JOURNAL OF THEORY AND PRACTICE IN SPORT

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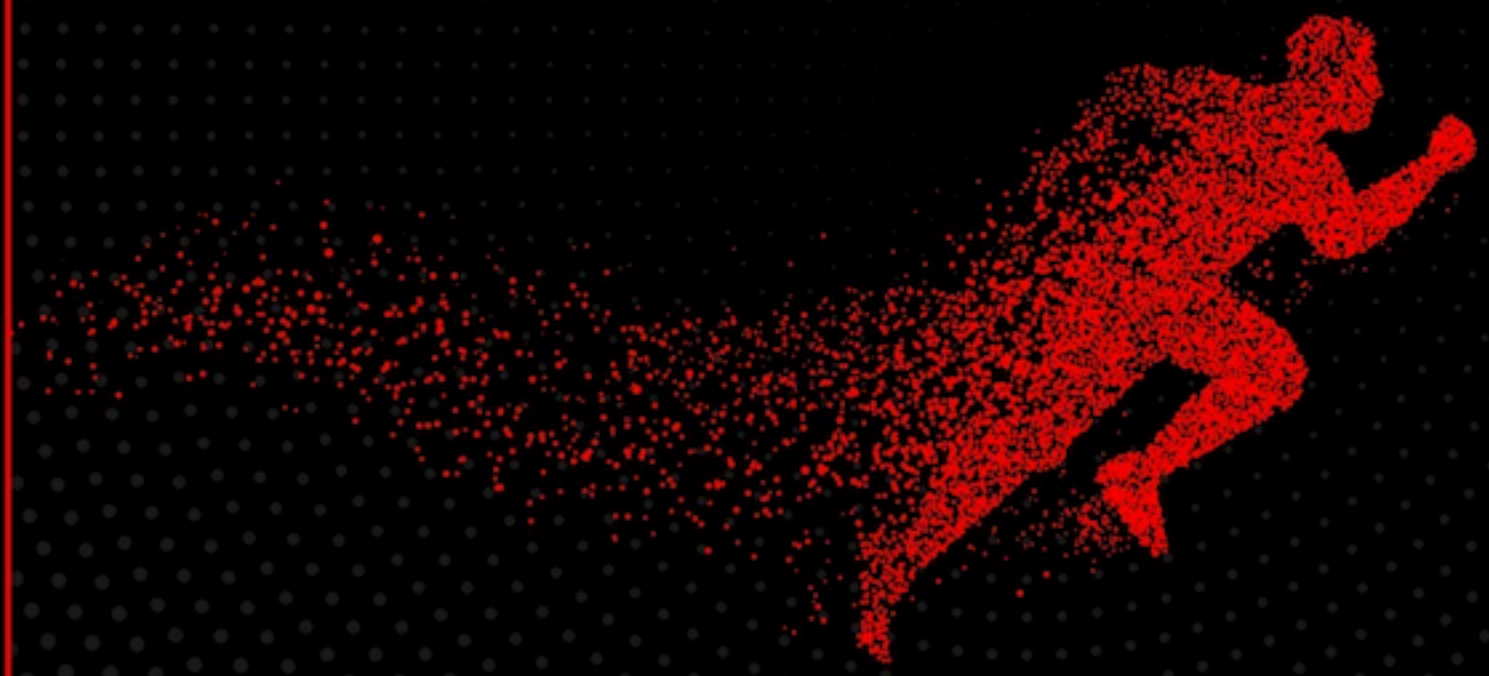
FACULTY OF SPORT SCIENCES



Volume 1
Issue 1

SPORDA TEORİ VE UYGULAMA DERGİSİ
JOURNAL OF THEORY AND PRACTICE IN SPORT
2022, Cilt 1, Sayı 1 / 2022, Volume 1, Issue 1

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Journal of Theory and Practice in Sport is published biannually; it is a scientific and peer-reviewed journal.
https://dergipark.org.tr/tr/pub/jtps

JOURNAL OF THEORY AND PRACTICE IN SPORT
Volume 1
Issue 1
December

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A study of lower-limb bilateral and unilateral strength asymmetry in Maltese sprinters using the modified sphygmomanometer test

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To cite this article: Magro, H. K., & Muscat-Inglott, M. (2022). A study of lower-limb bilateral and unilateral strength asymmetry in Maltese sprinters using the modified sphygmomanometer test. *Journal of Theory and Practice in Sport, 1*(1), 1-20.

Received: 29.08.2022

Accepted: 12.09.2022

Published: 25.12.2022

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A study of lower-limb bilateral and unilateral strength asymmetry in Maltese sprinters using the modified sphygmomanometer test

Abstract

In track and field athletics, sprint events require athletes to negotiate both straight as well as curved segments of the track. Athletes specializing in the longer sprints must thereby execute symmetrical as well as inherently asymmetrical movement patterns. Few studies have investigated lower-limb strength asymmetry in sprinters internationally, or indeed other factors related to the health and performance of sprinters in the specific case of Malta. This study aimed to explore the general state of affairs with regard to bilateral and unilateral strength asymmetries, specifically in Maltese sprinters, using the modified sphygmomanometer test as a convenient and low-cost method of assessment. We also tested a series of hypotheses investigating the effects on asymmetry of training age, running the curve and leg-dominance. The participants exhibited efficient hamstring to quadriceps strength ratios for sprinting, and generally stronger non-dominant hamstrings bilaterally. Running the curve and left- or right-leggedness did not have significant impacts on any form of lower-limb strength symmetry. There was some evidence to suggest that experienced sprinters may, to a limited degree, manage asymmetrical force production efficiently just where it matters the most. We also discuss the merits of sphygmomanometer testing in the context of purposive asymmetry-reducing neuromuscular control as a learned skill on the part of athletes and make recommendations for future research.

Keywords words: Lower-limb, Bilateral asymmetry, Unilateral asymmetry, Maltese sprinters, Modified sphygmomanometer test

Modifiye tansiyon aleti testi kullanılarak Maltalı kısa mesafe koşucularında alt ekstremite iki taraflı ve tek taraflı kuvvet asimetrisi üzerine bir çalışma

Özet

Atletizm atletizminde, sprint etkinlikleri, sporcuların pistin hem düz hem de kavisli kısımlarını aşmasını gerektirir. Daha uzun sprintlerde uzmanlaşan sporcular bu nedenle hem simetrik hem de doğası gereği asimetrik hareket kalıpları uygulamalıdır. Uluslararası düzeyde sprinterlerde alt ekstremite kuvveti asimetrisini veya Malta özelinde sprinterlerin sağlığı ve performansıyla ilgili diğer faktörleri araştıran çok az çalışma vardır. Bu çalışma, uygun ve düşük maliyetli bir değerlendirme yöntemi olarak modifiye tansiyon aleti testini kullanarak, özellikle Maltalı sprinterlerde iki taraflı ve tek taraflı kuvvet asimetrileri ile ilgili genel durumu araştırmayı amaçladı. Ayrıca antrenman yaşının asimetrisi, virajda koşma ve bacak hakimiyeti üzerindeki etkileri araştıran bir dizi hipotezi de test ettik. Katılımcılar, sprint için verimli hamstring - kuadriseps güç oranları ve genellikle iki taraflı olarak daha güçlü baskın olmayan hamstringler sergilediler. Eğriyi koşmak ve sol veya sağ bacaklı olmak, herhangi bir alt ekstremite kuvvet simetrisi üzerinde önemli bir etkiye sahip değildi. Deneyimli sprinterlerin, en önemli olduğu yerde, sınırlı bir dereceye kadar, asimetrik kuvvet üretimini verimli bir şekilde yönetebildiklerini gösteren bazı kanıtlar vardı. Ayrıca, atletler tarafından öğrenilmiş bir beceri olarak amaçlı asimetri azaltıcı nöromüsküler kontrol bağlamında tansiyon aleti testinin yararlarını tartışıyor ve gelecekteki araştırmalar için önerilerde bulunuyoruz.

Anahtar Kelimeler: Alt ekstremite, Bilateral asimetri, Unilateral asimetri, Malta sprinterleri, Modifiye tansiyon aleti testi

Introduction

Lower-limb asymmetry can be conceptualized either in terms of strength differences between legs (dominant versus non-dominant, or left versus right), or the hamstrings to quadriceps strength ratio in each leg. These are also referred to as inter- and intra-leg imbalances, respectively, or, bilateral and unilateral asymmetry. Where Q are the quadriceps and H the hamstrings, bilateral asymmetry would suggest an undesirable Q:Q or H:H discrepancy, while unilateral asymmetry would suggest an undesirable Q:H discrepancy (Maley et al., 2014). Based on the assumption that asymmetry is in fact undesirable, and is something to be minimized, some experts have recommended it not only be measured and identified, but also actively addressed using corrective training/conditioning programs (Zahálka et al., 2013; Maley et al., 2014; Girard et al., 2017; Tatlıcıoğlu et al., 2019; Pietraszewski et al., 2020).

There is a general lack of peer-reviewed literature on Maltese sprinters or other track athletes, and studies about lower-limb strength asymmetries in sprinters of any nationality, are also as yet rare. Furthermore, the studies on lower-limb asymmetry that do exist, have not yielded much of a meaningful consensus on key issues. For instance, using a spring-mass model based on observed kinetic and kinematic factors, Girard et al. (2017) found acceptable degrees of lower-limb mechanical asymmetry among athletes performing repeated hill sprints on a treadmill. They also did not observe any significant fatigue-induced increases in asymmetry. On the other hand, using electromyography (EMG), Pietraszewski et al. (2020) found that soccer players exhibited asymmetrical motor activity in the hamstrings and gluteus muscles during maximal sprinting.

These studies were focused on performances of the sprinting action itself, and it should be noted that literature on lower-limb asymmetry tends to take on either of two perspectives, that of observing kinetic and kinematic factors in functional, integrated or in-action performances (like sprinting, jumping landing, throwing, etc.), or force-production in isolated tests of strength (like knee extension/flexion tests). The two approaches imply various types of contributing neuromuscular phenomena. In other words, functional movement tests necessarily involve a degree of coordinated and controlled (or partially "inhibited") motor performance, while all-out force production tests by definition involve as little neuromuscular inhibition as possible.

Based on tests of maximal force production, which is referred to here simply as *strength*, evidence supporting any potentially ill effects of asymmetrical results, meanwhile, has so far been mixed. Sannicardo et al. (2017) reported a correlation between explosive strength and

balance performance, which would strongly suggest that greater symmetry would enhance, via improved balance, explosive capacity. Indeed, bilateral strength discrepancies have been linked with decreased performance in jumping or changing direction, particularly during maximal efforts (Bishop et al., 2016). However, Rutkowska-Kucharska (2020) conversely found no correlation between bilateral strength asymmetry and jump performance in athletes. While Coratella et al. (2018) similarly showed that in under-21 elite soccer players, short sprint performance was correlated with asymmetry in the hamstrings, they stressed that more research is needed, since the ability to produce maximal overall force was the more significant factor affecting performance in their study. Using a seven-test functional movement screen, Sannicandro et al. (2017) showed that while asymmetry may not have had a clear effect on the expression of maximal force, it nonetheless had an important role in submaximal actions like maintaining balance and performing safe movement patterns.

Looking at the link between asymmetry and performance from a different perspective, Beato et al. (2021) argued that among soccer players, bilateral and unilateral strength asymmetry may decrease in the professional ranks as opposed to non-professional. Fousekis et al. (2010) also specified that professional soccer players with more than 10 years of experience, expressed less bilateral asymmetry in their hamstrings. In track athletes, Mo et al. (2020) similarly found that bilateral asymmetry decreased as performance/experience level increased. So, despite relatively weak evidence supporting the link between performance and asymmetry, the findings of Beato et al. and Mo et al. imply that asymmetry nonetheless affects performance indirectly, since it ultimately differentiates higher- from lower-level performers. There are, however, likely additional extraneous factors mediating this relationship, reinforcing the need for further study in the area.

Apart from functional performance, some studies have investigated prospective links between various forms of asymmetry and injury. This evidence, however, also remains as yet unclear (Fousekis et al., 2010). Maulder et al. (2010) argued that increased risk of injury occurs when bilateral strength asymmetry exceeds 10%. Vaisman et al. (2017) similarly suggested that strength asymmetry should not exceed 15%, particularly if powerful movements are to be performed with the lower limbs during the rehabilitation process. In a systematic review of the literature, Helme et al. (2021) showed that out of 31 studies looking at strength asymmetry and its effects on injury risk, eight found no statistically significant association, 10 found only partial associations, and 10 actually reported significant findings. Given that positive findings

are probably more likely to be published, these numbers do not present a particularly strong case for any prospective significant association between strength asymmetries and injury.

Based on some of these key themes in the literature, and the central notion that asymmetry may have real-world implications for athletes either in terms of performance or injury outcomes, we aimed to survey the general state of affairs in terms of lower-limb strength asymmetry in Maltese sprinters by asking, first:

Q_1: What is the status of Maltese sprinters in terms of bilateral and unilateral lower-limb strength asymmetries?

And, building on the assertions of Beato et al. (2021) and Mo et al. (2020) regarding measurable changes in such asymmetry over time:

Q_2: Do bilateral and unilateral lower-limb strength asymmetries vary among Maltese sprinters as they become more experienced or seasoned?

Maltese sprinters are generally competitive at the GSSE (Games for the Small States of Europe), and less so at Commonwealth or Olympic level. For context in terms of standards, they could be classified outside Malta anywhere from the amateur level, up to a small number of competitors practicing at a semi-professional level. Nevertheless, asymmetry represents an important area of enquiry for sprinters, since they run either exclusively symmetrically on the straight portion of the track (as in the 100m), or both symmetrically and asymmetrically combined when the curved portions of the track are used (as in the 200m, 400m). As researchers have shown from their investigations of the specific biomechanics involved in running the curve (Chang & Kram, 2007; Alt et al., 2015), the action is inherently asymmetrical. Measurable lower-limb strength asymmetries can therefore reasonably be expected to result from repeated performances of such asymmetrical action. While Beukeboom (2000) found little evidence to clearly indicate that running tight curves on an indoor track had any effect on injury risk, it did tend to result in changes in the strength of various muscle groups. Ishimura and Sakurai (2016), meanwhile, reported that step length and frequency are asymmetrical when sprinting the curve, and that the outside leg plays a particularly important role in the action. These findings have at least two important implications, namely, that running the curve may produce measurable strength asymmetries, and second, that such asymmetry may systematically disadvantage left-legged sprinters, since the "important" role of the outside (necessarily *right*) leg, constitutes a special loading on the non-dominant side for these athletes. We also asked, therefore:

Q3: Does running the curve have an effect on lower-limb strength bilateral or unilateral asymmetry in Maltese sprinters?

And:

Q4: Does asymmetry vary across left- and right-leg dominant sprinters?

Bishop et al. (2016) called for more research on asymmetry to effectively measure and ultimately clarify its effects on performance as well as injury risk or other outcomes. In this sense, the present study looks to make an additional contribution through its choice of methodology. The study uses an alternative method for measuring strength asymmetry that could enhance convenience and long-term feasibility of such testing. Doing more research naturally depends on the availability of valid and reliable testing equipment, and many of the studies cited above were based on the use of isokinetic dynamometers. As elaborated below, we employed an alternative, more easily accessible and cost-effective type of equipment also capable of being used in the field.

Method

Rather than isokinetic testing, the Modified Sphygmomanometer Test (MST) (Helewa et al. 1981; Mondin et al., 2018), which can be performed either in the lab or in the field, was selected for use in the study. The generally widespread availability of standard manual sphygmomanometers used for blood pressure testing, means that track and field, and strength and conditioning, coaches can more easily carry out strength asymmetry testing without the need for more complex or expensive equipment. Naturally, the availability of more data collected in the field as a result of using more convenient methods may eventually lead to a better understanding of asymmetry and its effects over time. High test-retest validity has been reported for the MST (Mondin et al., 2018), and it has been used as a low-cost valid means of assessing hip strength (Toohey et al., 2017), as well as shoulder strength in Rugby players (Dow Morrison, 2020). While the MST has been used in a wide range of sports contexts for testing muscular strength, Souza et al. (2013) encourage researchers to more meticulously describe the precise methods followed when applying the test, if it is to gain more traction specifically in clinical settings. In the present study, the method of application of the MST followed that described in Mondin et al. (2018).

Figure 1. Preparation of the sphygmomanometer for the MST

The "Boston" sphygmomanometer used in the study (Figure 1) was acquired from a licensed medical equipment vendor, together with a spare cuff (of the same brand and design). After approximately 30 tests, the original cuff indeed began to lose pressure, and was immediately replaced, with affected tests redone. Further to the protocols discussed by Mondin et al., participants were instructed to apply maximal force to the cuff for a period of five seconds, followed by 15 seconds of rest, and a final five-second maximal attempt. The best of the two attempts was recorded for each participant. The test was performed on the hamstrings and quadriceps muscle groups in both the 30° and 90° positions of flexion, as illustrated in Figure 2.

Figure 2. Hamstring and quadriceps test positions

Note: (A) Hamstrings at 90°, (B) Hamstrings at 30°, (C) Quadriceps at 30°, (D) Quadriceps at 90°

Positions A and B depict the 90° and 30° hamstrings strength tests using stacked weight plates to support the cuff and facilitate the desired angle of knee flexion. Positions C and D depict the 30° and 90° quadriceps tests using ankle weights and weight plates to support the cuff, respectively. In position C, the lower shin area was held in place by the tester, while the participant was instructed to flex the quadriceps, compressing the cuff. A consistent set of

verbal cues was used to instruct the participants throughout the tests to avoid any changes in performance that might be attributable to different types of cues and/or encouragement. The cues used were, “Push as much as you can, but you have to hold it for five seconds”, “Picture trying to bend your knee as much as possible”, and “Keep your whole body touching the floor”. The participants were tested in their own training environments and instructed to carry out their normal preferred warm-up routine prior to testing. Sprint coaches were instrumental in assisting with the recruitment process, promoting the study among their athletes within the respective clubs, and allowing time out of their normal training sessions to facilitate the testing procedure.

Ethical clearance was obtained from the institutional review board at the Malta College of Arts, Science and Technology in January 2021. A stratified convenience sampling strategy was used to recruit 20 Maltese (eligible for Malta national team duty), adult (18 years or over), track athletes with up to 400m as their specialty event. Participants had to be injury-free and in regular training at the time of the study. All participants completed a PAR-Q to help ensure their safe participation in the active test. The sample (N=20) eventually comprised 13 male and seven female sprinters, ranging from 18 to 30 years of age (M=22.50, SD=10.17). Their training age (years engaged in formal training) ranged from four to 20 years (M=11.20, SD=4.61). A majority (n=11) nominated the 100m as their main event, with remainder (n=9) nominating the 200m and 400m events as their specialty. In terms of leg dominance, the same distribution was noted across right-leg-dominance (n=11) and left-leg-dominance (n=9). All data resulting from the tests were eventually collated and organized using an open-source spreadsheet application (*LibreOffice Calc v7.2.2.2*).

Data analysis

Bishop et al. (2016) presented a number of different equations commonly used in the literature in the strength and conditioning context relating to lower-limb strength asymmetry. For the present study, we used the equations reported in Tatlıcıoğlu (2019). According to Bishop et al. (2016) the LSI equation used in Tatlıcıoğlu (2019) is the Bilateral Asymmetry Index (BSI) from Nunn and Mayhew (1988) and Impellizzeri et al. (2007), although they conceptualize it using stronger and weaker, rather than dominant and non-dominant. The equations were defined as:

$$LSI = \frac{DomLegForce - NonDomLegForce}{DomLegForce} \times 100$$

(Equation 1)

$$H{:}Q = \frac{HamForce}{QuadForce}$$

(Equation 2)

Since each muscle group was tested at both 30° and 90° degrees of flexion, using Equations 1 and 2 resulted in the operationalization of eight main variables of interest; LSI for quadriceps at 30° (LSI_{Quad30}), LSI for hamstrings at 30° (LSI_{Ham30}), LSI for quadriceps at 90° (LSI_{Quad90}), LSI for hamstrings at 90° (LSI_{Ham90}), H:Q for dominant leg at 30° ($H{:}Q_{Dom30}$), H:Q for non-dominant leg at 30°, ($H{:}Q_{NonDom30}$), H:Q for dominant leg at 90° ($H{:}Q_{Dom90}$), and H:Q for non-dominant leg at 90° ($H{:}Q_{NonDom90}$). The LSI and H:Q values were calculated in the spreadsheet software, and finally the updated dataset was imported into an open-source statistical analysis software package (*GNU PSPP v1.4.1*).

To address Q_1, basic descriptive statistics were run to explore the general state of affairs in terms of bilateral and unilateral asymmetry in our sample. For additional insight, 95% confidence intervals were generated with a view to comparing the MST values across different muscle groups and sides. To address Q_2, regarding prospective changes in asymmetry over time, Pearson's *r* was used to construct a correlation matric for comparing training age with each of the eight outcomes. To address Q_3 and Q_4 regarding the association between asymmetry and competitive running on the curve or not, and left- or right-side dominance, respectively, *t* tests were run with each of the eight outcomes as the dependent variable. An Alpha level of .05 was used to determine statistical significance when interpreting the results of all inferential statistical procedures.

Results and Discussion

Tables 1 and 2 below show the MST results for the quadriceps and hamstrings at 30° and 90°, for the dominant and non-dominant legs, respectively. The mean, standard deviation, standard error, and 95% confidence intervals are reported.

Table 1. Descriptive statistics for all tests on the dominant leg.

Test	*Mean*	*SD*	*SE*	*95% CI*
Hamstrings at 30°	174.30	36.78	8.22	157.09, 191.09
Quadriceps at 30°	223.50	46.94	10.49	201.53, 245.47
Hamstrings at 90°	179.55	44.34	9.92	158.80, 200.30
Quadriceps at 90°	201.40	47.58	10.64	150.31, 186.39

Table 2. Descriptive statistics for all tests on the non-dominant leg.

Test	*Mean*	*SD*	*SE*	*95% CI*
Hamstrings at 30°	168.35	38.54	8.62	150.31, 186.39
Quadriceps at 30°	212.25	46.01	10.29	190.72, 233.78
Hamstrings at 90°	183.10	32.81	7.34	167.75, 198.45
Quadriceps at 90°	196.55	44.99	10.06	175.50, 217.60

In varsity American football players, Tatlıcıoğlu et al. (2019) reported evidence supporting increased strength in the quadriceps of the dominant, as opposed to non-dominant, leg. Table 1 shows that at both 30° and 90°, the overlapping 95% confidence intervals do not suggest any such difference was evident in this study. However, the quadriceps of the dominant leg were significantly stronger at 30° (*95% CI* = 201.53, 245.47) than at 90° (*95% CI* = 150.31, 186.39), showing that more pronounced increases in force production were possible specifically in the dominant leg. The raw data help establish some context for coaches and/or researchers intent on making use of the MST for the purpose of comparison, at least in the context of sprinters. Tables 3 and 4 present the MST scores further differentiated by sex.

Table 3*:* Descriptive statistics for all tests on the dominant leg, by sex.

Test	***Female***		***Male***	
	Mean	***95% CI***	***Mean***	***95% CI***
Hamstrings at 30°	140.00	123.11, 156.89	192.77	174.45, 211.09
Quadriceps at 30°	217.14	188.04, 246.25	226.92	194.07, 259.78
Hamstrings at 90°	137.29	117.71, 156.87	202.31	180.64, 223.98
Quadriceps at 90°	175.00	166.15, 183.85	215.62	183.00, 248.23

Table 4. Descriptive statistics for all tests on the non-dominant leg, by sex.

Test	***Female***		***Male***	
	Mean	***95% CI***	***Mean***	***95% CI***
Hamstrings at 30°	134.00	118.38, 149.62	186.85	166.35, 207.34
Quadriceps at 30°	190.71	144.59, 236.84	223.85	198.99, 248.71
Hamstrings at 90°	158.57	133.85, 183.29	196.31	179.14, 213.48
Quadriceps at 90°	174.00	147.40, 200.40	208.69	179.46, 237.93

Bilateral and unilateral symmetry in Maltese sprinters

Building on the above data, Tables 5 and 6 present the results for the eight main asymmetry variables of interest, derived using Equations 1 and 2 for LSI and H:Q values, respectively. Together, they provide insight for addressing Q_1, and ascertaining the general status of Maltese sprinters in terms of bilateral and unilateral asymmetry.

Table 5: Descriptive statistics for the LSI measurements.

Outcome	*Mean*	*SD*	*SE*	*95% CI*
LSI_{Ham30}	2.84	13.24	2.96	-3.35, 9.04
LSI_{Quad30}	4.18	14.77	3.30	-2.73, 11.09
LSI_{Ham90}	-4.87	18.95	4.24	-13.74, 4
LSI_{Quad90}	1.38	14.32	3.20	-5.32, 8.08

Taking into account Maulder et al.'s (2010) cut-off of 10% for bilateral asymmetry as reflected in the LSI scores, the mean values for the sample (-4.87 to 4.18) were well within the 10% threshold. However, taking the sample as representative of the larger population of Maltese sprinters, and considering the 95% confidence intervals reported, the claim cannot be generalized that there is any systematic trend towards symmetry. The confidence intervals surrounding LSI_{Quad30} (*95% CI* = -2.73, 11.09) and LSI_{Ham90} (*95% CI* = -13.74, 4) indicate possible population parameters exceeding ±10% (11.09, -13.74). We cannot, therefore, conclude that Maltese sprinters do *not* exhibit bilateral asymmetry. For those accepting the assumption that asymmetry is something to be remedied via corrective training (Zahálka et al., 2013; Maley et al., 2014; Tatlıcıoğlu et al., 2019; Pietraszewski et al., 2020), Maltese sprint coaches are advised to exercise caution, and endeavor to more closely monitor their athletes for signs of bilateral asymmetry, based on these findings. The MST, in this sense, represents a valuable opportunity for coaches to carry out their own regular asymmetry testing over the long-term.

Table 6. Descriptive statistics for the H:Q measurements.

Outcome	*Mean*	*SD*	*SE*	*95% CI*
$H{:}Q_{Dom30}$	0.81	0.22	0.05	0.70, 0.91
$H{:}Q_{NonDom30}$	0.82	0.23	0.05	0.72, 0.93
$H{:}Q_{Dom90}$	0.94	0.41	0.09	0.75, 1.14
$H{:}Q_{NonDom90}$	1.00	0.42	0.09	0.80, 1.19

A slightly larger discrepancy between hamstrings and quadriceps was observed at 30° (0.81, 0.82) as opposed to 90° (0.94, 1.00). The 95% confidence intervals, however, suggest that, ultimately, no significant differences in the H:Q ratio were evident in any of the muscle groups tested, between the dominant and non-dominant legs. Tatlıcıoğlu et al. (2019) cited two cut-offs commonly used in the literature for H:Q ratio testing, namely >.47 and >.60. Similarly, Coombs and Garbutt (2002) discussed widespread "general acceptance" of .66 as the optimal ratio for concentric strength, with the broader range ideally spanning anywhere from .43 to .90. There does not appear to be a strong consensus on what precisely constitutes a valid threshold for the H:Q ratio. Regardless of which threshold was used to interpret our data, however, none of the 95% confidence intervals incorporated any of the cut-offs stated above (.47, .60, .66), suggesting a satisfactory H:Q ratio in Maltese sprinters. Two of the values ($H{:}Q_{Dom30}$ and $H{:}Q_{NonDom30}$) just exceeded the maximal limit of .90 established by Coombs and Garbutt (2002). This suggests that at least at 30°, Maltese sprinters demonstrate comparatively strong hamstrings in relation to their quadriceps. This relatively high capacity for force production in the hamstrings, specifically, is not surprising when considering that the hamstrings are known to play a dominant role in the sprinting action (Morin et al., 2015; Pandy et al., 2021).

Fousekis et al. (2010), meanwhile, made the argument that optimal ratios are more important in the dominant leg, but this was not evident in our findings. Both the mean values as well as the 95% confidence intervals indicated that the H:Q ratio did not differ significantly across the dominant and non-dominant sides. The findings indicate, overall, that Maltese sprinters exhibit generally low degrees of asymmetry, particularly unilaterally. Bilaterally, athletes in the study generally scored inside the 10% asymmetry threshold, but caution should be exercised in generalizing this finding to the general population of Maltese sprinters. In the case of the hamstrings at 90°, the LSI score was expressed in a negative number. This suggests that Maltese sprinters tend towards increased hamstring strength in their non-dominant side. Accordingly, it is worth noting that in any consideration of bilateral asymmetry, the dominant and non-dominant sides are not necessarily equivalent to stronger and weaker sides. Fort-Vanmeerhaeghe (2016) showed that in a sample of volley-ball players, self-reported leg dominance was not a reliable indicator of comparative limb strength.

Change in asymmetry over time

Changes in asymmetry as a function of training age were initially explored by surveying the Pearson correlation coefficients and significance values. Table 7 shows the resulting non-significant findings in all instances except for $H{:}Q_{NonDom90}$.

Table 7. Pearson's correlations for training age with all eight outcomes

Outcome	*Pearson's r*	*p value (two tailed)*
LSI_{Ham30}	-.35	.13
LSI_{Quad30}	.12	.60
LSI_{Ham90}	-.11	.66
LSI_{Quad90}	-.33	.16
$H{:}Q_{Dom30}$	-.26	.27
$H{:}Q_{NonDom30}$	-.04	.86
$H{:}Q_{Dom90}$	-.39	.09
$H{:}Q_{NonDom90}$	-.46	.04*

For $H{:}Q_{NonDom90}$ the null hypothesis of no relationship between training age and unilateral asymmetry in the non-dominant leg could be rejected. In other words, there appeared to be a relationship between training age and unilateral symmetry in the non-dominant leg. Overall, the evidence did not lend considerable support to the overarching alternative hypothesis that training age was significantly related to asymmetry in Maltese sprinters. Older players generally tend to exhibit a more optimal ratio at least in their *dominant* leg, according to Fousekis et al. (2010). The fact that only one in four measures of unilateral asymmetry in our analysis returned a significant result, and that this occurred on the *non-dominant* side, indicates that, according to the MST, asymmetry does not generally appear to decrease to any significant degree as sprinters become more experienced.

Further research, however, is warranted. Taking into account the prior LSI scores (in particular LSI_{Quad30} and LSI_{Ham90}, which exceeded the 10% by virtue of their 95% confidence intervals), the significant result is interesting, since bilateral hamstring strength appeared to favor the non-dominant side. This means that the non-dominant hamstrings were a key muscle group, and it was precisely in this muscle group exclusively that improvements in symmetry over time were evident. This indicates that whatever small degree of adjustment appeared to be taking place by the more seasoned sprinters, seemed to occur where it was most needed.

Effects of running the curve and leg-dominance

A series of *t* tests were run to test for variations in LSI and H:Q outcomes across curve-running and leg-dominance as the independent variables. Tables 8 and 9 report the *t*, and *r* values denoting effect size, as well as the significance levels.

Table 8. *t* tests for competing on the curve or not, across all eight outcomes (*df* = 18)

Outcome	***t***	***Effect size (r)***	***p value (two tailed)***
LSI_{Ham30}	.55	-.13	.59
LSI_{Quad30}	-.18	.04	.86
LSI_{Ham90}	-.90	.21	.38
LSI_{Quad90}	-.08	.02	.94
$H{:}Q_{Dom30}$	-.29	.07	.78
$H{:}Q_{NonDom30}$	-.24	.06	.82
$H{:}Q_{Dom90}$	-1.28	.29	.22
$H{:}Q_{NonDom90}$	-.83	.19	.42

It was clear that no form of asymmetry in Maltese sprinters appeared to vary according to whether or not athletes' main event involved sprinting on the curve (200m, or 400m). Despite the inherently asymmetrical biomechanics involved in sprinting on the curve (Chang & Kram, 2007; Alt et al., 2015; Ishimura & Sakurai, 2016), Beukeboom (2000) argued that curve running did not increase injury-risk, but could produce measurable differences in the strength of different muscle groups. The results of the MST, however, at least in the case of Maltese sprinters, do not support the notion that significant strength asymmetries result from running the curve.

Further to the focus on the non-dominant hamstrings reflected in the trend towards negative values for LSI_{Ham90}, it was interesting to note that this strength asymmetry was not affected by the inherent asymmetrical mechanics of competing on the curve. If increased power expression in the non-dominant hamstring, regardless of left- or right-footedness, was not affected by increased curve sprinting, then it would appear that having a stronger non-dominant side is

likely instead a response to simply sprinting straight, perhaps as some form of counter-balancing action in coordination with the dominant side.

Table 9. *t* tests for leg-dominance across all eight outcomes (*df* = 18)

Outcome	***t***	***Effect size (r)***	***p value (two tailed)***
LSI_{Ham30}	1.64	-.36	.12
LSI_{Quad30}	-.93	.21	.37
LSI_{Ham90}	.65	-.15	.53
LSI_{Quad90}	1.27	-.28	.22
$H{:}Q_{Dom30}$	-.67	.16	.51
$H{:}Q_{NonDom30}$	-1.81	.39	.09
$H{:}Q_{Dom90}$	.47	-.11	.65
$H{:}Q_{NonDom90}$	.67	-.16	.51

As was the case with running the curve, Table 9 indicates that leg-dominance had no significant effects on any form of asymmetry. In other words, asymmetry did not differ significantly between left- and right-leg dominant athletes. Despite Ishimura and Sakurai's (2016) observation that the "outside" leg plays a particularly important role in running the curve, the fact that this is necessarily the *right* leg during competitive sprinting on the curve, does not appear to disproportionately affect left-leg dominant athletes in terms of their strength symmetry.

Conclusion and Recommendations

Zahálka et al. (2013) showed that the best performances of elite soccer goalkeepers involved the most asymmetrical functional muscle recruitment patterns. The assumption that measures of strength asymmetry decrease in elite performers appears to be at odds with this observation. Beato et al. (2021) argued, in this sense, that rather than strength asymmetry itself, the key factor remains how athletes actively manage available force-production from participating muscle groups in a given performance, a capacity which experienced athletes appear to hone as they progress throughout their careers. Given that some sports techniques are inherently

asymmetrical in nature, like running the curve, it seems reasonable that the ability to recruit muscular force efficiently in response to external conditions be considered the more important factor, regardless of the maximal force individual muscle groups are capable of exerting in test conditions. It is an important consideration, therefore, when testing strength asymmetry, to what degree such an element of control is in fact also being tested.

Earlier it was pointed out that research on asymmetry tends to involve measurement of either functionally integrated sporting actions, on the one hand, or force-production in isolated tests of strength on the other. The former necessarily involves a degree of neuromuscular coordination or control, while that latter depends on decreasing neuromuscular inhibition as much as possible. The MST, in this sense, represents an interesting interplay between these poles. The test is not a truly maximal test of strength because subjects are told to, "Push as much as [they] can, *but* […] to hold it for five seconds." A degree of inhibition or "management" is thereby introduced, rendering the MST an assessment of controlled application of near-maximal muscular force. The results of the present study and the application of existing asymmetry thresholds/cut-offs should therefore by interpreted with this nuance in mind. Further research using the MST test in conjunction with EMG monitoring could yield some valuable insights in this regard, particularly if compared to additional measures like dynamometry, or other tests involving maximal force production.

It should also be noted in any discussion of curve running, that athletes who only compete in the 100m will still typically engage in a degree of curve running during training, although likely at a significantly lower intensity than 200m or 400m sprinters. Sample size was a limitation in this study, yet the general population of Maltese sprinters is similarly rather small. Malta is classified as a European micro-state with a population of around half a million people, and track and field athletics can be considered a relatively minor sport even within this setting. More research both in terms of studying sprinters specifically, as well as use of the MST, would enable more contextualization of the findings and consolidation of research efforts in the future. More studies based on MST data will facilitate comparisons between athletes, and more longitudinal studies in the club context may lead to more effective screening of asymmetry over time.

In conclusion, we are in a position to report that our sample exhibited relatively symmetrical performances according to the MST, particularly in the case of unilateral intra-leg symmetry. There was sufficient variation in the between-leg dimension, however, to challenge any broader claims that the larger population of Maltese sprinters do systematically possess optimum

bilateral symmetry. It was interesting to note that Maltese sprinters appear to exhibit a strength bias in the hamstrings in favor of their non-dominant side. In terms of H:Q ratio, it was clear that Maltese sprinters fit the expectation of having relatively strong hamstrings, given the known importance of this muscle group for the sprinting action. The sprinters did not show a great deal of asymmetry adaptation over time, however the minimal adaptation recorded among the more experience sprinters, given the emerging prominence of the non-dominant hamstring, appeared to occur just where it most counted. Running the curve and leg-dominance had no effect on any form of asymmetry in the participants.

Author Contribution

Magro, K. H. (Conceptual framework, data collection), Muscat-Inglott, M. (Data Analysis)

Conflict of Interest

All authors must declare that there is no conflict of interest.

Ethical Statement

Ethical review was provided by the institutional review board at the Malta College of Arts, Science & Technology.

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JOURNAL OF THEORY AND PRACTICE IN SPORT
MUĞLA SITKI KOÇMAN UNIVERSITY
FACULTY OF SPORT SCIENCES

Evaluation of plyometric training with bibliometric data: A descriptive study

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To cite this article: Uysal, H. Ş., & Uysal, S. N. (2022). Evaluation of plyometric training with bibliometric data: A descriptive study. *Journal of Theory and Practice in Sport, 1*(1), 21-35.

Received: 16.09.2022

Accepted: 07.11.2022

Published: 25.12.2022

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Evaluation of plyometric training with bibliometric data: A descriptive study

Abstract

Plyometric training is a training method that includes a stretch-shortening cycle and is designed with exercises that require explosiveness. Sports science has studied this training method for many years, and a great deal of research has been done at various levels. This study aims to evaluate the research articles on plyometric training in the field of sports sciences with bibliometric data and to reach specific norm values within the study's limitations. The study was carried out with a bibliometric analysis design, one of the quantitative research methods, and the Web of Science database was used as a data collection tool. The database related to the study; was included in the category of sports sciences; 358 research articles scanned in any of the SSCI, ESCI, or SCI-Expanded indexes were had. Statistical analyzes of the study were performed with the programming language R (ver. 4.2.2), and the bibliophily function was used. The findings of this study revealed that the most influential researcher on the subject is Rodrigo Ramirez Campillo, and the journal that most accepts plyometric training research is the Journal of Strength and Conditioning Research. However, there is a need to examine the effects of plyometric training on agility, change of direction, and sprint performance, to conduct more research on children and youth and to address the issue from different perspectives, especially on football players. As a result, the findings may be necessary for researchers and field experts who will research the subject of plyometric training. Furthermore, the study's findings can offer an idea to the researchers studying the topic.

Keywords: Strength training, stretch-shortening cycle, performance, exercise

Bibliyometrik verilerle pliometrik antrenmanın değerlendirilmesi: Tanımlayıcı bir çalışma

Özet

Pliometrik antrenman, gerilme-kısalma döngüsü içeren ve patlayıcılık gerektiren egzersizler ile tasarlanan bir antrenman yöntemidir. Bu antrenman yöntemi uzun yıllardan beri spor bilimi alanında incelenmekte olup, konu üzerine çeşitli seviyelerde çok sayıda araştırma yapılmıştır. Bu çalışmanın amacı, spor bilimleri alanında gerçekleştirilen pliometrik antrenman konulu araştırma makalelerini bibliyometrik veriler ile değerlendirmek ve çalışmanın sınırlılıkları kapsamında belirli norm değerlere ulaşmaktır. Çalışma, nicel araştırma yöntemlerinden bibliyometrik analiz deseni ile gerçekleştirilmiş olup, veri toplama aracı olarak Web of Science veri tabanı kullanılmıştır. Çalışmaya ilgili veri tabanında yer alan; spor bilimleri kategorisine dahil olan; SSCİ, ESCİ veya SCİ-Expanded indekslerinden herhangi birinde taranan 358 araştırma makalesi dahil edilmiştir. Çalışmanın istatistiksel analizleri R (ver. 4.2.2) programlama dili ile gerçekleştirilmiş ve biblioshiny fonksiyonu kullanılmıştır. Bu çalışmanın bulguları, konu üzerine en etkili yayım yapan araştırmacının Rodrigo Ramirez Campillo olduğunu ve pliometrik antrenman araştırmalarını en çok kabul eden derginin Journal of Strength and Conditioning Research olduğunu ortaya çıkarmıştır. Bununla birlikte pliometrik antrenmanın çeviklik, yön değiştirme ve sprint performansı üzerine etkisinin incelenmesine, çocuklar ve gençler açısından daha fazla araştırma yapılmasına ve özellikle futbolcular üzerine konunun farklı açılardan ele alınmasına ihtiyaç duyulmaktadır. Sonuç olarak elde edilen bulgular pliometrik antrenman konusu üzerine araştırma gerçekleştirecek araştırmacı ve alan uzmanları için önem taşıyabilir. Çalışmanın bulguları konu üzerine araştırma gerçekleştirecek araştırmacılara fikir sunabilir.

Anahtar Kelimeler: Kuvvet antrenmanı, esneme-kısalma döngüsü, performans, egzersiz

Introduction

Athletic strength requires the athlete to resist his body weight in different sports, win double battles in training and competition, and perform various movement actions at an optimal level. As a bio-motor feature, strength directly affects performance parameters, and researchers state that strength development and the development of bio-motor abilities are related (Alemdaroğlu, 2012; Sleivert & Taingahue, 2004). Training is applied at different loading intervals to improve strength (Dündar, 2012). Many training methods are developed to achieve maximum performance output (Docherty, Robbins & Hodgson, 2004; Elbadry, Hamza, Pietraszewski, Alexe & Lupu, 2019).

One of the training methods designed to develop strength is plyometric training. The definition of this training method is derived from the words plio and metric and is applied through exercises that include stretch-shortening cycles to increase muscle strength and endurance (Patel, 2014; Slimani, Chamari, Miarka, Del Vecchio & Chéour, 2016). While the history of the training method dates back to the 1960s (Radcliffe & Farentinos, 1985), this training method developed by the Russian scientist Yuri Verkhoshansky was defined primarily as shock training (Verkhoshansky, 2006). Today, explosive strength training is being investigated by researchers as ballistic training or plyometric training (Pancar, Biçer, & Özdal, 2018; Pretz, 2004; Yıldız et al., 2018).

Researchers state that plyometric training positively affects performance in sports such as football, basketball, volleyball, and handball (Chelly et al., 2010; Ramirez-Campillo, 2020; Slimani et al., 2016; Silva et al., 2019). Moreover, plyometric training is a required strength training method for athletic performance (Slimani et al., 2016). Improving the stretch-shortening cycles of the athletes may allow them to improve their strength, sprint, and jump performance (Radcliffe & Farentinos, 1985). In many meta-analyses, researchers have stated that plyometric training positively affects athletic performance levels (Asadi, Land, Young, & de Villarreal, 2016; de Villarreal, Requena, & Cronin, 2012; Stojanović, Ristić, McMaster, & Milanović, 2017).

Plyometric training is examined within the scope of sports science with many athletic performance parameters such as power, strength, sprint, and vertical jump. However, it continues to be the subject of research in different disciplines. Indeed, its effect on ankle sprain and joint power absorption in orthopedics (Ismail, Ibrahim, Youssef & Shorbagy 2010; Van Lieshout, Anderson, Shelburne & Davidson, 2014); In the field of physiotherapy and

rehabilitation, the effect of athletes on injuries (Chmielewski, Myer, Kauffman & Tillman, 2006) and the effect of plyometric training on the human body in many other areas are investigated.

This research aims to present bibliometric data from the literature on plyometric training, a research topic in the sports sciences, to relevant researchers. This study aims for researchers who will research the subject to gain information about the literature more quickly. The study is essential because it contains primary sources about plyometric training, evaluates it in the historical process, determines the most influential researchers on the subject, and offers suggestions to researchers on a scientific publication.

Method

Research Model

This research was carried out with the bibliometric study design, one of the quantitative research methods. The bibliometric study design evaluates scientific research published by mathematical or statistical methods (Kırpık & Dönbak, 2021). Performance analysis, network analysis, and science map analysis can be performed within the scope of bibliometric studies, which are also accepted as a literature compilation method (Donthu, Kumar, Mukherjee, Pandey, & Lim, 2021). Within the scope of this research, research was carried out with the following problem statement: What bibliometric data can be presented to researchers on plyometric training?

Research Sample

While the universe of this research was composed of studies on plyometric training, the research sample consisted of research articles indexed in the Web of Science database, included in the category of sports sciences, and included in any of the SSCI, ESCI, or SCI-Expanded indexes. In this context, a total of 358 studies were included. The table containing descriptive information about the studies is given below.

Table 1. Basic information about plyometric training exercises

Primary Information About the Studies	**Results**
Time Range	1986-2022
References (Journals, Books, etc.)	62
Documents	358
Average citations per document	33.57
The annual average number of citations per document	3.087
References	6801
Document Types	
Articles	342
Articles; early access	9
Articles; conference paper	3
Articles; book section	4
Authors	
Authors	1170
Author Views	1579
Authors of single-author documents	15
Authors of multi-author documents	1155
Collaboration of the Authors	
Single-author studies	18
Number of studies per author	0.306
Author per research	3.27
Co-authors per research	4.41
Collaboration Index	3.40

Data Collection Tools

This study used the Web of Science database as a data collection tool. The database was searched using the keywords plyometric training and plyometric exercises. Studies indexed in the relevant database from 1986 to 2022 were included according to the inclusion criteria.

Analysis of Data

In this study, the R (Ver. 4.1.0) programming language was preferred for statistical analysis. The bibliometrics package was designed for bibliometric analysis in the R programming language (Aria & Cuccurullo, 2017). With the Bibliometrix package, analyses of various variables such as publication, researcher, keyword, scientific productivity, and journal were applied to create a literature map for the subject area.

Results

In this study, the scientific productivity rates of researchers on the subject were first examined within the scope of bibliometric analysis. It was determined that the first research indexed on the topic in the Web of Science database dates to 1986 (Figure 1). Researchers have carried out a limited number of studies from this date until 1994, and since 1994, research on plyometric training has continued with certain breaks every year. Plyometric training, designed as strength training in the early 1960s, continues to increase yearly, with a growth rate of 9.59% today. A template showing the scientific productivity rate from 1986 to 2022 is given in Figure 1.

One of the bibliometric data, which is thought to be useful for researchers who want to research the subject, is the determination of the researchers who have done the most research on plyometric training. In this context, ten studies indexed

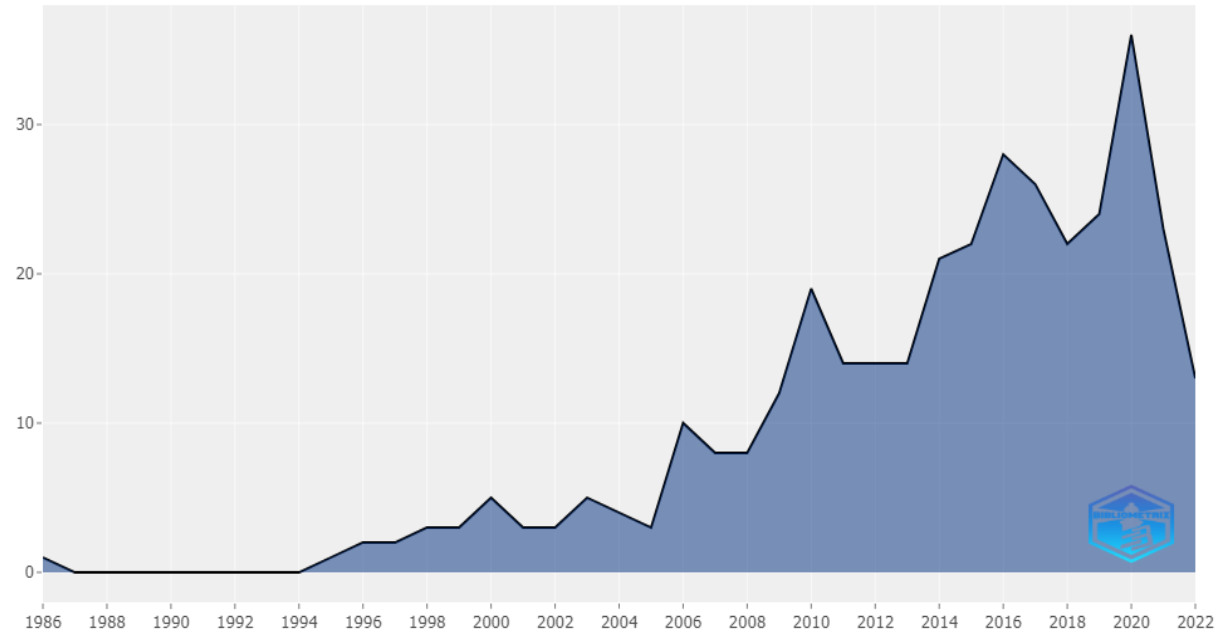

Figure 1. Annual scientific production rates of plyometric training research

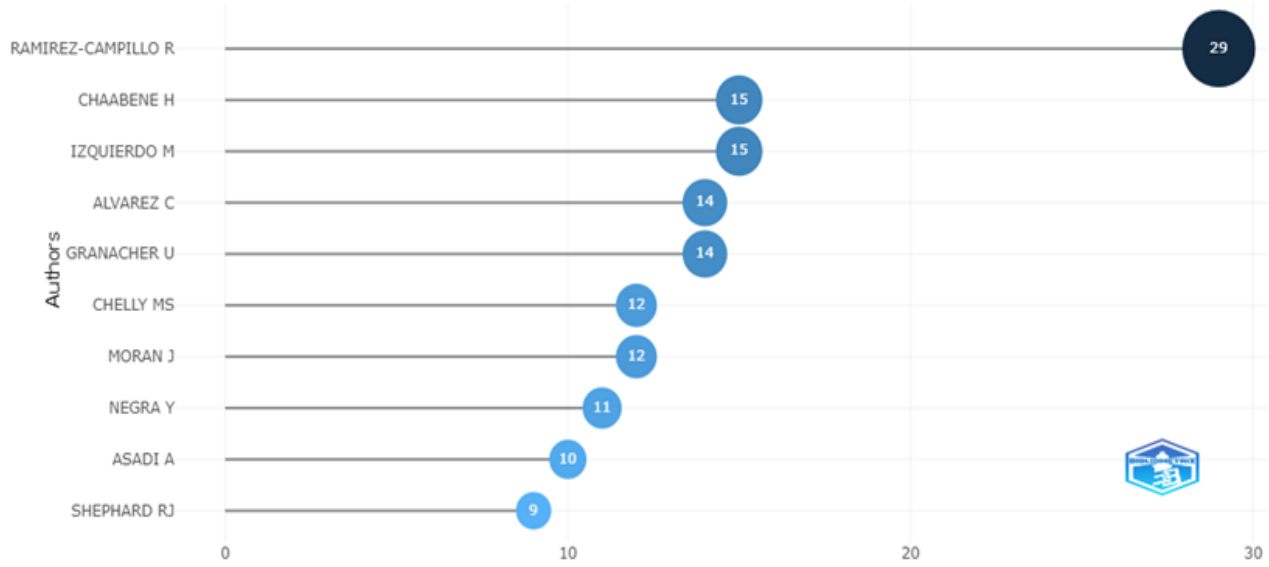

Figure 2. List of researchers who have done the most research on plyometric training

in the Web of Science database were included in the study. As a result of the analysis, it was concluded that the researcher who did the most research on plyometric training was Rodrigo Ramirez Campillo. Information on the relevant data is given in Figure 2.

Table 2. Characteristics of the ten most influential researchers about plyometric training

Authors	H Index	G Index	M Index	Total Citation	Number of Publication	Time to start
Ramirez-Campillo R	16	27	1,6	888	27	2013
Izquierdo M	14	14	0,824	917	14	2006
Alvarez C	12	14	1,333	556	14	2014
Chaabene H	10	14	1,667	241	14	2017
Chelly Ms	10	12	0,769	397	12	2010
Granacher U	10	13	1,111	280	13	2014
Negra Y	9	11	1,286	196	11	2016
Moran J	8	11	1,333	140	11	2017
Nakamura Fy	8	8	1,143	194	8	2016
Shephard Rj	8	9	0,615	267	9	2010

H index values of the researchers were evaluated to determine the researchers working on plyometric training and having the highest author effect level. In this context, citation numbers to the studies and index values of the researchers were accepted as a quality standard. In addition, ten researchers who carried out the most qualified studies on plyometric training are given in Table 2. As a result of the analysis, it was concluded that Rodrigo Ramirez Campillo carried out the most qualified studies on the subject.

Keyword selection in research is a factor that affects the visibility of the published article. The compatibility and similarity of the keywords with the article content can enable the articles published in databases controlled by automation systems to be displayed in the foreground. Within the scope of this research, the most preferred keywords about plyometric training are included. In the analysis, the following criteria were used to identify the most frequently used words; (1) To be used in at least 20 research per year, (2) to be used as a keyword an average of 20 times per year. The keywords used in line with the determined criteria are given in Figure 3. The size of the fonts indicates the frequency of the keywords used. As a result of the analysis, it was determined that the most preferred keywords in plyometric training studies were words such as performance, strength, power, program, and exercise.

Figure 3. The most frequently used keywords in plyometric training research

Numerous studies have been conducted on plyometric training since the 1960s. This may cause a problem in accessing studies that guide the subject. For this reason, the top 10 most cited studies in the Web of Science database in the historical process are included in the research. As a result of the analysis by Spurs et al. (2003), it was determined that the plyometric training study received the most citations. The study was undertaken to examine the effect of plyometric training on running performance and explosive movement actions. Spurs et al. (2003) investigated the effects of six weeks of plyometric training on participants' CMJ, maximum

isometric power, strength development speed, five-step jump, lactate threshold, three km test time, and Vo2max performances. At the end of six weeks, improvement was observed in many performance parameters, especially the Vo2max level of the participants. Detailed information about the most cited studies on the subject and their DOI numbers are given in Table 3.

Table 3. List of authors directly cited in the historical process

Authors	Title	DOI	Year	Number of Local Citations	Global Citations
FATOUROS I. G.	Evaluation of plyometric exercise training, weight training, and their combination on vertical jumping performance and leg strength	-	2000	46	191
SPURRS R. W.	The effect of plyometric training on distance running performance	10.1007/s00421-002-0741-y	2003	42	292
HERRERO J. A.	Electromyostimulation and plyometric training effects on jumping and sprint time	10.1055/s-2005-865845	2006	31	108
MILLER M. G.	The effects of a 6-week plyometric training program on agility	-	2006	31	179
KOTZAMANIDIS, C,	Effect of plyometric training on running performance and vertical jumping in prepubertal boys	10.1519/00124278-200605000-00034	2006	43	130
MARKOVIC G.	Effects of sprint and plyometric training on muscle function and athletic performance	10.1519/00124278-200705000-00044	2007	42	169
MEYLAN C.	Effects of in-season plyometric training within soccer practice on explosive actions of young players	10.1519/JSC.0b013e3181b1f330	2009	53	178
THOMAS K.	The effect of two plyometric training techniques on muscular power and agility in youth soccer players	10.1519/JSC.0b013e318183a01a	2009	45	196
RAMIREZ-CAMPILLO R.	Effects of plyometric training volume and training surface on explosive strength	10.1519/JSC.0b013e318280c9e9	2013	31	86
RAMIREZ-CAMPILLO R.	Effects of in-season low-volume high-intensity plyometric training on explosive actions and endurance of young soccer players	10.1519/JSC.0000000000000284	2014	34	96

After the research is carried out, the publication process can take months. For this reason, choosing journals with a high acceptance tendency on publication may provide an advantage to researchers in writing to publish. For this reason, the journals that mainly included the issue of plyometric training were analyzed. The top 10 journals scanned in the Web of Science database

and showing the most acceptance tendency on the subject are given in Table 4. As a result of the analysis, it was determined that the Journal of Strength and Conditioning Research published the most significant number of studies on plyometric training.

Table 4. Journals with the most publications on plyometric training

Journals	Article acceptance count
Journal of Strength and Conditioning Research	117
Journal of Sports Medicine and Physical Fitness	23
İnternational Journal of Sports Medicine	12
Journal of Human Kinetics	10
Journal of Sports Science and Medicine	10
Journal of Sports Sciences	10
İnternational Journal of Applied Exercise Physiology	9
Pediatric Exercise Science	9
European Journal of Sport Science	8
İnternational Journal of Sports Physiology and Performance	8

Identifying the weak and vital aspects of a subject area may enable more qualified studies to be carried out and these studies to be accepted at higher rates in journals with high impact factors. Therefore, the thematic map related to plyometric training was created in the research. The deficiencies and strengths of the subject were determined within the scope of 358 studies included. The thematic map is the coordinate that consists of a plane and an axis as centrality and density. It enables the determination of the strengths and weaknesses of a subject area (Seyhan & Özzeybek Taş, 2021). Each part of the thematic map, which consists of four different positions, provides information about the subject area. The upper right of the thematic map covers essential research topics, is well-developed, and is linked to other sections.

On the other hand, the upper left part of the thematic map represents specialized research topics related to plyometric training (Cobo, López-Herrera, Herrera-Viedma & Herrera, 2021; Nasir et al., 2020). However, the lower left part of the thematic map includes research topics that are

not well-developed and do not directly represent the subject area. The lower right part includes research topics that are not well-developed but are directly related to plyometric training (Cobo et al., 2021; Nasir et al., 2020). The thematic map created because of the analysis is given in Figure 4. In this context, it can be said that the effect of plyometric training on exercise selection, power and jump issues is frequently studied.

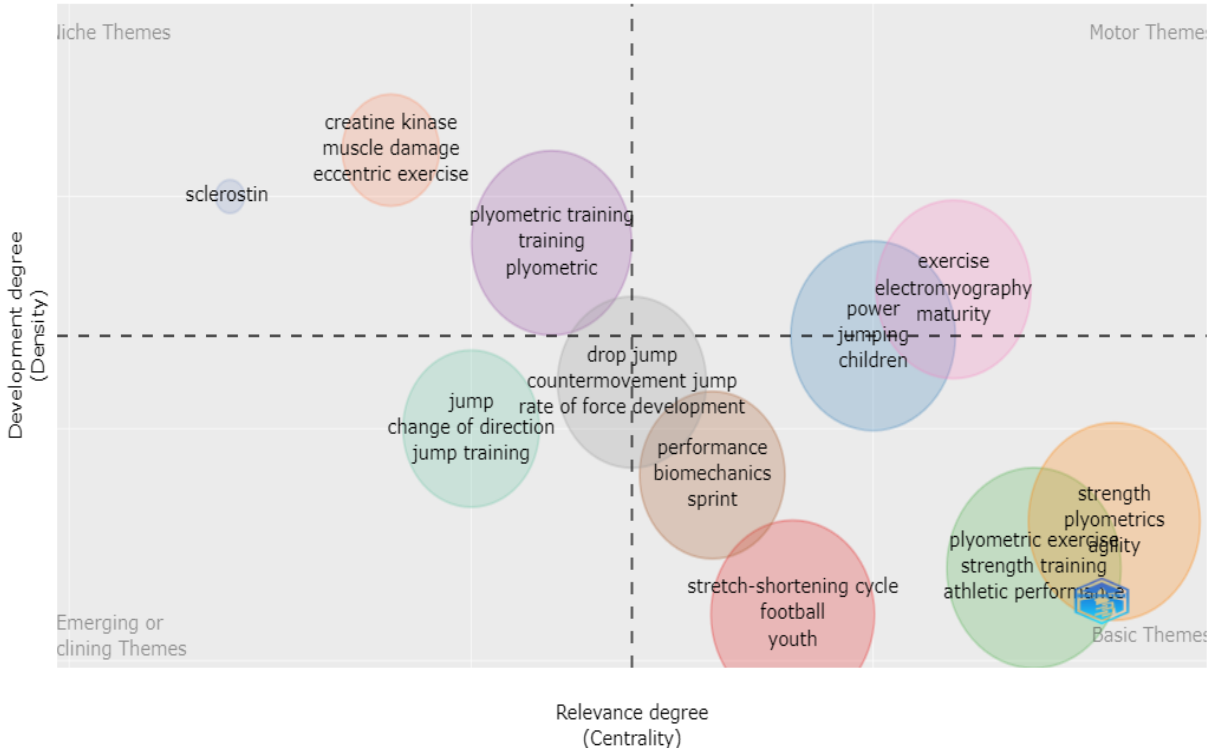

Figure 4. Plyometric training with thematic map

On the other hand, the effect of plyometric training on physiological parameters has been frequently investigated, but the impact of research topics in different sections has not been discussed. Furthermore, although the effect of plyometric training on change of direction performance has been discussed, there has not been enough research on this subject. Finally, researchers have not sufficiently investigated the impact of plyometric training on children, youth, football players, and sprint and agility performance.

Conclusion

Although the effect of plyometric training on performance has been researched for more than 50 years, it continues to be studied with different topics. Most of the studies on the subject are carried out by multiple authors. In the field of sports sciences, the effect of plyometric training on motor abilities is focused. However, there is a need for a clearer understanding of the effect of populations on sports branches. Research on this subject tends to be primarily accepted in

American journals. The fact that plyometric training is being studied with more and more research every year shows that it is a subject area that keeps up-to-date, and more research is needed for the related subject area.

Suggestions

As a result of the bibliometric analyzes, researchers who want to research plyometric training may consider the following suggestions:

(1) The works of Rodrigo Ramirez Campillo can be followed to have an idea about the subject area.

(2) Journal of Strength and Conditioning Research may be preferred for article publication.

(3) In terms of bio-motor properties, the effect of plyometric training on agility, change of direction, and sprint performance can be examined. Children and young people can be preferred in terms of population, and the effect on football players can be discussed.

(4) Keywords such as performance, strength, and exercises can be preferred in plyometric training research.

Author Contribution

Uysal, H.Ş. (Research concept and study design), Uysal, S.N. (Literature review), Uysal, S.N. (Data collection), Uysal, H.Ş. (Data analysis and interpretation of statistics), Uysal, H.Ş. ve Uysal, S.N. (Article writing), Uysal, H.Ş. ve Uysal, S.N. (Reviewing/editing the manuscript)

Conflicts of Interest

There is no conflict of interest between the authors of this study.

Ethical Statement

Subjects such as humans or animals were not used in this study. Therefore, an ethics committee is not required for the study.

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JOURNAL OF THEORY AND PRACTICE IN SPORT
MUĞLA SITKI KOÇMAN UNIVERSITY
FACULTY OF SPORT SCIENCES

Examination of the Social Achievement Goal of the Students in the Faculty of Sports Sciences in Terms of Various Demographic Variables

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To cite this article: Öntürk, Y., Özsoy, D., Satılmış, S. E., Yaraş, A. (2022). Examination of the social achievement goal of the students in the faculty of sports sciences in terms of various demographic variables. *Journal of Theory and Practice in Sport, 1*(1), 36-46.

Received: 24.10.2022

Accepted: 28.11.2022

Published: 25.12.2022

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Examination of the Social Achievement Goal of the Students in the Faculty of Sports Sciences in Terms of Various Demographic Variables

Abstract

This study aims to examine the social achievement goals of the students who continue their education at the Faculty of Sport Sciences and to compare them in terms of various demographic variables. The study group consists of a total of 230 volunteers, 74 females and 156 males. "Social Achievement Goal Scale" (SAGS) was used as a data collection tool in the study. The Cronbach Alpha internal consistency coefficient was calculated to determine the scale's reliability. In the analysis of the data obtained, the Shapiro-Wilk Test was applied to determine the normality level of the dependent variable as well as the descriptive statistical methods of the independent variables. Mann-Whitney U Test, the nonparametric test, was used to determine the difference between the groups of the sample that did not comply with the normal distribution. When the results of the U-Test were examined, the independent variables of the individuals who "exercise regularly," "have a professional athlete background," "take duty in a sports organization," and "o team sports" showed a significant difference in terms of the total mean score of SAGS. However, when the results were analyzed in terms of gender variables, it was seen that there was no significant difference. As a result, it has been determined that the Faculty of Sport Sciences students have a high social success target. In addition, it was determined that individuals with an athletic background showed behaviors related to social success more intensely than other groups.

Keywords: Social Success, Goal Orientation, Achievement Goal

Spor Bilimleri Fakültesindeki Öğrencilerin Sosyal Başarı Hedefinin Çeşitli Demografik Değişkenler Açısından İncelenmesi

Özet

Bu araştırmada, Spor Bilimleri Fakültesi'nde öğrenimine devam eden öğrencilerin sosyal başarı hedefinin incelenmesi ve çeşitli demografik değişkenler açısından karşılaştırılması amaçlanmıştır. Çalışma grubunu 74 kadın ve 156 erkek olmak üzere toplam 230 gönüllü birey oluşturmaktadır. Araştırmada veri toplama aracı olarak "Sosyal Başarı Hedefi Ölçeği" (SBHÖ) kullanılmıştır. Ölçeğin güvenirliğini belirlemek için Cronbach Alpha iç tutarlık katsayısı hesaplanmıştır. Elde edilen verilerin analizinde bağımsız değişkenlerin betimsel istatistik yöntemlerinin yanı sıra bağımlı değişkenin normallik düzeyini tespit etmek için Shapiro-Wilk Testi uygulanmıştır. Normal dağılıma uymayan örneklemin grupları arasındaki farklılığı tespit etmek amacı ile nonparametrik testlerden Mann-Whitney U Testi kullanılmıştır. Yapılan U Testi sonuçları incelendiğinde "düzenli egzersiz yapan", "profesyonel sporcu geçmişine sahip olan", "spor organizasyonunda görev almış", ve "takım sporları yapan" bireylerin bağımsız değişkenleri SBHÖ toplam ortalama puanı açısından anlamlı farklılık göstermiştir. Bulgular, cinsiyet değişkeni açısından incelendiğinde anlamlı farklılık olmadığı görülmüştür. Sonuç olarak Spor Bilimleri Fakültesi'ndeki öğrencilerin yüksek düzeyde sosyal başarı hedefi içerisinde olduğu tespit edilmiştir. Ayrıca sporcu geçmişine sahip olan bireylerin sosyal başarıya ilişkin davranışları diğer gruplara kıyasla daha yoğun biçimde gösterdiği belirlenmiştir.

Anahtar Kelimeler: Sosyal Başarı, Hedef Yönelimi, Başarı Hedef

Introduction

The concept of social is derived from the Latin word "socius," which means "friend." When the meaning of the word social is examined, we come across definitions based on cooperation between people and the tendency to establish relationships. The concept of success, on the other hand, is the level of competence for the specific skill area of the individual. Success in psychology has been expressed as the stage of realizing the goals that the individual or society dedicates to himself (Alkan, 2019). The concept of social success describes the expectations of individuals and the results of their activities (Taysaeva, 2022). People's goals for their social relations constitute the goals of social success (Alkan, 2019).

While goals are expressed as the purpose of realizing behaviors, it is seen that social goals are essential for people to achieve success in their social interactions. For example, in the sportive activities that take place within an event, the achievements affected by the event are associated as an indicator of the person's social status since they are evaluated by people (Drozdov, 2020). The goals people acquire to succeed in their social interactions are their social goals. Social achievement goals, which show different ways of defining a person's social competence, reveal various patterns in socialization belief and behavior (Arslan et al., 2018).

Human is a social being, and how others think, influence, and establish interpersonal relationships is considered a scientific discipline in social psychology. Solving problems between people in society allows for the development of a healthy lifestyle and happiness. In this direction, community refers to social life. A person who has a self-image in society is a social being. Forming, developing, and strengthening a person's self-image constitute the main goals (Üzbe & Bacanlı, 2015). In theory, as stated in the success goals, the main success goal, which is the action taken by the person to define the behavior, is fundamental. The characteristic expressed in achievement motivation is based on one's perception of one's ability. There appears to be a distinction between the task and ego approaches in achieving goals. Sports psychologists stated that the effect of task approach goals in the struggle in case of failure is vital in maintaining performance (Bozkurt, 2014).

Beliefs and emotions that determine the purpose of one's behavior are expressed as success orientation (Palancı et al., 2010). The presence of people in social groups represents social identity. Social identity is critical in athletes' communication skills, self-expression, or relationships within the team. A strong athlete identity is a psychological and sociological

phenomenon that provides an advantage in interpreting the results of positive or negative behaviors (Esenkaya et al., 2021).

Method

Study Group

The study group consists of 230 undergraduate students, whose average age is 74 women and 156 men, studying at the faculty of sports sciences.

Data Collection Tools

A form consisting of two parts was used to collect data. In the first part of the applied form, in addition to the sociodemographic personality characteristics of the individuals, the status of exercising regularly, the variable of taking duty in the sports organization, the variable of having a professional athletic background, and the independent variables related to the sports consisted of questions. In the second part, Horst et al. (2007) Social Achievement Goal Scale developed by Arslan et al. (2018) adapted it into Turkish. The scale has three sub-dimensions, including 11 items. The sub-dimensions are skill, performance approach, and performance-avoidance, respectively. In addition, the scale varies in a 5-point Likert type.

Analysis of Data

In the data analysis part, the results from the Shapiro-Wilk test were examined to determine the normality distribution. It was determined that the group did not provide a normal distribution ($p<0.05$). In addition to descriptive statistics such as frequency and percentage in data analysis, nonparametric test techniques were used in data analysis. Mann Whitney U Test was applied to determine the difference between the independent variables of the two groups.

Hypotheses

The hypotheses created in the research are as follows:

• H1: Social success target differs significantly according to gender variable.

• H2: The goal of social success differs significantly according to the experience of participating in the sports organization.

• H3: Social success target differs significantly depending on the professional athletic background.

• H4: Social success target differs significantly according to the sports branch.

Results

Table 1. Distribution of the Study Group in terms of Demographic Variables

Variable	N	Percent
Gender		
Male	156	67,8
Female	74	32,2
Regular Exercise		
Yes	147	63,9
No	83	36,1
Taking on Duty in a Sports Organization		
Yes	135	58,7
No	95	41,3
Professional Athletic Background		
Yes	50	21,7
No	180	78,3
Sport		
Individual	111	48,3
Team	119	51,7

The presentation of some demographic characteristics of the participants participating in the research is given in the table. When the frequency and percentage results were analyzed regarding gender, a total of 230 university students, 156 (67.8%) male and 74 (32.2%) female participated in the study. While 147 (63.9%) exercised regularly, 135 (58.7%) participated in sports organizations. In addition, 180 participants (78.3) did not have a professional athlete background, while 119 participants (51.7) were engaged in team sports.

Table 2. Scale Score Distribution

Scale	Items	N	Mean	C.Alpha
Social Achievement Goal	11	230	3.22	0.919

The internal consistency of the items in the scale is analyzed with the alpha coefficient, and the value range of $0.60 \leq \alpha < 0.80$ indicates that the scale is quite reliable (Lorcu, 2015). When the Cronbach Alpha internal consistency coefficient was calculated for the total scale, the result was determined to be 0.919. It has been statistically proven that the obtained result is quite reliable.

Table 3. Shapiro-Wilk Normality Test Result

Scale	Items	Count	p
Social Achievement Goal	11	,970	0.00

When the normality test results of the sample group are examined, it is seen that the group does not exhibit a normal distribution ($p<0.00$). For this reason, nonparametric test techniques were used to analyze the data.

Table 4. U-Test Results of Social Achievement Goal by Gender Variable

Gender	N	Mean	U	p
Male	74	116.19	5721.00	0.91
Female	156	115.17		

Social achievement goal total scores were examined in terms of the gender variable in Table 4, and no significant difference was found when the averages of men and women were compared ($p>0.05$).

Table 5. U-Test Results Regarding Regular Exercise Status

Regular Exercise	N	Mean	U	p
Yes	147	128.09	4249.500	0.00
No	83	93.20		

Social achievement goal total scores differed significantly in the regular exercise variable ($p<0.05$). The significant difference detected is in favor of individuals who exercise regularly.

Table 6. U-Test Results for the Variable of Taking on Duty in a Sports Organization

Participating in Sports Organizations	N	Mean	U	p
Yes	135	136.98	3512.500	0.00
No	95	84.97		

In Table 6, the results of the test conducted regarding the participation of the participants in the sports organization showed a significant difference in terms of the total score of the social

achievement goal (p<0.05). Again, the significant difference is in favor of the individuals involved in the sports organization.

Table 7. U-Test Results for the Variable of Having a Professional Athlete Background

Professional Athletic Background	N	Mean	U	p
Yes	50	147.89	2880.500	0.00
No	180	106.50		

The variable of having a professional athlete background, the participants showed a significant difference in terms of social achievement goal total score (p<0.05). The significant difference is in favor of participants with a professional athlete background.

Table 8. U-Test Results Regarding the Sport Variable

Sport	N	Mean	U	p
Individual	111	100.69	4960.500	0.00
Team	119	129.32		

In Table 8, it is seen that the test result for the sports variable in terms of social success target differs significantly (p<0.05). The significant difference is in favor of the participants engaged in team sports.

Discussion and Conclusion

In this study, the social achievement goals of undergraduate students studying in sports sciences were examined according to their sociodemographic characteristics, regular exercise status, previous involvement in a sports organization, professional athlete background, and sports branches.

In the studies conducted, it is seen that the purpose of success is associated with self-efficacy, being comfortable in front of an audience, and extroverted expectations. It is known that individuals will succeed when they accept their talents and characteristics; that is when they are at peace with their essence. It has been observed that children with low self-esteem are unsuccessful in adapting to formal education and school (Palancı et al., 2010). The relationship between success goal orientation and passion for work was examined, and it was concluded that

mastery goal orientation contributed more positively to work engagement than proving goal orientation (Turgut, 2013). In the studies on the subject, it was concluded that the goal of social success affects motivation in young adolescents. It has been determined that male students have higher levels of social development, social approach, and social avoidance goals compared to female students (Bahar et al., 2018).

In the literature on social achievement goals, it is seen that emphasis is placed on social and academic goals. It has been determined that social aspects are associated with achievement motivation (Horst et al., 2007). The factors in achieving success are many and varied, but the common primary factor is assumed to be motivation (Maehr, 2009). It is seen that the concept of goal, which can be defined as a form of inspiration, is at the center of the study of human motivation (Murayama, 2012). Recently, researchers stated that social achievement goals along with academic goals are critical to understanding motivational dynamics better (Anderman & Anderman, 1999; Covington, 2000; Deci & Ryan, 2000; Dowson & McInerney, 2001; Patrick, Anderman, & Ryan, 2002; Urdan, 1997; Wentzel, 2000). Liem (2015) stated that the importance and meaning of social success goals and the coordination of multiple goals in the daily academic life of individuals constitute an issue that should be considered. In addition, in the related research in the literature, it was concluded that the increase in success motivation in sports activities affects and increases the happiness of the athletes (Özgün et al., 2017).

As a result, it has been determined that the students studying at the faculty of sports sciences have high social achievement goals. The goal of social success shows a significant difference in favor of individuals doing regular exercise, participating in sports organizations, having a professional athlete background, and people who have mainly dealt with team sports. According to the result obtained from the dependent and independent variables, the fact that the students participate in any sports activity in the faculty of sports sciences shows that it plays an essential role in their social identities. Being interested in sports activities creates a situation that brings social success. The fact that the average scores of the participants, especially those involved in team sports, regarding their social achievement goals were higher is an essential outcome of the positive effect of sports on social identity.

Author Contribution

Öntürk, Y. (Conceptual framework, data collection); Özsoy, D. (Conceptual framework, data collection); Satılmış, S. E (Data analysis); Yaraş A. (Data analysis, writing)

Conflict of Interest

All authors must declare that there is no conflict of interest.

Ethical Statement

Ethical review was provided by the institutional review board.

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JOURNAL OF THEORY AND PRACTICE IN SPORT
MUĞLA SITKI KOÇMAN UNIVERSITY
FACULTY OF SPORT SCIENCES

The Association of Physical Activity, Sports Participation and BMI with Academic Performance: A Quantitative Study on Post-Secondary Students in Malta

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To cite this article: Magro, A., Kerr Cumbo, R., & Zarb, A. (2002). The association of physical activity, sports participation and BMI with academic performance: A quantitative study on post-secondary students in Malta. *Journal of Theory and Practice in Sport, 1*(1), 47-65.

Received: 08.11.2022

Accepted: 25.11.2022

Published: 25.12.2022

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The Association of Physical Activity, Sports Participation and BMI with Academic Performance: A Quantitative Study on Post-Secondary Students in Malta

Abstract

Several studies have argued that physical activity and sports participation or scoring high in the Body Mass Index (BMI), may impede students from achieving high marks throughout their scholastic year. The rationale behind this study was to test for these hypotheses to scientifically test if such variables have a causation effect on students' marks. Using a quantitative approach through self-reported online questionnaires, the produced results prove that there is no correlation between sports activity and the unweighted average mark obtained by University of Malta (UoM) students and those following courses within the Malta College of Arts, Science and Technology (MCAST). Furthermore, the study did not produce any statistically significant correlations between the amount of physical activity by the student and the average mark obtained by students at the end of their academic year. However, the produced regression models prove that the BMI score of a person has a negative causation effect on the academic mark obtained by the student, whereby for every additional BMI category that students reach, their average end-of-year score decreases by 1 mark, signaling that obesity is having a negative impact on students' academic performance. Also, despite regular physical activity having no direct effect on academic performance, still it was proven to influence the BMI score. This leads this study to suggest the promotion of more physical activity within educational institutions ultimately affects students' performance.

Keywords: Sports activity, Sports participation, BMI, Academic mark

Fiziksel Aktivite, Spora Katılım ve VKİ ile Akademik Performansın İlişkisi. Malta'daki Lise Sonrası Öğrenciler Üzerine Niceliksel Bir Çalışma

Özet

Çeşitli araştırmalar, fiziksel aktivite ve spora katılımın ya da Beden Kitle İndeksinde (VKİ) yüksek puan almanın, öğrencilerin eğitim yılları boyunca yüksek notlar almalarını engelleyebileceğini ileri sürmüştür. Bu çalışmanın arkasındaki mantık, bu tür değişkenlerin öğrencilerin notları üzerinde nedensel bir etkiye sahip olup olmadığını bilimsel olarak test etmek için bu hipotezleri test etmektir. Kendi kendine bildirilen çevrimiçi anketler yoluyla niceliksel bir yaklaşım kullanarak, elde edilen sonuçlar, spor aktivitesi ile Malta Üniversitesi (UoM) öğrencileri ve Malta Sanat, Bilim ve Sanat Koleji'ndeki dersleri takip edenlerin aldığı ağırlıksız ortalama not arasında bir ilişki olmadığını kanıtlıyor. Teknoloji (MCAST). Ayrıca çalışma, öğrencinin fiziksel aktivite miktarı ile akademik yılın sonunda öğrencilerin aldığı ortalama not arasında istatistiksel olarak anlamlı herhangi bir ilişki üretmedi. Ancak üretilen regresyon modelleri, bir kişinin BMI puanının öğrencinin akademik notu üzerinde olumsuz bir nedensellik etkisi olduğunu kanıtlamakta ve öğrencilerin ulaştığı her ek BMI kategorisi için yılsonu ortalama puanı 1 puan azalmaktadır. , obezitenin öğrencilerin akademik performansı üzerinde olumsuz bir etkiye sahip olduğuna işaret ediyor. Ayrıca, düzenli fiziksel aktivitenin akademik performans üzerinde doğrudan bir etkisi olmamasına rağmen, yine de BMI puanını etkilediği kanıtlanmıştır. Bu, bu çalışmayı, eğitim kurumlarında daha fazla fiziksel aktivitenin teşvik edilmesinin nihayetinde öğrencilerin performansını etkilediğini önermeye yönlendirir.

Anahtar Kelimeler: Spor etkinliği, Spora katılım, VKİ, Akademik not

Introduction

Malta has been ranking as one of the most obese countries in Europe and the world for more than a decade. To add insult to injury, according to the Country Health report published by the Organisation for Economic Co-operation and Development (OECD) and the European Observatory on Health Systems and Policies (2021 p.7), "rates of overweight and obesity in Malta have increased over the past decade and are the highest in the European Union (EU) for both adults and adolescents." It is alarming to notice that Maltese children are classified as having one of the highest obesity rates in Europe (WHO, 2022, Figure 1) and that 37% of men and 33% of women in Malta are predicted to have a Body Mass Index (BMI) above 30kg/m^2 by 2030, ranking Maltese men and women first and fourth respectively in the charts of European countries with the highest estimated prevalence of obesity (World Obesity Federation, 2022).

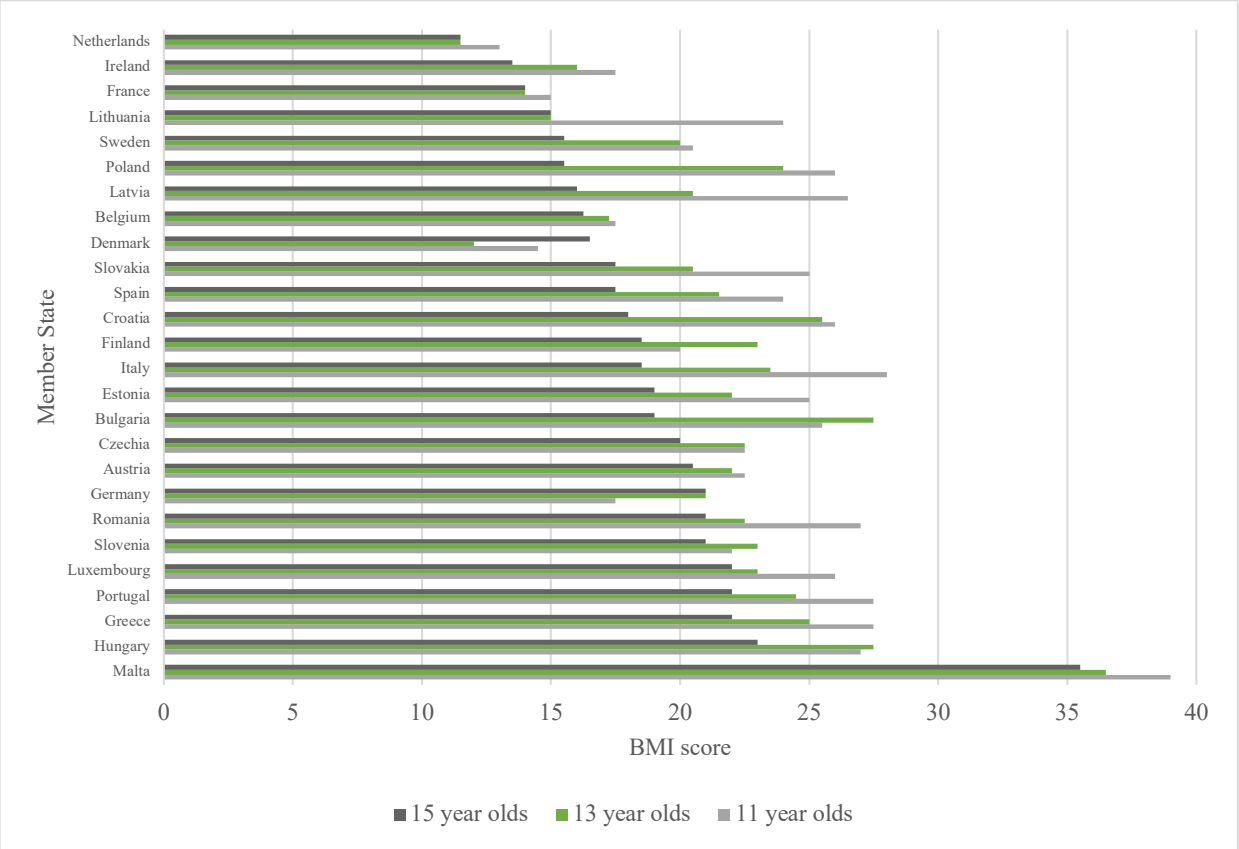

Figure 1. Obesity among children within the European Union (EU) (WHO, 2022)

These statistics justify the ongoing debate underlining the attention sports and physical activity should be given on the Maltese Islands. In fact, there is consensus in the international literature that regular participation in sports and physical activity can improve health (WHO, 2012), including positive causation of physical and mental wellbeing (Wilson *et al.*, 2022), and lowering the risk of developing various diseases (Elmagd, 2016). The gains from sports

participation were also acknowledged in Kenioua and Abd Elkader's (2016) paper, concluding that participation in sports and physical activity have positive benefits on the public, whereby students who are athletes enjoy better physical and mental wellbeing. Also, by being active as from a young age, according to Eime *et al*. (2013), it prevents the development of other health problems since students can refresh their minds from their school related work, as well as maintain a healthy body weight that prevents diseases, strengthens muscles and bones, and reduces the risk of harmful diseases (Elmagd, 2016).

Purpose of the Study

Despite the benefits that sports participation as from a young age have on individuals, students, especially those in higher education, may get discouraged from participating in sports or physical activity due to the time needed for practice (Rees & Sebia, 2010). There is agreement that less time for school work and for employment purposes may lead to sub-optimal academic results and lower income for students (Pfeifer & Corneliben, 2007). Recently, there has been an international widespread interest to examine for the possible association of physical activity and sport participation with academic performance (Dyer *et al*., 2017), as well as for the association of students' body weight with their academic performance (Santana *et al*., 2017).

Both the benefits indicated by research and the widespread interest found in international research were catalysts for this study. The rationale behind this study was to explore for the possible association between the practicing of sports, being physically active, as well as being healthy (as measured using the BMI score) on students' academic performance. It specifically focuses on post-secondary students in higher education in the small Mediterranean archipelago of Malta.

Literature

The WHO (2020 p.2) considers physical activity to be,

> "Any bodily movement produced by skeletal muscles that requires energy expenditure. Physical activity refers to all movement including during leisure time, for transport to get to and from places, or as part of a person's work."

Still, although these can be considered as part of an individual's daily routine, one should reach the recommended requirements to have a healthy lifestyle (Matiba, 2015; WHO, 2014). Under such a definition of physical activity lie physical exercises which are known to maintain or

improve different components of physical fitness through repetitive, planned and structured body movements (Elmagd, 2016).

Although Sutula (2018) acknowledges that there are multiple definitions of sports, the definition adopted in this study is that of Oxford Learner's Dictionary (2022) which considers sports as an "activity that you do for pleasure and that needs physical effort or skill, usually done in a special area and according to fixed rules". Then, sports participation refers to "purposeful active participation in sports related physical activities performed during leisure-time" (Deelen, Ettema, & Kamphuis, 2018, p. 4).

There are a wide range of sports available, some require athletes to exert vigorous physical activity while others demand minimal effort (Ghildiyal, 2015). Moreover, individuals have the choice to decide to take part in a particular sport for personal enjoyment, recreation, or to win a reward (International Council of Sports Science and Physical Education [ICSPE], 1991; Coakley 1994).

Another focus of this study is on obesity which is universally measured using the Body Mass Index (BMI) (Centre for Disease Control and Prevention, 2022). The BMI is calculated by dividing weight (in kilograms) by the square of the person's height (in centimetres) (BMI calculator, n.d.). According to Coulman and Toran (2020), the BMI could be categorised as depicted in Table 1, whereby a person is considered as obese if the BMI score exceeds 30.

Table 1. BMI categories

BMI	BMI classification
Below 18.5	Underweight
18.5 – 24.9	Normal weight
25.0 – 29.9	Overweight
30.0 – 34.9	Obesity class 1
35.0 – 39.9	Obesity class 2
Above 40	Obesity class 3

Sports, physical activity, and academic performance

Academic achievement can be split into different learnings such as communicative (oral, writing, reading), mathematical, social science, and thinking skills, being all factors that may help students to succeed on both an academic and societal level (Moore, 2019). However, the appropriate measurement of students' academic achievement is still not agreed by all the stakeholders in the industry (educators, experts and policymakers) which allow researchers to use various ways of measuring academic performance, including Grade Point Average (GPA), teacher ratings, memory tests, grade retention, and dropout rates (Ampofo & Osei-owusu, 2015).

Determinants behind academic performance

According to Hamid (2019) and Navarro *et al*. (2020) there are two factors affecting students' academic performance, categorised as internal and external factors. Internal influences are formed with talents and biological traits, including students' competences and aptitude towards learning, self-motivation, hard work and having a good memory (Georgiou, 1999; Hamid, 2019). Conversely, external influences are determinants affecting students' academic performance for which the student has no control, including the socio-economic status of the students' family background and the demands by educators (Roman, 2013). According to Roslan *et al*. (2011) these two factors play an essential role in shaping students' academic achievements.

However, besides such factors, the literature identifies other factors which may affect the students' performance while at school, whereby Al-Muslimawi and Hamid (2019) proposes a balanced mix of academic and extra-curricular activities that could enable students to attain a positive experience during their years in college. On the other hand, according to the same authors, an imbalance towards one of the two areas can lead to stress and anxiety. This is also corroborated in Akey's (2006) finding which argues that engagement in non-academic activities motivates the student to learn more academic aspects. In return, according to Sivrikaya (2019) such motivated students have an increased chance of achieving good academic levels.

Sports participation, physical activity, and students' wellbeing

The WHO (2022) stated that participation in physical activity or sports can be beneficial for students because it helps them to keep their body fit and keep their brain fresh for everyday life. Moreover, according to Wichstrøm and Wichstrøm (2009), participation in sports has a lot of benefits when dealing with addictions as it may prevent individuals from consuming unhealthy

substances such as drugs, alcohol, tobacco, and gambling, amongst others. This is especially because participation in sports requires a lot of time and dedication that could otherwise be used for the previously mentioned adverse purposes.

In addition, sports organisations promote a healthy lifestyle and therefore it requires that players do not consume illicit substances out of respect for their audiences (Pate *et al*., 2000). This is also corroborated by Yu *et al*. (2006) who argue that students who engage in different activities that they enjoy, and are excellent at them, have a lower chance of resorting to unhealthy lifestyles or unlawful actions, while sedentary students may experience different repercussions associated with inactivity which may further develop into health conditions such as obesity.

Sports participation, physical activity, and academic scores

In a 12-month study aimed at investigating the association between sports participation, physical activity, and students' GPA, Fox *et al*. (2010) found that high school girls who participated in physical activity and sports had better GPA scores than those who do not, while for the boys, only those who practiced in a team experienced better GPA scores than their counterparts. This is also corroborated in Dyer *et al*.'s (2017) study when investigating the association between sports participation and grades in both English and Mathematics. Other studies that have drawn the same positive conclusions about the two variables, including Rees and Sabia (2010), and Morales *et al*., (2011), amongst others. Other positive conclusions were drawn by Teferi (2020) who found that participation in sports does not only positively affect students academically, but also in terms of behaviour, causing students to further engage in learning (Uzzaman, Uddin, & Banu, 2009).

However, Pfeifer and Corneliben (2007) found that students who typically achieve high grades might find it challenging to juggle between the two roles since both participation in sports and studying for the exams are exceptionally time-consuming. Still, the authors suggested that the culture of competitiveness, effort and persistence that athletes build as part of their routine could be applied in school to maximise academic performance.

Still, even though several authors proved a significant positive association between participation in either physical activity or sports, and academic performance, other researchers have found opposing results (Daley, 2000; Lumpkin & Favor, 2012). For instance, Shulman and Bowen (2001), and Poolton *et al*. (2006) discovered that students who participate in sports scored achieved lower scores when compared with non-athlete students. In fact, those students who lack academically and participate in extra curriculum activities such as drama, art, music,

and particularly physical activity, may have a higher chance of successfully improving in their chosen activity, leading to an imbalance between the two roles, as previously identified by Muslimawi and Hamid (2019).

Locally, such a relationship has been tested by a few authors, including Cremona (2015) who investigated the relationship between physical activity and sports participation on the academic performance of second and third-year students at the University of Malta (UoM), resulting in a statistically insignificant relationship among the two variables. Similarly, Saliba and Xuereb (2011) conclude that students who practice a sport do not improve their academic results, however, for male students there was a slight improvement in Mathematics, Maltese, and English.

Obesity and academic performance

Overweight and obesity are well known global epidemics, whereby 53% of Europeans are categorized as overweight (Eurostat, 2022). In particular, the problem with obesity in Malta has been rising and has been one of the highest in Europe for a number of years (Cuschieri *et al.*, 2016).

Costs of obesity

The condition of obesity is considered as one of the diseases that may cause substantial harmful effects on our bodies by allowing too many adipocytes and body fats (Wehigaldeniya *et al*., 2017). This condition can be developed when a person consumes surplus calories which are converted into body fat (Reinehr, 2018; Tobin, 2013; Valenzia, 2017). Moreover, according to Reinehr (2018), if obesity develops during the period of adolescence, it normally prolongs to adulthood, which may result in premature death. One contributor to such an increase in obesity, especially among teenagers, is the excessive use of technology, such as the internet and other electronic devices, leading individuals to spend their time static rather than participating in physical activity (Alotaibi *et al*., 2020).

To counteract for such problems, the WHO (2011) recommends that individuals take part in physical activity, especially those between 18 and 64 years who should perform at least 150 minutes of moderate-intensity aerobic exercise or 75 minutes of vigorous intensity per day. Other recommendations were proposed by Reinehr (2018) who believes that a well-planned food nutrition could be an important solution to help individuals eat healthy and hence lessen the chances of increasing the weight.

The impact of obesity on students' academic scores

In a rich dataset of 72,399 respondents among South Korean adolescents, Kim and So (2013) discovered that both boys and girls who were considered as overweight or obese attained poorer academic performance vis-à-vis others who were considered as underweight or normal. This conclusion was also made by Do and Finkelstein (2011) in a similar study within the same country. Other research that complements such a conclusion includes the study by Tobin (2013) who discovered that there is a negative association between fast-food consumption and test scores in Mathematics and reading, while the results from Anderson and Good's (2017) study demonstrates that the higher the BMI score of the student, the lower his/her academic performance. Such an impact of obesity among children was not only tested to examine its impact on students' academic performance, but also on students' memories, being an important factor during the exams. Moreover, the results produced by Wu *et al*. (2017) conclude that obese students are associated with poorer scores in memory tests than those who are considered as healthy.

However, in a systematic review, Santana *et al*. (2017) concluded that more than 55.9% of the papers that they reviewed have reported that the association between obesity and academic performance is still uncertain. In fact, the authors suggested that there is a need for more longitudinal and further studies to be performed to have a better idea in this area.

Literature gap

Following such a review of different research done globally and locally, it noticed that few local studies have been done on this subject. The only two studies that are published in relation to this topic were done by Xuereb and Saliba (2011) and Cremona (2015), whereby both studies focused solely on the relationship between sports participation and academic performance. However, the aim of this study is to merge the association between physical activity, sports participation, and BMI with academic performance. Hence, such a comprehensive study will be providing a richer view of these factors among post-secondary students.

Method

The study aimed to investigate the association between participation in physical activity, sports participation, and BMI on academic performance, by performing a quantitative study amongst post-secondary students in Malta. Therefore, the hypotheses that are being tested in this study are:

H_0: Students' participation in physical activity is not associated with students' average grade.

H_1: Students' participation in physical activity is associated with students' average grade.

H_0: Students' participation in sports is not associated with students' average grade.

H_2: Students' participation in sports is associated with students' average grade.

H_0: Students' BMI is not associated with students' average grade.

H_3: Students' BMI is associated with students' average grade.

Research Design

Following a review of the work produced by past authors on the subject, including Do and Finkelstein (2011), and Kim and So (2013), primary data was sought for the purposes of this study through the collection of quantitative data so as to scientifically answer the research hypotheses.

Participants of this study

Students who attended a course at the UoM and the Malta College of Arts, Sciences and Technology (MCAST) between 2019 and 2020 have been invited to participate in this study by filling-in an online self-completion questionnaire. Participants were rigorously chosen to ensure that adequate analyses could be performed. Specifically, the selection criteria set for this study required students to have been attending the same higher education institution for at least one year and they had to be over 18 years of age. Such a criteria ensures that there is comparability between the two institutions and all students would have already received the marks during the 2019/2020 academic year.

Sampling strategy

Convenience sampling was the most effective way to obtain valid and reliable data to acquire data from the two categories of students, whereby participants of this study were selected from the two selected clusters (MCAST and UoM), and hence ensure proportional representation of both clusters. These two clusters provide a statistical overview of higher educational institutions in Malta since a considerable number of students attend these institutions.

The questionnaire was sent to a total of 15,444 students following a course at MCAST and the UoM. While MCAST students received the questionnaire through their MCAST electronic mail, making it easier for the participants to access the link, UoM students received the link via an application called esims. Based on a 95% confidence interval and a 5% margin of error, the

sample required to be collected was of 375 responses. In total after receiving the answers, 300 responses were left valid since some respondents did not satisfy the previously set criteria. Although the above set rate was not met, the sample is closer than the 90% confidence interval and 10% margin of error criteria which requires 68 responses.

Data Collection

Data was collected through an online self-reported questionnaire, whereby every potential participant received the questionnaire via his/her institution's email address or eSims account. Moreover, the available social media groups for such two groups of students were used to further distribute the questionnaire which was created through Google Forms. The benefit of using such a program is that it can be sent to many participants at once and then it allows the researcher to analyse the data collected. Moreover, such a platform allows participants to feel as comfortable as possible to answer sensitive questions, in particular their weight.

In-line with the questionnaires designed by past researchers on the subject (Cremona, 2015; Kim & So, 2013), personal data was asked, specifically regarding the participants' age, sex, weight, height, physical activity levels, and sports participation. The quantification of the degree of physical activity and sports participation of the individual was possible by including several frequencies as options, allowing the participant to choose the one that most applies to his/her situation. This was followed by asking participants to provide their obtained marks for each subject based on how many academic units they had during the academic year 2019/2020. Moreover, for the purpose of better data management, rather than taking individual grades, the average grades were calculated to construct an unweighted GPA, as was done by Fox *et al*. (2010). The BMI score was computed following the collection of the weight and height of the student and based on the interpretation by Coulman and Toran (2020) in Table 1.

Data Analysis

To provide an answer to the three research hypotheses, regressions were designed and computed to capture the individual impact of each independent variable on the dependent variable. For the purposes of this study, two sets of regressions were set, intended to model the changes in students' academic score (measures using the unweighted GPA scores) and their BMI level. Each regression was performed using the Ordinary Least Squares (OLS) technique which minimises the errors. However, for OLS regressions to be efficient, a suitable sample size is required.

The regressions models adopted in this study are displayed below, together with an explanation of each variable in Table 2.

$$\begin{aligned}\text{MARKS}_i = \beta_0 + \beta_1\text{AGE} + \beta_2\text{GENDER} + \beta_3\text{LEVEL} + \beta_4\text{BMI} + \beta_6\text{UNITS} + \beta_7\text{ENROLMENT} + \beta_8\text{SPORT} \\ + \beta_9\text{BMI}_{\text{CATEGORIES}} + \beta_{10}\text{WEIGHT} + \beta_{11}\text{HRS}_{\text{PHYSICAL}} + \beta_{12}\text{PHYSICAL}_{\text{ACTIVITY}} + \beta_{13}\text{UNI}_{\text{SPORT}} \\ + \beta_{14}\text{UNI}_{\text{PHYSICAL}} + \varepsilon_i\end{aligned}$$

$$\text{BMI}_i = \beta_0 + \beta_1\text{AGE} + \beta_2\text{GENDER} + \beta_3\text{SPORT} + \beta_4\text{HRS}_{\text{PHYSICAL}} + \beta_5\text{PHYSICAL}_{\text{ACTIVITY}} + \varepsilon_i$$

Results

The Descriptive Statistics output in Table 3 is used to examine, compare, and contrast the dataset between UoM and MCAST participants. It can be noted that there are no significant differences among the two group of participants with regards to:

- The age of the two groups.
- The gender of the respondents.
- The level of studies at which the student is studying.
- The enrolment type of the respondents, whether full-time or part-time.
- The average marks obtained by the end of the year.

Such findings ensure that the two groups are comparable to each other. The Descriptive Statistics exercise also enables us to examine the socio-demographic characteristics of the participants, revealing that there were more female over male participants and that most students were following level 5 and 6 courses. Moreover, it can be noted that the median BMI score among all participants is 25, being considered as overweight, while on average, 8 hours per week are spent in training, although MCAST students tend to practice slightly more than UoM participants.

Preliminary analysis

Academic mark and hours of physical training

To examine the first research hypothesis, the Spearman correlation test was used to assess whether there is a statistically significant correlation among the two numerical variables. The results in Figure 3 prove that there is no statistically significant correlation between the hours of physical training (per week) and the marks obtained by the participants by the end of the year, leading the null hypothesis not to be rejected.

H_0: There is no linear relationship between the two variables

H_A: There is a linear relationship between the two variables

Table 2. Academic marks versus number of hours per week in training

			HRS_ TRAINING	MARK
Spearman's rho	HRS TRAINING	Correlation coefficient	1.000	.028
		Sig. (2-tailed)	.	.811
		N	80	78
	MARK	Correlation coefficient	.028	1.000
		Sig. (2-tailed)	.811	.
		N	78	289

Therefore, training or not training are not correlated with lower or higher marks. Similar conclusions were also produced by Poolton, Masters and Maxwell (2006) who concluded that students who engaged in more physical activity did not perform any better academically than other students who do not.

Academic mark and practicing sports

The second analysis aims at examining whether there is a statistically significant correlation between the academic mark obtained by the participants and whether they practice a sport or not, intended to test the second research hypothesis. The Mann Whitney U-test output displayed in Figure 2 tests whether there is a statistically significant correlation between e participants who practice sports (SPORT) and the average end-of-year mark obtained by the participant (MARK). Since the p-value of the Mann-Whitney test is greater than 0.05, then the null hypothesis is not rejected, meaning that there are no statistically significant differences in the marks obtained by the participants between those who practice a sport (Sport = 1) and those who do not (Sport = 0).

H_0: There is no significant difference between the two groups

H_A: There is a significant difference between the two groups

Table 3. Academic marks versus whether the participant practices sports

Ranks

	SPORT	N	Mean rank	Sum of Ranks
MARK	.0	211	147.36	31092.50
	1.0	78	138.62	10812.50
	Total	289		

Test Statistics[a]

	MARK
Mann-Whitney U	7731.500
Wilcoxon W	10812.500
Z	-.789
Assymp Sig. (2-tailed)	.430

a. Grouping Variable: SPORT

These findings corroborate with those by Cremona (2015) who also produced a statistically insignificant link between sports participation and academic performance among second and third year UoM students.

Regression analyses to determine students' marks

The aim of this study is to identify whether the participation in sports, the number of hours of training and the BMI of the student affects the GPA score obtained. Therefore, a series of regressions were tested (Table 4) to test for the possible relationship among the following variables, in line with the research hypotheses set earlier.

Following a multicollinearity test to examine for the degree of association between the independent variables it was revealed that there exists severe multicollinearity between 'BMI_CATEGORIES' and 'BMI', and 'PHYSICAL_ACTIVITY' and 'HRS_PHYSICAL'. Therefore, such variables will not be regressed together in the model. Moreover, White heteroskedastic consistent standard errors were used to overcome for the possible problem of heteroskedasticity which would have led to biased results.

Following the trial of several regression models, intended to be able to examine possible results and choose the best model out of those available, the optimal regression model is regression 8. This is concluded based on A.C. Harvey's criteria which guides researchers to choose the model which has the highest goodness of fit model, is theoretically consistent, and does not have insignificant variables so as not to incur irrelevant variable bias in the model.

The chosen model is explaining 4.1% of all the changes in the dependent variable, being common in regression analyses based on questionnaire data collection, especially since the dependent variable was constructed based on participants' recollection of memories (Steele *et al*., 2009). The resulting regression is:

$$\mathrm{MARK_i} = 72.82 + 0.15\mathrm{AGE_i} + 2.75\mathrm{GENDER_i} - 1.00\mathrm{BMI_{CATEGORIES}} + \varepsilon_i$$

The constant term of the chosen regression is 72.82, meaning that when all the independent variables are equal to zero, the individual would obtain 72 marks. Then, the coefficient for the variable 'AGE' is 0.15, meaning that for every year of the participant, his/her marks increase by 0.15. For instance, if the age of the participant increases by 20 years, the age increases by 3 marks over the constant terms.

The variable 'GENDER' has a positive coefficient, meaning that whenever the participant was a female, her mark increases by 2.75 marks over and above male participants. The term 'BMI_CATEGORIES' has a negative coefficient which means that as the individual moves from one BMI category to a higher one, the marks obtained by the participant decreases by 1 mark. The last term represents the error term which includes other factors that were not captured by the model to explain changes in the dependent variable.

Therefore, such results corroborate with the findings by Franz and Fereesu (2013) who concluded that students who eat unhealthy food and have a poor nutrition experience and experience lower academic results, compared to students who eat healthy food. Moreover, this result was also evident in Wehigaldeniya *et al*.'s (2017) study which pointed out that students with normal weight get better results than those who are classified as obese.

Regression analyses to determine students' BMI

The second regression model was constructed to identify the factors that determine the participants' BMI. Several regressions have been tested (Table 5) to explain changes in the BMI of the participant. Following the performance of several statistical models, the chosen regression is model 6 since it has the highest number of significant variables, as well as having a relatively high goodness of fit measure (R^2). Therefore, the chosen regression model is:

$$\mathrm{BMI_i} = 26.18 + 0.15\mathrm{AGE_i} - 1.58\mathrm{GENDER_i} + 1.85\mathrm{SPORT_i} - 1.01\mathrm{HRSPHYSICAL_i} + \varepsilon_i$$

This chosen regression model is explaining 12.57% of the changes in the BMI of the participants, whereby the rest are captured under the error term. The constant term is 26.18 meaning that when all the independent variables are equal to zero, the participant has such BMI value. For every additional age of the participant, his/her BMI value increases by 0.15 basis

points. Moreover, female participants have a BMI value which is less than males by 1.58 basis points. The results produced also explain how those participants who practice sports tend to have a higher BMI than those who do not by 1.85 basis points, due to higher muscle which contributes to higher weight. However, for every additional hour of physical training that the participants practiced, their BMI value decreases by roughly 1 basis points.

Discussion

Maltese sports and physical activity enthusiasts constantly advocate for more school time to be allocated on such activities as they directly help students improve their grades. However, the results from this study contend with the findings by Din (2005), Saliba and Xuereb (2011) and Cremona (2015), that those who practice sports or other physical activity do not experience improved academic achievements, as evident in Table 4. Still, the results in Table 5 prove that longer hours of physical activity per week help lower the person's BMI, and then the results in Table 4 prove that those participants who had lower BMI experience an increase in their academic marks. Therefore, although physical activity and training do not have a direct positive effect on students' academic marks, it indirectly contributes to an ultimate positive effect.

Conclusion

The purpose of the study was to look at the effect of students' participation in physical activity and sports, and their BMI has on the average grades obtained among higher educational students following a course at the UoM and MCAST. The produced results prove that the participation in sports or physical activity does not seem to contribute to improved academic scores but as students have higher BMI, measured by categorising the BMI using international established criteria, their grades decline. However, the second set of regressions has proven that the number of hours of training has a direct impact on the students' BMI which therefore leads this study to conclude that the participation in physical activity, although it does not have a direct impact on improving students' academic score, it has an indirect impact as it reduces students' BMI which in turn leads to improved academic grades.

Recommendations

Policy recommendations

Such findings corroborate with recommendations made by the International Survey of Children's Subjective Well-being which proposes child-friendly spaces for play and physical exercises to improve the quality of life of children. Research shows that an effective calendar

of initiatives creates a culture of physical activity within higher secondary institutions. Therefore, college administration should ensure that ongoing physical activity events are present throughout the academic year to create a culture of physical activity. Moreover, Cumbo *et al*. (2019) suggested that students' timetables should be fixed for students to be able to engage in some form of physical activity. Furthermore, college fitness centres, if available, must remain open after school hours to allow further use of such facilities provided by the institutions. In addition, investing in sports facilities, such as pools, athletic tracks and training classes could help encourage students to be more active, which could lead to such students to be motivated throughout their studies.

Limitations of the study

The collected sample, although substantial, did not meet the 95% confidence interval criteria. The reason for such a low response rate was due to the technique adopted to distribute the questionnaire, whereby students might not check their institution's emails and esims messages frequently, leading to a moderately low response rate. Moreover, the collected sample was slightly over-represented by MCAST students, not being a true representation of the population. Furthermore, the chosen technique required students to recollect past academic marks, referred to in the literature as recall bias. Therefore, this might contribute to biased results.

Author Contribution

Alessio Magro worked on developing the idea for such a study, worked on the write-up and data collection for such a study. Dr. Renzo Kerr-Cumbo conceptualized this study, helped further develop the idea and contributed towards the write up of this paper. Ayrton Zarb worked on the data analysis and the write up of the findings of this study.

Conflict of Interest

All authors declare that there are no conflict of interest present in this work.

Ethical Statement

This study has passed ethical clearance which was granted by the Research Ethics Committee (REC) within MCAST.

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SPORDA TEORİ VE UYGULAMA DERGİSİ
MUĞLA SITKI KOÇMAN ÜNİVERSİTESİ SPOR BİLİMLERİ FAKÜLTESİ

Teaching Handball Game Rules with Computer Simulation

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To cite this article: Ayan, İ. & Sakallı, D. (2022). Teaching handball game rules with computer simulation. *Journal of Theory and Practice in Sport, 1*(1), 65-76.

Received: 21.011.2022

Accepted: 29.11.2022

Published: 25.12.2022

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Teaching Handball Game Rules with Computer Simulation

Abstract

This research aims to teach pre-service teachers the rules of the international handball game through a simulation developed using the Tactic3D program. The study was carried out in a single group pre-test and post-test experimental design. A total of 32 teacher candidates (13 females and 19 males, mean age: 18.84) enrolled in the Physical Education and Sports Teaching program of Muğla Sıtkı Koçman University Faculty of Sport Sciences in the 2022-2023 academic year participated in the research. The students were selected from among the teacher candidates who had not taken handball lessons before, did not participate in the competition as licensed in the branch of handball, and had not played handball before. A descriptive information form and the Handball Game Rules Knowledge Test developed in the current study were used as data collection tools. The research data were collected online in the fall semester of the 2022-2023 academic year. The obtained data were analyzed with SPSS 22 program. According to the findings of the study, there was a statistically significant difference between the pre-test (49.32) and post-test mean scores (85.26) of the participants ($p<0.05$). In addition, there was a significant difference in favor of females between genders regarding post-test scores ($p<0.05$). Concerning the findings, it is seen that simulation training contributes to the handball knowledge level of teacher candidates. Consequently, it can be suggested that educational tools, as in the current research, can be added to the undergraduate education of prospective teachers and used as a tool to enrich teaching.

Keywords: Handball, Game rules, Simulation, Tactic3D

Bilgisayar Simülasyonu ile Hentbol Oyun Kurallarının Öğretilmesi

Özet

Bu araştırma, öğretmen adaylarına uluslararası hentbol oyununun kurallarını Tactic3D programı kullanılarak geliştirilen bir simülasyon aracılığıyla öğretmeyi amaçlamaktadır. Araştırma, tek gruplu ön test ve son test deneysel deseninde gerçekleştirilmiştir. Araştırmaya 2022-2023 eğitim-öğretim yılında Muğla Sıtkı Koçman Üniversitesi Spor Bilimleri Fakültesi Beden Eğitimi ve Spor Öğretmenliği programına kayıtlı 13 kadın ve 19 erkek, yaş ortalaması: 18.84 olmak üzere toplam 32 öğretmen adayı katılmıştır. Öğrenciler daha önce hentbol dersi almamış, hentbol branşında lisanslı olarak müsabakalara katılmayan ve daha önce hentbol oynamamış öğretmen adayları arasından seçilmiştir. Veri toplama aracı olarak tanımlayıcı bilgi formu ve bu çalışmada geliştirilen Hentbol Oyun Kuralları Bilgi Testi kullanılmıştır. Araştırma verileri 2022-2023 eğitim-öğretim yılı güz döneminde online olarak toplanmıştır. Elde edilen veriler SPSS 22 programı ile analiz edilmiştir. Araştırmanın bulgularına göre, katılımcıların ön test (49,32) ve son test puan ortalamaları (85,26) arasında istatistiksel olarak anlamlı bir fark vardı ($p<0,05$). Ayrıca son test puanları açısından da cinsiyetler arasında kızların lehine anlamlı bir fark bulunmuştur ($p<0,05$). Bulgulara bakıldığında simülasyon eğitiminin öğretmen adaylarının hentbol bilgi düzeyine katkı sağladığı görülmektedir. Sonuç olarak, mevcut araştırmada olduğu gibi eğitim araçlarının da öğretmen adaylarının lisans eğitimlerine eklenerek öğretimi zenginleştirecek bir araç olarak kullanılması önerilebilir.

Anahtar Kelimeler: Hentbol, Oyun kuralları, Simülasyon, Tactic3D

Introduction

The developments in science and technology have been effective in educational environments, just as in all areas of life. The need to keep up with this change has led to reorganizing educational settings (Atam & Tekdal, 2010). Furthermore, the increase in digital materials and software in daily life has become a part of our learning experiences (Tutal & Üzer, 2021). In particular, the concept of mobile learning, a new learning model, has emerged to meet the differentiating demands and needs of the new generation, which has grown intertwined with technology today. This learning method provides the opportunity to learn independently of time and place. In addition, using mobile apps and tools such as games and videos makes learning more fun and effective (Sümer, 2020).

The use of technology in education has many benefits for students. Educational technology creates multiple possibilities for individual initiative and freedom for teachers and students. It ensures that information is obtained from a primary source, creates equality of opportunity by saving people from the pressure of time and space, and increases diversity and quality compared to individual education. Educational technology improves creativity with the multiple and alternative learning opportunities it offers students. It individualizes teaching as it is shaped by student initiative and increases learning speed with the new environment and methods it has developed (Alkan, 2011). Sümer (2020) states that mobile application technology increases students' motivation and interest in the lesson and gives them a chance to access information quickly.

Computers are crucial course material in educational technologies. However, the frequent use of computers in education causes their efficiency to be questioned in animation and simulation environments (Emrahoğlu & Bülbül, 2010). Simulation can be defined as the realization of guided learning in a vibrant environment as close to reality as possible to achieve educational goals through experiential learning. It is used for education, evaluation, and research purposes (Sezer & Elçin, 2017). Simulation-based activities reveal students' prior knowledge and increase learning speed. In addition, simulation helps to develop inquiring and exploratory features (Karabudak, 2019).

Studies indicate that the use of simulation in education contributes positively to learning (Akbulut, 2018; Dağdalan & Taş, 2017; Emrahoğlu & Bülbül, 2010; Gürcüoğlu et al., 2019; Okumuş 2016; Öner & Yaman, 2020). In addition, simulation is catchy and fun for students, provides easy and meaningful learning, and saves time (Harman & Yenikalaycı, 2019).

Technology-supported education also contributes positively to student learning in the field of physical education and sports (Çakıt & Karadeniz, 2020; Ölmez, 2021; Karaşahinoğlu, 2013).

Information and communication technologies should be used in educational processes to succeed in sports (Yücel & Devecioğlu, 2012). Yang (2014) emphasizes that simulation technology benefits in gaining skills and ensures that the education-teaching process is organized effectively.

Handball is one of the most popular team sports in the world, where players from two teams try to score goals against the other team (Atalay et al., 2018). It extends the features of thinking and acting together, obeying the rules, harmonizing with the team, making decisions, and developing skills (Çakıt & Karadeniz, 2020). Therefore, handball is one of the sports branches that can be carried out within the scope of Team Sports courses in Physical Education and Sports Teaching programs. In the course content, it is expected that the definition of the related sport, basic stances and movements, strategies and tactics, individual and team defense, team attack, game systems, and rules should be included (Council of Higher Education (YÖK), 2018). In addition, handball in physical education classes, movement skills, movement concepts, principles, related life skills, and movement strategy and tactics is a sport that can be preferred to reach achievements in the sub-learning area (MEB 2018a, 2018b).

This research aimed to teach the rules of the international handball game rules to physical education and sports teacher candidates through a simulation developed using the Tactic3D program, which is a program that allows sportive skills to be drawn in 2D and viewed in 3D.

Method

Research Design

The research is in a single group pre-test post-test experimental design. The testing procedure is interpreted based on the measurement difference before and after the intervention (Tuncer, 2020).

Participants of the Study

A total of 32 teacher candidates (13 females and 19 males) from 14 different sports branches enrolled in the Physical Education and Sports Teaching program of Muğla Sıtkı Koçman University Faculty of Sport Sciences in the 2022-2023 academic year participated in the research. The participants were selected from pre-service teachers who had not taken handball lessons before, did not participate in the competition as licensed in the branch of

handball, and had not played handball before. The ages of teacher candidates are between 17 and 23 (mean age 18.84).

Data Collection Tools

In the research, descriptive information form and the Handball Game Rules Knowledge Test developed by the researchers were used as data collection tools.

Descriptive Information Form: It includes questions about pre-service teachers' grade levels, gender, age, sports branches, and whether they have taken handball lessons before.

Handball Game Rules Knowledge Test: It was developed by the researchers to measure the knowledge level of the handball game rules of the participants. It is a multiple-choice test consisting of 14 questions in total. Although the questions have four options each, each question has only one correct answer.

The researchers sent the test to two physical education and sports teachers and one academician who had played handball before. Then they asked the experts for their opinions on whether the test was appropriate. After receiving expert opinions, a pilot study was conducted. At this stage, the test was applied to 23 first-year students in the Physical Education and Sports Teaching program's spring semester of the 2021-2022 academic year. The results obtained from the pilot study were transferred to the Test Analysis Program (TAP), and the reliability coefficient of the test was found to be KR20 (Alpha) = 0.738.

Data Collection

International handball game rules were drawn using the Tactic3D program within the scope of the research (https://www.tactic3d.com/handball/handball-software.html). The rules were drawn in 2D and recorded in 3D.

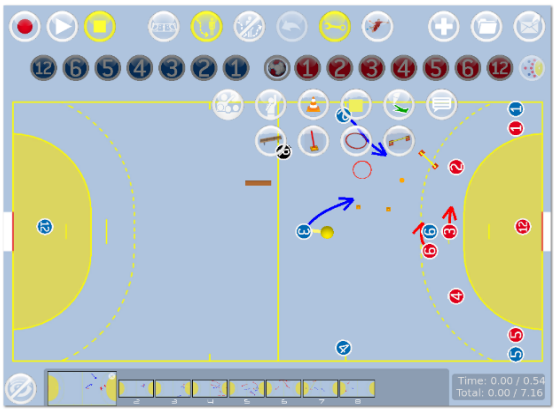

Figure 1. 2D drawing of the rules of the handball game

Figure 1. 3D video representation of the rules of the handball game

A website was created to participate in the research. General information, the aims, objectives, and the necessary links for participation in the study have been added to the website. The research data were collected online in the fall semester of the 2022-2023 academic year (http://www.hentbol2209a.mu.edu.tr/).

Pre-service teachers were informed about the research subject in a lesson held at the beginning of the semester. Then, candidates were directed to the website where the tests were located to participate in the research. Participants accessed the pre-test from the link on the Project Participation page on their website. When the pre-test data were collected, the pre-service teachers were directed to the educational videos via the link below the test.

Participants who completed the pre-test accessed the educational videos by clicking the link at the end of the test. The pre-service teachers who completed watching the videos were directed to the post-test via the link at the bottom of the page with the videos. The videos were initially only available to those who participated in the research. However, at the end of the study, it was made available as open access (http://www.hentbol2209a.mu.edu.tr/tr/egitim-videolari-8230).

Data Analysis

The data collected within the scope of the research were recorded in the computer environment. The pre-test and post-test scores of the participants were transferred to the SPSS 22 program. Whether the data showed a normal distribution was evaluated with the Kurtosis and Skewness coefficients, and it was determined that the data obtained in the study had a normal distribution. Paired t test was used to analyze differences between groups.

Results

The data obtained from the research are presented in the tables below.

Table 1. Comparison of participants' pre and post-test scores

	N	$\bar{x}$	*ss*	*t*	*p*
Pre-test	32	49.32	15.95	-10.42	**.000***
Post-test	32	85.26	13.81		

*p<0.05; Skewness: 0.33; Kurtosis: -0.90

According to the data obtained from the research, the average pre-test score of the participants is 49.32, and the post-test mean score is 85.26. Watching handball educational videos increased the pre-service teachers' scores by 35.94 points. In addition, this score increase was found to be statistically significant (p<0.05).

Table 2. Comparison of participants' pre and post-test scores by gender

		N	$\bar{x}$	*F*	*t*	*p*
Pre-test	F	32	51.12	1.93	.765	.450
	M		46.69			
Post-test	F	32	89.46	1.92	2.20	**.035***
	M		79.11			

*p<0.05, F: female, M: male; Skewness: -1.67; Kurtosis: 4.02

According to Table 2, while there was no significant difference between the genders in the pre-test (p>0.05), there was a significant difference between the genders in the post-test scores (p<0.05). When taking into consideration mean scores, this difference is in favor of females.

Discussion

This research aimed to teach the rules of the international handball game rules to physical education and sports teacher candidates through a simulation developed using the Tactic3D program.

The findings show that the international handball game rules can be taught with simulation-supported training. Many studies in the literature state that utilizing educational technologies contributes positively to students. Atam and Tekdal (2010) determined that simulation-based software prepared in the science and technology course contributed positively to the academic success of the students and the permanence of the knowledge. Aycan et al. (2002) determined that computer-assisted simulation education positively affected the success of classroom teaching students. Öner and Yaman (2020) stated that the simulation and animation-supported 5E learning model significantly increased pre-service teachers' science achievement and motivation scores compared to the traditional education method group. Also, Emrahoğlu and Bülbül (2010) determined that animation and simulations positively affect academic achievement and permanence of knowledge. Dağdalan and Taş (2017) found that simulation-assisted science education increased academic achievement. Gürcüoğlu et al. (2019) stated that simulation is an effective method for acquiring cognitive skills. Okumuş (2016) determined that interactive simulation course software positively affects academic achievement, and students respond better to comprehension and application questions with simulation.

There are also studies in the physical education and sports field that deal with the positive effects of technology use. For example, Ölmez (2021) determined that using video and visual material support in taekwondo training is effective in executing technical, tactical, and psychological features specific to taekwondo. According to a study by Mirzeoğlu et al. (2006), basketball lessons taught with computer-assisted teaching contribute to the student's cognitive development more than traditional teaching methods. Çakıt and Karadeniz (2020) revealed that the blended educational activities supported by internet-based online environments such as Facebook, Youtube, and Blogs contribute to the development of handball skills. Hu (2020) stated that using computer technology to teach badminton education helps students learn, increases communication and cooperation, and develops lifelong sports awareness by encouraging students' initiative and enthusiasm for learning. Another study showed that the use of animation in teaching the basic rules of the handball branch contributes to the learning of children aged 7-10 (Karaşahinoğlu, 2013). The mentioned studies show parallelism with the current research results.

According to the findings, there is a statistically significant difference between the genders in the post-test scores ($p<0,05$). The difference in post-test scores is in favor of females. Yaman (2007) determined that female physical and sports teachers use educational technologies more than male teachers. On the other hand, Ulucan and Karabulut (2012) found that physical

education and sports teacher candidates' self-efficacy regarding educational technology standards did not differ in gender. Similarly, Çar and Aydos (2022) state that there is no significant gender difference in technological pedagogical content knowledge levels of physical education and sports teachers. According to another study, techno-pedagogical education proficiency levels of male physical education teacher candidates are higher than female candidates (Erbaş & Ünlü, 2017). These studies show that different findings regarding the gender variable have been found in the literature. The fact that female pre-service teachers have higher scores than male pre-service teachers in the current study may have emerged due to the characteristics of the student group participating in the research.

Conclusion

The use of simulation in education contributes positively to the knowledge levels of pre-service physical education and sports teachers' handball game rules.

Suggestions

The findings obtained from the research are limited to the level of international handball game rules knowledge of physical education and sports teacher candidates. In future research, simulation education for the technical and tactical features of the handball branch can be added. In addition, the effect of simulation education on the affective and psychomotor skills of teacher candidates and their cognitive characteristics can be examined. Similar studies can be carried out for different sports branches and grade levels. On the other hand, the effect of simulation training on candidates in different sports branches can be examined by increasing the number of participants in the research.

Finally, the educational tools used in the current research can be added to the undergraduate education of pre-service teachers as an enriching tool for teaching.

Author Contribution

Ayan, İ and Sakallı, D (Conceptual Framework, Preparation of Educational Materials), Ayan, İ (Data Collection), Sakallı, D (Data Analysis), Ayan, İ and Sakallı, D (Writing).

Conflicts of Interest

All authors declare that there is no conflict of interest in this study.

Ethical Statement

Before starting the research, the ethics committee approval was obtained by the Social and Human Sciences Research Ethics Committee of Muğla Sıtkı Koçman University by protocol 210035 and decision number 31.

Acknowledgment

This research was produced from the project titled "Teaching Handball Game Rules with Computer Simulation," which was supported by TUBITAK 2209-A University Students Research Projects Support Program. We would like to thank TÜBİTAK for its support and contributions to the project.

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JOURNAL OF THEORY AND PRACTICE IN SPORT
MUĞLA SITKI KOÇMAN UNIVERSITY
FACULTY OF SPORT SCIENCES

Investigation of Injury Anxiety of Sports Sciences Faculty Students in Terms of Some Variables

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To cite this article: Güler, H. (2022). Investigation of injury anxiety of sports sciences faculty students in terms of some variables. *Journal of Theory and Practice in Sport, 1*(1), 77-93.

Received: 29.08.2022

Accepted: 12.09.2022

Published: 25.12.2022

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Investigation of Injury Anxiety of Sports Sciences Faculty Students in Terms of Some Variables

Abstract

Two hundred one volunteer students studying at Aydın Adnan Menderes University Faculty of Sports Sciences participated in this research, which was carried out to examine the injury anxiety of students studying at the faculty of sports sciences in line with various variables. The Sports Injury Anxiety Scale (SYI) developed by Rex and Metzler (2016) and adapted to Turkish society by Caz et al. (2019) and a personal information form developed by the researcher were used. SPSS 25.00 package program was used to analyze the data obtained within the scope of the research. The related analysis program determined that the data obtained from the students did not show a normal distribution, and in this context, Non-Parametric tests were used. As a result of this research, which was carried out to examine the injury anxiety of the students studying at the Faculty of Sports Sciences in line with various variables; As result of the test conducted between the injury anxiety of sports sciences students and the age variable, there was a statistically significant difference only in the sub-dimension of perceived weak; it is seen that there is no statistically significant difference in the variables of gender, department, being a licensed athlete, class level, branch and having a previous injury ($p>0.05$).

Keywords: Anxiety, Injury anxiety, Sports

Spor Bilimleri Fakültesi Öğrencilerinin Yaralanma Kaygılarının Bazı Değişkenler Açısından İncelenmesi

Özet

Spor Bilimleri Fakültesinde öğrenim gören öğrencilerin yaralanma kaygılarının çeşitli değişkenler doğrultusunda incelenmesi amacıyla gerçekleştirilen bu araştırmaya, Aydın Adnan Menderes Üniversitesi Spor Bilimleri Fakültesi'nde öğrenim gören 201 gönüllü öğrenci katılım sağlamıştır. Rex and Metzler (2016) tarafından geliştirilen, Caz ve arkadaşları (2019) tarafından Türk toplumuna uyarlanan Spor Yaralanması Kaygı Ölçeği (SYKÖ) ve araştırmacı tarafından geliştirilen kişisel bilgi formu kullanılmıştır. Araştırma kapsamında elde edilen verilerin analizinde SPSS 25.00 paket programından yararlanılmıştır. İlgili analiz programında, öğrencilerden elde edilen verilerin normal dağılım göstermediği tespit edilmiş ve bu bağlamda Non-Parametrik testler kullanılmıştır. Spor Bilimleri Fakültesinde öğrenim gören öğrencilerin yaralanma kaygılarının çeşitli değişkenler doğrultusunda incelenmesi amacıyla gerçekleştirilen bu araştırmada sonuç olarak; spor bilimleri fakültesi öğrencilerinin yaralanma kaygıları ile yaş değişkeni arasında yapılan test sonucu sadece zayıf algılanma kaygısı alt boyutunda istatistiksel olarak anlamlı farklılık olduğu; cinsiyet, bölüm, lisanslı sporcu olma, sınıf düzeyi, branş ve daha önce yaralanma değişkenlerinde istatistiksel olarak anlamlı farklılık olmadığı görülmektedir ($p>0.05$).

Anahtar Kelimeler: Kaygı, Yaralanma kaygısı, Spor

Introduction

Emotions are an indispensable element of interpersonal relations as well as physical and mental health, which are very important in human life (Altınışık & Çelik, 2022). Anxiety, which is a feeling of fear and worry, comes from the Greek word "antixetas". According to Geçtan (1981), anxiety is defined as the ability of the individual to maintain their life by adapting to the dangers of both the physical and social environment. Anxiety, seen as a part of life, emerges in different dimensions for individuals. According to Uluç and Duman (2020), many factors are influential in the emergence of anxiety. According to Alshetiwi (2022), economic and health problems cause individuals to worry. Anxiety, which is a contagious motive, varies depending on the behavior of the environment of the individual. Anxiety that arises due to the stressful environment they live in also plays an essential role in the practical decision-making of the athlete at some point. According to Karabulut et al. (2013), athletes may exhibit negative behaviors by forgetting the exercise they have done before due to the anxiety that arises. According to Kahya (2019), anxiety negatively affects the psychological structure of the athlete. According to Alshetiwi (2022), athletes can be uneasy, restless, and sometimes hesitant due to the importance of competition or competition. In addition to the anxiety of injury in sports, many factors occur in the emergence of this situation in athletes. According to Ayala et al. (2012), athletes experience injuries of varying severity in specific periods of their lives.

When the literature on injury anxiety in sports is examined, some studies show that athletes with high sports anxiety experience more injuries (Johnson & Ivarsson, 2011; Ivarsson et al., 2013). According to Kalyon (2003), these injuries that occur in athletes are called sports injuries. In addition to the physical dimensions of these injuries, it is vital to examine the psychological dimensions (Andersen et al., 2016) because athletes do not take into account the psychological role of these injuries that occur in them.

The stress factor assumes a vital role in the occurrence of sports injuries. According to Sarıkaya (2021), the increase in the muscle tension of the athlete during a brutal fight disrupts the motor coordination system and reduces flexibility. Accordingly, the state of anxiety that occurs in athletes can cause the athlete's attention to be distracted. According to Olmedilla et al. (2018), the anxiety that arises in the athlete during the fight distracts the athlete at some point and causes the athlete to be injured. It is thought that athletes who are injured once during a sportive struggle cannot forget the injury they have experienced. When the literature on the subject is examined, there are studies stating that behavioral and psychological factors influence injury

anxiety (Damsgard et al., 2010). In this context, the present study aimed to examine the injury anxiety of students studying at the faculty of sports sciences.

Method

This research was carried out to determine the injury anxiety of Aydın Adnan Menderes University students. In this part of the study, explanations about the research model, universe and sample size, data collection process, and data analysis are given.

Research Model

In our research, the descriptive survey model was used within the scope of the survey model. Descriptive research is research that aims to determine any situation in a subject (Karasar, 2015).

Study Group

The study group of the research consisted of the students at Aydın Adnan Menderes University Faculty of Sports Sciences in the 2021-2022 academic year.

Data Collection Process

Survey applications were made face-to-face to the participants, and participation was based on volunteerism. As a result, a total of 201 participants were reached.

Data Collection Tools

Data collection in the study consists of three parts. In the first part, the personal information table created by the researcher was used. In the second part, the Sports Injury Anxiety Scale (SYI) was developed by Rex and Metzler (2016) and adapted to Turkish society by Caz et al. (2019).

Personal Information Form

An 8-question personal information form created by the researcher was used to determine the participants' information such as age, gender, department, being a licensed athlete, class level, branch, and previous injury.

Sports Injury Anxiety Scale (SYI)

The Sports Injury Anxiety Scale (SYI) developed by Rex and Metzler (2016) and adapted to Turkish society by Caz et al. (2019) and a personal information form developed by the

researcher were used. The Sports Injury Anxiety Scale consists of six sub-dimensions and 19 items. These dimensions are “Anxiety of Losing Talent,” “Anxiety of Being Poor,” “Anxiety of Suffering,” “Anxiety of Disappointment,” “Anxiety of Losing Social Support,” and “Anxiety of Re-Injury,” were included in the scale. All questions scored between 1 and 5 (1: strongly disagree; 5: strongly agree) in this five-point Likert-type scale was included positively. Therefore, the highest score obtained from the scale is 95, and the lowest score is 19 points. The Cronbach α internal consistency coefficient for SYLS was calculated as 0.870. In our study, the Cronbach α internal consistency coefficient was 0.849.

Data Analysis

In the analysis of the data in this study, the SPSS 25.00 package program was used, and it was evaluated at the 95% confidence interval and the 0.05 significance level. Descriptive statistics on personal information such as age, gender, educational status, income status, and sports history were calculated. It was decided whether the data showed normal distribution by calculating the Kolmogorov-Smirnov scores. Statistically, Mann Whitney U test, Kruskal Wallis H test, frequency, percentage, and reliability coefficient calculations were made.

Results

Table 1. Demographic Variables

		f	%
Gender	Female	73	36,3
	Male	128	63,7
	Total	201	100
Age	18-19 ages	33	16,4
	20-21 ages	82	40,8
	22-23 ages	64	31,8
	24 age and over	22	10,9
	Total	201	100,0
Department	PE Teaching	43	21,4
	Coaching	105	52,2
	Sports Man.	42	20,9
	Recreation	11	5,5
	Total	201	100
Licensed athletes	Yes	103	51,2
	No	98	48,8
	Total	201	100
Garde	First	61	30,3
	Second	34	16,9
	Third	44	21,9
	Four	62	30,8
	Total	201	100
Sport	Individual	87	43,3
	Team	114	56,7
	Total	201	100
Injured	Yes	106	52,7
	No	95	47,3
	Total	201	100

According to the analysis results in Table 1, most of the participants are male, with 128 people (63.7%). Variables with the highest rate in their category; 20-21 years (40.8), students of coaching education department (52.2%), 4th-grade students (30.8%), licensed athletes (51.2%). It consists of those who do team sports (56.7%) and participants who had a previous injury (52.7%).

Table 2. Normality Analysis Results for Scales

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
The anxiety of Losing Talent	,161	200	,000	,897	200	, 000
The anxiety of Being Poor	,270	200	,000	,733	200	,000
Anxiety of Suffering	,132	200	,000	,950	200	,000
Anxiety of Disappointment	,194	200	,000	,830	200	,000
The anxiety of Losing Social Support	,331	200	,000	,667	200	,000
Re-Injury Anxiety	,086	200	,001	,971	200	,000
Sports Injury Anxiety	,083	200	,002	,974	200	,001

Table 2 shows the results of the normality test for the findings obtained from the participants. Since the number of participants was more than 50, the Kolmogorov-Smirnov test was applied. It was concluded that the data did not have a normal distribution since the significance level was less than $p<0.05$. Therefore, it was decided to use non-parametric tests for analysis.

Table 3. Descriptive Values for Scales

Dimensions	N	Min.	Max.	Mean	Std. Dev.
Anxiety of Losing Talent	20	1,0	5,00	2,0116	,93771
Anxiety of Being Poor	20	1,0	5,00	1,5896	,85586
Anxiety of Suffering	20	1,0	5,00	2,4204	1,00320
Anxiety of Disappointment	20	1,0	4,67	1,7883	,89865
Anxiety of Losing Social Support	20	1,0	5,00	1,5467	,91106
Re-Injury Anxiety	20	1,0	5,00	2,6750	1,00470
Sports Injury Anxiety	20	1,0	3,68	2,0809	,62325

Considering the injury anxiety levels of the participants, it is seen that it is low in all dimensions.

Table 4. Kruskal Wallis H Test Results According to Age Variable of Participants' Injury Anxiety

Dimensions	Age	n	Average	Chi-square Value	df	p	Post Hoc
Anxiety of Losing Talent	(1)18-19 ages	33	95,47	,770	3	,857	-
	(2)20-21 ages	82	104,96				
	(3)22-23 ages	64	99,51				
	(4)24 and over	22	98,86				
Anxiety of Being Poor	(1)18-19 ages	33	78,27	12,514	3	**,006***	**2,4>1**
	(2)20-21 ages	82	107,96				
	(3)22-23 ages	64	95,31				
	(4)24 and over	22	125,70				
Anxiety of Suffering	(1)18-19 ages	33	92,47	1,253	3	,740	-
	(2)20-21 ages	82	100,20				
	(3)22-23 ages	64	106,18				
	(4)24 and over	22	101,70				
Anxiety of Disappointment	(1)18-19 ages	33	99,80	1,770	3	,621	-
	(2)20-21 ages	82	97,91				
	(3)22-23 ages	63	99,02				
	(4)24 and over	22	115,41				
Anxiety of Losing Social Support	(1)18-19 ages	33	93,58	6,510	3	,089	-
	(2)20-21 ages	82	105,98				
	(3)22-23 ages	63	90,79				
	(4)24 and over	22	118,30				
Re-Injury Anxiety	(1)18-19 ages	33	97,36	,161	3	,984	-
	(2)20-21 ages	82	101,51				
	(3)22-23 ages	63	100,04				
	(4)24 and over	22	102,77				
Sports Injury Anxiety	(1)18-19 ages	33	92,61	2,256	3	,521	-
	(2)20-21 ages	82	102,39				
	(3)22-23 ages	64	98,50				
	(4)24 and over	22	115,68				

p<0,05*

In Table 4, it is seen that there is a statistically significant difference only in the sub-dimension of the anxiety of being perceived as weak as a result of the test performed between the injury anxiety of the students of the faculty of sports sciences and the age variable ($p<0.05$). In the difference analysis made to determine the difference between the groups, In the sub-dimension of the anxiety of being perceived as weak, it was revealed that the participants aged 20-21 and those aged 24 and over had a higher concern of being perceived as weak than the participants aged 18-19.

Table 5. Kruskal Wallis H Test Results According to Age Variable of Participants' Injury Anxiety

Dimensions	Gender	n	Average	Ranking Total	U	z	p
Anxiety of Losing Talent	Female	73	104,26	7611,00	4434,000	-,608	,543
	Male	128	99,14	12690,00			
Anxiety of Being Poor	Female	73	96,02	7009,50	4308,500	-,987	,324
	Male	128	103,84	13291,50			
Anxiety of Suffering	Female	73	107,35	7836,50	4208,500	-1,177	,239
	Male	128	97,38	12464,50			
Anxiety of Disappointment	Female	73	99,14	7237,50	4536,500	-,259	,796
	Male	127	101,28	12862,50			
Anxiety of Losing Social Support	Female	73	98,08	7160,00	4459,000	-,508	,611
	Male	127	101,89	12940,00			
Re-Injury Anxiety	Female	73	101,28	7393,50	4578,500	-,145	,885
	Male	127	100,05	12706,50			
Sports Injury Anxiety	Female	73	101,21	7388,50	4656,500	-,039	,969
	Male	128	100,88	12912,50			

In Table 5, it is seen that there is no significant difference in all sub-dimensions and an overall score of the Man Whitney U Test applied between the injury anxiety of sports science students and the gender variable ($p>0.05$).

Table 6. Kruskal Wallis H Test Results by Participant's Injury Anxiety by Section Variable

Dimensions	Department	n	Average	Ci square value	df	p	Post Hoc
Anxiety of Losing Talent	PE Teaching	43	102,78	,710	3	,871	
	Coaching	105	97,90				-
	Sports Man.	42	105,33				
	Recreation	11	107,09				
Anxiety of Being Poor	PE Teaching	43	103,33	6,258	3	,100	
	Coaching	105	94,18				-
	Sports Man.	42	107,20				
	Recreation	11	133,36				
Anxiety of Suffering	PE Teaching	43	101,62	,843	3	,839	
	Coaching	105	98,03				-
	Sports Man.	42	107,67				
	Recreation	11	101,50				
Anxiety of Disappointment	PE Teaching	43	102,70	2,200	3	,532	
	Coaching	104	97,09				-
	Sports Man.	42	100,83				
	Recreation	11	122,91				
Anxiety of Losing Social Support	PE Teaching	43	99,20	6,794	3	,079	
	Coaching	104	95,06				-
	Sports Man.	42	106,24				
	Recreation	11	135,09				
Re-Injury Anxiety	PE Teaching	43	103,53	2,922	3	,404	
	Coaching	104	98,46				-
	Sports Man.	42	95,45				
	Recreation	11	127,18				
Sports Injury Anxiety	PE Teaching	43	103,72	4,219	3	,239	
	Coaching	105	95,19				-
	Sports Man.	42	104,94				
	Recreation	11	130,77				

In Table 6, it is seen that there is no statistically significant difference in the scale mean and all sub-dimensions as a result of the test performed between the injury anxiety of the students of the faculty of sports sciences and the department variable (p>0.05).

Table 1. Mann Whitney U Test Results According to the Variable of Being a Licensed Athlete of Injury Anxiety of the Participants

Dimensions	License	n	Average	Rank Total	U	z	p
Anxiety of Losing Talent	Yes	103	103,90	10701,50	4748,500	-,733	,463
	No	98	97,95	9599,50			
Anxiety of Being Poor	Yes	103	102,94	10603,00	4847,000	-,522	,601
	No	98	98,96	9698,00			
Anxiety of Suffering	Yes	103	102,07	10513,00	4937,000	-,269	,788
	No	98	99,88	9788,00			
Anxiety of Disappointment	Yes	102	102,74	10479,50	4769,500	-,575	,565
	No	98	98,17	9620,50			
Anxiety of Losing Social Support	Yes	102	103,73	10580,50	4668,500	-,913	,361
	No	98	97,14	9519,50			
Re-Injury Anxiety	Yes	102	98,17	10013,50	4760,500	-,582	,560
	No	98	102,92	10086,50			
Sports Injury Anxiety	Yes	103	102,58	10566,00	4884,000	-,396	,692
	No	98	99,34	9735,00			

p<0,05*

In Table 7, it is seen that there is no significant difference in all sub-dimensions and an overall score of the Man Whitney U Test applied between the injury anxiety of sports science students and the variable of being a licensed athlete (p>0.05).

Table 8. Kruskal Wallis H Test Results According to the Class Variable of Participants' Injury Anxiety

Dimensions	Grade	n	Average	Ci square value	df	p	Post Hoc
Anxiety of Losing Talent	First	61	102,43	,186	3	,980	
	Second	34	98,47				
	Third	44	102,89				-
	Four	62	99,64				
Anxiety of Being Poor	First	61	101,73	1,295	3	,730	
	Second	34	106,04				
	Third	44	104,66				-
	Four	62	94,92				
Anxiety of Suffering	First	61	96,25	4,121	3	,249	
	Second	34	101,44				
	Third	44	91,14				-
	Four	62	112,43				
Anxiety of Disappointment	First	61	94,37	2,639	3	,451	
	Second	34	97,00				
	Third	43	98,45				-
	Four	62	109,87				
Anxiety of Losing Social Support	First	61	105,97	6,401	3	,094	
	Second	34	104,12				
	Third	43	109,21				-
	Four	62	87,10				
Re-Injury Anxiety	First	61	99,88	,260	3	,967	
	Second	34	105,07				
	Third	43	99,36				-
	Four	62	99,40				
Sports Injury Anxiety	First	61	101,09	,102	3	,992	
	Second	34	99,91				-
	Third	44	103,27				
	Four	62	99,90				

In Table 8, it is seen that there is no statistically significant difference in the scale average and all sub-dimensions as a result of the test performed between the injury anxiety of the sports sciences faculty students and the grade level variable ($p>0.05$).

Table 9. Mann Whitney U Test Results of Participants' Injury Concerns According to the Variable of Previous Injury

Dimensions	Injury History	n	Average	Rank Total	U	z	p
Anxiety of Losing Talent	Yes	106	104,48	11074,50	4666,500	-,906	,365
	No	95	97,12	9226,50			
Anxiety of Being Poor	Yes	106	102,09	10821,50	4919,500	-,302	,763
	No	95	99,78	9479,50			
Anxiety of Suffering	Yes	106	105,46	11179,00	4562,000	-1,157	,247
	No	95	96,02	9122,00			
Anxiety of Disappointment	Yes	105	99,22	10418,00	4853,000	-,339	,735
	No	95	101,92	9682,00			
Anxiety of Losing Social Support	Yes	105	98,73	10367,00	4802,000	-,515	,607
	No	95	102,45	9733,00			
Re-Injury Anxiety	Yes	105	103,32	10848,50	4691,500	-,726	,468
	No	95	97,38	9251,50			
Sports Injury Anxiety	Yes	106	103,21	10940,50	4800,500	-,570	,569
	No	95	98,53	9360,50			

In Table 9, it is seen that there is no significant difference in all sub-dimensions and an overall score of the Man Whitney U Test applied between the injury anxiety of sports science students and the variable of having a previous injury ($p>0.05$).

Table 10. Mann Whitney U Test Results According to the Sports Branch Variable of Participants' Injury Anxiety

Dimensions	Sport	n	Average	Rank Total	U	z	p	Dimensions
Anxiety of Losing Talent	Individual	87	109,21	9501,00	4245,000	-1,770	,077	
	Team	114	94,74	10800,00				-
Anxiety of Being Poor	Individual	87	94,27	8201,50	4373,500	-1,543	,123	
	Team	114	106,14	12099,50				-
Anxiety of Suffering	Individual	87	94,01	8179,00	4351,000	-1,498	,134	
	Team	114	106,33	12122,00				-
Anxiety of Disappointment	Individual	87	95,49	8308,00	4480,000	-1,105	,269	
	Team	113	104,35	11792,00				-
Anxiety of Losing Social Support	Individual	87	95,47	8305,50	4477,500	-1,224	,221	
	Team	113	104,38	11794,50				-
Re-Injury Anxiety	Individual	87	101,30	8813,00	4846,000	-,172	,864	
	Team	113	99,88	11287,00				-
Sports Injury Anxiety	Individual	87	97,13	8450,50	4622,500	-,824	,410	
	Team	114	103,95	11850,50				-

In Table 10, it is seen that there is no significant difference in all sub-dimensions and an overall score of the Man Whitney U Test applied between the injury anxiety of sports science students and the variable of the sports branch ($p>0.05$).

Discussion and Conclusion

When the literature on injury anxiety in sports is examined, studies show that athletes with high sports anxiety experience more injuries (Johnson & Ivarsson, 2011; Ivarsson et al., 2013). These injuries that occur in athletes are called sports injuries (Kalyon, 2003). In addition to the physical dimensions of these injuries, it is crucial to examine the psychological dimensions (Andersen et al., 2016). The present study found that 201 students studying at the faculty of sports sciences had low levels of injury anxiety in sports. İrhan (2022), who examined the anxiety levels of physical education and sports teacher candidates, concluded that the students' anxiety levels were low. On the other hand, Adar (2021), who examined the injury anxiety levels of the wrestlers, concluded that the anxiety levels of the athletes were above average. While this result reached by İrhan (2022) is not similar to the current research finding, it is similar to the result reached by Adar (2021).

This finding shows that the students studying in the faculties of sports sciences come with a certain sports background, and therefore, they do not experience sports injury anxiety.

Budak (2021), who examined the injury anxiety levels of female basketball players according to the age variable, concluded that there was no difference between these two variables. In their study, Budak et al. (2020) concluded that football players over the age of 20 playing in development leagues have higher anxiety levels about being perceived as weak compared to other age groups. According to the study conducted by Namlı and Buzdağlı (2020) on athletes who do individual and team sports, it has been determined that as the age of the athlete increases, the re-injury anxiety as a result of injury increases. In their study, Bağrıçık and Açak (2005) found that the risk of re-injury increases as age increases, and in parallel, the anxiety of re-injury also increases. The injury anxiety levels of the students participating in our study were examined according to the age variable, and it was found that the weak perception sub-dimension average score of the students in the 18-19 age range was lower than the students in other age groups. While this finding obtained from the research is not similar to the results reached by Budak (2021), it is similar to the results reached by Namlı and Buzdağlı (2020) and Bağrıçık and Açak (2005). The main reason why the finding of our study did not support the results reached by Budak (2021) is that the study's sample group consisted of female athletes.

Bayındır (2021), who examined the injury apricot levels of elite wrestlers, concluded that the re-injury apricot sub-dimension averages of the athletes differed according to the gender variable. In the study conducted by Tanyeri (2019), it was concluded that male athletes had a higher average score of disappointing and losing social support sub-dimensions than female athletes. Unlike these studies, no difference was found between gender variables and re-injury anxiety levels (Karayol & Eroğlu, 2020; Meeuwisse et al., 2003; Stevenson, 2000). In this study, which was carried out with students studying at the faculty of sports sciences, it was determined that the injury anxiety levels of the students did not differ according to gender. While this finding obtained in the present study is not similar to the results reached by Bayındır (2021) and Tanyeri (2019), it is similar to the results reached by Karayol and Eroğlu (2020), Meeuwisse et al. (2003) and Stevenson (2000). This finding obtained in the study is not similar to the results obtained by Bayındır (2021) and Tanyeri (2019) and is thought to be due to the characteristics of the research groups.

Karayol and Eroğlu (2020), who examined the physical education and sports school students' injury anxiety in sports, concluded that the average score of the student's anxiety about losing social support differed according to the department variable. However, in this study, in which the injury anxiety levels of the students studying at the faculty of sports sciences were examined according to the department variable, it was determined that there was no significant difference between the department and injury anxiety. Therefore, the current research finding is not similar to the results reached by Karayol and Eroğlu (2020).

Yıldız (2022), who examined the injury anxiety levels of the students of the faculty of sports sciences according to the variable of being a licensed athlete, determined that the sub-dimension score averages the anxiety of losing ability, being perceived as weak and suffering at a better level than the athletes who did not have a sports history. In this research conducted with students studying at Aydın Adnan Menderes University Faculty of Sports Sciences, The injury anxiety levels of the students were examined according to the variable of being a licensed athlete, and it was determined that there was no difference between these two variables. This finding obtained in our study is not similar to Yıldız (2022) results.

In addition, the apricot competition levels of the students participating in our study were examined according to the variables of grade, injury, and sports branch. It was determined that the student's anxiety levels did not differ according to these three variables.

Karayol and Eroğlu (2020) examined the competition anxiety levels of students according to their classes and found no significant difference between these two variables. The results of the research reached by Karayol and Eroğlu (2022) are similar to the current research findings. This

finding was obtained from research since university students participate in the same leagues and tournaments. The study by Budak (2021) determined that athletes who had previously been injured experience anxiety about losing their talent, anxiety about being perceived as weak, and anxiety about re-injury. In our study, the injury anxiety of the athletes was examined according to the variable of having an injury, and it was determined that there was no significant difference between these two variables. This finding obtained from the research is not similar to the results reached by Budak (2021). In addition, within the scope of the study, the injury anxiety levels of the students were also examined according to the sports branch variable, and it was found that there was no significant difference between these two variables. He examined the injury anxiety levels of the Physical Education and Sports School students according to the variable of sportsmanship level and found that these amateur athletes experienced poor perception anxiety. This result reached by Yıldız (2022) does not coincide with the current research finding.

As it is known, the effect of sports injuries on athletes is quite significant. According to Erol and Karahan (2006), intense training programs, hard blows, and movements without warming up can cause injuries in athletes. As a result of this research, which was carried out to examine the level of injury anxiety in sports students studying at the faculty of sports sciences, according to the age variable, it was concluded that the average score of the students' poor perception anxiety sub-dimension differs. However, when the studies conducted by researchers on sports injuries are examined, it has been seen that this subject has only recently been studied in the field of sports sciences, so there are limited studies.

Suggestions

It can be suggested that researchers who will work on this subject should work on different populations and sample groups by using various variables. In this context, it is thought that the results obtained from the present study will shed light on other researchers.

Authors Contribution

HG; (Conceptual framework), HG; (Data Analysis), HG; (Data Collection), HG; Reporting of the Article.

Conflict of Interest

Any personal and financial conflicts of interest within the scope of the study

Ethical Statement

The ethical trail of this research was obtained from the social and human sciences research ethics committee of Aydın Adnan Menderes University with the decision no. 18 on 05.12.2022.

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