mental State Examination. 40 older adults recruited from the University of Monastir were allocated into two groups: the intervention group (IG, $N = 20$), enrolled in a badminton program, and the control group (CG, $N = 20$) participants were given typical duties and asked to stick to their daily schedule (book reading, home tasks). The physical activity protocol was performed three times a week, one hour per session, for a total period of two months. The activities proposed were not systematized and were aimed at promoting social interaction among participants. Our findings show no significant difference in the initial components between the intervention and control groups. Significant improvements in cognitive parameters were found after the physical program in the IG ($p < 0.05$), except the Mini-Mental State Examination test ($p = 0.33$). Physical activity is considered one of the most therapeutic methods for improving mental capacities in older adults.

INTRODUCTION

The link between physical activity and cognitive performance for older adults has been the primary objective of various research projects. Previous research states that the number of elderly people (65 and over) is predicted to double from 703 million globally in 2019 to 1.5 billion by 2050 (Kasai, 2021).

A comprehensive awareness of the lifestyle factors and interventions that can improve cognitive health and lower the risk of neurodegenerative disorders in this aging population is essential considering this substantial shift in demographics. Advanced cognitive capacity, or executive parameters/function (EP, EF), is the core of individuals' social, emotional, mental functions (Miyake et al., 2000), and it is composed of three components: mental flexibility, short-term/working memory, and inhibition (Diamond, 2013). The decreasing of executive parameters leads to cognitive dysfunction in individuals, and it can also lead to increasing behavioral and psychological disorders (Costanzo et al., 2013; Frost et al., 2019). Therefore, improving the executive function of older adults leads to enhancing the quality of life and realizing successful aging. Another important aspect of cognitive function is working memory (WM), particularly among the elderly population. In the brain, WM is responsible for acquiring and modulating numerous forms of information (Kato et al., 2018). The ability to retain information has been demonstrated to reach its maximum at age of 30 and to drastically decline around age of 60 (Elliott et al., 2011).

The value of physical activity is further highlighted by several recent long-term research studies demonstrating that frequently moderate-intensity physical activity can lower the risk of cognitive problems (Wilke, 2020; Livingston, 2020). Studies conducted throughout multiple scientific domains indicate that physical activity programs such as badminton enhance psychological health and well-being (Lawton et al., 2017), with a multitude of other benefits such as lowering the levels of stress, anxiety, and depression and increasing the beneficial effects of cognitive parameters. Furthermore, while many sports and exercises emphasize the physical and motor aspects of performance, others, such as racquet sports, necessitate a particularly advanced level of mental capacity. Badminton is an open-skills sport, a suitable game for both younger and older people. It requires participants to select appropriate actions that can positively improve brain activity and muscle contraction during physical exercise. Furthermore, it also enhances brain plasticity and cognitive function (Hülsdünker et al., 2019). The combination of these improvements ultimately enhances general well-being. The number of people engaging in dual sport racquets to perform physical

qualities has increased considerably (Tator, 2008). A study conducted by Oja et al. (2017) showed that playing sports racquet has been linked to a lower death rate (47%) and reduced cognitive disorders (53%). It has been demonstrated that the time invested in playing racquet sports has an impact on biological and psychological factors.

While it is evident that regular engagement in a variety of physical activities has a positive impact on health, very limited studies have examined whether participation in racquet sports (such as badminton) influences mental abilities in older adults. This research aims to investigate whether playing different kinds of badminton exercises might change or improve cognitive abilities. We hypothesize that badminton physical programs will exhibit higher scores in the MMSE, Stroop, and Digit Span tests as instruments for measuring cognitive function in older adults.

METHODS

A controlled randomized experiment was created to address the research questions concerning the effect of a two-month badminton physical program on cognitive function in older adults. All cognitive tests (Stroop, Digit Span, and MMSE tests) were measured pre-and post-intervention. Participants were recruited with an invitation questionnaire addressing the procedure and the protocol with all details. Participants were selected under the same conditions and with the same staff members (medical and trainer staff). Participants must be accompanied by their relative partners or their family representative members.

Participants

40 older adults participating in this study (25 men and 15 women) were separated into two groups: intervention (n = 20) and control (n = 20). The participant's average age was 65.80 ± 3.93 years, with no significant difference between groups. Their height was 168.68 ± 10.29 cm, weight was 72.25 ± 14.25 kg, and BMI was 25.05 ± 4.12 kg/m2. Gender differences were assessed using crosstabs in SPSS version 22.0. The initial analysis revealed no significant distinctions among both groups in age, height, body mass, and BMI (all > 0.05). Table 1 displays the baseline characteristics.

The protocol was conducted from June to August 2023. The inclusion criteria were: (1) 60–70 years; (2) no previous badminton training; (3) no history of chronic disease; (4) no physical disorder, and a score of the Mini Mental State Examination test (MMSE) between 25

and 30. The exclusion criteria were: (1) attention disorders, (2) aggressive, (3) perception deficits, (4) and those unable to engage in the regular physical programs.

Table 1
Demographic Characteristics of the Participants

Groups Measurements	(IG; N=20)		(CG; N=20)	
Sex	Men (n=12) Women (n=8)	*p*	Men (n=13) Women (n=7)	*p*
Age (year)	66.00 ± 3.64	0.486	67.60 ± 4.32	0.371
Height (cm)	168.53 ± 9.23	0.378	170.83 ± 11.46	0.161
Body Mass (kg)	70.51± 12.98	0.467	73.98 ± 15.26	0.233
BMI	24.87 ± 4.52	0.378	25.24 ± 3.84	0.387

Note. BMI: body mass index, BMI = weight in kg divided by height in meters squared.

Procedures

After receiving the medical report, eligible participants who completed the initial screening process were invited to the Sport Physiology Laboratory (ISSEP Ksar Said, Tunis). Upon their arrival, participants received a full explanation regarding the objectives and procedures of the tests. Following anthropometric measurements individually. Participants spent 10 minutes in a quiet environment at a thermoneutral temperature of around 22°C. After that, all subjects were asked to complete the cognitive function assessments. The evaluation was based on two neurocognitive tests, which included the Digit Span test and the Stroop test. A two-minute interval was allowed between each test. The cognitive tests listed below were conducted both before and after the intervention.

Stroop test

We used the Stroop test (Stroop, 1935) to assess inhibition capabilities and executive malfunction, and for the evaluation of cognitive flexibility, we used a modified version incorporating a fourth board (Chatelois et al., 1996). The Stroop test consists of four boards, each representing a different condition. The first board represents the name, with rectangular items of red, yellow, blue, or green colors. Participants must name the colors they see. The second board represents the reading task, with the words yellow, blue, red, and green written in black. The aim is simply to read the words. For the third board, representing the interference, the words indicating colors are written with a different ink color, i.e. GREEN - YELLOW. The objective of this board is to disrupt the time takes to read the word and concentrate on indicating the color of the ink. The final board, which stands for flexibility, is identical to the third one after certain words have been framed; in this instance, the participant

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is required to read the word. The difficulty is the alternate reading of the word when it is framed and the designation of the color of the ink.

Each board consists of ten items per line on ten lines. The test consists of counting the total responses of correct answers in 45 seconds. Evaluation of the first two boards helps train and evaluate the time the practitioner needs to read and name the color. In contrast, the third and fourth boards are used to assess flexibility and inhibition.

Digit Span

Digit Span (DGS) is a validated test assessing both short-term and working memory, it can be administered in two formats: forward digit span and backward digit span. This is a verbal indicator instrument assesing tasks with stimuli produced auditorily, comments stated by the participant, and immediately scored by the software. A random sequence of numbers is shown to the participants, they are asked to repeat it according to the initial order (digit forward) or in the opposite order (digit backward). Tasks were almost very comparable; and both examine cognitive parameters: the forward span task evaluates short-term memory, while the backward span measures working memory ability (Wechsler, 1955).

Mini-Mental State Examination

Cognitive aging was assessed using the Mini-Mental State Examination test. This is the most frequently used test employed for rapid screening measures to determine the presence of cognitive impairments in older adults. The procedure of this test takes only 5–10 minutes, and the following aspects are examined: memory , language and praxis , perception , and attention. The total score is 30 points, a score below 24 indicates a typical cognitive level. A score under 24 signifies "mild dementia," 19-24 means "moderate dementia," and 10-18 reveals "severe dementia" (<10) (Folstein et al., 1983).

Badminton Intervention Program Development and Content

We established the exercise intervention with new technical modifications in this research on previous badminton intervention programs completed in relevant domains that used a total of around 20 to 24 weeks, 2-3 times per week, for sixty minutes each time (Yang, 2017). The training program was developed by a multidisciplinary team composed of exercise physiologists, psychologists, and physical education professionals with a specialization degree in badminton coaching, with proper care for the psychological and physical situations of older persons. The intervention content was designed to stimulate cognitive parameters, primarily short-term memory, working memory and inhibitory control. When participants learned and performed certain specific moves, they were capable of conducting them correctly

using the instructions supplied. Furthermore, it was essential to strengthen their control to improve their ability to manage and prevent inappropriate activities.

For working memory, participants were required to regularly retain information, analyze data and maintain movements during the training. Participants were asked to switch between working memory states to exhibit cognitive flexibility. The physical program began with a preparation period, which consisted of warm-up exercises and jogging, followed by particular badminton skills training, gradually modifying the type of exercise task, followed by 10 minutes of static stretching period (Table 2). The level of exercise was evaluated. After each exercise session, six individuals were randomly selected, their heart rates were measured manually, and the supervisor reported their observed physical states. During the skills training period, the participants' average heart rate was 135.74 beats per minute, which is similar to 65-75% of the maximal heart rate for this age group, indicating moderate-intensity exercise. All sessions were carried out under the instructions of the same coaches.

Table 2
Badminton Intervention Protocol

Time Period	Repartition of Badminton Program 12 Sessions	Lenght
Week 1-2: Session 1 to 3:	Discovery of badminton/ equipment Handling Equipment Jongles exercises	60 min Session
Week 3-4: Session 3 to 6:	Muscle Strengthening Lower M/ put learning into practice Muscle Strengthening Lower M/ reverse service learning Muscle Strengthening Lower and Upper M/ reverse service / gait	60 min Session
Week 5-6: Session 6 to 9:	Service learning / gesture release Service learning / gait + coordination exercises Passing Exercises (Moving footwork practice + eye contact	60 min Session
Week 7-8: Session 9 to 12:	Transfer of learning during matches Quality training: full command footwork, (Moving footwork practice + eye contact)	60 min Session
Cool down	Static stretching	10 min

Data Analysis

The information obtained was analyzed using SPSS version 23.0 for MAC (IBM Corporation, Armonk, NY, USA). First, the Kolmogorov-Smirnov test was applied to determine whether the data followed a normal distribution. To investigate the impact of the badminton physical program, we used a student t-test on all cognitive variables. Statistical significance was determined at $p < 0.05$.

RESULTS

To verify if our two study groups had comparable baseline scores before establishing the physical training program, we compared diagnostic evaluation scores between both groups using the student *t*-test. All variables showed no significant difference between the control and intervention groups. Except for one variable, on the digit-backward test, the CG has a significantly higher working memory score than the intervention group (*p < 0.05*). The MMSE test indicates that both groups have normal cognitive scores <27 without any mental deficits. Table 3 presents the average and standard deviation of each group. The values obtained in the student test and their significance are also listed in this table.

Table 3
Comparison of Characteristics of the Control Group vs Intervention Group in Pre-program

Measurement	(IG) (N=20)	(CG) (N=20)	t	p
Stroop Test				
Reading Score	42.39 ± 12.98	51.31 ± 15.90	1.27	0.22
Inhibition	31.61 ± 12.62	36.06 ± 8.95	0.82	0.42
Cognitive flexibility	32.39 ± 11.01	40.68 ± 12.21	1.47	0.16
Digit Span Test				
Digit Forward	5.78 ± 1.48	7.50 ± 2.30	1.84	0.08
Digit Backward	2.56 ± 0.73	4.13 ± 1.96	2.24	0.04*
MMSE	28.87 ± 0.91	27.38 ± 2.87	0.99	0.33

Note. M = Mean; SD = Standard Deviation; MMSE = Mini Mental State Examination; *p<0, 05

Comparison of Post-to-Pre-Program Control Group Scores

To determine if there would be a test-retest effect on the control group, the student t-test was applied to assess the control group's results before and after the intervention. Table 4 summarizes the analysis findings, which show no significant change in cognitive parameters (i.e., *p >.05*).

Table 4
Comparison of Pre vs. Post-program Scores in the Control Group

Measurement	Before Intervention	After Intervention	t	p
Stroop Test				
Reading Score	51.31 ± 15.90	54.37 ± 14,87	0.85	0.42
Inhibition	36.06 ± 8.95	35.87 ± 10.28	0.06	0.96
Cognitive flexibility	40.68 ± 12.21	40.50 ± 8.5	0.04	0.96
Digit Span Test				
Digit Forward	7.50 ± 2.30	7.12 ± 2.69	2.04	0.08
Digit Backward	4.13 ± 1.96	4.37 ± 2.06	1.00	0.35

Note. M = Mean; SD = Standard Deviation.

Score Comparison of the Post-versus Pre-program Intervention Group

To test the impact of the badminton program on our different study variables, we compare the post-program scores with those of the pre-program. Our results were analyzed by a student t-test, showing significant improvements in executive function for the intervention group. Participants got a significantly higher reading score in the post-program (p = 0.001), and we also found that the inhibition score was significantly higher in the post-program (p = 0.05). Significant results were shown on the cognitive flexibility task (p = 0.05). Concerning the capacity of data related to the short-term memory function, we found a significant difference ($p < 0.001$) in working memory after the badminton program (p = 0.01). However, the mean score has changed for the MMSE test, but without any significant difference. The complete analysis and measures are presented in Table 5.

Table 5
Comparison of the Score of the Intervention Group Post Versus Pre-program

Measurement	Before Intervention	After Intervention	*t*	p
Stroop Test				
Reading Score	42.39 ± 12.98	49.6 ± 13.31	4.82	0.0013**
Inhibition	31.61 ± 12.62	35.94 ± 11.33	0.95	0.01*
Cognitive flexibility	32.39 ± 11.01	37.28 ± 10.28	0.91	0.02*
Digit Span Test				
Digit Forward	5.78 ± 1.48	7.00 ± 1.50	0.96	0.00003***
Digit Backward	2.56 ± 0.73	4.00 ± 1.41	0.36	0.01*

Notes. M = Mean; SD = Standard Deviation; *p<0,05; **p<0,01; ***p<0,001

Intergroup Comparison of Scores (Post-Pre Program)

To test the interest/impact of the adapted physical activity program on our various study variables, we created new variables called subtractions. These consist of subtracting the scores obtained in pre-program tests from those obtained in post-program tests. We obtain different scores that allow us to highlight the impact of our physical activity program on independent elderly individuals. The complete substractions measures are presented in Table 6.

Table 6

Comparison of Subtraction Scores (Pre and Post-Program) Between the Intervention and the Control Group

Measurement	Before Intervention (M±SD)	After Intervention (M±SD)	t	p
Stroop Test				
Reading Score	7.22 ± 4.49	3.06 ± 10.15	1.12	0.28
Inhibition	4.33 ± 4.05	-0.18 ± 9.55	1.29	0.21
Cognitive flexibility	4.89 ± 4.74	-0.19 ± 10.79	1.28	0.22
Digit Span Test				
Digit Forward	1.22 ± 0.44	-0.37 ± 0.52	6.87	< 0.001***
Digit Backward	1.44 ± 1.33	0.25 ± 0.70	2.26	0.03*

Note. M = Mean; SD = Standard Deviation; *p<0,05; **p<0,01; ***p<0,001.

DISCUSSION

This study examined the impacts of physical exercise programs based on multiple badminton activities on cognitive parameters in older healthy adults. 40 participants were taken for data analysis, and both groups were well matched in terms of demographic and initial variables. There was no statistically significant difference in age between the two groups (p = 0.371). However, there was no dropout; however, there was no dropout, and all the participants were stable during the entire follow-up period.

Our results showed that two months of physical exercise positively affected executive function, working memory, and cognitive flexibility, with faster reaction time and reading scores. However, no subcomponent of executive function among individuals in the control group showed significant changes. Patients in the control group have better baseline results in the Degit Backward test than the intervention group; this could be explained by the degree of social interaction with the medical staff and family assistance. According to the overall results of the current research and consistent with previous studies, we believe that a physical training program is a promising way to enhance cognitive characteristics in the elderly population.

Impacts of Physical Exercise on Executive Function

A large number of studies suggest that exercise is an essential method for older people to prevent cognitive decline and chronic diseases. The current study's findings demonstrate the positive effects of physical activity on cognitive function, particularly on executive and memory processes. Many research studies have revealed a significant correlation between cognitive performance and physical exercise (Pindus et al., 2019). The research evidence shows that physical exercise is beneficial for executive function and that improvements are related to the type of training (Colcombe & Kramer, 2003). The World Health Organization (WHO)

survey additionally shows the connection between physical activity and enhanced neurocognitive function, especially memory and executive function (WHO, 2008). The findings in the present study are similar to those in other research studies. Low-to-moderate-intensity badminton training helps older people improve their executive function, which includes attention, memory, and calculation skills (Yu & Zhao, 2021). Different types of exercise, such as aerobic, anaerobic, and mental exercise activities, can help healthy older adults improve their mental and cognitive functions (Northey et al., 2018). The study of Takahashi (2019) demonstrates how badminton can stimulate cognitive function (the capacity to use self-control over behavior, emotions, thoughts, and concentration in order to demonstrate the link between physical exercise and cognitive function). An analysis of comparative data revealed that senior racket sport athletes with at least 20 years of experience had a 3.1% quicker reaction time than other athletes, and this improvement is directly linked to the duration and the exercise intensity (Culpin, 2018).

Effects of Physical Exercise on Working Memory

The brain's capacity to simultaneously store and process information is based on working memory, which is one of the most significant aspects of cognitive function. According to pertinent research, physical activity improves cognitive characteristics and has a good impact on working memory, a result similar to that of the present study (Guo, 2022). Different types of exercise may have favorable physiological and neurobiological impacts on WM. Accordingly, Wilke (2020) found that working memory performance does improve following a regular physical exercise program. Ikudome et al. found that even simple balance and resistance exercises can decrease the progression of aging factors and contribute to a healthy lifestyle in older people (Ikudome et al., 2017). Different workouts may stimulate various areas of the brain when playing badminton; the duration and intensity of the selected exercises are directly related to this activation, leading to physiological and psychological improvements. In a badminton match, players must rapidly analyze the shuttlecock information of their opponent, screen out irrelevant data, and then select the right stroke action from their conscious memory. This mechanism contributes to reorganizing brain information and contributes to the development of new skills.

Effects of Physical Exercise on Cognitive Flexibility

Multiple perspectives exist concerning how playing badminton enhances cognitive flexibility. Following previous research, we found in our study that ratings of cognitive flexibility significantly improved with a decreasing in mean values, which was statistically

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significant (p = 0.02). This enhancement could be attributable to increased concentration and the ability to select the right task and suppress extraneous actions. Several researchers say playing badminton may increase cognitive flexibility and attention (Yu et al., 2022). However, opposing data suggest that racquet sports do not reduce cognitive flexibility in older adults, but rather improve inhibitory control and working memory (Churchill et al., 2002). The chosen exercises in this study focused on distinct movements and approaches related to the activity of badminton, with dual exercises that require a high demand of cognitive performance. The challenges of conducting a trial with older patients should be mentioned as one of the barriers to reaching the established goals, the need for adequate coordination among the different professionals, and the necessary adherence to the physical exercise programs by the participants to obtain the expected benefits.

Limitations

This study has certain strengths and limitations that should be addressed. First, a strength of the current research was that a unique sample of elderly adults participating in badminton physical programs with a more varied range of exercise tasks was used to evaluate the impacts of physical exercises on cognitive function, which may more accurately reflect the psychological and cognitive functioning of older patients. In the Degit Backward test, the control group showed better performance than the intervention group; these differences can reasonably be attributed to the increased amount of personal contact (nursing home routine and social contact with clinical staff) (Katona, 2007). However, the process of two different tests measuring cognitive parameters before the physical intervention may negatively affect mental capacities. Second, social interaction may play a solid role in improving cognitive parameters. The selected program was enrolled between two groups in a social environment, which was beneficial for improving cognitive parameters. Larger sample sizes should be used in future research to provide more representative results. It might be beneficial to extend the intervention time and include multiple tests with the pre-intervention and post-intervention assessments, measuring the degree of physical activity of each patient, the use of drugs, and more baseline assessments such as marital status, work status, and many other variables that can be interesting.

CONCLUSION

In conclusion, this research highlights the importance of physical exercise on cognitive function, demonstrating that regular participation in a badminton physical program may

improve and enhance cognitive function in older people. Badminton, due to its multi-component activities, appears to offer significant cognitive advantages. While participants in these physical exercises showed better executive function, short-term memory, working memory, and cognitive flexibility, no significant differences were found in the MMSE test between the two groups. More evaluation of cognitive abilities might be important in future studies.

PRACTICAL IMPLICATIONS

The data from this study reveals several practical applications important for future studies. Physical activity is considered to be an affective treatment in older, healthy adults and for those who suffer from chronic disease and needs to be prescribed to correspond to the mental and physical needs of each patient.

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Authors' Contributions

The first author contributed to the conception of the article, the second author reviewed the conception and the design, the third author participated to the interpretation and statistical analysis, and the fourth author was responsible for the manuscript's submission and approval.

Declaration of Conflict Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethics Statement

The study received ethical approval from the institutional review board committee of the university of Manouba, Higher Institute of Sport and Physical of Ksar Said and the ethical commission of Monastir Hospital on 27 Aprol 2023, numbered HE24FEB2006-B223877.

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Review

The Utilization of Differentiated Learning in Improving Physical Fitness and Active Lifestyle of Junior High School Students: Literature Review in Physical Education

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ABSTRACT

There are still very limited studies that integrate differentiated learning with physical education subjects that need to be studied more deeply, even though differentiated instruction is a learning model that adheres to the principles of Developmentally Appropriate Practice (DAP), where every learning experience must align with the characteristics and needs of students. This study aims to review the scientific literature in several countries regarding differentiated learning in physical education to improve physical fitness and active lifestyle. Article search is carried out with the help of the Harzing Publish or Perish program based on the Scopus database. The analysis of the search and screening of articles was carried out by the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) procedure. Of the 51 articles identified, only six remain in the criteria after the implementation of the exclusion stage. This research found that the application of differentiated learning (DL) in physical education (PE) to improve junior high school students' physical fitness and active lifestyle is still very limited and requires further research. In addition, in some literature, there is no previous research that specifically explores the impact of this model on junior high school students, so it is recommended for future researchers to add searches through various other databases, such as Web of Science, PubMed, and Google Scholar.

INTRODUCTION

Physical ability is a person's ability to carry out the physical activity he is undergoing; the better a person's physical ability, the longer the activity is carried out (Lopez-Sanchez et al., 2019). In carrying out daily activities, a person needs a fit physical state because with a fit physique, a person will do a job to the maximum (Ferdianto & Prihanto, 2017). Physical fitness is the length of time a person takes to do physical activity. The U.S. Department of Health & Human Services defines physical fitness as a set of physical components that a person possesses in carrying out physical activity (The President's Council on Physical Fitness and Sports, 2012). Having good physical abilities or fitness makes a person work more optimally because not only physical aspects are good, but also other aspects, such as psychological and intellectual, can be good (Levine et al., 2021; Yorks et al., 2017).

Physical fitness is closely related to an active lifestyle, an active person tends to have a higher level of physical fitness compared to a less active person (Kapoor et al., 2022). Physical fitness indicates the degree of a person's health; the fitter the person is, it can be said that the quality of health degree is higher (Lang et al., 2019), and in general, health can be achieved by leading a more active lifestyle (Edgy & Aaron, 2019). An active lifestyle reflects healthy living because engaging in physical activities directly contributes to physical fitness. Adequate physical activity enhances both physical and mental health, including improving immune system function (Filgueira et al., 2021); this is in line with the theory that physical fitness can be affected by physical activity (Nylén et al., 2019), the leading cause of the decline in students' physical fitness is due to their lack of activity in moving (Fajar & Iswahyudi, 2018). Physical activity is a promotion to get physical health and is also beneficial in dietary arrangements (Galan-Lopez et al., 2018; Kapoor et al., 2022); in addition, Physical fitness encompasses key components such as cardiorespiratory endurance, muscle strength, and flexibility, all of which are closely related to an individual's overall health status (Filgueira et al., 2021). The importance of physical fitness and an active lifestyle requires everyone, especially junior high school students, to continue to strive to improve the quality of their fitness and health (Hills et al., 2012; Yuksel et al., 2020) because, At this age, students are in a very crucial stage of development where healthy habits and an active lifestyle need to be instilled in order to continue into adulthood (Lawrence et al., 2017).

However, the achievement and application of physical activity for physical fitness and a good active lifestyle among junior high school students remain a concern. This is evidenced by several research results, such as the results of the SDI report (Sport Development Index)

which measured 1,578 subjects aged 10-15 years spread across 34 provinces, that As many as 77.12% of children from early adolescence (10-15 years old) have a low to one level of physical fitness, and this is influenced by participation in sports activities (Mutohir et al., 2023). Then, the data shows that 20% of junior high school students have a moderate level of physical fitness, while 80% have a low level of physical fitness (Fadria, 2015). Furthermore, other studies showed that the level of physical fitness of junior high school students was in the category of less, with details of 0% for very good, 1.68% for good, 47.90% for the medium category, 37.82% in the poor category, and 12.61% in the very poor category (Dartini et al., 2017), even research conducted in West Java shows that at the first school level, students' fitness is still lacking because 36.87% of their physical fitness level is still at a low level (Sulistiono, 2014). Some of these studies indicate that the physical fitness level of children is still in the low category, which is quite worrying, even though children aged 5-17 should have at least a good fitness level (World Health Organization, 2010).

Some of these problems are certainly influenced by several factors, such as lack of space for movement in doing physical activities at school. Physical education that should ensure the breadth of students' movement activities seems to be limited, even though it has been recommended to maintain health and fitness, the physical activity carried out must be 3-5 days for aerobic exercise, 2-3 sessions for strength training and flexibility training between 2-3 sessions (American College of Sports Medicine, 2006). Furthermore, it is also recommended to do physical activity with moderate intensity for at least 30 minutes with a frequency of five days a week, and some even recommend doing it every day with a duration of 60 minutes (Kurniarobbi et al., 2013; Lee et al., 2007). In addition to the lack of physical education hours provided at school, factors such as a sedentary lifestyle (sedentary lifestyle) is also alleged to be of the factors that inhibit children's physical development, such as watching television, playing games, Opening the internet, and playing social media are done by 2/3 of children in developing countries (Dicaraka et al., 2014; Katzmarzyk & Lee, 2012), most 10-year-olds are active for only 20 minutes a day, especially in girls only 4% of their time (except sleep) is spent doing light activities, when ideally it is done for 60 minutes a day (Pearce et al., 2012). This will be a challenge for the physical education learning process in the future: how to maximize the applicable curriculum program with the process of children's activities outside of school hours so that children's physical fitness does not decrease.

An initial step is to analyze and identify the impact of the physical education program in schools, then develop one suited to students' characteristics and needs. This poses a challenge for teachers to implement an effective model that meets all students' needs, with

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differentiated learning being a potential solution. Differentiation learning is a very important thought in preparing for the learnking process in the 21st century (Akhbar et al., 2019). This concept of differentiated learning aligns with the philosophy of Ki Hajar Dewantara, that learning must be adjusted to the needs, readiness and level of students (Ayu Sri Wahyuni, 2022). Differentiated learning is born based on the idea that each individual is not the same as other individuals; they have their own strengths and weaknesses, thus affecting their learning style (Haelermans, 2022). Teachers facilitate students with different applications of the teaching process, both in terms of methods, materials, media, and also standards for achieving learning outcomes (Dapa, 2020). Differentiated learning is a set of learning activities that pay attention to the learning needs of students and are in line with the school of progressivism, which strongly supports student-centered education (student center; Adisjam & Saparia, 2023). Differentiated learning is a learning concept that uses a variety of learning approaches (multiple approaches) in terms of content, process, and product (Tomlinson, 2001). Content includes what students learn; the process is how students process ideas and information, and products include how students show what they have learned (Mulyawati et al., 2022).

In the context of differentiated learning, several studies have examined the effectiveness of this approach in improving physical fitness and active lifestyles. For example, a study by Smale-Jacobse et al. (2019) found that differentiated learning in physical education can increase student motivation and participation and help students achieve individual fitness goals. Research by González-Cutre et al. (2014) also supports these findings, showing that differentiated learning can increase students' engagement in physical activity and improve their physical fitness levels. However, other studies have shown that there are challenges in the implementation of differentiated learning. Rock et al. (2008) Identify some of the obstacles teachers face, including time constraints, lack of training, and inadequate resources. In addition, there are also challenges when it comes to assessment, where teachers must develop assessment methods that are fair and appropriate for all students, which can be a complicated and time-consuming process (Atjonen, 2014).

In this study, we will review the existing literature to better understand how differentiated learning can be effectively applied in physical education in junior high schools. By understanding the best practices and challenges, we hope to provide recommendations to help teachers implement differentiated learning to improve physical fitness and encourage an active lifestyle among middle school students.

METHODS

Research Design

This study employs a literature review design to collect and analyze data from various existing studies to answer specific and clear research questions (Snyder, 2019). A systematic literature review is an approach. This design was chosen because it allows researchers to obtain a comprehensive picture of the researched topic and identify trends and gaps in the existing literature related to the use of differentiated learning in improving the physical fitness and active lifestyle of junior high school students. It should be emphasized that in this study, the researchers did not enroll in PROSPERO because the main focus was on reviewing physical education literature, not on medical studies or clinical interventions.

Search Strategy

The search strategy in this study uses the help of the Harzing Publish or Perish application program. The search began using data based on Scopus, this is because Scopus is still one of the preferred citation indexing systems used by researchers around the world (Pranckute, 2021). Search strategies include combinations of keyword variations ("differentiated instruction AND physical education AND physical fitness OR active lifestyle AND junior high school"), and where the search is conducted by the procedures of the Preferred Reporting Item for Systematics Reviews and Meta-Analyses (PRISMA) which emphasizes review reports to evaluate randomized trials that can also be used as a basis in reporting systematic reviews for other types of research (Moher et al., 2010).

Exclusion Criteria

The exclusion criteria used in this study are as follows: (1) Articles that are not published in journals that are based on Scimago Journal Rank (SJR) data, (2) The language used is not English, (3) Articles published in a period other than the last 10 years, (4) Articles that do not explicitly mention differentiated learning in physical education to physical fitness and active lifestyle of school students junior high school.

Procedures

Initially, as many as 861 publications were identified through a data-based search (Scopus: 56 articles). After adjusting to the exclusion criteria, there are only 6 articles left (Figure 1). Most of the articles were discarded because they did not mention differentiated learning in improving junior high school students' physical fitness and active lifestyle. All articles are extracted from the source and then analyzed through the Mendeley program to deduplicate articles. Data extraction was performed by two independent reviewers using

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Mendeley to manage references and avoid duplication. Any discrepancies in the quality assessment were resolved through discussion until a consensus was reached. The selection of Scopus data is based on the broad coverage of academic journals. However, it is possible that in the future, the search can also be extended to other databases such as PubMed, WoS, and PsycInfo for more comprehensive coverage.

Figure 1
PRISMA Flowchart in This Research
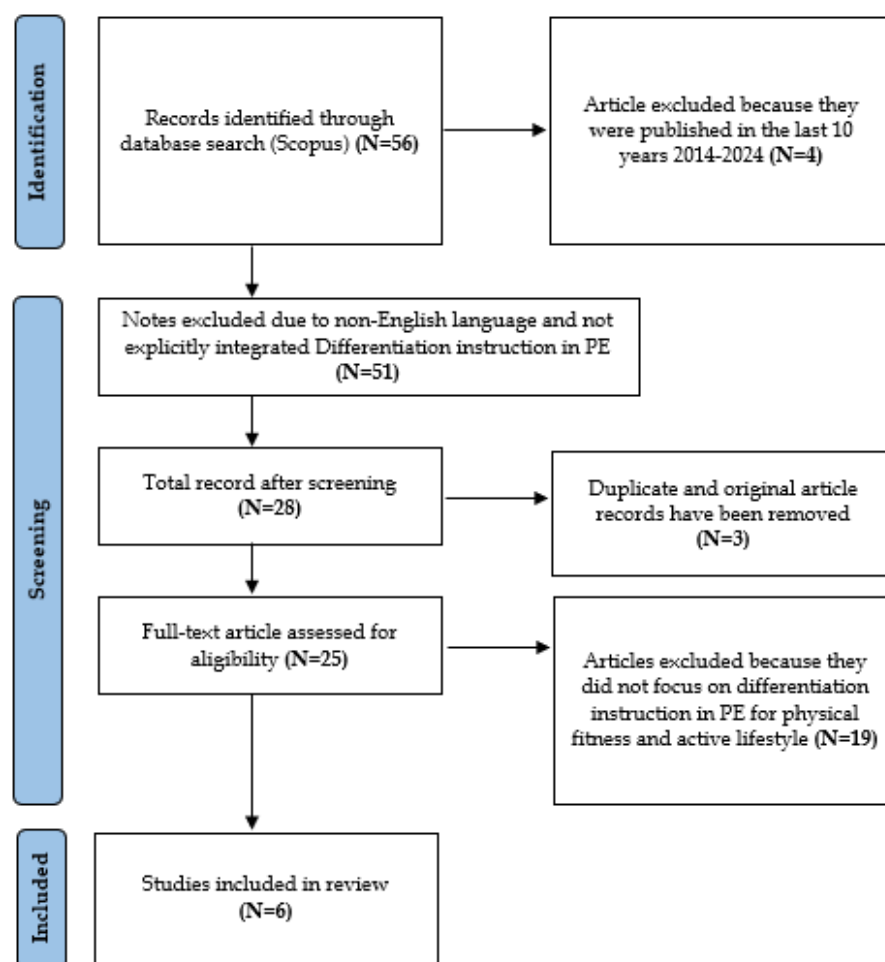
Data Analysis

The data analysis in this study was conducted through a qualitative approach by synthesizing findings from the selected articles. The process involved coding and categorizing themes related to the application and outcomes of differentiated learning in physical education. Using thematic analysis, the extracted data was systematically reviewed to identify patterns, relationships, and gaps in the literature. To ensure rigor, all coding and thematic development were independently reviewed by two researchers. Any discrepancies were resolved through collaborative discussion, enhancing the reliability and validity of the analysis. The analysis highlights both the potential and limitations of differentiated learning

as a pedagogical approach in physical education, providing a foundation for empirical research in future studies.

RESULTS

The literature review results aimed at Table 1 below are explained and discussed in one article. Country categories are not listed; article searches focus on differentiated learning in physical education for physical fitness and active lifestyles. The results can be seen in the following Table 1.

Table 1
Article Summary on Differentiated Learning in Physical Education

Author and Year	Research Methods and Types	Content	Research Objectives	Research Results
(Adkins et al., 2015)	Review literature with surveys, interviews, & observations	The use of QR Code in PE learning	To find out the application of QR codes in PE classes given through differentiated learning	The application of QR codes in PE allows for increased student engagement and also allows for improved learning outcomes, and student participation in motor skills, as well as a positive impact if applied to differentiated learning
(van Munster et al., 2019)	Case study approach, through thematic analysis, observation, and interviews	Application of Universal Design for learning (UDL) and differentiated learning in PE	To describe the UDL approach and differentiated learning used by PE teachers	Differentiated learning and UDL can be applied and accommodate students with disabilities in their sports activities, and are the most commonly used approaches in New York.
(Özbal et al., 2019)	Classroom Action Research, analysis using qualitative and quantitative descriptive	Application of differentiated learning in physical exercise and sports learning	To test the application of differentiated learning approaches in physical exercise and sports in grade 5 elementary school	There was a significant increase in student attitudes and data showed that students actively participated and moved more, socialized, cooperated, learned independently and obeyed rules, and showed respect for individual differences.
(Dorfberger & Eyal, 2023)	Survey research with data analysis using regression analysis, the DI-Quest questionnaire instrument	Teachers' perceptions and attitudes in implementing differentiated learning in elementary and junior high schools	To understand how a PE teacher views and applies differentiated learning as an effort to meet the diverse needs of students	There is a significant relationship between a thriving teacher mindset and flexible group work, the higher the mindset the higher the application of differentiated learning and principle-related practices
(Blegur & Hardiansyah, 2024)	Research the review literature with the help of the PoP program from google scholar data	Review of publications on differentiated learning in physical education	To analyze the metrics and visualizations of differentiated learning publications using the VoSviewer program	Differentiated learning has great potential to be developed in physical education to contribute to the fulfillment of students' learning experiences according to their learning potential
(Razali et al., 2024)	Qualitative research, instruments using open-ended questions (conception, uses, problems to constraints and solutions	Exploring the experience of physical education teachers in promoting life skills using differentiated learning	To explore several key areas in the context of teaching life skills through physical education (PE) using differentiated learning	Teachers already have well-integrated concepts and life skills in physical education, such as analytical and critical thinking, communication, and product development. Teachers promote students' life skills through differentiated learning that accommodates students' learning needs with diagnostic assessments through content, processes, products and learning environments

DISCUSSION

Research Methods and Types

Based on the review of categories and types of methods, it can be seen that the six articles have different methods namely there are two types of literature review research (Adkins et al., 2015; Blegur & Hardiansyah, 2024), a type of classroom action research (Özbal et al., 2019), a survey study with a regression analysis approach (Dorfberger & Eyal, 2023), and the other two are qualitative research types (Razali et al., 2024; van Munster et al., 2019).

Content

The results of the study show various kinds of content related to the application of differentiated learning in physical education lessons, such as the use of QR codes in physical education lessons as an effort to implement a differentiated learning model to meet the diverse needs of students (Adkins et al., 2015), the application of the UDL model and differentiation instruction in PE as an effort to accommodate students with disabilities in doing their sports (van Munster et al., 2019), the use of differentiated learning models in physical exercise and sports learning using classroom action research in grade 5 elementary school students (Özbal et al., 2019). In addition, there is content about teachers' perceptions and attitudes in implementing differentiated learning in elementary and junior high schools (Dorfberger & Eyal, 2023). The content reviews several studies on differentiated learning in physical education (Blegur & Hardiansyah, 2024). Finally, regarding the exploration of the experience of physical education teachers in promoting life skills using differentiated learning (Razali et al., 2024).

Various studies that discuss the content of differentiated learning, especially in physical education learning, are still very limited, even though research and publications on differentiated learning in various subjects have developed rapidly in the world (Struyven et al., 2019), therefore as an effort to promote pedagogical-didactic philosophy centered on the nature of student learning (Colquitt et al., 2017). This is certainly in line with the explanation that differentiated learning offers an inclusive teaching method so that teachers provide various learning opportunities based on students' backgrounds, readiness, interests, and profiles (Esther & DeCoito, 2023), to support social emotional and academic success for all students in a heterogeneous classroom context (Gaitas et al., 2022; Pozas et al., 2021). Meanwhile, content about differentiated learning that is directly aimed at improving physical fitness and active lifestyle is still not available until now, and perhaps this is one of the future opportunities that must be researched.

Research Objectives and Results

Based on the results of the review of several articles that have been summarized in Table 1 earlier, it can be seen that the purpose of the research and the results are divided into two major aspects, namely to find out the development of the application of differentiated learning in physical education theoretically (Adkins et al., 2015; Blegur & Hardiansyah, 2024) and the other aims to find out the impact resulting from the implementation of differentiated learning, especially for motor skills and also student participation in participating in the physical education learning process (Özbal et al., 2019), as well as his social life skills (Razali et al., 2024).

In more detail for the first article aims to find out the application of QR codes in PE classes given through differentiated learning, and to conclude that the application of differentiated learning with QR codes in PE allows increased student engagement and also allows for improved learning outcomes and student participation in motor skills (Adkins et al., 2015). The second article which aims to describe the Universal Design Learning (UDL) and differentiated learning (DI) approaches used by PE teachers, and the results of the research reveal that Differentiated Learning and UDL can be applied and will accommodate students, especially students with disabilities in their sports activities (van Munster et al., 2019). In the third study, which is a classroom action research with the purpose of the research is to test the application of differentiated learning approaches in physical exercise and sports in grade 5 elementary school, it was concluded that there was a significant increase in student attitudes, and the data showed that students were more actively participating and more active in doing sports activities, able to socialize, cooperation, independent learning and obeying regulations, and showing respect for differences between individuals (Özbal et al., 2019). This is supported by the concept of differentiation itself that in differentiated classrooms, students have differences in their needs, both in terms of their abilities and goals (Tomlinson, 2000), so teachers must be proactive in planning ways for students to be able to express their actions in their learning because differentiation instruction is a way of teaching based on different talents and learning styles of students (Magableh & Abdullah, 2020; Muh. Asriadi et al., 2023).

The following research aims to understand how a PE teacher views and applies differentiated learning as an effort to meet the needs of diverse students. The results of the study say that there is a significant relationship between a developed teacher mindset and flexible group work; the higher the mindset, the higher the application of differentiated learning and principle-related practices (Dorfberger & Eyal, 2023). Furthermore, the fifth research aims to analyze the metrics and visualization of differentiated learning publications

using the VoSviewer program, where data is obtained from Google Scholar sources through the Publish or Perish (PoP) application. This research is a literature review research and the results of the research reveal that differentiated learning has great potential to be developed in physical education to contribute to the fulfillment of student learning experiences following Learning Potential (Blegur & Hardiansyah, 2024). Then for the sixth research aims to explore several main areas in the context of teaching life skills through physical education (PE) using differentiated learning. The results of the research reveal that teachers in this research subject have well-integrated concepts and life skills of physical education, such as analytical and critical thinking, communication, and product development. Teachers promote students' life skills through differentiated learning that can accommodate students' learning needs with diagnostic assessments through content, processes, products, and learning environments (Razali et al., 2024).

Some of the studies that have been described can conclude that differentiated learning in physical education can meet every student's needs as a whole because the basic essence of the process and the purpose of this differentiation instruction model is to provide opportunities for each student to determine their success. It can increase student motivation and participation up to 20% higher compared to traditional methods (Smale-Jacobse et al., 2019); differentiation instruction has become increasingly significant in meeting the needs of students (Gibbs, 2023). Teachers are constantly shifting their focus to students as individuals by implementing effective and efficient approaches, methods, and learning strategies with their skills, personalities, and social relationships to explore students' maximum potential in responding to diverse student needs rather than focusing on a series of practices that individualize or adapt tasks in learning (Magableh & Abdullah, 2020; Santangelo & Tomlinson, 2012; Tomlinson, 2003). In this way, the main focus of each student is to determine physical activity to improve their physical fitness and health, which will be more appropriate to their abilities. This is as explained by Franklin et al. (2022) that there is a dose-response relationship between the volume of weekly physical activity and health outcomes, as can be seen in Figure 2.

However, differentiated learning also has shortcomings that require teachers to work more, such as in preparing evaluations or assessments. Since each student possesses different abilities and goals, the assessment must be individualized accordingly (Blegur & Hardiansyah, 2024; Dorfberger & Eyal, 2023). Meanwhile, the limitation of this research lies in the database used, which is only taken from one Scopus database, which may be taken from various national and international databases.

Figure 2
Conceptual Overview of the Dose-Response Association Between Weekly Physical Activity Volumes and Health Outcomes
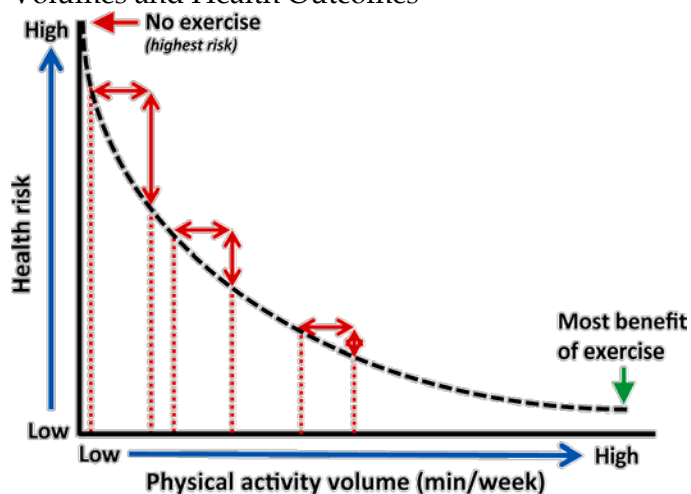
CONCLUSION

The results of this literature review have contributed to updating the study of differentiated learning in physical education to improve physical fitness and active lifestyle. However, explicitly there has been no research on differentiated learning on physical fitness and active lifestyle. At first, quite a lot of studies were found, but after applying the exclusion criteria, the number was reduced to just six. The findings of this review confirm that while differentiated learning has great potential for improving physical fitness and active lifestyles, its implementation remains limited. Further research using empirical methods is needed to evaluate the specific impacts of this approach. Future studies should explore how differentiated learning can improve measurable physical fitness outcomes. This is intended to explore the need for consistent research promotion to produce new knowledge about the application of differentiated learning in improving physical fitness and active lifestyles, especially for students at the junior high school level. Then, the findings of this study are in terms of the use of methods and types of research; there are quantitative and qualitative research using quantitative descriptive analysis and regression approaches. Especially in the research instrument section, many use open and closed questionnaires. However, from several studies studied in this study, no one has directly examined the impact of the application of differentiated learning to improve physical fitness and active lifestyle of junior high school students, so it is recommended for future researchers to add searches through various databases other than Scopus, such as Web of Science, PubMed, and Google Scholar.

PRACTICAL IMPLICATIONS

The implications of the results of this study prove that the application of differentiated learning, especially in physical education subjects, is still very rarely published, especially in Indonesia. This indicates that each school's physical education learning process may still be oriented to the conventional model and does not look at the characteristics and needs of students in each individual. In addition, this study provides a challenge and opportunity in the physical education learning sector. The challenge is that a teacher must be able to design, implement, and assess the learning process specifically for each student because later teachers will be faced with a variety of characteristics, needs, and learning styles of students. However, the opportunity is that teachers will become more creative and able to think critically in dealing with each student and will have many types and grades of assessment to evaluate the progress of each student.

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Authors' Contribution

Designing ideas, determining methods, verifying data sources, analyzing findings, completing the final manuscript.

Declaration of Conflict Interest

There is no conflict of interest in this study.

Ethics Statement

This research only examines literature reviews, so ethnic approval from institutions or institutions is not required.

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Research Article

Athlete A Documentary Analysis: Breaking the Silence on Harassment and Abuse in Sports

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ABSTRACT

Listening to the voices of athletes is important for advancing safe sports and preventing harassment and abuse in sports. This study aims to listen to the voices of athletes of the United States of America (USA) Women's Artistic Gymnastics Team (WAG) against the sexual abuse and organizational neglect they have been exposed to for more than 30 years in order to understand the reasons that lead to abuse. In this context, "Athlete A: The truth behind USA Gymnastics", a Netflix documentary, was analyzed. Analysis was carried out by conducting Baltruschat's "Film Interpretation According to the Documentary Method" process in the Nvivo analysis program. Foucault's concept of biopolitics was utilized to understand the mechanism of power in gymnastics and how this mechanism intervenes in the female athlete's body (on the visible side). The process of proving these behaviors after the athletes broke their silence against organizational negligence and sexual abuse is discussed in the findings section. The case was examined in depth with quotes from the athletes' discourses on the confirmation of the crimes and the healing processes of the athletes after the revealed practices of organizational neglect and sexual abuse. In conclusion, the case of the USA WAG team demonstrates how a culture of silence and failed leadership can lead to complicity and perpetuate harassment and abuse in sports. In order to advance the safe sports, sports organizations need to develop safeguarding policies and procedures that take into account the voices of athletes.

INTRODUCTION

On August 4, 2016, former gymnast Rachael Denhollander sent an email to The IndyStar, a local newspaper in Indiana, USA: "I recently read the IndyStar article 'Out of Balance'. My experience may not be relevant to your investigation, but I am sending an email to report an incident." (Alesia et al., 2017). In her email, Denhollander detailed how she was abused by Larry Nassar. On September 12, 2016, after Denhollander filed a criminal complaint and another athlete sued the United States Gymnastics Federation (USA Gymnastics), The IndyStar published the first story about Larry Nassar's mistreatment of athletes. In publishing the story, The IndyStar reporters included statements from Nassar, who said that the medical procedures he used on athletes were misunderstood and that he had done nothing wrong. On September 25, 2016, the IndyStar reported that sixteen more athletes had made allegations against Nassar (Smith & Pegoraro, 2020). On November 22, 2017, Nassar pleaded guilty to seven counts of sexual abuse as part of a plea deal (Udowitch, 2020). One hundred fifty-six women spoke on the stand during Nassar's eight-day sentencing hearing, which began on January 16, 2018. The USA Gymnastics board of directors was forced to resign under pressure from the Olympic committee, and on January 24, Nassar was sentenced to 60 years in federal prison (Axon & Armour, 2018). He also pleaded guilty to ten counts of first-degree sexual assault and was sentenced to 40 to 175 years in prison. Judge Rosemarie Aquilina told Nassar: "I have just signed your death warrant. As it is my honor and privilege to listen to survivors, it is my honor and privilege to punish you. Because you do not deserve to leave the prison again." (Meadows & Meadows III, 2020).

In this research, we want to spread the voices of women who were subjected to Larry Nassar's sexual harassment and abuse and who call themselves an army of survivors through a documentary film, Athlete A (Cohen & Shenk, 2020) explores the prevalence and complexity of sexual harassment and abuse in sport through the case of former USA WAG's doctor Larry Nassar. The documentary on the Nassar case is a work that provides us with the analysis we need to understand the risk factors for sexual harassment and abuse in sports, the power relations, and the negligence of sports organizations in perpetuating abuse. This documentary, literature, and case reports were evaluated together and analyzed using the documentary analysis method, which is explained in detail in the method section.

Significance of the Nassar Case

The Larry Nassar case has led to important developments not only in the US, where the incident took place but also in the entire sports ecosystem, especially in the world

gymnastics community. The case exposed the organisationalized failure of USA Gymnastics, which led to changes in sports policies; new policies were developed, linked to legislation, and procedures were established to safeguard athletes from harassment and abuse.

In the US, the legal definition of child abuse is determined on a state-by-state basis and under federal law. In the wake of the Nassar case, a federal law, the "Protecting Victims from Sexual Abuse and Safe Sport Authorization Act of 2017", was enacted in the US. This law includes an immediate mandatory reporting of any allegation of abuse against a minor amateur athlete to the U.S. Center for Safe Sport (Burke, 2021). USA Gymnastics' "Safe Sport Policy", published in 2019, references the Victims of Child Abuse Act (1990) and defines child abuse as physical or mental harm to a child, sexual abuse or sexual exploitation, or neglect of a child. Also, the "Child Abuse Prevention and Treatment Act (CAPTA)," named federal legislation, provides states with a legal basis for preventing child abuse and neglect (ACF, 2023). CAPTA defines sexual abuse as the use, enticement, or coercion of a child to engage in sexually explicit conduct or to produce a visual depiction of such conduct; or rape, prostitution, and other forms of sexual exploitation of children. According to the "Child Protection Law" of Michigan (1975), which is the basis for the Larry Nassar case, child abuse is the unintentional physical or mental injury, sexual abuse, sexual exploitation, or maltreatment of a child by an adult (parent, teacher, responsible person, etc.) that causes harm to the health or welfare of the child.

As new laws and sports policies take shape, the international gymnastics community, including the International Gymnastics Federation (Fédération Internationale de Gymnastique, FIG), has initiated discussions on the risk factors of harassment and abuse specific to gymnastics. Also, "Finding Solutions for a Respectful Culture and Safe Training Environment" e-conference organized by the FIG in 2020 (FIG, 2020), national gymnastics federations presented their organizational work on the prevention of harassment and abuse. For example, The Royal Dutch Gymnastics Federation stated that in 2018, they relaxed the gymnastics leotard rules and allowed girls, especially those in their teenage years, to wear shorts. In 2020, the New Zealand Gymnastics Federation took a similar decision. They explained that this gender-sensitive decision aims to break gender stereotypes associated with female gymnasts, empower athletes, and ensure that sports media coverage focuses only on the performances of female athletes. Reflections of FIG's work can also be encountered in Turkey, the country where this article was written. In 2021, safeguarding trainings were organized for coaches with the initiative of a few members of the Technical and Education Board of the Turkish Gymnastics Federation. These trainings were an extension of the safe

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gymnastics and positive sports culture movement that FIG initiated through the national federations of the Nassar case. The examples show that they have begun to bear fruit in many parts of the world.

One of the reasons why the Nassar case has become a global sensation is the size of the social media movement around the issue. It was not until 2017, when the #MeToo social media campaign went viral, that the public was adequately informed about survivors' reports about Nassar. #MeToo movement helped launch a thorough investigation into Nassar (Liao & Craig, 2023). Following the release of the Athlete A, the subject of this article, gymnasts from around the world shared their experiences of mistreatment on social media using the hashtag #GymnastAlliance. In these posts, athletes described incidents where they were silenced, disclosed experiences of mistreatment (such as body shaming, bullying, intimidation, racism, nutritional neglect, overtraining, health neglect, sexual harassment, and assault), called for change, and called for building a community of support (Kerr et al., 2019; Kerr et al., 2020). With a global reach similar to #BlackLivesMatter and the #MeToo movement, the #GymnastAlliance movement has been recognized as an important movement for challenging normalized codes of silence and acceptance of mistreatment (Willson et al., 2022).

The Nassar case is a case of organizational abuse that started with a single complaint of sexual harassment and has been going on systematically for many years. It is a case of organisational sexual abuse of hundreds of athletes, including gymnasts who are among the most important and Olympic athletes in the world. The International Olympic Committee (IOC) classifies sexual abuse as a relational threat to child athletes; however, it also recognizes it as an organisational threat, since in the case of Nassar there was medical mismanagement (Mountjoy, 2019). For this reason, researchers discuss an approach to understanding sexual abuse as an organizational phenomenon rather than an individual one (Way, 2023). In line with this approach, it is important to understand the culture of elite sport and the power of organisations within this culture in order to analyze sexual harassment and abuse cases correctly. In the next section, elite sports culture will be discussed in light of the literature on sexual harassment and abuse in elite sports.

Conceptual Framework in Elite Sport: Sexual Harassment and Abuse and Grooming

Sport is a social field with many actors and organisations, including governing bodies, sports clubs, athletes, coaches, medical staff, parents, sponsors and media, and fans (Milroy et al., 2022). Elite sport is a field dominated by a competitive culture for rewards, status attainment, and career advancement for athletes (Carter et al., 2022). However, the fact that an athlete competes in international competitions or is an Olympian also expands the network of

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hierarchical relationships in which the athlete is embedded. For example, sports federation managers, club managers, sports physicians, or sports specialists are more involved in the athlete's performance development and daily life. The elite athlete lives more on social relationships than an amateur athlete in terms of the length of training, the need for competition-specific training, travel, nutrition, sleep patterns and control of mental health processes. For elite athletes, this network of relationships is conditioned to win at all costs, i.e. the goal of success and perfectionism (Wilinsky & McCabe, 2021). This elite sport framework brings different risk factors for elite athletes.

In the specific context of this research, elite athletes are known to be subjected to high rates of sexual harassment and abuse (Bjørnseth & Szabo, 2018; Vertommen et al., 2016). The examination of the prevalence and risk factors of sexual harassment in sports, which accelerated with the studies of Brackenridge and Fasting (2002), gained momentum with the Safe Sport approach, which entered the agenda of national and international sports organizations with the Larry Nassar case, and numerous scientific studies on sexual harassment in sport have been conducted in the last decade. The prevalence rates and risk factors measured in these studies vary according to the conceptual framework used in the study. This is because researchers may develop different definitional criteria when using concepts according to their own cultures and laws. However, when the recent literature on sexual abuse of children in sports is examined (Carter et al., 2022; Dodd et al., 2024; Hartill et al., 2021), it is seen that the definition developed by the World Health Organization (WHO) (2022) is mostly used: "Involving a child in a sexual activity that the child cannot fully comprehend, consent to, is not developmentally ready for, or violates the law or social acceptance of society."

"Sexual abuse", defined as child maltreatment in the new WHO training manual "Responding to Child Maltreatment: a clinical handbook for health professionals" (2022), refers to the forced or tricked involvement of children and adolescents in sexual behavior that they may not understand is wrong and may be afraid to tell someone. The guidelines define sexual abuse in three categories: non-contact sexual abuse (e.g. threat of sexual abuse, verbal sexual harassment, sexual solicitation, indecent exposure, pornographic exposure of a child); contact sexual abuse involving sexual intercourse (e.g., sexual assault or rape); and contact sexual abuse involving other than sexual intercourse (such as inappropriate touching, fondling and kissing; World Health Organization, 2022).

It is critical to evaluate sexual harassment and abuse in sports and accompanying forms of abuse within the socio-cultural context on a social and organizational basis (Brackenridge

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& Rhind, 2014). When the phenomenon of abuse is considered in the context of the dynamic relationship between structure and agent, it is related to social and contextual values, social interactions, and social structures to a degree that cannot be explained by the abuser's behavior, personality, or psychosexual pathology. Because, as in every different social sphere, sexual abuse in sports often occurs through the manipulation of the athlete by an authority figure (International Olympic Committee, 2007). This manipulation can be considered part of the "sexual grooming" process.

The specific objectives of grooming include providing access to the child, gaining the child's compliance, and protecting the child's confidentiality to prevent disclosure. This process serves to reinforce the perpetrator's abusive behavior, as it can be used as a way to justify or deny their actions (Craven et al., 2006). Intentional behaviors to establish a friendly and emotional bond with the child are part of the grooming (Acar et al., 2018). Grooming is, therefore, a psychological game involving manipulative inputs (Bjørnseth & Szabo, 2018). Giving gifts to make the child feel special, acting as a confidant and providing support in negative situations, emotionally manipulating, normalizing sexually abusive behaviors, and ultimately desensitizing the child in the sense of security, but making the child feel "unique."

In order to understand the prevalence and behavioral patterns of sexual abuse in sport, it is necessary to build on the criteria included in the research. For example, in a study published in the US sports field, Carter et al. (2022) included only "contact behavior/action" patterns (e.g., kissing, oral sex, penetration, attempted sexual assault) in the sexual assault/abuse category and did not include verbal behaviors in the survey (e.g., exhibitionism, voyeurism). The results of the study show that 3.8% (n=18) of 473 elite athletes were sexually abused as children. It is observed that 61% of the sexual abuse was perpetrated by an adult authority figure (usually a coach) and 44% by a peer. It is also underlined that none of those athletes complained about it. Hartill et al. (2021), in their research on the prevalence of violence, harassment, and abuse in sports in six countries, defined the conceptual framework on the basis of the WHO and UN Committee on the Rights of the Child and defined sexual violence as "encouraging or coercing a child to engage in any illegal or psychologically harmful sexual activity". According to the data obtained from 10,302 adults, the researchers state that 35% of the participants were exposed to non-contact sexual violence, and 20% were exposed to contact sexual violence. One of the important findings of the study is that while the rate of exposure to different types of violence is 68% in recreational sports, this rate is 84% for athletes competing in international competitions. While another study showed that female athletes (21%) were exposed to sexual abuse more than male athletes (11%) during childhood

(Liao & Craig, 2023), there are also studies indicating that men (26%) experience sexual abuse at least once in sports more than women (14%; Hartill et al., 2021).

Cultural and Political Context of Elite Sport: Foucault's Biopolitics

Foucault's concept of biopolitics can guide us in understanding the culture of elite sports and its risk factors that can lead to harassment and abuse. Biopolitics is a concept developed in order to reveal the regulations that power implements in order to control the population it wants to intervene in, and today it has become one of the concepts that are the focus of research on women's bodies, gender, and power (Deveaux, 1994; Repo, 2015). In this article, the concept of biopolitics allows us to understand how the mechanism of power that regulates the female athlete body in gymnastics culture intervenes in this body.

Biopolitics is, in general, the sum of all actions that concern and regulate human life and the body (Koç, 2018). Since biopolitics is not oppressive and restrictive compared to the old disciplinary model of power, it meets the needs of the body while controlling it (Koç, 2018). Power can be empowering or oppressive, it can restrict people's freedoms or help them realize their potential (Foucault, 2019). In elite sport, this is done through the use of information and technology to enable the body to realize its capacity and push its limits to achieve its goal. Foucault's power is therefore not repressive negative power, it has a productive function; power has a productive function that uses strategic means (Foucault, 1996).

Biopolitics allows us to understand how people consent to the mechanisms that power uses to control individual lives. People accept the values and logic, the norms, of the power that controls their lives. According to Foucault, power produces knowledge and discourse in the field. The reproduction of this knowledge and its normalization into a norm in this process takes place through the actors in the field, in other words, through its embedding in every cell of social relations in the field. Power, which used to survive through laws, now lives through norms. This coercion is achieved through a supportive form of communication and a network of relationships, not through law and coercion as in previous forms of power. Society internalizes norms and spreads through relationships (Kalan, 2014). As a social organisation, the norms set forth by elite sport intervene in the athlete's their bodies and consequently their whole selves by functioning like the control mechanisms of power. In elite sport, and in gymnastics in particular, power is the authority to determine the norms and values of the field and to regulate the position of people in the field.

Foucault emphasizes that the body is not only a biological entity but also one of the means of production of political and social structure. In addition to being a space directly intervened by power relations, the body is also considered as a space that can be used

economically (Elekler, 2023). In his book "History of Sexuality" (2007), Foucault mentions biopower shaped through biopolitical mechanisms. Biopower is related to the fact that the body, which is at the center of population activities in capitalism, is an object of production by being controlled according to the economy (Foucault, 2012). We can say that all mechanisms for regulating and controlling the athlete's body in the sports ecosystem have been developed around the focus of making optimum use of the athlete.

Foucault's form of biopower does not exist through violent force, but through the desires it creates; this existence is a form of control over the individual. Instead of directly directing the actions of the individual, biopolitics aims to ensure that individuals in society shape their own bodies according to the desires of biopower, thus ensuring that individuals spontaneously turn to desired social behavior (Sejfula, 2023). Gymnasts' desire for bodies that are trained and disciplined to become Olympic athletes is central to their athletic identities. Thus, the aim is to create norms that will control individuals by binding them to certain identities and to make this a reality in their small community (Sawicki, 2020).

To understand power in gymnastics as an elite sport and how this power regulates the female athlete's body, it is necessary to consider the history of the field/power. The following section presents the power relations in USA Gymnastics in this context.

Eastern Bloc Gymnastics Defection to the USA

An important step in understanding the source of Larry Nassar's perpetuation of his systematic sexual abuse is to examine the training method and culture of USA Gymnastics. The turning point for USA Gymnastics began in the late 1960s when Marta and Bela Karolyi, practitioners of the gymnast training policy shaped in Romania and the Soviet Union, defected to the West, to the USA (Barker-Ruchti et al., 2020). The Karolyi, who brought this training method to the USA, planted the first seeds of the method with the Artistic Gymnastics School founded in Romania in 1969 (Petracovschi, 2022). Until the beginning of the Karolyi's method, it was customary to watch young female gymnasts with an average age of 28 compete in national and international arenas (Cervin, 2015), but with a radical change, girls as young as 5-6 years old started to be selected for gymnastics school (Petracovschi, 2022). In the 1970s, girls as young as 14-15 years old were competing at the Olympic level (Cervin, 2015). Kerr et al. (2019) termed this new gymnast phenotype "Fairy-style" and described it as a system in which short, underdeveloped, underweight and cute girls are considered suitable for gymnastics. According to the Fairy-style model, "The ideal gymnast looks sweet and lovely. Rebellious and disobedient behavior is not tolerated by anyone" (Kerr et al., 2019). Coaches

who achieved success and associated media fame due to the fairy-style had no difficulty getting authorities to accept its validity (Kerr et al., 2019).

The biggest influence on the acceptance of the style was the performance of the athlete Nadia Comaneci, coached by the Karolyis', in the 1976 Montreal Olympics in a performance called "Perfect Ten" (Kerr & Obel, 2015). After Karolyi's realized that their training model based on psychological and physical abuse to win work, they continued to increase this abuse (Petracovschi, 2022). The defection of Karolyi's system to the USA is also considered to have been the source of Nassar's systematic sexual abuse for years (Udowitch, 2020). In USA WAG, not only the systematic sexual abuse by one person (Larry Nassar) encountered, but also the training methods that were seen as essential for success (Wittman, 2020). The culture created by this history was evaluated with literature and as reflected on the silver screen in 2020. The following sections explain the purpose and methodology of the research in this context.

Purpose of the Research

In many studies on the Nassar case and in research on sexual harassment and abuse in sport in general, it is stated that the "culture of silence" and "obedience to power" created by the culture of elite sport prevents cases of abuse from coming to light. This is one of the reasons why Nassar's abuse of children was not exposed for so long and why so many children were abused. On the other hand, the effort of the women survivors to make their voices heard and the depth and power of this voice, which enabled the whole world to hear them, also affected us (the writers) from a very distant geography. McCradden and Cusimano (2019) argue that in order to prevent future abuse, we have a moral obligation to listen to the stories of survivors who have been ignored for so long in order to understand how we can make sports safe for every athlete. As the authors of this article, we take this moral obligation upon ourselves. As Nassar was sentenced to 175 years in prison, more than 300 women stood up and spoke out against him: "Little girls don't always stay little. They grow up, grow into strong women and come back to bring down your world," and we want to make this voice heard from a distant geography. For this reason, we politically prefer to use the names of the survivors as stated in the court records and the documentary. Just as Kyle Stephens, who was the first to tell her story, said in an interview with the BBC, "I believe that coming out and telling my whole story from beginning to end has given me strength" (BBC, 2018), we too believe that the stories of these women will give strength to all women as a basis for our political stance.

METHODS

Athlete A: The Truth Behind USA Gymnastics Documentary

The research data source is the movie "Athlete A: The Truth Behind USA Gymnastics". The genre of the film, released by Netflix in 2020, is documentary. Directed by Bonni Cohen and Jon Shenk, the film was shot in Indianapolis, Indiana, USA, and is 1 hour and 43 minutes long. The documentary examines the culture of gymnastics that continues to perpetuate the systematic sexual abuse of athletes on the US WAG team by doctor Larry Nassar. Police records describe the criminal complaint initiated by national team athlete Maggie Nichols, codenamed "Athlete A," and her parents, as well as the follow-up and investigation process that developed after newspaper articles on the subject appeared. The archives contain testimonies from female athletes, parents, experts, and reporters from the IndyStar newspaper. However, the documentary presents the case from different perspectives, such as archival footage of the national team training center and the Rio Olympics trials, as well as archival footage of the investigative process that took place in the police office in the city of Indianapolis. The documentary takes a chronological approach from the beginning of the case to its aftermath and presents Nassar's trial in detail by sharing the moments of the investigation and defense. The reason why we chose to analyze this documentary within the scope of the research is that it provides a detailed background on the Nassar case and conveys the case process to the audience using archival footage.

Documentary Analysis

In this research, we aimed to understand the social phenomena and human behaviors presented in depth. Since the documentary is a visual document, we preferred the qualitative analysis method (Patton, 2005).

We used the Nvivo software program to analyze the documentary. Nvivo is a software program developed to work with qualitative research data (documents, audio, video, etc.), which provides tools to analyze and report data by seeing them as a whole and is frequently used in social sciences (Borish et al., 2021; Estrada et al., 2017; Phillips & Lu, 2018). We conducted the analysis of the research using Baltruschat's (2010) "Film Interpretation According to the Documentary Method" process in the Nvivo program. Baltruschat developed the Film Interpretation process by utilizing the texts of the German Sociologist Ralf Bohnsack's (2009, 2014) "Documentary Method". The Documentary Method is explained as the study of documents, moving from the question of what cultural and social phenomena are to the question of how they are constructed (Bohnsack, 2009, 2014). "Film Interpretation According

to the Documentary Method" explains how this method can be adapted to the process of film analysis. The process of Film Interpretation explains how documentaries reflect the messages they want to convey to the audience and how the process of shaping social phenomena can be revealed (Baltruschat, 2010). In this research, using Baltruschat's Film Interpretation process, we aimed to understand how the culture of the US WAG is constructed to perpetuate systematic sexual abuse.

The process of Film Interpretation is explained in six stages. The first stage is the transcription of the movie. The transcription process is basically the coding of the image projected on the screen and the lines used in the movie. Here, only the image on the screen and the subtitles are verbalized without any interpretation. The second stage is to write explanations according to the progression of the movie. The flow of the movie is followed, and notes are taken about its progress. In the third stage, a structural outline of the film is made by evaluating the basic codes and the notes taken on the flow of the film. The draft forms the basis for the fourth stage, which is the interpretation of the film. The interpretation of the film is carried out by analyzing the outline and reflecting on the meanings. The fifth stage involves incorporating the title of the movie into the process. The sixth and final stage is to complete the interpretation by seeing the film as a whole. Baltruschat (2010) suggests that his six-stage explanation need not follow a fixed sequence, but rather, the process should be cycled as a "circle of interpretation". He argues that the transition between substances in the cycle should be continuous and that substances should be stages that feed each other. Based on these explanations, the documentary titled "Athlete A: The Truth Behind USA Gymnastics" was uploaded to the Nvivo program with Turkish subtitles to be analyzed by the researchers. We analyzed the documentary and Turkish subtitles simultaneously in the Nvivo program. In the analysis, we carried out the six stages of the Film Interpretation process as an "interpretation circle". The documentary, its visuals, and subtitles were evaluated and interpreted at the same time, and the findings of the process were thematized and reported. We tried to understand the social and organizational reality by establishing a relationship between all the elements used by the directors in the documentary (characters, locations, space-time relationship, etc.) and the concepts of sexual harassment and abuse. During the analysis, different principles were taken into consideration to ensure reliability (Noble & Smith, 2015). Two researchers conducted the process to ensure consistency in interpretation during the analysis. During the interpretation of the film analysis conducted with the Nvivo analysis program, triangulation was achieved by using literature sources and case reports. Additionally, screenshots from the relevant documentary broadcast on Netflix were used in the findings section of the study.

These screenshots were used only to support the findings within the "Fair Use Principle" scope and were kept in limited numbers. They were used for scientific purposes only and without any profit, in a way that would not violate the platform's copyrights.

RESULTS

We presented the findings in the same way as in the documentary, with the revelation of the Larry Nassar case and its aftermath. The documentary shows the case's first suspicions, the athletes' first complaints, and the subsequent investigation and follow-up process. We interpreted the findings to understand the culture of silence created in the US WAG and the process of perpetuating abusive behaviors caused by this culture.

Athlete A Breaking the Silence

The documentary begins with images of athletes training in a gymnastics hall. Figure 1 shows Athlete A practicing in the gym and being interviewed. The first person interviewed in the documentary is Athlete A, who talks about her love and passion for gymnastics. In the first figures, in which the parents of Athlete A are also included in the interview, the first expressions of the sadness the athletes and their parents felt about the details of the case that will be presented throughout the documentary are reflected on the screen.

Figure 1
Athlete A

It is known that within gymnastics culture, harsh training conditions are glorified to improve performance, and parents unquestioningly accept the methods of coaches who resort to abusive practices (Nite & Nauright, 2020; Willson et al., 2022). For example, in an interview with Jamie Dantzscher, one of the athletes said, "I started with 18 hours of training a week and worked my way up to 30, 35 hours. At that time... it was like I couldn't get enough. I was in a position to do everything they told me to do to get to the Olympics" is a reflection of this culture of acceptance.

The athletes' commitment to gymnastics and their Olympic dreams serve as a basis for them to do "anything" they are told to do. For athletes, meeting the expectations set by power,

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in this context, the coaches, becomes their own "insatiable" desire. Athlete A's father described this system as "We had to do what they wanted us to do. They were the ones who selected the Olympic team. We were at their beck and call. They had the Olympics as leverage", explaining where he, as a parent, necessarily stood in the relationship between his child and the federation. Like athletes, parents also aim for the Olympics for their children, and this goal reinforces loyalty to other actors (coaches, federation managers, etc.) and concern about failure (Jacobs et al., 2018). This concern puts athletes and parents in the predicament of remaining silent. After all, it is known that silence does not prevent any abusive behavior and creates an environment for subsequent ones to continue (Wortley & Smallbone, 2006).

When the relevant statements about the dream of being an Olympic athlete, the most desired success in gymnastics culture, are re-read from Foucault's biopolitics approach, the control mechanism coaches and the federation create over athletes is seen. The "powerful" federation officials revealed in the statements transformed their position as decision-makers on athletes' careers into a control mechanism. This control mechanism is oppressive, but it has the role of helping athletes to achieve their goals. This helping role and repressive practices are intertwined to become the only channel through which athletes must engage in order to achieve their goals. In other words, power, which is not only about repression and punishment (Foucault, 2012), creates the desire of athletes and their parents to become Olympic athletes and controls this desire through norms and discourses in the field.

The transformation of the US WAG culture into an oppressive and abusive one accelerated in the 1980s with the appointment of coaches Bela and Martha Karolyi, who used their strict methods to train American Olympians (Hampel, 2018). The documentary presents the Karolyi Ranch, founded by the Karolyis' as a gymnastics center, as a center where oppressive knowledge was produced and applied through the testimonies of athletes and parents.

Figure 2
Karolyi Ranch and the Karolyi's

In Figure 2, on the left side, there is an overhead view of the Karolyi Ranch. Immediately afterward, the documentary shows photographs of Bela and Martha Karolyi. Athlete A's father, describing Karolyi Ranch in the documentary, said: "Families were not allowed to go to the ranch. We could hardly talk when we were there because there was no cell phone reception. It was a strict method so that they could gain strength for their sport and get better. We had to believe and trust in their system." It is understood that athletes and parents accept the norms of power in the field because of Olympic desires; they do not question these norms, even if they contain abusive practices, because they think that they have a productive function as a result.

It is known that while on the ranch, athletes do not have access to quality medical treatment and have to struggle with malnutrition; Davis (2021) explains that this is because athletes know that if they eat too much, they will be subjected to psychological abuse by their coaches that they are not performing well because of their weight. In the documentary, athlete Jamie Dantzscher says, "I had the flu, I threw up for five days straight. I think I lost about three kilograms because of the illness. I remember Beth (Karolyi) saying to me, 'You've lost three kilograms, now we have to find a way not to gain it back'," Jamie Dantzscher says, describing patterns of physical and psychological abuse that she was unaware of at a young age. These regulations mentioned in the documentary, such as restricting the athletes' nutrition, continuing to train and compete while injured, forbidding contact with their parents, and restricting communication with those outside the camp to make them forget that there is a world outside Karolyi Ranch are restrictive interventions that provide surveillance and control exerted by power to achieve the desired result by controlling the athlete's body and therefore her entire self athlete's body and therefore her entire self.

Another challenge that athletes have to deal with is the humiliation and sarcasm of coaches. The risk of making a mistake in the process of learning a new skill later than the rest of the team means for athletes to be insulted and humiliated in front of the whole team (Davis, 2021). The documentary reflects this through an interview with Geza Poszar, the choreographer with whom the Karolyis' defected to the US. Pozsar reports that Karolyi's methods of training athletes included hitting, slapping, training to exhaustion, scolding, and so on, and since this was the "normal" of the time, the Karolyis' was not warned by anyone. He also emphasizes that when USA Gymnastics hired the Karolyis' as national team coaches, they knew their training methods and did not object because they wanted to win. It does not matter to USA Gymnastics which methods are used to achieve the desired goals. "America

loves a winner," said one of the witnesses, former athlete Jennifer Sey, who also said, "When Bela and Martha came here, we copied their style and started practicing it in the US. We knew their system, but we also knew that they won all the time," indicating that the acceptance of coercive methods is related to the goal to be achieved. In order to achieve this goal, coaches' "successful" track record leads to the perpetuation of abusive practices.

Such a culture of gymnastics becomes the basis for an authority figure to continue the process of preparing the child for abuse. Especially in gymnastics, the frequency with which coaches use physical contact to help athletes acquire technical skills, ensure safety, or get support for the movement, combined with the fact that child athletes do not know what violations related to "body contact" are, normalizes body contact. Therefore, the national team doctor Nassar touching their bodies during the treatment process is a normal behavior for gymnasts (Udowitch, 2020). Athletes consent to the surrender of control over their bodies with the dream of achieving the created desire (to become an Olympian, a national team athlete). Desires and norms of consent reinforce the culture of silence.

In the documentary, the person who breaks the culture of silence is the athlete who goes by the code name Athlete A. With the support of the club coach and parents, the athlete's complaint led to the launch of the investigation and the exposure of the Nassar case. The documentary reveals that when Athlete A, who was aiming to compete in the Olympics, filed a sexual abuse complaint against Nassar, it was the beginning of a crisis for USA Gymnastics. The fact that another athlete's allegations against Nassar were published in The IndyStar newspaper at the same time as Athlete A's complaint and that former gymnast Rachael Denhollander saw this news and contacted the newspaper after she was sure that she had been sexually abused, are conveyed to the audience through the interviews of investigative reporters in the documentary. Each testimony of the witnesses deepens the questioning of the USA Gymnastics system, and the questioning threatens to undermine the federation's oversight mechanism.

Figure 3
The IndyStar Investigative Reporters
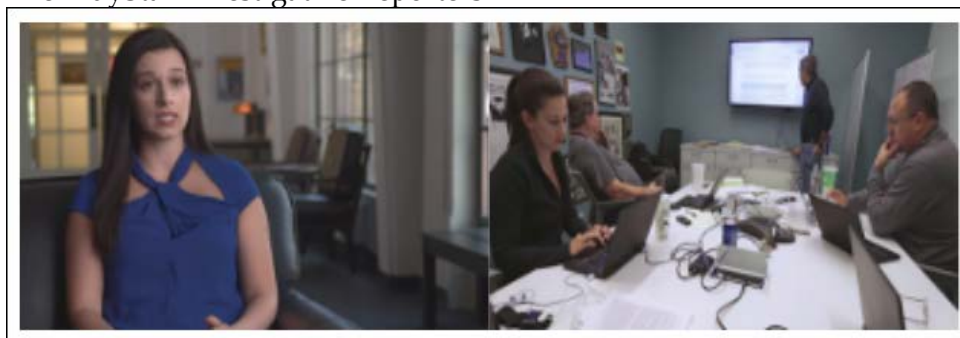
There is now a new case on the journalists' desk: The case of Dr. Larry Nassar. As seen in Figure 3, the documentary constantly reminds viewers of the pioneering role of The IndyStar investigative reporters in uncovering this case and, therefore, shows their workspace. Ultimately, journalists are the voice of athletes subjected to abuse; the documentary aims to bring this voice to the audience through witness accounts and archival work. First, with a tip-off followed by dozens of whistleblowing emails, journalists analyzed websites related to USA Gymnastics and Nassar on the basis of the tip-off files. The second stage is to investigate the validity of Nassar's actions, which he claims to be a method of treatment, in the medical literature. This phase is described in the documentary through interviews with investigative reporters. In analyzing the case, understanding Nassar's relationship with athletes and other actors in the field and examining his positional power based on his expert knowledge shape the investigative reporters' questions about the case. Nassar is a medical doctor who uses his profession and the norms of the field to perpetuate sexual abuse. In this context, the next theme focuses on Nassar through the visuals and witness statements presented in the documentary.

The Only Nice Adult: Larry Nassar

"He was nice, he was funny, he made them laugh... He secretly gave snacks, food, and that gave the children confidence. He was the opposite of the Karolyis'" (Jonh Manley, Lawyer).

The statements in John Manley's interview show that the image of Nassar as trustworthy and nice has helped him maintain his status as a beloved doctor. Many athletes go to Nassar for treatment after injuries. Nassar is indispensable with his trusted image and expert knowledge for athletes who have Olympic dreams and want to keep their place on the national team. Nassar uses the athletes' dream of becoming an Olympic athlete and the "acceptance of pain" as a tool. In every context, the documentary shows that suffering is necessary to achieve dreams and that actors accept this norm. As Olympic athlete Jamie Dantzscher says in the documentary, "I know I've competed and trained with a broken toe. I competed even though I hurt my back, but still, whenever I got injured, nobody believed me." As Jamie Dantzscher has shown, athletes are forced to fight despite injuries and are understood to have lost control over their bodies in an area where they know no one will believe in them. The loss of control over the body is apparent on the surface, but when examined more deeply in the background, it can be read that the athletes' self and subjectivity are being destroyed. The lack of adults (such as parents) around athletes who listen and try to

understand them when they are injured, ill or not feeling well also makes it easier for them to "trust" an authority due to their professional status.

In this culture, Nassar "listens" and "understands" the athletes. Working at Michigan State University, one of the most prestigious universities in the USA, while being a member of the US Olympic medical team at all four Olympics gives him great privilege, responsibility and power as a team doctor. Nassar's trustworthy image, which he has established over all the actors in USA Gymnastics, ensures that his treatment methods are not questioned for a long time and that there is no doubt about him. There are more than four hundred videos on Nassar's website where he shares the treatment methods he developed for gymnasts (Figure 4). "To justify his methodology, he has produced dozens of videos of himself performing various osteopathic procedures on little girls, as he calls them, to legitimize his methodology... His anatomical vocabulary is excellent, and it all seems legitimate," lawyer John Manly said in an interview, noting that Nassar had consulted different sources to support his method.

Figure 4
Videos of Nassar Teaching the Medical Treatment Method

The documentary reveals that Nassar perpetuated his sexually abusive behavior, which he concealed with his expert knowledge, by taking advantage of the organizational culture of abuse to which gymnasts were subjected. Nassar also knows that the gymnasts he treats idolize Olympic athletes and strive to be like them. When we look at the images of Nassar's office presented in Figure 5, we can see that he used to hang photographs of successful athletes he had treated on the wall. Kerri Strug, whose photograph is in the lower left corner of Figure 5, is commemorated in a part of the documentary for her performance at the 1996 Olympics. Strug's fight for her team's gold medal by competing in the competition despite injuring her ankle has placed her among the legendary gymnasts referred to as "warriors". The fact that Strug's photo is also in Nassar's office is effective in increasing the admiration for Nassar for the athletes who look up to her (Strug). In the documentary, the investigative reporters explain this behavior as Nassar's use of influence to increase the confidence of the child gymnasts in him.

Figure 5
Wall of Nassar's Examination Room at Karolyi Ranch

The documentary also frequently includes the athletes' reflections on their communication with Nassar during the camp and competition periods when they were part of the national team. For example, when Jamie Dantzscher says in her interview, "I hate to say it, but I would look forward to treatment because Larry... was the only nice adult", she is describing Nassar, who was the only adult who communicated with her in the gymnastics culture where she was isolated. Nassar strives to be seen as a "savior of girls," "accomplice," and "confidant," and this effort is part of the grooming (Bennett & O'Donohue, 2014; Salter, 1995). In the documentary, witness testimonies reveal Nassar's caring, trustworthy, and confiding nature, leaving chocolates under his pillow or food in his room as a surprise. One of the witnesses, lawyer John Manly, said in an interview, "Larry Nassar was the only bright light in the room," giving clues to how Nassar built trust with athletes for sexual abuse by creating a nice and gentle image. The relationship between the gymnasts and Nassar keeps them in the sport, and this is invaluable for USA Gymnastics, which needs the success and continuity of athletes (Way, 2023). His volunteer service, benevolence, and kind-heartedness are the qualities that made him a member of USA Gymnastics' national team for many years.

Nassar's non-coercive and supportive network of relationships with athletes is the source of his perpetuation of sexual abuse. The documentary tells the viewer that a great fear - the fear that no one will believe him, that he will not be understood, that his career will end, and that he risks being removed from the national team roster - covers up the testimonies of athlete witnesses and their interrogations of Nassar's sexualized physical contact. In this way, the documentary directors do not allow the viewer to ask the question, "Why didn't the athletes tell anyone?" but rather they try to make the viewer ask the question, "Why couldn't Larry Nassar be prevented?". In an environment where discomfort, anxiety, and pain are silenced, Nassar knows that his sexual abuse of athletes will also be silenced (Wellman et al., 2021). To abuse athletes, he built trust with every adult, manager, parent, and athlete, and

acted systematically and deliberately to build this trust. As the documentary highlights, the culture of silence, combined with USA Gymnastics' concern for organizational reputation, fueled Nassar's sexually abusive behavior for years. The answer to the question "Why couldn't it be prevented?" which we are encouraged to question as viewers, is sought in the next theme in the direction drawn by the documentary.

Organisational Cover-up: The Invisible Part of the Iceberg

The documentary reveals that it is not only Nassar who is guilty of sexual abuse but that USA Gymnastics is complicit in the crime and that organizational negligence is effective in its continuation. As Way (2023) points out in her study, while Nassar's position as a provider of treatment or having easy access to athletes is a risk factor, the main factor that should be focused on is the mismanagement of the organization that allows Nassar to continue his abuse, the ignoring and failure to prevent abuse under the goal of success. "Nassar was the tip of the iceberg," Shenk, one of the documentary directors, said in an interview with TIMES, drawing attention to organizational neglect (Gajanan, 2020). On the invisible side of the iceberg, USA Gymnastics' efforts to cover up sexual abuse and its numerous omissions are presented in the documentary. The documentary documents the email correspondence between the federation official and Nassar, thus revealing the tip of the iceberg for the viewer, who is informed that the federation decided not to allow Nassar to take part in the competitions due to growing suspicions, citing the excuse that he was ill. As presented in Figure 6, this correspondence is one of the main pieces of evidence of the federation's organisational cover-up.

Documentary Athlete A presents the email cover-up and the reprisals against athletes and their parents. Athlete A's father said, "As parents, we were seated at every competition. Camera crews were following us... When we went to the Olympic trials, our seats were not reserved. We didn't have microphones. There were no cameras following us. So... there was definitely something strange" is an example of organisational retaliation targeting the athlete and her parents after Athlete A's complaint. In the documentary, Athlete A recounts how USA Gymnastics president Steve Penny prevented her from appearing in a commercial with her national teammates and then denied her a spot on the 2016 Rio Olympics team, even though she had enough points. These practices can be interpreted as retaliation by USA Gymnastics and, when interpreted from a Foucauldian perspective, as punishment for athletes who do not conform to the norm.

Figure 6
USA Gymnastics Federation Official and Nassar's E-mails
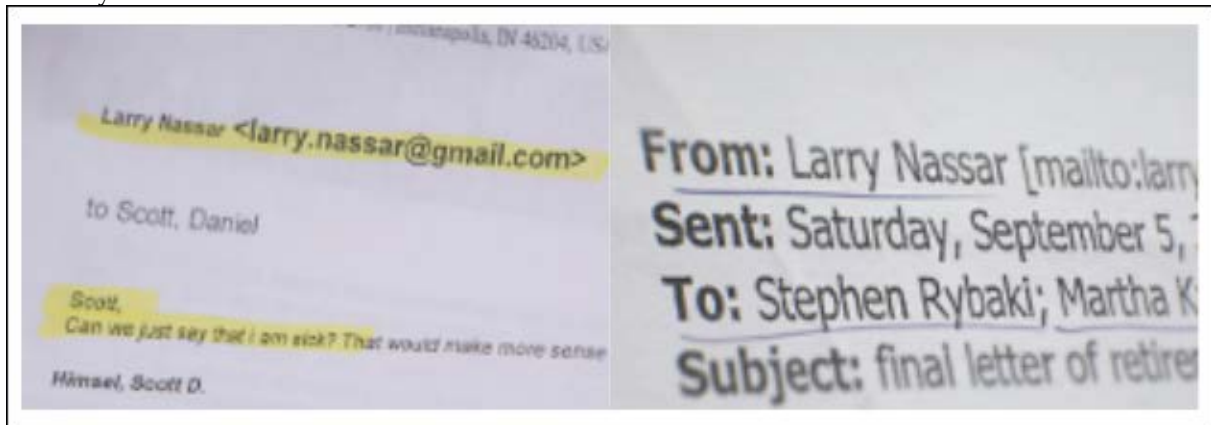
Allegations suppressed by reprisals and reports of sexual abuse hidden in drawers only surfaced years later. It is known that the first police investigation was opened against Nassar in October 2004. During the police investigation, Nassar claimed that he had performed a valid medical procedure to treat the patient and provided the police with a presentation documenting this technique. The fact that the police believed Nassar and did not think that Nassar had committed a crime led the police to close the case (Gajanan, 2020). Earlier than that, in 1997, the gymnasts' complaint to Michigan State University was ignored by MSU, USA Gymnastics, and the US Olympic Committee, the same year Nassar was hired as a sports physician at MSU. Evidence is presented in the documentary that despite numerous warning signs and complaints against Nassar over three decades, MSU was slow to act on reports of the doctor's abuse of young girls and young women. In addition, the facilities where the athletes train are seen in the documentary as facilities where many cases of abuse were reported to USA Gymnastics and the Olympic Committee. The authorities to whom the reports were submitted ignored them, Nassar was not investigated, and all this evidentiary information did not come to light until years later, following the work of investigative reporters and prosecutors.

The evidence shows that USA Gymnastics made strategic moves to destroy complaints, potentially revealing statements and documents to avoid damaging its reputation. Steve Berta, the editor of The IndyStar, said, "The organization was run by a sports marketing expert (Steve Penny, Former USA Gymnastics President). That's what he cared about. It was marketing the brand." seen this statement shows that while USA Gymnastics' organizational priority was marketing and brand image, its priority was not the athletes. As Foucault states while explaining the concept of biopower, the federation sees the athlete's body as a means of production (Foucault, 1996). By controlling the means of production and turning it into an

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object of production, athletes for USA Gymnastics have become marketing products. Restrictions and cover-ups are in place for all risks that could damage the brand. Abusive organizational practices have suppressed athletes, put them under absolute control, caused them to recalibrate their expectations of what is normal and acceptable, and ultimately facilitated abuse. Foucault's discourse on the body as a tool that produces political and social structure gains meaning at this point. For Steve Penny, the body of gymnasts is the main source for the continuation of the political and social structure he has built as the president of the federation. The health and well-being of the athlete are not important within this structure. Penny, one of the representatives of biopower, continues biopolitics with these tools.

The documentary's chronological case study shows that it took many years for the culture of abuse to be recognized and stopped and that the main reason for this was a series of organizational mismanagement and negligence. The process of athletes speaking out after the abuse is exposed is presented as a healing process because human beings always need hope.

> *Sentences upheld and recovery process begins: "I can finally say I'm proud to be an Olympic Athlete"*

The documentary emphasizes that the process of Nassar's legal investigation accelerated in the wake of mounting allegations and published newspaper reports. Interrogation records, surveillance footage, and police archives are all utilized to narrate this process, and ultimately the Nassar scandal culminates in the arrest and conviction of Nassar, Steve Penny, and other perpetrators of organizational negligence within USA Gymnastics (Figure 7).

Figure 7
Steve Penny and Nassar's Arrest

It is also important to note that the documentary states that "non-disclosure" agreements" were among the reasons why Nassar was able to sexually abuse athletes for decades without being caught. The investigative reporter said, "I learned that McKayla Maroney was forced to sign a non-disclosure agreement. I think they made other athletes who were Nassar's victims sign non-disclosure agreements. USA Gymnastics went to great lengths to cover it up and minimize the damage." It appears from his words that the confidentiality agreement included terms that did not allow Maroney to publicly disclose that Nassar had sexually assaulted her and that she could not disparage Nassar or USA Gymnastics. In 2016, after the crimes were revealed and Nassar was arrested, McKayla Maroney not only attended the hearings and testified during Nassar's trial but also filed a civil lawsuit against USA Gymnastics and won 1.25 million dollars in compensation (Akel, 2018).

The documentary also includes archival footage of Rachael Denhollander testifying face-to-face with Nassar at the first hearing. Beforehand, Rachael says, "I know that if the prosecution considers it, I will have to testify in court, in front of him, sharing the same memories, and I hate the idea. I hate it, but if I don't do it, it can continue. This idea feels worse," she testifies in court, looking Nassar in the face. Archival footage is then shared of many Olympic and national athletes attending the hearings and reading their written statements in front of Nassar (see Figure 8).

Figure 8
Athletes Testifying During the Trial

Jamie Dantzscher, one of the survivors, testified, "Larry, you saw the physical and emotional abuse that our coaches and the USA Gymnastics national team staff inflicted on us. You pretended to be on my side and called them 'monsters'... You knew I was weak... I'm here to tell you to your face that you can't fool anyone anymore," and the documentary now focuses on the athletes who broke their silence and looked Nassar in the eye and complained. One of the athletes, Rachael Denhollander, said of the other athletes' speeches, "It was always an incredibly powerful speech because it meant that they now felt safe, that they were no longer blaming themselves but their abusers" celebrating the fact that survivors had exposed years of

sexual abuse and that they had stopped "blaming" themselves. Speaking out, announcing to the world that the patterns of abuse they could not make sense of as children were abused, breaking down the walls of fear, and going to trial to protect the young athletes who will come after them are all part of healing and become survivors.

As an abused athlete, Jamie Dantzscher said, "Now that I can say that you no longer have power over me as an Olympic gymnast, I can finally say that I am proud to be an Olympic athlete," and that she is an athlete who has regained her freedom of speech and her identity as an athlete. For the athletes, the freedom to speak out, the end of repression, and the idea that they have protected future generations from Nassar and the dirty politics of USA Gymnastics is a source of pride for the reconstruction of their identity. It has been part of the healing process for the athletes to confront Nassar and to become young women who can now speak out with support from each other and their families. The final scenes of the documentary show Athlete A, whose true identity is revealed - Maggie Nichols - participating in competitions while enjoying the sport. Stating that she was happy in college sports, Maggie's athletic life, free from the dirty politics of USA Gymnastics, is conveyed to the audience with the statement, "Elite gymnastics wore me down, but I grew as a human being and a woman. I fell in love with this sport again." Maggie's mother then shared, "I think it was a big epiphany for her because she saw that she was treated well when she went there. Gymnastics is fun; the coaches are very good, the medical staff is very, very good. It's not like when she was on the elite team." These statements are proof that abuse in gymnastics is not normal and that happy athletes can build successful careers.

Athlete A - Maggie Nichols - who also bears the title of the documentary, is a powerful athlete who, by the end of the film, wants her name to be known to everyone and does not want it hidden on shelves in secret documents. Maggie Nichols, a survivor of sexual abuse, is one of the victors of the freedom to "speak out" that all survivors aim to achieve together.

DISCUSSION

The documentary Athlete A focuses on Larry Nassar's systematic sexual abuse of child athletes on the US WAG team and the organisational negligence that led to the abuse. Emphasizing Nassar's manipulation of athletes to prevent their sexual abuse from being exposed, the documentary reveals the process from the discovery of the case to Nassar's arrest through the testimonies of witnesses, actual footage, police and journalists' archives. In this context, the documentary depicts the dynamics of psychological, physical, and sexual abuse perpetrated on athletes by those who hold organisational power with the understanding of

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"win at all costs" and the transformation of organisational (USA Gymnastics, FBI) negligence into complicity.

In this study, the findings we obtained as a result of the analysis of the Athlete A Documentary are based on the chronologically presented fiction of the documentary and include a) the abuse caused by power relations in the field of gymnastics and Athlete A's breaking the silence of abuse, b) Nassar's identity of authority in the grooming process, c) the organisational negligence and complicity of USA Gymnastics administrators, and finally d) The healing process for athletes that began with Nassar's trial became evident. Since the documentary presents the power dynamics in the world of gymnastics and their systematic control over athletes, we employed Foucault's concept of biopower. We thus had the opportunity to discuss from another geography how Nassar's biopower renders athletes vulnerable to abuse.

The documentary focuses on how an authority figure, who has control over the bodies of athletes as a physician, uses his positional authority by manipulating the administrators in his organisation and thus deepens the culture of silence. Olympic medal goals, as presented to spectators, seemingly control not only athletes' bodies but also their minds and dreams. Here, every move made with the goal of athletes' health or success becomes a risk factor for sexual abuse, and Nassar represents biopower through the power relations he establishes over athletes in the name of treatment. Therefore, the struggle of athletes who have been subjected to sexual abuse to make their voices heard in their organizations has also turned into a struggle for survival. At the same time, Cohen and Shenk, the directors of the documentary, managed to draw attention to the systemic abuse and neglect taking place in USA Gymnastics during the documentary-making process (Gajanan, 2020). Thus, representing failed leadership (Mountjoy, 2019), USA Gymnastics' (and the FBI's) failure to take athletes' complaints seriously, to conduct investigations, to prevent abusive behavior, and to pave the way for athletes to be subjected to sexual abuse appears as complicity.

CONCLUSION

There are lessons we can learn from the abuse case in USA Gymnastics in order to end harassment and abuse in sports and for athletes to participate in sports in safe environments. As sports scientists, we have a responsibility to consider survivors' voices and be part of building safe sports so that this dark history does not repeat itself (Mountjoy, 2019). The world of sport owes a debt to the survivors. This debt is too deep to be compensated by the US

Department of Justice's payment of $138.7 million to the athletes for the FBI's failure to investigate, as announced on April 23, 2024 (Reuters, 2024).

The Nassar case has led to a shift in sports policy and the development of policies and procedures to safeguard athletes from harassment and abuse. However, it is evident that this whole process needs to be carried out before a case arises. Every sentence of the survivors should be a lesson for decision-makers and sports scientists. Just like the Olympic athlete Simone Biles said about USA Gymnastics in a newspaper interview, "We had one goal and we did everything they asked us to do, even if we didn't want to, and they couldn't do one damn thing. You had one job. You literally had one job and you couldn't protect us" (CNN, 2019): Sporting organizations should establish effective policies and procedures to prevent harassment and abuse and safeguard athletes from harassment and abuse.

Authors' Contribution

All authors contributed to the conception and design of the study, data collection, data analysis and interpretation, drafting the article and/or its critical revision, and approved final version of the study.

Declaration of Conflict Interest

There is no conflict of interest between the author(s) of the study or the institution to which the author(s) are affiliated

Ethics Statement

As stated in Article 2 of the scope of Hacettepe University, Institute of Health Sciences, Social Sciences and Humanities Research Ethics Committee Directive, ethics committee approval is required for research conducted under the aforementioned conditions:

"All kinds of questionnaires, interview guides or questionnaires and scales applied face-to-face, online, telephone or computerised data collection activities with quantitative or qualitative research design in the field of social sciences and humanities at Hacettepe University or by Hacettepe University members, and non-medical observation, file or data source scanning or secondary data sources are within the scope of this directive."

We hereby declare that the article submitted to Pamukkale Journal of Sport Sciences is not within the scope of the relevant directive and ethics committee approval has not been obtained. Ethics committee approval is not required for this article.

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Exploring Exercise Behaviors and Health Knowledge in Secondary School Students: A Mixed-Methods Study in One School

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ABSTRACT

The study aimed to: a) determine the exercise stages of change (ESC) and health-related fitness knowledge (HRFK) levels in one secondary school students in 6th, 7th, and 8th grades, and b) investigate how students with varying ESC and HRFK levels apply HRFK in their daily lives and identify the key sources and support systems (such as family, teachers, and peers) that facilitate this process. For the first aim of this mixed-method study, the Exercise Stages of Change Questionnaire and Health-Related Fitness Knowledge Test were applied to all 6th, 7th, and 8th grade students in one school (n= 511, 233 girls, 278 boys). Based on their scores, students were divided into four groups. For the second aim, four focus group interviews were conducted with 30 students (13 girls, 17 boys), selected through purposeful sampling from the four groups. The study found significant differences in the physical activity behaviours of students in the four different groups based on their ESC and HRFK. Students with high HRFK often had support from family and coaches, and they verified their information. In contrast, those with low HRFK needed more support and focused more on sports performance than HRFK. It underscores the importance for educators to implement targeted strategies that address the diverse needs of students, ultimately fostering an inclusive environment that promotes active and healthy lifestyles.

INTRODUCTION

Regular participation in physical activity has been shown to positively impact health worldwide (Warburton & Spray, 2017). However, the World Health Organization (2018) reports that over 80% of the world's adolescent population does not participate sufficiently in physical activity and exercise. Physical activity includes all physical movements that require energy expenditure, including daily tasks and unstructured activities (walking, housework). At the same time, exercise is defined as planned, structured, and repetitive activities (Dasso, 2018) and is considered a sub-dimension of physical activity (Katsagani et al., 2023). For this reason, it is two closely related concepts. Physical activity and exercise are among the effective strategies to protect public health by reducing the risk of cardiovascular diseases, diabetes, and some types of cancer (Kern & Armstrong, 2022).

Physical education classes are essential to support students' participation in physical activity (Harris & Cale, 2018). Traditional physical education programs have yet to successfully instill lifelong physical activity habits in students (Mahardika et al., 2024). At this point, studies also indicate that physical education lessons should emphasize valuing a physically active life rather than focusing on sports (Bowler et al., 2022). Therefore, alternative approaches and health-related achievements have been added to physical education classes to promote a healthy and active lifestyle (Siedentop, 2009). In Turkey, health-related outcomes were added to the physical education curricula for secondary schools (grades 5-8) in 2006 and for high schools (grades 9-12) in 2010 to encourage students to participate in physical activity (MoNE, 2006; MoNE, 2010). "Maintaining lifelong physical activity" was also added as a learning outcome in both programs. However, studies in Turkey have shown that more than physical education classes are needed to provide students with active and healthy lifestyles (Cengiz et al., 2014; Hunuk et al., 2013).

Health-Related Fitness Knowledge (HRFK) refers to health and well-being-related physical fitness concepts, including the relationship between xercise and health, healthy physical skills, and the importance of exercise in maintaining a healthy lifestyle (Saputra, 2023). HRFK, which is a crucial aspect of physical education curricula, may help support healthy life behavior and lifelong physical activity (Castelli & Williams, 2007; Ferkel et al., 2014). Additionally, studies reveal a significant relationship between HRFK and active and healthy life behaviors (Hannon & Thompson, 2012; Haslem et al., 2016). Physical education classes should provide children between the ages of 5-16 with HRFK to combat physical inactivity (Lloyd et al., 2010). Although it has been stated that having HRFK is practical in

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gaining active and healthy life behaviors, more is needed on its own (Placek et al., 2001), having HRFK can be the first step in supporting healthy life behaviors (Ferkel et al., 2014). Even though it is known that having HRFK positively affects participation in active, healthy living, studies on the HRFK level of students show that their HRFK needs to be more accurate and complete (Hannon & Thompson, 2012). In addition, studies have shown that students' physical activity and HRFK levels are far below their physical education learning goals (Keating et al., 2009; Khairuddin et al., 2023). For this reason, intervention studies have been carried out to increase exercise and HRFK levels and improve school health outcomes in Turkey (Akıncı, 2014; Cengiz & İnce, 2014).

HRFK is essential for adolescents as it enables them to make informed decisions about their physical activity and well-being. Also, Exercise Stages of Change (ESC) is a framework to assess an individual's readiness to engage in regular physical activity (Toth et al., 2022). According to the framework, individuals progress through a series of stages. These ESCs can monitor physical activity patterns, evaluate specific interventions that facilitate movement to the following stages, and increase awareness of the importance of regular physical activity (Prochaska et al., 1992). ESC outlines five stages of readiness for adopting regular exercise: Precontemplation, Contemplation, Preparation, Action, and Maintenance. In contemplation, individuals lack the intention to change and show low self-efficacy and intention to participate in physical activity (Oka, 2003; Rosenkranz et al., 2015). Contemplation involves considering change without commitment, with slightly higher intention than pre-contemplation (Rosenkranz et al., 2015). Preparation includes planning and taking small steps, though motivation and social support barriers may arise (Gronmark, 2018). The action reflects active behaviour modification, with individuals striving to meet goals like 10,000 daily steps while facing self-consciousness (Gronmark, 2018; Rosenkranz et al., 2015). Finally, maintenance is characterized by consistent behaviour change over six months, improved self-efficacy, and lower relapse risk to physical inactivity (Oka, 2003; Rosenkranz et al., 2015). This framework provides a structured approach to understanding and supporting physical activity adoption. Those with high HRFK adolescents are more likely to transition from the early stages of inactivity to preparation and action. With a deeper understanding, they are better equipped to maintain long-term healthy habits, fostering lifelong health and fitness. The "Stages of Change", often associated with exercise behaviour modification, outlines individuals' progression when adopting new health behaviours, such as exercise. Research indicates that individuals in advanced stages (Action and Maintenance) exhibit higher self-determined motivation and exercise levels compared to those in earlier stages (Pre-contemplation and

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Contemplation; Pope et al., 2021). Barriers to exercise vary by stage; for instance, motivational support is critical during preparation, while self-confidence becomes more significant in the action and maintenance stages (Gronmark, 2018). A study involving adolescents highlighted that health knowledge positively influences progression through the ESC, with males more likely to be in active stages (Ricardo et al., 2015). Furthermore, achieving specific physical activity goals, such as 10,000 steps per day, is more likely among individuals in the action or maintenance stages, emphasizing the importance of readiness in promoting physical activity (Rosenkranz et al., 2015). These findings showed that the need for tailored interventions considering individuals' stages of change to enhance physical activity adherence. For this reason, it is thought that it is important to investigate how secondary school students with varying ESC and HRFK levels apply HRFK in their daily lives. The key sources also identify exercise and HRFK support systems that facilitate this process.

Studies on students' physical activity levels in Turkey showed that students' exercise knowledge, skills, and attitudes toward regular physical activity decreased with age (Kin-Isler et al., 2009; Serbes et al., 2017). When studies on school-based health interventions were examined, it was seen that school-based health interventions could increase students' ESC and HRFK levels (Akıncı, 2014; Cengiz & İnce, 2014). In studies on school-based health interventions in the worldwide and in Turkey, students' knowledge, skills, or level of participation in physical activity were not taken into consideration when they were included in the physical education class (Akıncı, 2014; Cengiz & İnce, 2014; Pritchard et al., 2015; Ward et al., 2017).

In this context, the Theory of Planned Behavior (TPB) offers a valuable framework for addressing these gaps by linking physical education to behavior change in exercise (Ajzen, 1985). In physical education, TPB explains how attitudes, subjective norms, and perceived behavioural control influence students' readiness to engage in physical activity. For example, positive attitudes toward exercise, often shaped by acquiring health-related fitness knowledge (HRFK), are associated with higher intention to participate in physical activity (Park et al., 2009). Similarly, encouragement from teachers, peers, and family (subjective norms) can enhance motivation. At the same time, students' confidence in their ability to perform the exercise (perceived behavioural control) facilitates the transition from intention to action (Kirk & Haegele, 2019). Structured physical education lessons play a crucial role in operationalizing these TPB components. By fostering positive attitudes through HRFK, emphasizing social support, and creating inclusive environments that build confidence, physical education can help students overcome barriers to participation. Research highlights those interventions

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aligned with TPB, particularly those addressing these three constructs, effectively promote exercise behaviour across diverse populations (Dermatis et al., 2023).

For students to transfer the HRFK they acquired in the physical education class environment to their daily lives and to increase their physical activity levels, it seems important to first determine the different student needs in the classroom environment and to provide lesson environments according to student needs. Based on this importance, the study aims to: The study aimed to: a) determine the exercise stages of change (ESC) and health-related fitness knowledge (HRFK) levels in one secondary school student in 6th, 7th, and 8th grades, and b) investigate how students with varying ESC and HRFK levels apply HRFK in their daily lives and identify the key sources and support systems (such as family, teachers, and peers) that facilitate this process.

METHODS

Participant

In the study, the researchers selected a secondary school through convenient sampling in one of the primary districts of the Denizli province, which predominantly comprises mid-income families and consistently achieves average academic records. In the first part of the study, all 6th grade (n = 207, 76 girls and 131 boys), 7th grade (n = 152, 83 girls and 69 boys), and 8th grade (n = 152, 74 girls and 78 boys) students in a secondary school were reached (n = 511, 233 girls, 278 boys). The study covered all secondary school students except for 5th-grade students in one school. The reason why 5th-grade students were not included in the study is that the HRFK test and the ESC Questionnaire are not reliable and valid measurement tools for this age group. Both measurement tools were developed when 5th-grade students were still included in primary school classes. Therefore, to ensure the validity and reliability of the measurement tools, the study was conducted with students starting from the 6th grade age group.

In the second part of the study, 30 students (13 girls, 17 boys) were selected using the purposeful sampling method. These students were divided into four groups according to the questionnaire and knowledge test levels. Four different focus group interviews were conducted with these groups.

This study used extreme or deviant case sampling from purposeful sampling (Creswell, 2002). In extreme or deviant case sampling, individuals in a research group are ranked according to their values, and those with very high or low values are deliberately selected. This method can elucidate situations that cannot be obtained from people with

average values (Creswell, 2002). In this study, the purposeful sampling method was used because the students with the highest and lowest levels were reached according to the questionnaire and knowledge test. While the ESC of students in the group with high ESC (1st and 3rd group) is 5, the ESC of students in the group with low ESC (2nd and 4th group) is 1. In terms of their knowledge levels, the students were ranked according to the levels they received from the knowledge test and were selected from those with the highest and lowest knowledge. No value was determined for the knowledge test, and the average values of the groups were calculated based on the student selections. Ethics committee permissions were obtained from Pamukkale University (2018 and 60116787).

Procedures

This study used extreme or deviant case sampling from purposeful sampling (Creswell, 2002). In extreme or deviant case sampling, individuals in a research group are ranked according to their values, and those with very high or low values are deliberately selected. This method can elucidate situations that cannot be obtained from people with average values (Creswell, 2002). In this study, the purposeful sampling method was used because the students with the highest and lowest levels were reached according to the questionnaire and knowledge test. While the ESC of students in the group with high ESC (1st and 3rd group) is 5, the ESC of students in the group with low ESC (2nd and 4th group) is 1. In terms of their knowledge levels, the students were ranked according to the levels they received from the knowledge test and were selected from those with the highest and lowest knowledge. No value was determined for the knowledge test, and the average values of the groups were calculated based on the student selections. Ethics committee permissions were obtained from Pamukkale University (2018 and 60116787).

Data Collection Tools

Data were collected through the Exercise Stages of Change Questionnaire, Health-Related Fitness Knowledge Test, and focus group interviews.

Exercise Stages of Change Questionnaire

The ESC Questionnaire was used to measure the participants' exercise stages of change in the study. The questionnaire was developed in 1992 to measure healthy behavior change (Marcus et al., 1992). In 2014, it was adapted into Turkish by Cengiz, Hunuk, and İnce, and its validity and reliability were ensured for sixth-, seventh-, and 8th-grade students. The questionnaire categorizes individuals' exercise participation level into five categories according to the answers given. Pre-contemplation (1 point), Contemplation (2 points),

Preparation (3 points), Action (4 points), Maintenance (5 points). The questionnaire evaluates the highest level of ESC as 5 points and the lowest level as 1 point. People at level 1 have yet to become aware of participating in exercise, while people at level 5 are considered to participate regularly.

Health-Related Fitness Knowledge Test

In the study, the 36-item Health-Related Fitness Knowledge Test, developed by Mott et al. (1991) and adapted into Turkish by Hunuk and Ince (2010), was used to measure the students' HRFK level. In the adaptation of the test, which initially had 25 items, to Turkish, 11 more items were added by the researchers (Hunuk & Ince, 2010). The test was finalized with 36 items by obtaining opinions about the items from expert physical education teachers, and its reliability and validity were ensured by applying it to 420 secondary school students (Hunuk & Ince, 2010). The test included questions about heart rate, physical fitness, flexibility, cardiovascular endurance, strength, exercise, and the importance of warm-up. There are three options for each item of the 36-item test, with one correct answer for each question. The highest level that can be obtained from the test is 36, while the lowest level is 0.

Focus Group Interviews

In the study, focus group interviews were held with 30 students determined by purposeful sampling, according to the results of the HRFK test and the ESC Questionnaire. Focus group interviews are a data collection method in which individuals are asked questions and openly communicate with each other and convey their thoughts (Kitzinger, 1995). In this regard, focus group interviews are used to investigate the knowledge and experiences of group members to explain not only what they think but also how and why they think this way (Kitzinger, 1995). A semi-structured interview form was used in focus group interviews. Three researchers examined the interview form used, and its validity was ensured by determining whether the questions were prepared.

30 students were divided into four groups according to their HRFK and ESC levels and focus group interviews were conducted with each group. During the interviews, students were focused on what kind of exercises they participate in outside of their physical education class, the motivations of those who regularly participate in an exercise, how and where they update their HRFK, what resources they use, and the roles of physical education teachers and coaches (if any) in this regard. There were some differences in the questions depending on the groups the students were in. Data triangulation was made for trustworthiness by comparing the levels obtained from focus group interviews with students, questionnaires, and knowledge

tests. In addition, the trustworthiness of the data obtained from the students was ensured through member checking.

Data Collection Process

After obtaining the necessary permissions from the University Ethics Committee and Denizli Provincial National Education, data were collected from a public school with socio-economically middle-income families in the central district of Denizli. The data was collected in the second semester of the 2018-2019 academic year from a secondary school where two physical education teachers, a male and a female, worked during physical education classes. Data was collected according to the two aims of the study. Within the scope of the study's first aim, the Health-Related Fitness Knowledge Test and the Exercise Stages of Change Questionnaire were applied to all 511 6th, 7th, and 8th-grade students. After data were analyzed, 30 students with the highest and lowest HRFK level and ESC level in the school were determined. According to these values, the students were divided into four groups, as explained in the sample selection. The first group consists of nine students with the highest ESC and HRFK; the second group consists of nine students with the highest HRFK but the lowest ESC; the third group consists of six students with the lowest HRFK but the highest ESC, and the fourth group consists of six students with the lowest ESC and HRFK.

Within the scope of the study's second aim, data were collected from 30 students, determined by purposeful sampling through focus group interviews. Four focus group interviews were held with four different student groups. In each focus group interview, students were asked different questions according to their characteristics and analyzed student views. Each interview lasted between 30 and 40 minutes. Semi-structured focus group interviews were conducted by the study's second researcher, who is an expert in qualitative research methods and teaches graduate-level qualitative research methods courses. During the interviews, the first researcher participated in the interviews to take written notes. All interviews were recorded with a voice recorder with the permission of the parents.

Data Analysis

Descriptive statistics (frequency, percentage, min., max.) were used to analyze the quantitative data of the research. The thematic analysis method was used to analyze qualitative data. Thematic analysis is an analysis method that aims to identify and reveal patterns of meaning in a qualitative data set (Braun & Clarke, 2006). Thematic analysis shows which themes are important in defining the phenomenon to be defined (Joffe, 2011). In this study, the thematic analysis was informed by priori themes, which were established prior to

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data collection based on the research objectives. The priori themes derived from the research objectives guide the coding process and interpretation of the data. In this study, student quotes were included under pseudonyms.

RESULTS

Findings on Quantitative Data

According to the study's first aim, the Exercise Stages of Change Questionnaire and the Health-Related Fitness Knowledge Test were administered to 511 students in a school. Table 1 shows the minimum, maximum, and average values of the ESC levels and HRFK test of 511 students.

Table 1
ESC Questionnaire and HRFK Test Levels of Students (N = 511)

Variables	n	Min.	Max.	Mean	SS
ESC Questionnaire	511	1	5	3.25	1.43
HRFK Test Level	511	10	32	24.27	4.14

Four groups were created by selecting 30 students with values in the questionnaire and test results. The quantitative values of these students are shown in Table 2. Accordingly, the average HRFK test level of the students in the first group was 31.22, and their level, according to the ESC, was 5. While the HRFK test average of the students in the second group was 30.22, their level, according to the ESC, was 1. The HRFK test average of the students in the third group was 12.66, and their level, according to the ESC, was 5. While the HRFK test average of the students in the fourth group was 14.50, their level, according to the ESC, was 1 (Table 2).

Table 2
Demographic Characteristics of 30 Students in Focus Group Interviews

Groups / Grades	GROUP 1		GROUP 2		GROUP 3		GROUP 4	
Total	9 Students (5 Boys ,4 Girls)		9 Students (5 Boys, 4 Girls)		6 Students (6 Boys)		6 Students (3 Boys, 3 Girls)	
8th grade	3 students		4 students		1 student		1 student	
7th grade	5 students		3 students		5 students		5 students	
6th grade	1 student		2 students		-		-	
Values	HRFK $\bar{x}$	ESC $\bar{x}$	HRFK $\bar{x}$	ESC $\bar{x}$	HRFK $\bar{x}$	ESC $\bar{x}$	HRFK $\bar{x}$	ESC $\bar{x}$
	31.22	5	30.22	1	12.66	5	14.50	1

The reason for choosing people with very low or high values rather than typical people in this study is that the researchers wanted to obtain more detailed data by identifying specific groups. In this context, four student groups were determined using the purposeful sampling method in the study.

Findings of Qualitative Data

According to the second aim of the study, it was interviewed with four groups to investigate how students with varying ESC and HRFK levels apply HRFK in their daily lives and identify the key sources and support systems (such as family, teachers, and peers) that facilitate this process. The interview data was explicitly analyzed for each group. Here are the findings obtained from the interviews of each student group;

Results From the Student Group With the Highest ESC and HRFK Level

Nine students with the highest ESC and HRFK level were interviewed in a focus group. It was found that the students in this group willingly participated in regular exercise at least three days a week. These students also participated in exercise or sports outside of school. These students are noteworthy as students who participate in sports outside of school and physical education classes. The female students in the group stated that they attended volleyball, gymnastics, and swam clubs. Also, they walked with their families outside of school. Male students regularly participated in karate, swimming, and basketball activities in sports clubs. The students in this group primarily relied on their coaches in sports clubs, family members, and the internet as sources of their HRFK. When looking at their participation in physical activity, it was found that students' intrinsic motivation to exercise was high, and their current HRFK also positively influenced this participation.

All of the students in this group participated in physical activity or sports outside of school, and they saw their coaches in the clubs they attended as the most reliable source of HRFK. Below are some quotes about the coaches of students with high ESC and HRFK levels.

"I ask my coach about my shortcomings and how I can improve by training. I ask what I should and should not eat before or after the matches." Arda (male student)

Students in this group had a family member who regularly participated in physical activity or sports; they also had a background in sports. These family members were very conscious and encouraged the students to engage in exercise. It was also found that these students mainly learned HRFK from their fathers. Below are quotes from students with high ESC and HRFK levels.

"My father is researching knowledge about exercise. My father helps us, we are three siblings, he helps all of us and gives us knowledge about health." Duru (female student)

"I worked with many coaches, but my father is my greatest coach." Yaren (female student)

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The students in this group are adept at utilizing the internet to acquire knowledge about nutrition and training. They follow various websites to stay up to date with the latest HRFK. Furthermore, they try to incorporate their training and nutrition plans into their routine by following the social media accounts of notable athletes. Some student quotes about their Internet and social media usage are as follows:

> *"For example, I often search for knowledge about bones on the internet. I wonder what will happen if we do sports, and I often look at such things."'* Tahsin (male student)

> *"I follow social media sites that share daily menus or exercise programs. For example, they suggest what to eat and what exercises to do for the day."* Yaren (female student)

> *"I was very obsessed with aerobic exercises. I watched videos on YouTube, such as rope skipping and cross-jumping."* Ayşe (female student)

According to some students, they often use the internet or social media to obtain HRFK. However, they have encountered instances where the HRFK they obtained was incorrect. As a result, they felt the need to verify the reliability of the HRFK they obtained from these platforms. They did this by consulting their coaches and seeking confirmation of the validity of the HRFK. Only after their coaches confirmed the accuracy of the HRFK did students begin to apply it to their lives. Some of the student quotes on this matter include:

> *"'I have received incorrect knowledge from the internet; for example, I have come across articles such as "You should push yourself too hard during exercise." But I asked my coach, and he warned me that this knowledge is not correct. He advised me that one should not continue exercising when having a hard time."* Tahsin (male student)

After analyzing the factors that influence students' participation in physical activity, it was found that personal curiosity is the most significant reason. Students with higher HRFK and ESC find participating in physical activity enjoyable and tend to incorporate them into their daily routines. Furthermore, they also expressed their interest in continuing sports or physical activity.

> *"'I am interested in every type of sport. Very rarely do sports seem boring to me; I don't know, I like volleyball and basketball, I love them all, and I'm curious; I want to join."*
> Halime (female student)

"Maybe I can be a basketball player or a swimmer in the future because I love it so much. I want to be selected for the NBA in basketball, for example, and I also want to be a professional athlete." Arda (male student)

Unlike their peers in other groups, the students in this particular group stated that their current HRFK positively impacted their exercise participation. Moreover, their high level of HRFK also positively impacted their intention to exercise. These students were more conscious about exercising than their peers in other groups. For example, a student who knew that he needed to take 10,000 steps a day mentioned that he walked longer on his way home from school as follows:

"My biggest problem is my weight. After leaving the school, I knew I had to take ten thousand steps a day to maintain my health. Although they (his family) were coming to pick me up by car, I decided to take the long way home instead of taking a ride. That's why I refused the ride and started walking towards home." Birce (female student)

Results from the Group of Students With the Lowest ESC Level and Highest HRFK Level

In the focus group interview with the group of nine students who had the lowest ESC level despite the highest level of HRFK, it was found that these students did not participate in regular exercise and did not participate in any physical activity or sports outside of physical education and sports classes at school. They learned about HRFK from television, science teachers, and social media. The students said they disliked participating in physical activity because they thought their skill levels were insufficient. However, these students had high academic expectations and were academically successful. In this group, science teachers played a significant role in imparting HRFK. The students in this group were academically successful at school, and it was seen that the role of the coach in the first group was taken by the science teachers at the school in this group. A related student quote was as follows:

"I learned about the human body in my science class, including knowledge about heartbeats, muscles, and bones." Kemal (male student)

"Here (referring to the knowledge test) it says heartbeat, I heard this in science classes." Tamer (male student)

Additionally, students in this group stated that they obtained their HRFK from television. They stated that they constantly follow some sports channels and update their knowledge through these channels. The internet was another source of HRFK for these students. Even though the students did not participate in physical activity, they said they

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followed famous athletes and sites related to physical activity on the internet. They could access topics that they were curious about via the internet. Student quotes on the subject are as follows:

> *"There are some websites or applications related to sports, I download them to my phone and get them from there."* Kemal (male student)

> *"Whenever I hear things I'm curious about or words I don't know about this subject, I look them up on the internet."* Gamze (female student)

> *"There is a channel called Bein Sports, they talk about all kinds of sports there, I follow it there or watch movies about sports."* Kemal (male student)

When the physical activity participation of the students in this group was analyzed, it was found that the students were reluctant to participate in physical activity or sports. Students perceived their skill levels as lower than their peers. That is why they wanted to avoid participating in physical activity or sports, including physical education classes. Student quotes regarding this are as follows:

> *"I don't think I'm talented. Come on, watch me for 5 minutes and you'll see me... I mean, there are people better than me, I'm not the best at anything, so I don't want to participate."* Aslı (female student)

> *"I don't participate in physical activity much because I don't like it. I can't do it anyway."* Gamze (female student)

In addition, these students thought their families or teachers did not guide or support them regarding physical activity or sports participation. These students, who had high academic expectations, did not participate in physical activity or sports because they feared their academic success would decrease.

> *"I was going to join the school team, my physical education teacher said don't be a disgrace, he said you are not practicing, he said practice and come. I didn't participate to avoid embarrassment."* Bartu (male student)

> *"I'm very busy, there is an exam next year, and my mother is against it, so I can't attend because it might affect my exams."* Kemal (male student)

Results From the Group of Students With the Highest ESC Level and the Lowest HRFK Level

After conducting focus group interviews with six students who had the highest ESC, it was found that all of them were male and had the lowest level of HRFK. However, they all regularly participated in physical activity or sports outside of school for four to seven days a week. Five students attended the football club, while one regularly exercised in the fitness centre. It was noticed that the primary motivation for participating in physical activity was to improve their sporting abilities. It was noted that coaches in sports courses and the internet were the primary sources of HRFK for this group. Unlike the first group, it was worth mentioning that none of the students in this group had family members who regularly engaged in sports or physical activity. This group of students in the study consisted only of male individuals interested in either football or fitness. Their coaches provided them with exercise training principles to enhance their sports performance. However, unlike the first group, students in the third group did not need to know about HRFK. This knowledge was essential in promoting their conscious participation in exercise.

During the interviews, it was found that most students in this group attend football clubs outside of school. They relied on their coaches in these clubs for the current HRFK. However, it was concluded that the students in this group primarily received HRFK from their coaches regarding performance improvement, skill, and technical training rather than HRFK. It is thought that their HRFK is inaccurate because some of the HRFK they obtained from their coaches is incorrect. Because their coaches placed more emphasis on performance than HRFK, the students in this category were currently taught false HRFK. The following are quotes from students about the topic:

> *"My coaches give place-keeping or tactical HRFK in training. He says you lack speed, accelerate faster, etc. When you get home, make 2000 passes and run for 1 hour. It mostly gives HRFK to improve your performance in football."* Kazim (male student).

> *"In gyms, they say, this weight is high, do it with less, do it slowly. For example, if you lift 7.5 kg dumbbells in the gym, he tells you to lift 10 kg dumbbells by placing your knees on the floor. There is a movement called dumbbell; everyone is doing wrong but it shows them right. He told me to take additional nutrients as the training increased (protein powder). He tells or shows how to do the movement correctly or well, so there is not much knowledge about health, so mostly technical knowledge is given."* Hasan (male student)

It was seen that the students in this group also used the internet and social media as sources of knowledge, but they mostly gained HRFK about football from the Internet. Instead

of HRFK, they learned about teams and athletes from social media. Student quotes on the subject are as follows:

> *"For example, I look at photos while browsing Instagram. Galatasaray beat 3-1. There are caps about Fenerbahçe, I see funny things."* Mustafa (male student)

> *Results from the Student Group With the Lowest ESC Level and HRFK Level:*

After conducting a focus group interview with six students with the lowest ESC level and HRFK at the school, it was discovered that these students lacked interest and curiosity in physical activity and sports. They mentioned that they only participated in physical activity during physical education classes. It was also found that these students were passive in physical education lessons and wanted to avoid participating. They did not put in any effort to gain HRFK and were not supported by their families or teachers to learn or participate in the exercise. Additionally, their physical education teachers stated that their participation in physical activity in the lesson could have been higher, and their academic success in other courses was below average. Student quotes on the subject are as follows:

> *"I have concluded that you do not participate in much regular exercise. Can you tell me a little about the reasons for this? Why don't you join"* (interviewer)

> *"I don't like doing sports, I did it when I was a child and I don't like it now."* Esra (female student)

> *"I do not like."* Ahmet (male student)
> *"'Do physical education teachers at school support your participation in exercise or sports? How?"* (interviewer)
> *"No, he doesn't support me."* Esra (female student)
> *"Do your families support your participation in exercise or sports? How?"* (interviewer)
> *"No, they don't support me."'* Murat (male student)
> *"No"* Ahmet (male student)

DISCUSSION

The first group of students with the highest ESC and HRFK were found to have positively transferred this knowledge to their daily lives, which increased participation in physical activity. The study also found that these students regularly engaged in physical activity outside school. Studies connected with this finding indicate that HRFK positively

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influences lifelong physical activity (Haslem et al., 2016). The students in the first group acquired their HRFK from various sources such as coaches, family, internet, and social media. Although these students use the internet and social media to obtain HRFK, as revealed in other studies in the literature (Daum, 2020; Yılmaz et al., 2022), they made sure to confirm the reliability of their knowledge by having their coaches validate the HRFK. This group of students was distinguished from others by the support they received from their families, especially fathers, in adopting healthy and active lifestyles. The study also found that social support perceived by family members, particularly fathers for boys and mothers for girls, is positively related to students' participation in physical activity. When studies in the literature were examined, it was revealed that the social support perceived by family members (King, Wilson, & Tergerson, 2008) and the social support perceived by girls from their mothers and boys from their fathers are related to students' participation in physical activity (Ay, 2019). These findings are significant as they shed light on the importance of reliable sources of HRFK and the role of family support in promoting physical activity.

The second group of students comprised individuals with high levels of ESC but low HRFK. Studies have shown that having HRFK does not necessarily lead to increased exercise participation (Placek et al., 2001). Similarly, despite the fact that the students in this particular group had a high level of HRFK, their intention to participate in exercise was still quite low. Based on the findings, it can be concluded that HRFK alone is insufficient to increase exercise. The students in this group usually acquire HRFK from the internet, social media, science courses or their teachers. Unlike other groups, these students obtain HRFK with academic expectations, mostly in science classes. Health gains are incorporated in physical education curricula and other courses such as science (MoNE, 2018). The students in these courses gained HRFK from their teachers, but this knowledge alone did not lead to developing active and healthy lifestyle habits. By structuring physical education lessons well, students can develop active and healthy lifestyle habits (Harris & Cale, 2018). Because a well-designed physical education course, in addition to improving students' lifelong participation in physical activity (Tannehill et al., 2013; Yilmaz & Hunuk, 2022), can develop the necessary knowledge and skills for maintaining a healthy lifestyle (Sun et al., 2012).

The students in the third group had a remarkable feature. They had low HRFK but high ESC. These students were all boys interested in licensed football clubs outside of their school. Their participation in physical activity was solely to enhance their sports performance. The primary sources of knowledge for these students were their coaches in football clubs and the Internet. However, the HRFK they received from these sources may not always be accurate

and is mainly related to performance-based. Therefore, it can be concluded that HRFK alone cannot increase physical activity levels (Jayakumar et al., 2023). According to the findings in this study, relying on coaches and the accuracy of online resources for HRFK may lead to performance-orientated knowledge, neglecting the health aspects of HRFK. While HRFK is necessary, it alone does not guarantee increased physical activity. A more holistic approach that integrates health education with performance training may be required to promote healthier lifestyles among students.

The fourth group of students had low HRFK and ESC, and they did not try to acquire it. Like the second group of students, they felt that they did not have enough skills to participate in physical activity and, therefore, did not enjoy them. In addition, they did not receive support from their families or teachers to participate in physical activity. Students in both the second and fourth groups had low intentions to participate in physical activity because they felt they lacked the skills to do so. Studies have shown that physical self-perception is associated with physical activity (Makar, 2016). Unlike the students in the first and third groups, the students in the second and fourth groups did not participate in sports clubs outside of school. Physical education was the primary source of HRFK for these students. However, the fact that the courses were not structured according to the student's needs could prevent these students from developing an active and healthy lifestyle. A well-structured physical education course is known to positively influence students' active and healthy lifestyles (Cale, 2020; Pot, Whitehead, and Durden-Myers, 2018). Physical education teachers should not only structure their lessons with inclusive and varied teaching methods for all students. They should also provide students with satisfying, enjoyable, and meaningful learning environments. To encourage participation in physical activity and support lifelong physical activity habits, it is essential to personalise students' physical activity experiences and provide learning environments that are aligned with their interests (Gillies & Boyle, 2010). One of the distinguishing features of the fourth group of students was the absence of social support from their families or physical education teachers for physical activity, similar to the second group of students. These findings support existing literature highlighting the relationship between physical activity and perceived social support (King et al., 2008). Therefore, physical education teachers have the responsibility to help students become more physically active and to create lesson environments that increase their commitment to an active lifestyle (Cale, 2020). To achieve this, teachers need to be aware of the different needs and interests of students (Gillies & Boyle, 2010) and approach lessons in a more holistic way.

The findings of this study align with the Theory of Planned Behavior (TPB), which posits that behaviour is influenced by attitudes, subjective norms, and perceived behavioural control (Ajzen, 1985). In the context of physical activity, students' attitudes towards exercise are shaped by their HRFK. At the same time, the social support they receive from family and coaches reinforces subjective norms. For example, students in the first group, with high ESC and HRFK, exhibited positive attitudes and higher engagement in physical activity, supported by strong family involvement, particularly from fathers, as highlighted by King et al. (2008) and Ay (2019). On the other hand, students in the second and fourth groups, with low ESC and limited social support, lacked the motivation and perceived ability to exercise regularly, underscoring the importance of perceived behavioural control (Gillies & Boyle, 2010). This indicates that interventions aimed at enhancing HRFK should simultaneously target the development of supportive environments and positive attitudes towards exercise, consistent with TPB-based strategies that emphasize linking intention to action through education and social support (Park et al., 2009; Dermatis et al., 2023).

Limitations

This study has several limitations that should be acknowledged. Firstly, the research was conducted in a single secondary school in a specific region, which may limit the generalizability of the findings to other schools or areas with different socio-economic and cultural characteristics. Secondly, the study relied on self-reported data for assessing ESC and HRFK, which may be subject to social desirability bias or inaccuracies in students' responses. Thirdly, the study's cross-sectional design does not allow for conclusions about causality between ESC and HRFK. Future research could address these limitations by employing longitudinal designs, expanding the sample size and geographical scope, and incorporating objective measures of physical activity and HRFK.

CONCLUSION

It has been found that the needs and expectations of individuals vary based on the group they are associated with. Notably, students in groups 1 and 3, who exhibit the highest ESC, share a common trait of engaging in regular physical activity outside school. Furthermore, students who have high HRFK receive significant support from their families, particularly their fathers, whereas those with limited HRFK lack such support. Those with robust HRFK seek HRFK from reliable sources such as coaches, families, and the internet. In

contrast, individuals with limited HRFK often do not verify the accuracy of the HRFK they receive and tend to prioritize sports performance over HRFK.

There were notable differences between students with low HRFK in the second and fourth groups and those with high HRFK. The main differentiating factor was that those with high HRFK gained it through academic-focused science lessons. However, simply possessing high HRFK did not necessarily translate to active and healthy habits in life. The students in both low ESC and high groups struggled to develop habits related to physical activity and often did not feel confident enough to participate in it. They also needed more social support from their families and teachers, discouraging them from being active. These students typically only participated in physical activity during physical education lessons. However, even then, the classroom environment needed to be more inclusive for all student groups to develop active and healthy living habits. This study contributes to the literature by revealing distinct behavioral patterns across different student groups, underscoring the necessity for educators to adopt targeted strategies that address the diverse needs of students. We propose several recommendations for researchers, practitioners, and educators in light of the study's findings. Researchers are encouraged to explore the impact of social support from family and peers on students' HRFK and their progression through the ESC. They should also investigate the obstacles faced by students in lower ESC groups in terms of motivational factors and the influence of social and environmental contexts.

PRACTICAL IMPLICATIONS

Practitioners are urged to prioritize disseminating accurate HRFK by ensuring that evidence-based HRFK is readily available to students, particularly those in lower ESC groups, through reputable community and school programs. A group of secondary school students, especially those participating in physical activity or sports outside of school, acquire the related HRFK from their coaches. Therefore, physical education teachers should establish direct communication with these coaches to enhance the quality of students' participation in physical activity and to stay updated with the latest knowledge. Educators are advised to create inclusive physical education environments where all students feel empowered to participate in physical activity. Additionally, they should integrate academic content with practical applications to emphasize the importance of health over performance.

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Authors' Contribution

Both authors contributed equally to all parts of the study.

Declaration of Conflict Interest

There is no conflict of between the authors.

Ethics Statement

This research was found ethically appropriate with the decision of Pamukkale University of Applied Sciences Ethics Committee (30.05.2018, 11).

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Research Article

Effect of Bodyweight Squat Exercise With Blood Flow Restriction on Sprint and Jump Performance in Collegiate Soccer Players

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ABSTRACT

This study investigated the effect of bodyweight squat (BWS) with blood flow restriction (BFR) exercise on sprint and jump performance in collegiate male soccer players. Twenty-four male collegiate soccer players (age: 19.3±1.0 years; height: 178.8±5.8 cm; body mass: 73.5±10.7 kg) were randomly divided equally into BFR or control groups. The BFR group performed BWS with BFR, while the Control group performed BWS without BFR 3x/week for eight weeks on nonconsecutive days. Both groups performed BWS for 30-15-15-15 repetitions with 30-second rest between sets (with continuous BFR pressure between sets). Limb occlusion pressure (LOP) was measured in a supine position after 10 min of passive rest by the automated device. Progressive overload was achieved by increasing LOP % weekly. The pressure was set at 60% LOP for the first four weeks and then was increased to 70% LOP for weeks 5 and 6 and then to 80% LOP for weeks 7 and 8. Countermovement jump (CMJ) and 30m sprint performance were assessed before and after the exercise program. No statistically significant differences between groups were identified. Both groups significantly increased sprint and CMJ performance (p<0.05). BFR and control groups increased jumping performance by 7% (ES: 0.55) and 2% (ES: 0.13), respectively. As for sprint performance, BFR and control groups increased by 5% (ES: 1.53) and 3.5% (ES: 1.14), respectively. In conclusion, the BFR group showed a larger effect size for sprint performance, suggesting that BFR may have a moderate to large effect on performance.

INTRODUCTION

Athletes continuously seek a competitive advantage to improve performance in many challenging sporting environments. Enhancing muscular power, speed, and injury recovery is the highest priority. Professional organizations such as the National Strength and Conditioning Association (NSCA) and the American College of Sports Medicine (ACSM) recommend resistance exercise at 65% or more of one repetition maximum (1RM) to promote muscle strength and hypertrophy (Haff & Triplett, 2016; Ratamess et al., 2009). Blood flow restriction (BFR) training can be a good alternative training method for athletes, patients, or elderly individuals who cannot work with heavy loads or exert the desired level of effort (Wortman et al., 2021). Low loads reduce mechanical stress on joints and bones (Loenneke et al., 2012), which is especially useful for groups unable to lift heavy loads, as in the case of clinical rehabilitation. Furthermore, BFR training can be performed safely with 20–30% of 1RM when compared to conventional high-load resistance training (HL-RT; Burgomaster et al., 2003; Patterson et al., 2019).

Blood flow restriction (BFR) training is a type of exercise where a pneumatic tourniquet device is used to create a partial arterial occlusion in the most proximal muscles (Rolnick et al., 2021). The reduction in oxygen supply to the muscles activates high threshold motor units responsible for muscle growth, leading to improvements in muscle building (Spranger et al., 2015). The use of BFR during resistance training at low loads (20-40% 1RM) has been shown to improve muscular strength and hypertrophy both in recreationally trained males and professional soccer male players (Kamiş et al., 2024; Korkmaz et al., 2022). Research revealed that this type of exercise produced comparable muscle growth with conventional resistance training even though individuals in BFR training only employed 20–40% of their 1RM (Fabero-Garrido et al., 2022). Numerous research demonstrates that BFR can be an effective means of stimulating hypertrophy in both the upper and lower limbs across a variety of populations, when compared to traditional resistance training (Bjørnsen et al., 2019; Bowman et al., 2020; Centner et al., 2019; Hughes et al., 2019; Wang et al., 2023).

Furthermore, studies demonstrate that using autoregulated pressure applications during BFR exercise can improve performance while reducing discomfort, effort, and delayed onset muscle soreness. Moreover, autoregulated pressure applications reduce the risk of adverse events in both the 30-15-15-15 reps scheme and failure protocols (Ewoud et al., 2023). Autoregulated cuffs in BFR devices are designed to accommodate changes in thigh circumference due to muscular contraction. These cuffs adjust pressure during exercise, preventing excessive intramuscular pressures and hypoxia, which can lead to less delayed

onset muscle soreness (DOMS) compared to non-autoregulated devices (Dancy et al., 2023; Rolnick et al., 2023). Research suggests that autoregulated BFR devices have a lower adverse event rate than non-autoregulated ones, making them well-tolerated and safe for training protocols (Dancy et al., 2023). Therefore, using an autoregulated BFR device can enhance performance with less discomfort and exertion.

Resistance training with high loads (70% 1RM) is superior to low loads (20-30% 1RM) for maximizing strength (Schoenfeld et al., 2015). However, it has also been revealed that BFR combined with low-load resistance training (LL-RT) can lead to strength improvements similar to that of HL-RT (Grønfeldt et al., 2020; Loenneke et al., 2012). Although using significantly lighter loads, applying BFR during training may produce muscular growth and strength responses similar to those seen following conventional HL-RT (Yasuda et al., 2011). Team sport athletes may be able to enhance muscular growth without significantly higher training demands by incorporating low-load BFR exercise, which has been identified to increase muscle size and strength (Scott, 2014; Scott et al., 2016). For instance, a study on young soccer players found that BFR training improved knee extension strength and quadriceps muscle size (Korkmaz et al., 2022). Improving players' specific and essential athletic characteristics unique to their sport is the main objective of strength training in any sport. Research has shown that low to moderate-intensity resistance exercises with BFR may produce adaptations comparable to high-intensity resistance training and considerably similar muscle size and strength gain (Madarame et al., 2008; Moore et al., 2004; Takarada et al., 2000; 2002).

Although most BFR research has been done on healthy subjects, studies including athletes have revealed comparable performance advantages (Abe et al., 2005; Manimmanakorn et al., 2013; Yamanaka et al., 2012). Notably, this increase in muscle hypertrophy has led to better performance in acceleration and sprinting activities (Abe et al., 2005; Cook et al., 2014) and in change of direction, aerobic shuttle run, and muscular endurance tests (Manimmanakorn et al., 2013). BFR training may also increase lower-body power production (Cook et al., 2014). However, little is known about the potential benefits of bodyweight exercise combined with BFR training for sports-related performance (Abe et al., 2005; Madarame et al., 2011; Scott et al., 2017). With respect to some clinical situations, high mechanical loads might not be the most appropriate. Therefore, this study aimed to examine the impact of bodyweight BFR exercise on sprint and vertical jump performance in collegiate soccer players. We hypothesized that BWS exercise combined with BFR (via an autoregulated BFR device) would positively affect sprint and jump performance when compared to a bodyweight squat exercise without BFR in this population of collegiate soccer players.

METHODS

Research Design

We used pre- and post-test experimental designs to evaluate sprint and jump performance. This research was carried out during the preseason phase of the 2022-2023 season. Players underwent a two-day baseline measurement assessment at the start of the trial. On the first day, height, weight, and countermovement jump (CMJ) performance were evaluated, and on the second day, the 30m sprint performance was evaluated. Subjects performed a standardized warm-up protocol consisting of self-selected intensity jogging (5 minutes) and dynamic stretching exercises 5- 7 minutes (i.e., high knees, carioca) prior to all testing days, with all tests being performed in a university indoor athletic facility (Behm & Chaouachi, 2011; Pagaduan et al., 2012). Experimental research with pre-posttest was used to identify the effect of bodyweight squat exercise (BWS) on sprint and jump performance. After baseline testing, soccer players were randomly assigned to BWS with BFR group (BFR) or BWS without BFR (control). Forty-eight hours before and after the eight-week exercise program (3x/week), 30m sprint and CMJ performance were assessed.

Participants

Twenty-four male (age: 19.3±1.0 years; height: 178.8±5.8 cm; body mass: 73.5±10.7 kg) collegiate-level soccer players volunteered to participate in this study (Table 1). Athletes who were free of injury and did not show signs of or have a history of cardiovascular or blood clotting disorders were eligible to participate. Every participant gave written informed consent after noticing the objective of the study. The subjects trained together for the same squad and represented a variety of outfield positions: four attackers, ten midfielders, and ten defenders. Before each testing and training session, participants were instructed to refrain from engaging in vigorous activity outside team training for 24 hours. Participants also performed their regular soccer training team program during this period and were encouraged to continue their regular dietary and fluid intake routines throughout the study. A priori sample size calculation was performed using G-Power 3.1.9.7 (Dusseldorf, Germany) to determine the required sample size for an f-test via repeated measures ANOVA. The effect size used was f = 0.25 as a minimum effect, with an α significance level of p = 0.05 and a desired power level at 1-β = 0.80. The calculated sample size was found to provide an 81.57% chance of effectively rejecting the null hypothesis of no difference in the variables studied. Ethical approval was obtained by the Gazi University ethics committee (2022 – 932/E-77082166-604.01.02-417889).

Data Collection Procedure

Anthropometric assessment. On arrival at the laboratory for the first visit, participants' height and weight were measured using a digital scale (Seca 813, UK) to the nearest 0.1 kg. and a stadiometer (Seca model 213, Germany) with a precision of 5 mm.

30m Sprint Performance Test. Participants warmed up before the performance tests by performing self-selected intensity jogging and sport-specific dynamic mobility exercises. 30m sprint assessment was conducted in an indoor sports hall. Participants began in a split stance behind a starting line and, when ready, sprinted as fast as possible until crossing the finish line. All tests were measured with a wireless electronic photocell (Seven Electronic Hardware & Software, Türkiye). Subjects performed two trials of the 30m sprint and the best result was recorded for the analysis (with a three-minute rest between trials; Haff & Triplett, 2016).

Countermovement Jump (CMJ) Test. A Fitjump (vertical jump performance test device; Sporsis, Afyonkarahisar, Türkiye) was used to assess CMJ performance, peak power, velocity, and flight time (Yıldız & Fidan, 2020). Participants completed two CMJ trials after performing the warm-up. They were encouraged to jump as high as possible for each jump (Haff & Triplett, 2016). Participants were instructed to move quickly and continuously in one constant movement from a standing posture (without arm swings) to a self-selected depth while performing the downward phase of the CMJ. Each participant completed two trials (with a one-minute rest between trials), and the maximum CMJ height (cm) was recorded for analysis.

Bodyweight Squat (BWS) Exercise. The duration of the BWS session lasted 7.5 minutes for both groups. BWS tempo was normalized by a metronome (MAD-Up Pro BFR device has an integrated metronome feature) with a 2-0-2-0 tempo (30 BPM), represented by a two-second eccentric and two-second concentric phase. BFR groups performed BWS with an automatic personalized tourniquet BFR device (MAD-Up Pro, France). Limb occlusion pressure (LOP) is the minimum amount of pressure that is required to fully occlude the blood flow (Patterson et al., 2019). LOP was measured in a supine position after 10 min of passive rest. LOP was recorded by the automatic BFR device (MAD-up pro, France) for both legs (Figure 1). BFR cuffs were attached to the most proximal part of the lower extremity. The cuff width was 10.5 cm, and the length was 75 cm. Progressive overload was achieved by increasing LOP % weekly. For the first four weeks, LOP% was set at 60%, the 5th-6th weeks increased to 70%, and in the last two weeks (7th-8th weeks) the pressure increased to 80% of LOP. LOP was recorded for the entire session (24 sessions) for both the right and left leg. Control groups performed BWS without BFR cuffs with the same tempo (2-0-2-0).

Figure 1
Bodyweight Squat With Blood Flow Restriction and the Applied Cuffs

Statistical Analyses

To evaluate the effects of predictors (fixed effects) such as intervention (0 = BFR, 1 = control), training experience, and time on countermovement jump, sprint, peak power, velocity, and flight time, the generalized mixed model (GMM) statistic was used. The participants were considered a random effect in the model (West et al., 2007). Using participants as a random effect was based on theory, as individuals differed in the training experience. Akaikes's information criterion (AIC) statistic was used to assess model fit. The model diagnosis was used to identify assumptions and use of the GMM. Residuals were analyzed to determine outliers or potentially influential observations. Additionally, the covariance structure used for the analysis was unstructured. After verifying the statistical significance of the effects of interventions, time, and intervention*time interaction, Bonferroni's post-hoc test was used. The GMM statistic was chosen because violations in the homogeneity of the regression slopes and independence are verified for General Linear Models (GLM) type statistics in repeated measures designs. For comparisons between groups, an independent t-test was applied. Pre/post effect sizes (Cohen's d) were calculated with the following formula: ([post mean – baseline mean]/baseline SD) and interpreted as trivial (0-0.19), small (0.20-0.49), medium (0.50-0.79) and large (0.80 and more significant; Cohen, 1988). All data are represented as mean ± standard deviation. The significance level adopted in this study was $p \leq 0.05$, and the software used for all analyses was SPSS 20.0 (SPSS Inc., Chicago, IL, US).

RESULTS

Baseline Participant Characteristics

Table 1 shows the differences between the BFR and control groups. No statistically significant differences between groups were observed in terms of age, height, weight, training experience, or BMI. However, although normality was verified for training experience during exploratory analysis, outliers were confirmed. Training experience was used as a predictor variable during statistical analysis and considered a random effect during analysis.

Table 1
Baseline Characteristics Between Groups

Variables	BFR Mean ± sd	Control Mean ± sd	p
Age (years)	19.25 ± 0,86	19.42 ± 1.24	0.70
Height (cm)	178.50 ± 7.03	179.00 ± 4.51	0.83
Body mass (kg)	73.67 ± 11.45	73.33 ± 10.31	0.94
Training experience (years)	2.92 ± 0.99	3.17 ± 0.83	0.51
BMI (kg/m²)	23.09 ± 3.20	22.87 ± 3.09	0.86

Note. Sd: Standard deviation; BFR: Blood flow restriction; data are presented as mean and standard deviation

Countermovement Jump (CMJ) performance

There was no statistically significant difference in CMJ height for treatment $F (1, 20.95) = 0.11$; and group*time interaction $F (1, 22.00) = 4.13$; was verified. A statistically significant difference in CMJ was observed for time $F (1, 22.00) = 14.30$; $p = 0.001$ and training experience $F (1, 21.00) = 36.38$; $p = 0.001$. An increase in one unit of training experience is responsible for increasing a standardized β of 4.22 units in CMJ. Post-hoc differences between pre- and post-treatment (mean difference of 1.59; $p = 0.001$) were observed.
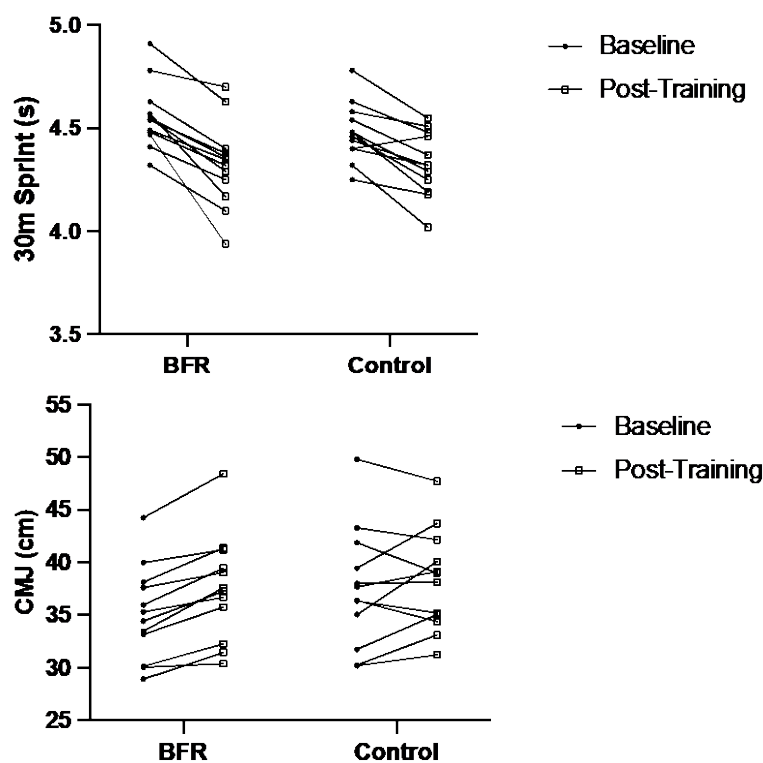
30m Sprint Performance

There was no statistically significant difference in sprint times for treatment $F (1, 20.92)$, training experience $F (1, 21.00) = 2.13$, and group*time interaction $F (1, 22.00) = 3.14$. A statistically significant difference in sprint times was observed for time $F (1, 22.00) = 68.74$; $p = 0.001$. Post-hoc differences between pre- and post-treatment (mean difference of -0.193; $p = 0.001$) were observed.

Table 2
Comparison of Sprint and Jump Performance

	BFR		ES	Control		ES	p		
	Baseline	Post		Baseline	Post		Group	Time	G*T
CMJ (cm)	35.11±4.46	37.57±4.98	0.55/M	37.50±5.68	38.24±4.76	0.13 /T	0.734	0.001*	0.054
Flight Time (ms)	516.92±32.85	541.75±36.55	0.75/M	526.33±46.48	534.08±36.52	0.16 /T	0.511	0.003*	0.088
Peak Power (W)	3374.49±471.80	3561.93±494.39	0.39/S	3365.74±367.42	3449.41±303.07	0.22 /S	0.512	0.001*	0.135
Velocity (cm/s)	176.27±19.46	189.92±25.90	0.70/M	186.24±30.54	191.72±23.53	0.17 /T	0.904	0.002*	0.140
30m (s)	4.55±0.15	4.32±0.20	1.53/L	4.48±0.14	4.32±0.15	1.14 /L	0.696	0.000*	0.090

Note. $*p \leq 0.05$ Data are presented mean ± standard deviation; CMJ: Countermovement jump; BFR: Blood Flow Restriction; ES: effect size; S: Small, T: Trivial, M: Medium, L: Large; G*T: Group Time Interaction

Figure 2
Graphical Presentation of Sprint and Jump Performance

Power and Velocity Performance

There was no statistically significant difference in muscular peak power output for treatment $F (1, 21.00) = 0.44$; $p = 0.51$, training experience $F (1, 21.00) = 4.04$; $p = 0.057$ and group*time interaction $F (1, 22.00) = 2.41$; $p = 0.135$ was verified. Also, for time $F (1, 22.00) = 16.47$; $p = 0.001$, a statistically significant difference in power production was observed. Post-hoc differences between pre- and post-treatment (mean difference of 135.55; $p = 0.001$) were observed.

Figure 3
Graphical Presentation of Velocity and Power
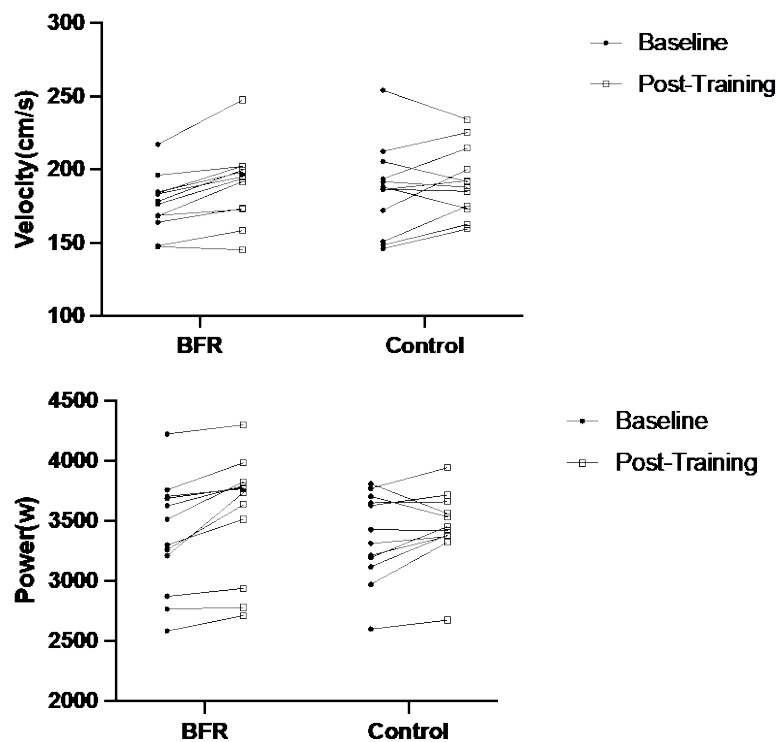
No statistically significant difference in velocity for treatment $F_{(1, 21.00)} = 0.11$ and group*time interaction $F_{(1, 22.00)} = 2.34$ was verified. A statistically significant difference in velocity was observed for time $F_{(1, 22.00)} = 12.84$; $p = 0.002$ and training experience $F_{(1, 21.00)} = 30.29$; $p = 0.001$. Increasing one unit of training experience is responsible for increasing a standardized β of 20.32 units in velocity. Post-hoc (pairwise comparisons) differences between pre-and post-treatment (mean difference of 9.56; $p = 0.002$) were observed.

No statistically significant difference in flight time for treatment $F_{(1, 20.70)} = 0.44$ and group*time interaction $F_{(1, 22.00)} = 3.18$ was verified. Also, a statistically significant difference in flight time was observed for time $F_{(1, 22.00)} = 11.59$; $p = 0.003$ and training experience $F_{(1, 21.00)} = 30.27$; $p = 0.001$. An increase in one unit of training experience is responsible for increasing a standardized β of 31.88 units in flight time. Post-hoc (pairwise comparisons) differences between pre-and post-treatment (mean difference of 16.29; $p = 0.002$) were observed.

DISCUSSION

The current research investigated the effect of BWS with BFR on sprint and vertical jump performance in collegiate soccer players. The primary conclusions of this study suggest that BWS with BFR has a similar effect when compared with only performing BWS in terms

of sprint and jump performance after eight weeks of training. The BFR group improved their CMJ and sprint performance by 7% and 5%, respectively, while the control group improved their sprint and jump performance by 2% and 3.5%, respectively, although effect estimates were favorable to BFR exercise (Table 2). Therefore, both exercise techniques may be an effective strategy to enhance jump and sprint performance, as there were no statistically significant differences between the groups.

A previous study identified that bodyweight exercise with BFR can elicit an acute improvement in jumping performance (Doma et al., 2020). Based on these findings, the authors suggest that lunge exercise with BFR may be an alternative strategy for warm-up protocols involving high-load exercise. Our study aimed to identify whether BWS with BFR could improve 30-meter sprint and jump performance in collegiate soccer players. The results identified in our study support performance improvements after the exercise program with BFR; however, this effect was also identified in the control condition (BWS without BFR). Although the CMJ and sprint performance increase were independent of groups, it tended to be more prominent in BWS with BFR group than in Control.

The results reported in the present study contradict those reported by Madareme et al. (2011). The authors identified no improvements in jumping performance after ten weeks of LL-RT with or without BFR. Unlike the current study, the authors used 30% of 1-RM as overload in a fixed repetition scheme. Additionally, they adopted arbitrary pressures (200-250 mmHg) (Madarame et al., 2011). These aspects may have contributed to the higher neuromuscular fatigue imposed in the study by Madarame et al. (2011), which may have resulted in null effects on jumping performance. Additionally, arbitrary pressures can generate variability in the level of BFR experienced by participants since LOP can be influenced by limb anthropometry (de Queiros et al., 2023). This aspect is of particular interest since BFR pressure can influence neuromuscular responses.

Although our results support improvement in the performance outcomes analyzed, this effect was not statistically significantly different from the control condition. However, we should point out that the effect estimates were more pronounced in the BFR condition. This effect may be due to neuromuscular adaptations elicited by BFR, primarily due to the methodological limitation in group allocation. We may conclude that the reason why both groups increased their performance is not only with BWS but also their regular soccer training program. Additionally, it can be argued that if the overall duration of 8 weeks of training were extended to 12+ weeks, those differences between conditions (favoring the BFR group) would continue to be pronounced.

Currently, several studies have investigated the effects of BFR training on sport-specific performance, such as jumpking (Abe et al., 2005; Horiuchi et al., 2018; Madarame et al., 2011) and sprinting (Abe et al., 2005; Behringer et al., 2017; Chen et al., 2021). However, there is a lack of research on the effects of bodyweight exercise with BFR on athletic performance, especially among team sports athletes. Longer BFR training durations might result in more considerable muscular hypertrophy and enhancements to jumping ability (Abe et al., 2005). The present study performed BWS exercise 3x/week for eight weeks (24 total sessions). However, a major contributor to not observing any advantages of BFR is that body weight is not enough external stimulus (especially for athletes). Therefore, using external load may help to observe improvements in outcomes. In contrast, Abe et al., (2005) did not find any improvement in standing jump performance among track and field athletes.

The present study reported no negative adverse side effects across the training intervention. We implemented autoregulated BFR. Autoregulation involves using a BFR cuff that automatically adjusts the pressure applied to the limb in conjunction with the phase of muscular action (Rolnick et al., 2023). When autoregulated (automatic) devices are used, the total pressure applied to the limbs is kept constant by inflating and deflating the cuffs during muscle contractions (Ewoud et al., 2023; Hughes et al., 2018). In a recent study investigating the autoregulation of applied BFR training pressures in physically active adults, the authors concluded that the autoregulation seems to improve safety and performance in both fixed (30-15-15-15 reps scheme) and repetitions to failure BFR training protocols compared to non-autoregulation (Ewoud et al., 2023).

Limitations

It is important to acknowledge that this research does have some limitations. First, subjects only used their body weight as resistance during the training sessions. We did not implement any additional load, and progressive overload was achieved by increasing LOP% weekly. Using additional loads based on 1RM performances would have been a good option. Secondly, we implemented a single type of exercise (squat); therefore, integrating different multi-joint (i.e., deadlift) and single-joint exercises (i.e., leg extension) can play an effective role in enhancing performance. Finally, the duration of the current training phase was only 8 weeks. Longer continuous durations with this training model could produce even more notable results.

CONCLUSION

The primary conclusions of this study suggest that BWS with BFR has a similar effect when compared with only performing BWS in terms of sprint and jump performance after eight weeks of training. The BFR group showed a more significant effect size for sprint performance, suggesting that BFR may have a moderate to significant effect on performance. Future studies should analyze the effect of exercise with autoregulated versus non-autoregulated cuffs on power measurements as well as extended durations and training protocols.

PRACTICAL IMPLICATIONS

The results of the present study indicate that BWS with BFR can elicit improvements in physical performance variables. BWS also elicits this effect without BFR, although the magnitude of adaptations may be more significant in the BFR condition. Both exercise techniques may be an effective strategy to enhance jump and sprint performance, as there were no statistically significant differences between the groups. Considering the possibility of other relevant adaptations, BWS with BFR may be a more viable option during reload weeks of a periodized training program or for return-to-play protocols for players rehabbing injuries.

Authors' Contributions

The first author contributed to conceptualization, methodology, project administration, formal analysis, visualization, writing - original draft, writing- reviewing and editing. The second author contributed to conceptualization, methodology, project administration, writing - original draft**.** The third, fourth and fifth authors contributed to visualization, writing - original draft, writing - reviewing and editing. All authors reviewed the results and approved the final version of the manuscript.

Declaration of Conflict Interest

The authors declared no conflicts of interest.

Ethics Statement

This research was performed following the Declaration of Helsinki and approved by the Gazi University ethics committees (2022–932/E-77082166-604.01.02-417889).

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