PES
PHYSICAL
EDUCATION
OF STUDENTS

PES PHYSICAL EDUCATION OF STUDENTS

ISSN 2308-7250
2024
02

The journal represents original scientific researches of scientists from the East-European region.
The Journal welcomes articles on different aspects of physical education, sports and health of students which cover scientific researches in the related fields, such as biomechanics, kinesiology, medicine, psychology, sociology, technologies of sports equipment, research in training, selection, physical efficiency, as well as health preservation and other interdisciplinary perspectives.

In general, the editors express hope that the journal "Physical Education of Students" contributes to information exchange to combine efforts of the researchers from the East-European region to solve common problems in health promotion of students, development of physical culture and sports in higher educational institutions.

23087250202302

PHYSICAL EDUCATION OF STUDENTS

2024
02

Key title: Physical Education of Students
Abbreviated key title: Phys. educ. stud.
ISSN 2308-7250 (English ed. online)
Publisher: IP Iermakov S.S. (Ukraine); (Doctor of Sciences in Pedagogy, professor).
Certificate to registration: KB 21884-11784P 21.12.2015.
Address of editorial office:
P.O.Box 11135, Kharkiv-68, 61068, Ukraine.
Tel. +38 0986839912
e-mail: sportart@gmail.com

Frequency - 6 numbers in a year.

http://www.sportedu.org.ua

Journal is ratified Ministry of Education and Science of Ukraine (online):
physical education and sport: (11.07.2019, № 975, "A" - 24.00.01, 24.00.02, 24.00.03; 017); (13.03.2017, № 374).

pedagogical sciences: (07.05.2019, № 612, "A" - 13.00.02; 011, 014); (22.12.2016, № 1604).

Indexing:

Web of Science Core Collection
[Emerging Sources Citation Index (ESCI)]
https://mjl.clarivate.com/home

DOAJ (Directory of Open Access Journals)
http://www.doaj.org

ERIH PLUS (The European Reference Index for the Humanities and the Social Sciences)
https://dbh.nsd.uib.no

WorldCat
http://www.worldcat.org

Open Science Directory (EBSCO information services)
http://www.opensciencedirectory.net

PBN (Polish Scholarly Bibliography)
https://pbn.nauka.gov.pl/core/#/home

Scilit - http://www.scilit.net

OpenAIRE - https://www.openarchives.org/

Dimensions - https://app.dimensions.ai/discover/publication

Open Ukrainian Citation Index (OUCI)
https://ouci.dntb.gov.ua/en/editions/3lDkV60E/

MIAR - http://miar.ub.edu/issn/2308-7250

BASE (Bielefeld Academic Search Engine)
http://www.base-search.net

Google Scholar
http://scholar.google.com.ua

Academic Journals Database
http://journaldatabase.org

V.I.Vernadskiy National Library of Ukraine
http://www.nbuv.gov.ua

Researchgate
https://www.researchgate.net/journal/2075-5279_Physical_Education_of_Students

Hinari Access to Research for Health
http://extranet.who.int/hinari/en/journals.php

PKP Index
http://index.pkp.sfu.ca/index.php/browse/index/2236

EDITORIAL BOARD

CONTENTS

PHYSICAL EDUCATION OF STUDENTS

ORIGINAL ARTICLE

Personality determinants of goal orientation in elite long-distance and mountain runners

Łukasz Bojkowski[1ABCDE], Dominika Kłoda[2ABD]

[1]*Department of Psychology, Poznan University of Physical Education, Poland*
[2]*Poznan University of Physical Education, Poland*

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim The achievement theory points to two motivational orientations that represent different views on an individual's perception of success. In sports, these aspects are closely associated with various individual characteristics and athletic achievements. The aim of the study is to determine the relationship between personality traits and aspects of goal orientation among long-distance and mountain runners of both genders.

Material and Methods The study involved 9 women aged 26 to 34 and 13 men aged 26 to 38 who were members of the national long-distance and mountain running teams (medallists at the Polish and European Championships in their disciplines). Among the participants there were graduate students. The Polish adaptation of Costa and McCrae's NEO Five-Factor Inventory questionnaire was used to examine the level of personality traits. The level of goal orientation dimensions was determined using the Polish adaptation of the Task and Ego Orientation in Sport Questionnaire. Statistical analysis was performed using Statistica 13 software.

Results In the studied group of male athletic competitors, three significant relationships were observed: a negative correlation between ego orientation and both neuroticism and openness to experience; a negative correlation between the overall level of goal orientation and neuroticism. These results are explained by the relationship that occurs between emotional balance and resilience to criticism and the desire to compare oneself to others and the tendency to demonstrate superior skills in front of others.

Conclusions The findings underscore the importance of considering individual characteristics in athletic competition. Emphasis is placed on the necessity of assessing personality traits and goal orientation dimensions among student and competitive long-distance and mountain runners of both genders. Additionally, the significance of these factors in predicting sporting achievement is highlighted, suggesting avenues for further research and practical application.

Keywords: long-distance running, mountain running, personality, ego orientation, task orientation

Introduction

The term personality describes the properties that make us who we are [1]. These properties are shaped by biological factors, situational factors and psychological processes, embedded in cultural contexts, social relationships and developmental levels [1]. Personality psychology, in turn, deals with the individual differences that occur between individuals. It pays attention to the person as a whole, examining the different aspects of his or her functioning (patterns of feelings, thoughts and behaviour), as well as the connections between them [2]. Among the many theories relating to the structure of personality are concepts in which the primary term used to describe personality is trait [3]. One of the most popular trait approaches nowadays is the Five-Factor Model, which allows personality to be characterised in a consistent and comprehensive manner. The basic dimensions of this approach can be presented as follows [4, 5]:

1. Neuroticism – characterises emotional adjustment or imbalance. Individuals scoring high on the neuroticism scale are characterised by a tendency to have irrational ideas, while those scoring low on this scale are emotionally stable, less likely to experience anxiety and irritability.
2. Extraversion – characterises social interactions, their quantity and quality, and level of activity. The level of extraversion also relates to the ability to feel positive emotions. Its opposite is introversion, characterised by, among other things, shyness, which, however, is not related to social anxiety.
3. Openness to experience – describes the willingness to seek out new experiences, valuing them positively. People characterised by a high level of this trait are, among other things, distinguished by their curiosity about the world. The opposite is true for people with more

doi:10.15561/20755279.2024.0201

conservative views and conventional behaviour.
4. Agreeableness – manifests itself in cooperative or competitive behaviour, sensitivity, or indifference to the concerns of others. Agreeable people are perceived as having a healthy personality, while people with a low level of agreeableness tend to be egocentric and sceptical.
5. Conscientiousness – a dimension characterising the degree of motivation, perseverance, organisation, and attitude of an individual towards work. A high level of conscientiousness may be associated with negative tendencies such as workaholism or perfectionism. Low conscientiousness means less motivation to act and a hedonistic approach to life [4, 5].

Motivation defines a certain intrinsic force, which is not a uniform phenomenon [6], by which it can be divided into extrinsic motivation (telling people to engage in an activity because of its external consequences) and intrinsic motivation (leading people to engage in an activity without external rewards) [6]. In turn, according to Goal Achievement Theory [7], motivation is supposed to lead to behaviour that serves the development of the individual [8]. The theory presented [7] distinguishes between two types of orientation:

1. Ego (personal) orientation – concerning the improvement of skills in order to present them in front of oneself or others. An important aspect of this is being better than others and defining competences by external standards [9]. Based on this belief, an individual who has achieved a goal with less effort is considered more capable [10].
2. Task orientation – characterised by an individual's commitment to improving his or her own skills, a focus on development and learning. It is characterised by comparing one's own progress with personal achievements in the past [11], and the overriding value is learning new skills, where success (including sporting success) is linked to effort [8].

Ego and task orientations represent different views of skills, understanding of abilities and perceptions of success [10, 12]. An individual with a strong ego orientation will seek to compare him/herself with others, whereas an individual with a high level of task orientation will believe that success depends on the effort put into learning and perfecting new skills [8, 12]. Thus – in sport – what one athlete considers a success may not necessarily be considered a success by another, even if it concerns representatives of the same sport [11].

The relationship between the level of motivation and the intensity of personality trait dimensions is often linked to sporting achievements [13, 14]. For example, in a study conducted on a group of athletes (the largest group here were representatives of football and basketball), it was determined that the most important trait that is associated with a high level of motivation (and thus performance results) is conscientiousness, understood as discipline and the ability to self-control. In addition to conscientiousness, openness to experience and extraversion were also distinguished. In the same study, neuroticism, on the other hand, was shown to be negatively related to achievement motivation and was linked to anxiety in the context of sport and related competition [14].

Materials and Methods

Participants

After applying the inclusion criterion for the study (being of legal age, being a member of a national team, podium of a national or international event held within the last three years and a minimum of 10 years of training experience), 22 subjects were selected and characterised as follows:

1. Female athletes training at the competitive level (N=9) were aged between 26 and 34 years (M=29.67; Me=29; SD=2.236). The training seniority of these female athletes ranged from 15 to 25 years (M=17.33; Me=16; SD=3.082).
2. Male competitive athletes (N=13) were aged between 26 and 38 years (M=31.62; Me=33; SD=3.884). Their training seniority ranged from 12 to 27 years (M=18.69; Me=19; SD=4.171).

The elite endurance athletes participating in the study included athletes, postgraduate participants, members of the national team in long-distance and mountain running (medallists of the Polish and European Championships in their respective sports). The study is part of a larger project on individual differences among competitive runners [15].

Research Design

Based on the information provided in the previous chapter, it can be determined that the intensity of motivation (including that related to sporting activity) is significantly related to the level of an athlete's personality traits. The aim of the present study is therefore to determine the relationship between personality traits and dimensions of goal orientation in postgraduate students, competitive long-distance and mountain runners of both sexes. Accordingly, the following research hypotheses were identified:

1. The level of goal orientation is positively related to conscientiousness, openness to experience and extraversion (understood as personality traits).
2. The level of goal orientation is negatively related to neuroticism (understood as a personality trait).

The NEO Five-Factor Inventory questionnaire by Costa and McCrae in the Polish adaptation by Zawadzki et al. was used to examine the level of

personality traits [4]. The questionnaire consists of 60 items, 12 for each trait: neuroticism, extraversion, agreeableness, openness to experience and conscientiousness. The dimensions of goal orientation were determined using the TEOSQ: Task and Ego Orientation in Sport Questionnaire [16] in the Polish adaptation by Tomczak et al. [17].

Statistical analysis

In the course of the statistical analysis (performed using Statistica 13), the r-Person correlation coefficient was used to assess the strength and direction of the linear relationships.

Results

The analysis of the relationships between goal orientation and personality traits among female athletes training at the competitive level was performed first (table 1).

In the group of female runners in competitive training, no significant relationships between goal orientation and its dimensions and personality traits were indicated. In the next step, the associations between the above-mentioned factors were analysed in the group of men training at the competitive level (table 2).

Three significant relationships were indicated in the group of male athletic long-distance running coaches surveyed. The first two relate to negative relationships between ego orientation and neuroticism ($r=-0.658$; $p<0.05$) and openness to experience ($r=-0.680$; $p<0.05$). The third indicates a negative relationship between the overall level of goal orientation and neuroticism ($r=-0.798$; $p<0.01$).

Discussion

The practical use of psychological research on, among other things, the relationship of selected individual differences to performance is intended to serve the personal development of athletes and the achievement of high sporting performance. It can be determined that learning about the personality profiles and motivational relationships characterising high-performance athletes is an important element for optimising sports training [18]. Therefore, a study was conducted to determine the relationships between personality traits and dimensions of goal orientation in students training long-distance and mountain running at the competitive level. A study showed a relationship between personality traits and the direction of goal orientation only among

Table 1. Relationship between variables in the female students studied.

Variables	Correlation N=9				
	N	**E**	**O**	**U**	**S**
Ego	0.0878	-0.4601	-0.0601	-0.6129	0.0874
	p=0.809	p=0.181	p=0.869	p=0.060	p=0.810
Task	0.1306	0.5700	-0.1834	0.5526	-0.0565
	p=0.719	p=0.085	p=0.612	p=0.098	p=0.877
OC	0.2167	-0.1169	-0.2246	-0.3235	0.0643
	p=0.548	p=0.748	p=0.533	p=0.362	p=0.860

N – neuroticism; E – extraversion; O – openness to experience; U – agreeableness; S – conscientiousness; Ego – personal orientation; Task – task orientation; OC – overall score for goal orientation; p – level of statistical significance.

Table 2. Relationship between variables in the male students studied.

Variables	Correlation N=13				
	N	**E**	**O**	**U**	**S**
Ego	-0.6584	0.1209	-0.6803	-0.4429	0.3837
	p=0.020	p=0.708	p=0.015	p=0.149	p=0.218
Task	-0.5316	0.1767	-0.0647	-0.0499	0.1914
	p=0.075	p=0.583	p=0.842	p=0.878	p=0.551
OC	-0.7978	0.1887	-0.5655	-0.3723	0.4017
	p=0.002	p=0.557	p=0.055	p=0.233	p=0.196

N – neuroticism; E – extraversion; O – openness to experience; U – agreeableness; S – conscientiousness; Ego – personal orientation; Task – task orientation; OC – overall score for goal orientation; p – level of statistical significance.

the male respondents, where it was noted – firstly – that there was a negative relationship between neuroticism and ego orientation. This result is explained by the relationship that occurs between emotional equilibrium and resilience to criticism and the desire to compete and compare oneself to others, which, in a situation of failure, can lead to lower self-esteem [8]. Furthermore, neuroticism was found to be inversely related to the overall level of goal motivation, which is moderately consistent with research hypothesis number 2 (moderately because the same relationship was not indicated in the group of female respondents), but fully confirms the results described by Mirković and Lovric [14]. The result obtained can be justified by the fact that neurotic people are characterised by a tendency to negative emotions, tension, stress and worry, which can have a negative impact on, among other things, a decrease in emotional resilience during the realisation of long-term goals, including those related to frequent sporting struggles. The third significant result was the reported negative relationship between openness to experience and ego orientation (a result that does not coincide with the assumed research hypothesis number 1). This result, in turn, is explained by a weaker tendency to dominate and demonstrate superior skills in front of others by those who are characterised by greater liberalism in views and actions.

The lack of individual relationships between personality traits (as distinguished by the Five-Factor Model) and task orientation is puzzling, especially since, as shown by Howard et al. [19], individual athletes show, among other things, a higher level of self-regulation than athletes representing team sports, which is also consistent with the results of Benar and Loghmani [20]. Furthermore, it is determined that task orientation and the training climate created around it is more related to adaptive, i.e. more positive work outcomes such as increased competence or positive affect [21]. Explaining the specific lack of relationships can be pointed to the small size of the athletes studied.

Individual differences in personality traits influence how individuals respond to perceived stimuli. Having different levels of intensity of certain traits – which are relatively stable and persistent – people behave in different ways, choosing actions in accordance with their personality traits [22]. Hence, it is important for trainers to verify the effectiveness of the actions taken and training methods used. At the same time, a key aspect when planning training methods is their purpose – different motives will drive professional athletes (to optimise performance) and amateur athletes (to develop their passions, interests or reduce body weight). Due to the different motives for participating in sport, it is important to keep in mind the differentiation of sports training programmes.

Conclusions

The research carried out indicated that the selection of athletes (in long-distance running and mountain running) is purposeful and works to compensate for the high level of neuroticism in athletes, which does not serve to shape high achievement motivation, including the definition of competence by external standards (ego-oriented motivation). A similar conclusion applies to the personality trait defined as openness to experience. The indicated relationships were not identified in the female athletes studied.

Limitations

The study was conducted on a group of 22 professional athletes. The selection of such a group was dictated by their highest sporting level – among other things, relevant training experience or medal achievements (championships). Enlarging the specific research group would go beyond the availability of athletes meeting the indicated criteria for inclusion in the study. It is recommended that analogous studies be carried out on groups of runners (long-distance and mountain runners) not declaring student status, representing a lower level of sporting sophistication, as well as with regard to different age categories.

References

1. Zimbardo P, Johnson R, McCann V. *Psychologia. Kluczowe koncepcje. Tom 1. Podstawy psychologii* [Psychology. Key Concepts. Volume 1. Foundations of psychology]. Warszawa: PWN; 2017. (In Polish).
2. Pervin LA. *Psychologia osobowości* [Psychology of personality]. Gdańsk: GWP; 2002. (In Polish).
3. Buksik D. *Z problematyki pedagogiczno-społecznej* [From pedagogical and social issues]. *Seminare*. 2000; 13: 147–166. (In Polish). https://doi.org/10.21852/sem.1997.12
4. Zawadzki B, Strelau J, Szczepaniak P, Śliwińska M. *Inwentarz Osobowości NEO-FFI Costy i McCrae. Adaptacja polska* [Costa and McCrae's NEO-FFI Personality Inventory. Polish adaptation]. Warszawa: GWP; 1998. (In Polish).
5. Strelau J. Psychologia [Psychologia]. In: *Psychologia ogólna. Osobowość jako zespół cech* [General psychology. Personality as a set of features]. Gdańsk: GWP; 2000. P. 525–560. (In Polish).
6. Ryan R, Deci E. Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions. *Contemporary Educational Psychology*, 2000; 25: 54–67. https://doi.org/10.1006/ceps.1999.1020
7. Nicholls J. Achievement Motivation: Conceptions

of Ability, Subjective Experience, Task Choice, and Performance. *Psychological Review*, 1984; 91(3): 328–346. https://doi.org/10.1037/0033-295X.91.3.328
8. Kuczek P. O potrzebie zastosowania w praktyce trenerskiej teorii motywacji osiągnięć [On the need to apply achievement motivation theory to coaching practice]. *Sport Wyczynowy*. 2001; 3-4: 435–436. (In Polish).
9. Taylor J, Wilson JC. Using our understanding of time to increase self-efficacy towards goal achievement. *Heliyon*, 2019; 5(8): e02116. https://doi.org/10.1016/j.heliyon.2019.e02116
10. Nessel K. *Bohaterowie drugiego planu w sporcie* [Secondary heroes in sport]. Kraków: WUJ; 2015. (In Polish).
11. Taylor J, Wilson G. *Applying Sport Psychology: Four Perspectives*. Evansville: Human Kinetics; 2005.
12. Haralabos K, Ioanniss A, Evaggelos, Athanasios L. The effect of task and ego orientation to athletic identity and anti social behavior of students and athletes. *J Hum Sport Exerc*, 2016; 11(2): 311–318. https://doi.org/10.14198/jhse.2016.112.04
13. Lodewyk K. Relations Between Trait Personality, Goal Orientation, and Adaptive Outcomes in High School Physical Education. *Journal of Teaching in Physical Education*, 2019; 38: 207–213. https://doi.org/10.1123/jtpe.2018-0094
14. Mirković B, Lovric S. Relations between big five personality traits model and achievement motive in athletes. *Physical Culture*, 2019; 73(2): 222–229. https://doi.org/10.5937/fizkul1902222M
15. Bojkowski Ł, Kłoda D. Wyczynowi biegacze długodystansowi w świetle charakterystyki osobowościowej [High-performance long-distance runners in the light of personality characteristics]. In: K. Litwic-Kamińska, editor. *Sport i aktywność fizyczna bez barier* [Sports and physical activity without barriers]. Bydgoszcz: UKW Publishing House; 2022. P. 92–101. (In Polish).
16. Duda JL. *Task and Ego Orientation in Sport Questionnaire (TEOSQ)*. APA PsycTests; 1989. https://doi.org/10.1037/t21903-000
17. Tomczak M, Walczak M, Kleka P, Walczak A, Bojkowski Ł. Psychometric Properties of the Polish Version of Task and Ego Orientation in Sport Questionnaire (TEOSQ). *J. Environ. Res. Public Health*, 2020; 17(10): 3593. https://doi.org/10.3390/ijerph17103593
18. Rutkowska K. Osobowość sportowców – członków uniwersjadowej kadry Polski [Personality of athletes – members of the Polish Universiade team]. *Medycyna Sportowa*. 2007; 5(6): 261–265. (In Polish).
19. Howard SJ, Vella SA, Cliff DP. Children's sports participation and self-regulation: Bi-directional longitudinal associations. *Early Childhood Research Quarterly*, 2018; 42: 140–147. https://doi.org/10.1016/j.ecresq.2017.09.006
20. Benar N, Loghmani M. Factor Analysis of Teenage Athletes' Goal Orientations and Sports Participation Motives in Leisure Time. *Annals of Applied Sport Science*, 2014; 2(1): 69–80. https://doi.org/10.18869/acadpub.aassjournal.2.1.69
21. Harwood CG, Keegan RJ, Smith JM, Raine AS. A systematic review of the intrapersonal correlates of motivational climate perceptions in sport and physical activity. *Psychol. Sport Exerc*, 2015; 18: 9–25. https://doi.org/10.1016/j.psychsport.2014.11.005
22. Weinberg RS, Gould D. *Foundations of Sport and Exercise Psychology*. Champaign: Human Kinetics; 2011.

Information about the authors:

Łukasz Bojkowski; (Corresponding Author); https://orcid.org/0000-0003-3777-0845; bojkowski@awf.poznan.pl; Department of Psychology, Poznan University of Physical Education; Poznań, Poland.

Dominika Kłoda; https://orcid.org/0009-0000-7910-1530; dominika_kloda@wp.pl; Poznan University of Physical Education; Poznań, Poland.

Cite this article as:
Bojkowski Ł, Kłoda D. Personality determinants of goal orientation in elite long-distance and mountain runners. *Physical Education of Students,* 2024;28(2):52–56.
https://doi.org/10.15561/20755279.2024.0201

Received: 27.01.2024

Accepted: 06.03.2024; **Published**: 30.04.2024

ORIGINAL ARTICLE

The association between the years and modes of sports training and levels of moral competence

Małgorzata Bronikowska[1ACDE], Michał Bronikowski[2ABCDE]

[1] *Department of Recreation, University of Physical Education, Poznań, Poland*
[2] *Department of Didactics of Physical Activity, University of Physical Education, Poznań, Poland*

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim: Research on moral competency in sports is rare, and findings are inconsistent. These findings point to moral development as a multifaceted and complex process. This process is mediated by various life situations and dilemma choices. Sport can play a crucial role in this area with its often 'role-taking' experience and confrontations with personal moral standards. This study aimed to analyze the relationship of competency levels and sport experience across different sports.

Material and Methods: A sample of university students in sport-related faculties (N = 947) was assessed with the use of Moral Competence test (MCT). The group was divided into 11 predetermined types of sports, training modes (amateur/professional), and indicated years of training practice.

Results: The general moral competency level in the overall researched sample of students was low, but similar to their peer-age reference groups found in relevant literature. The findings indicated some differences in moral competency levels between amateurs and professionals. Amateurs showed a higher competency levels in five types of sports (non-invasion games, martial arts/fighting sports, aquatic boating sports). In contrast, professionals showed a higher competency level in dance sports. The only positive, moderate correlation between years of training and moral competency level was found with professional athletes in aquatic boating sports: the longer they trained, the higher their moral competency level was.

Conclusions: These results offer new insight into the impact of sports on moral development and can act as a solid foundation for further in-depth research in this area.

Keywords: university students, moral competency, length of sport experience, amateurs, professional, athletes

Introduction

Youth sports can be an important part of the schooling process since they can help to promote physical fitness, teamwork, discipline, and other valuable skills and qualities, becoming a valuable tool for helping students develop their physical and mental abilities and their character and moral standards [1]. Most circumstances occurring during sporting activities can be easily modified and controlled by a skilful 'person in charge' (parent/teacher/coach) willing to foster a child's moral growth in both directions: the positive and negative outcomes from behaviors in sports [2].

Sport is a field of such clashes of views and behaviors heated by the desire to win, and yet under constraints of physical fatigue. Unfortunately, sports coaches and physical education (PE) teachers often lack professional training in stimulating moral/social development [3, 4, 5]. Little is known about the scale of influence their (coaches/PE teachers) own level of moral competence has on their trainees and whether and how this might relate to the actual training process. In yet another review Peláez et al. [6] findings suggest that modelling, creation of a socio-moral context, teaching moral skills and values, and discussions with young athletes are the main strategies that turn out to be the most effectively used by sport coaches in promoting positive moral behaviour, therefore coaches have to be sensitized about the moral role they play and be aware of potential (positive/negative) impact of their conduct and attitudes.

On one side, findings from a study by Johansson et al. [7] suggest that the most prominent way to teach moral values via school education is engaging children in moral activities, followed by teaching practices for transmitting moral values (not necessarily connected to sports). Whereas the literature in the field of sport has pointed at sport coaches as those with major contribution to the moral standards in children and youth [8]. It has been associated with ways of dealing and facing moral issues that arise in the practice of sport with children. Coaches indicated two possible perspectives of morality in sports – the moral perspective (helping children differentiate right from wrong) and the social perspective (concerning sport involvement and team dynamics), showing again the bridging link of sport with outside-of-sport life.

doi:10.15561/20755279.2024.0202

Some influence need also to be accredited to other educational factors. Jacobs et. al. [9] showed that when PE teachers design classes involving tasks stimulating development of moral skills they emphasize learning via social interaction and thus contribute to the social and moral sound development of their pupils. Jacobs et al. [9] state that commonalities in curricular practices found in their study and the individual differences together reflect a globalized socialization of PE teachers into and through sport, accompanied by differences rooted in how they as individuals make sense of their upbringing. Therefore they recommend the use of a contextually-based with bottom-up direction approach curricula contents and sport-related tasks enabling pupils to explore the dynamics of moral development and thus building their moral competences.

Interestingly, when comparing 15–17-year-old adolescents Bronikowska et al. [5] noticed that the interaction between levels of moral competence and sport amateur/professional involvement was insignificant. It was also observed that in examined youth moral competence levels did not correlate with years of training (neither in amateurs/professionals) nor team/individual sports. That finding was contrary to the one from a study by Miller and Jarman [10], who previously showed that basketball (as an example of a team sport), and swimming (as an example of individual sport) create ethical climates that differ significantly. The contradiction to the previously mentioned study by Bronikowska et al. [5] can be attributed to the difference in theoretical frameworks – Miller and Jarman [10] study had focused on ethical standards. In sports ethical principles guiding a person toward making the choices that would contribute to the common good for all concern usually qualities such as fairness, responsibility, integrity, sportsmanship or respect. While Bronikowska et al. [5] focused on moral competency. Bronikowska et al. [5] found no strong correlations between factors such as team/individual and amateur/professional training, indicating that, at adolescent age, the relatively short longevity of training experience might not be sufficient to mediate the level of moral competency. Interestingly, a significant association between years of sports training and moral competence levels was proved in college-age students in an earlier study by Bronikowska et al. [4]. However, this relationship only applied to male respondents (aged 19–24) professionally engaged in sports for a long time whose levels of moral competency was assessed as high. The opposite outcome was found with female peer respondents where higher levels of moral competency was presented by sportswomen with a shorter involvement in professional sports. It should be stressed that some previous studies have indicated differences between women and men in their moral development regarding various sports [11]. However, many findings show a lack of significant gender differences in moral development [4, 12, 13].

In 2016 Lind developed a tool MCT to help assess the level of moral competence [14]. Theoretical framework was set in the Kohlberg's theory of structural-developmental of morality. According to his theory moral competence was defined as the ability to resolve moral/social problems and potential dilemmas with the use of moral principles and via deliberate peaceful actions. These kinds of actions should be more appreciated that cheating, violence, or bowing down to others [14]. It was expected from an individual that while dealing with occurring arguments and dilemmas their will use own moral criteria, and will not rely on agreement-like criteria and the opinions of others – that kind of behavior was believed to indicate an individual's moral qualities. According to Kohlberg [15], it was life experiences encountered by a person in various contexts and settings that play a crucial role in their moral choices and behaviors. Kohlberg presented a model that was referring to the structure of reasoning with aspects like specific norms, values, and beliefs included as well. The three-level model [15] assumed that any person grows morally from the pre-conventional to the conventional to the post-conventional levels. However, it is worth noting that Kohlberg clearly stated that not everyone would be able to attain the most advanced stages of such development in their life; indeed, this may concern only a very few.

It is believed that higher the level of moral development increases the chances that individuals in their moral reasoning and actions would use justice-based orientation. However, Shields and Bredemeier [16] see it differently when they claim that in sports rules and goals are artificially designed, but with well-organized and hierarchical structures. In such environment the ones who represent authority might be less dominant. They predict that the likeness that in a specific context the values and norms of heteronomous morality will be prominent in an athlete's reasoning is greater, and that this explains why sportspersons employ a kind of 'game reasoning', and they use it in solving moral conflicts both inside and outside sports. Earlier findings [5] might indicate that a recreational approach to sports and other forms of physical activity, no matter whether team or individual, can be a great way to promote integration, teamwork, cooperation, and other valuable skills and qualities [17], and a fun and enjoyable way to stay active and healthy in early adulthood.

Nevertheless, many moral dilemmas can also arise in sports, concerning such issues as doping (performance-enhancing drug use), match-fixing (manipulating the outcome of a game for financial

gain), and violence on and off the field. These behaviors are generally considered immoral and could have serious consequences for the athletes and teams involved and the integrity and credibility of the sport. In addition, due to the global reach and popularity of broadcasted sports events, it often spills over into everyday life, lowering interpersonal standards and routines. Pierce, Gould, & Camiré [18] state that only when a sport skill is successfully transferred and applied outside the sport can it be considered a life skill. This is a clear linking bridge between outside of sport moral standards of everyday life situations and those taking place in a sport specific environment (on a sport arena/track/field). Bu the question whether it is a role of sport to provide such a bridge remains unanswered and is dealt with differently in all sort of cultural and education traditions of various countries.

Studies on long-term elite sport athletes indicate that sport-specific moral reasoning can also be applied to various moral dilemmas and conflicts outside the field of sport. In a study by Shields and Bredemeier [16] no differences in moral reasoning were found when comparing nonathletes and peer high school basketball players. Their research showed also that more mature moral reasoning was accredited to females peers (their sample was not very big, though). Nevertheless, the type of sport can presumably also be a crucial factor in stimulating the moral development.

It is understandable that different sport traditions and legal regulations in various countries will lead to forming different, often debatable definitions of sport practice. Therefore, for the purpose of this study, we have defined individual sports as sporting activities that involve a single individual competing against other individuals or against the clock, with success typically measured by an athlete's performance. These sports can be physically and mentally demanding since athletes must be self-motivated and self-disciplined to succeed. Individual sports can also involve complex strategies and tactics since athletes may need to adapt their approach based on the strengths and weaknesses of their opponents or the conditions of the competition. They also may create some moral dilemmas. For example, in some sports, an individual may be judged based on their performance and face pressure to win at all costs. It is easy to picture a scenario in which ethical challenges, such as the temptation to gain an advantage by cheating or engaging in other unethical behaviors, may become very tempting to someone with a flexible moral compass. In such situations, coaches must monitor the situation and remind the athlete of the importance of fair play and resisting the lure of cheating or engaging in other unethical behaviors.

In a meta-analysis review Milstein et al. [19] found that the relationship between rivalry and performance is more robust for individual rivalry compared to group rivalry. The findings have been analyzed further and indicated that for a group rivalry correlations were positive with significant impact only in sports and, when analyzed in outside-of-sport world only in donation-raising organizations. Context of rivalry can also create different moral challenges in team sports, where the focus is often on the entire team's performance. It would instead require balancing the interests of the team with those of individual players, hopefully via the promotion of teamwork and proper cooperation among team members. Therefore, in team sports, coaches must remind the players of the importance of working together, supporting one another, and respecting the game's rules and regulations. For this study, we have defined team sports as sporting activities that involve two or more teams competing against one another. These sports typically involve a group of players working together to achieve a common goal, such as scoring more points or goals than the opposing team. Players typically have specific roles and responsibilities, and success often depends on the ability of the team to work together effectively. Team sports can also involve complex strategies and tactics since teams may need to coordinate their movements and actions to outmaneuver their opponents.

Nia and Besharat [20] found that athletes from team sports performed better in tests on agreeableness and sociotropy, while those from individual sports performed better on conscientiousness and autonomy scales. This difference might be explained through the different ways of dealing with self-management. In individual sports, athletes learn to rely on themselves, which builds conscientiousness and a need for self-discipline. In team sports, where the outcome depends on the team's performance and many unpredictable stressors mediate the final score, agreeableness is more vital.

Some moral skills and thus moral competency levels might also differ due to the involvement either in individual or team sports, and even further, within individual sports (indicating differences between different environments, such as swimming and athletics), or team invasion (football) vs non-invasion (volleyball) games. In addition, an individual's moral development through sport might be shaped by the rules of a specific sport, the nature of the rivalry process, or other mitigating circumstances occurring during the many years of training. It may also depend on the kind of commitment to the training – amateur vs professional. For the purpose of our study we decided that engaging in a regular, federated system of competitions organized by sports federations will mean professional engagement, while participating in sports for pleasure as a hobby would be categorized as an amateur engagement [21]. The association

between the above mentioned issues have not been research to the depth yet.

Since no studies have examined these aspects of moral competency and others have reported inconsistent findings [22], we designed a study that aimed to assess moral competency levels across various types of sports and establish its potential relationship with the training experience (training modes: amateur vs professional), and years of engagement. Based on the conclusions of the abovementioned studies, this study hypothesized that the mode of involvement (amateur/professional) and years of engagement (sport experience) is related with the moral reasoning scores (C-index) of those participating in sports. This study also assumes that moral levels would vary significantly among various sports.

Materials and Methods

Participants

To determine reasonable sample size reflecting the targeted population (students of sport studies) a sample calculator was used [23, 24]. Based on the total population of students at Poznan Physical Education University (total N = 2921), adequate size of the study sample was established to be 904 responders, assuming a confidence level alpha of 0.97, fraction size of 0.5, and maximum error of 3%.

Study was conducted in year 2022, and included 974 respondents. All respondents came from the following faculties: Physical Education, Sport, Tourism and Recreation, and Physiotherapy. The study sample comprised 569 amateur (43.7% female) and 405 professional (45.2% female) athletes, with an additional 62 nonathlete respondents included in the study but excluded from analytic comparisons between sports as unfit for its purpose. The average age of the respondents was 20.78 ± 1.99 years.

Research Design

Division of activities (sports by type)

Sports can be classified by the type and intensity of exercise performed, the scoring system or environment used, the number of players (team/individual), and the danger of bodily injury from collisions. In our study, we divided sports based on similarities in the characteristics of their training process and the specifics of their competition regulations. For this study we created a classification of eleven types of sports: (1) invasion games, (2) non-invasion games, (3) net/wall racket games, (4) martial arts, (5) aquatic boating sports, (6) aquatic non-boating sports, (7) cycling sports, (8) track and field sports, (9) strength and fitness sports, (10) gymnastic sports, and (11) dance sports. The division and description of sports were based on various publicly available sources, including definitions in sports encyclopaedias and other online dictionaries [25, 26, 27], and the final division of sports was done by the authors. The list of sports divisions with their descriptions is presented below:

1. Invasion games are sports that typically aim at invading opponents' side of the field while creating opportunities of scoring a point/goal. Most of invasion sports are usually fast-paced and require teamwork (e.g., communication and cooperation skills and ability to submit) to control an object (e.g., ball, puck, frisbee), keeping possession, moving into a scoring position, and preventing the other team from scoring a point/goal. Typical examples of invasion sports would include football (also soccer), rugby, basketball, handball or hockey (both lawn and ice hockey).
2. Non-invasion games are sports that do not require players to move to the opponent's side of the field to a score point. Points are usually scored by the collective efforts of a team or by opposition mistakes. One example of this type of sport is volleyball.
3. Net/wall/racquet sports are those in which different types of racquets are used as playing equipment. Their main characteristic is individual or doubles competition. Points are earned by strategically hitting the ball/shuttlecock into the opponent's field (tennis, badminton, or table tennis) or against a wall (squash) such that the opponent misses it.
4. Martial arts and other fighting sports are usually traditional activities that originate from Japanese, Chinese, or Korean forms of fighting or defending (e.g. karate, taekwondo, aikido, and judo) or involve athletes using weapons (e.g., foil, epee, and sword; fencing) or their fists/feet (e.g., boxing and mixed martial arts). The training process in these disciplines is based on specific philosophy and a particular convention resulting from the long tradition of the regions where individual sports have evolved.
5. Aquatic boating sports (e.g., rowing, kayaking, and sailing) are those for which the training and competition environment is water. This discipline's characteristics are mastery of equipment (e.g., rowing boat, kayak, or boat/yacht) and coordinated work of athletes using oars, paddles, or sails to achieve the best possible outcomes. These are disciplines in which both precision and coordinated teamwork are essential.
6. Aquatic non-boating sports include mainly swimming and represent other 'water sports'. They are individual sports requiring specific, long-term, arduous training and performance in a water environment. They are characterized by the interaction between the athlete training in the water (pool) and the coach instructing them. Progress primarily depends on personal improvement and communication (relationship) between the two parties in this aquatic environment.

7. Cycling is the sport of riding a bicycle and has been classified as an individual discipline that mainly requires endurance training during long cycling routes outdoors. We are aware of indoor cycling and its possible differences from outdoor cycling. However, since we did not have any participants indicating indoor cycling, we did not list it as a sport in this study.

8. Track and field sports comprise a group of activities in which people compete, including running, jumping, throwing, and performing other technical skills. Athletes in these disciplines are usually individuals, although there are also team competitions within that sport discipline (e.g., relay races). However, the training process is usually conducted in large groups and only the fine-tuning of the details resulting from the specificity of the competition is conducted individually, usually at the elite level.

9. Strength and fitness sports include bodybuilding, cross fit, powerlifting, and various forms of fitness. They are defined by the ability to work against a resistance based on strength: the maximal force an individual can apply against a load. The training aims to improve muscle strength, including lifting weights or increasing the resistance against which the individual works.

10. Gymnastic sports include acrobatics, aerobics, and calisthenics. These sports involve performing systematic exercises, frequently with the use of different equipment or facilities (i.e., hoops, balls, skipping rope, rings, bars, and balance beam), either as a competitive sport (artistic or sports gymnastics) or to support improvements in strength, agility, coordination, and physical conditioning.

11. Dance sports represent all dance styles and pole dancing, which vary in their characteristics from the typical, abovementioned sports and are progressively being recognized as sports.

Research tools

The diagnostic survey was conducted using a validated structured questionnaire. This study used Lind's MCT [14] to measure the general moral competency level. Test included moral dilemmas where one concerned illegal behavior at work, while the second one referred to a medical dilemma (life-saving). Respondents were asked to evaluate how much they agree or disagree with the presented situations. According to the MCT's research protocol [14], students responded to twelve statements that were designed using a Likert scale where the range of answers was from totally disagree(-4) to totally agree(+4). Each of the abovementioned moral dilemmas had 12 statements: six for and six against the behavior described, corresponding to the phases of moral development (Kolhbergian model) [28]. The final score, called the C-index, is summarized using an algorithm created and described by Lind [14], ranging from 1 to 100 points. It is believed that the final score represents one's ability to evaluate a given dilemma based on their individual level of moral competency and quality of personal development. Lind [14] believed that C-index can help to assess the degree to which a person dis(allows) other moral concerns and external influential factors mediated their judgements more than inner individual set of principles and moral standards. The smaller the C-index score, the lower the individual's moral competency level. Scores <19 points are considered a low to very low moral competency, scores of 19–29 points are considered a moderate moral competency, and scores >29 points are considered a high to very high moral competency.

The respondents' modes of involvement in sports were determined by asking them to indicate whether they have been involved in sport in an amateur or professional way, or not at all. This question was followed by another one asking the respondents for a number of years of engagement and for the particular sport.

Ethics

We declare the study was conducted according the Declaration of Helsinki regulations (revised version 2013). Study protocol has been approved by the Bioethics Committee of the University of Medical Sciences, Poznan (decision number: 893/18). All study participants were instructed on the purpose and study procedure beforehand, and that the participation was voluntary. They could also withdraw from the study at any time. All participants personally provided written informed consent. They were also informed about the confidentiality and anonymity of data collection and storage and that their contribution would be unidentifiable in its final forms (publications and reports).

Statistical analysis

Potential interaction effects between examined variables was analyzed with the use of ANOVA. This was followed by Student's t-test (due to the normality of the data distribution) for the differences between mean C-index scores in particular sports and modes of training (amateur vs professional). To assess the potential influence of years of involvement in sports on levels of moral competence both in amateur and professional sportspersons Pearson's correlation coefficient (r) was employed; and correlations with an $r < 0.4$ were considered weak, those with an r of 0.4–0.6 were considered moderate, and those with an $r > 0.6$ were considered strong [29]. Independent Pearson's correlations were compared using Fisher's z-test. For the purpose of the study a significance level of statistical analysis was set at p-value of <0.05. Analyses were performed with the use of Statistica software (Stat Soft 13.3, Krakow, Poland).

Results

ANOVA analysis between years of training and modes of training on C-index level indicated neither main effects nor significant interaction effects with $F(18, 935)=1.0391$, $p = 0.4119$. Whereas ANOVA analysis of effects between different sports and modes of training indicated statistically significant interaction effect on C-index level with $F(10, 952)=1.9787$, $p = 0.0325$.

This was followed by t-test analyses presented in tab. 1, which compares C-index scores among respondents representing different training modes (amateur and professional), both as a whole, by gender, and by the eleven sports.

Table 1 shows that C-index differed significantly between amateur and professional athletes for some sports groups, indicating differences in moral competence levels. In non-invasion games, the moral competency level was significantly higher for amateur than professional players ($p = 0.0416$). A similar situation was observed for martial arts and other fighting sports ($p = 0.0434$) and aquatic boating sports ($p = 0.0265$), where C-index were significantly higher for amateurs than professionals. However, the opposite was observed for dance sports, with professional dancers having higher moral competency levels than amateur dancers ($p = 0.0144$). Amateurs generally had higher moral competency levels than professionals in five sports categories (invasion games, non-invasion games, martial arts and other fighting sports, aquatic boating sports, cycling). The highest moral competency levels among amateurs were in aquatic boating sports (mean [M] = 19.9), with a mean value indicating moderate moral competency. In contrast, amateurs had low moral competency in the other types of sports. Professionals had higher C-index for dance, aquatic non-boating sports, and strength and fitness sports (16.8–16.5), but all indicated low moral competency. The lowest C-index were observed for net/wall/racquet sports for amateurs (M = 9.7) and martial arts sports (M = 10.3), cycling (M = 10.3), and aquatic boating sports (M=10.4) for professionals, all indicating low moral competency.

To determine whether there were general differences between amateur and professional sports participants, we calculated mean C-index for all females and males engaged in sports and those not involved in sports. The mean C-index (ranging between 12.7 – 14.5) indicated low moral competency levels for the whole group.

To answer the research question on possible associations of moral competency levels with training experience and years of training, we calculated Pearson's correlation coefficients between C-index and years of training for amateur and professional athletes for each type of sport, and compared them using Fisher's z-test (Table 2).

Correlation analyses (Table 2) indicated one moderate positive correlation ($r = 0.43$). The correlation was noticed between the levels of moral competency (represented by C-index) and longevity of training involvement (represented by number of training years) for a professional group in aquatic boating sports (rowing, kayaking, and sailing), where the longer they trained, the higher their moral

Table 1. Comparative analysis of C-index scores (mean and SD) across sports and different training modes (amateur vs professional).

Types of sports	Amateurs		Professionals		Student's t-test p value
	N	C-index	N	C-index	
1. Invasion games	217	14.5 ± 10.4	145	13.1 ± 9.7	0.2102
2. Non-invasion games	82	14.4 ± 10.2	48	10.8 ± 7.8	0.0416
3. Net/wall/racquet sports	25	9.7 ± 6.7	10	11.9 ± 7.8	0.3855
4. Martial arts and other fighting sports	54	13.7 ± 9.5	44	10.3 ± 6.0	0.0434
5. Aquatic boating sports (rowing, kayaking, and sailing)	10	19.9 ± 17.7	24	10.4 ± 6.6	0.0265
6. Aquatic non-boating sports	42	14.5 ± 10.7	40	16.6 ± 10.2	0.0357
7. Cycling	8	14.0 ± 10.9	3	10.3 ± 5.2	0.5987
8. Track and field sports	49	14.8 ± 12.3	39	15.9 ± 10.1	0.6476
9. Strength and fitness sports	27	14.1 ± 12.3	5	16.5 ± 9.2	0.6873
10. Gymnastic sports	23	14.9 ± 9.3	12	15.9 ± 11.4	0.7824
11. Dance sports	32	11.8 ± 7.6	35	16.8 ± 8.2	0.0144
Mean values for all	569	14.1 ± 10.3	405	13.4 ± 9.2	0.2291
Male athletes for all sports	320	13.8 ± 10.4	222	13.9 ± 9.2	0.9485
Female athletes for all sports	249	14.5 ± 10.4	183	12.7 ± 9.1	0.0611
Non-sports participants	62	12.2 ± 7.7			

Table 2. Comparison of Pearson's correlation coefficients for years of training and C-index between amateur and professional athletes for each type of sport.

Types of sports	Amateurs			Professionals			Significance of differences between correlations
	N	Years of training	r	N	Years of training	r	p-value
1. Invasion games	217	6.9	−0.03	145	8.7	0.09	0.2673
2. Non-invasion games	82	5.8	−0.12	48	7.4	−0.03	0.6285
3. Net/wall/racquet sports	25	5.0	−0.06	10	10.1	0.33	0.3603
4. Martial arts and other fighting sports	54	5.7	−0.18	44	10.0	−0.05	0.5309
5. Aquatic boating sports (rowing, kayaking, and sailing)	10	4.2	-0.31	24	7.6	0.43	0.0838
6. Aquatic non-boating sports	42	6.6	-0.23	40	8.7	0.17	0.0809
7. Cycling	8	3.6	-0.34	3	8.6	-----	------
8. Track and field sports	49	4.4	-0.03	39	7.2	-0.01	0.9286
9. Strength and fitness sports	27	3.3	0.04	5	7.0	-----	------
10. Gymnastic sports	23	4.7	0.04	12	9.6	0.06	0.9605
11. Dance sports	32	7.8	-0.01	35	9.7	-0.14	0.6114
Correlations for all sports	569	6.0	-0.07	405	8.6	0.06	0.0462
Male athletes for all sports	320	6.4	0.01	222	8.8	0.06	0.4715
Female athletes for all sports	249	5.6	-0.19	183	8.3	0.03	0.0210

competency level was. However, the correlation did not differ significantly between amateurs and professionals in aquatic non-boating sports ($p = 0.0809$). A positive correlation approaching moderate was observed for professional athletes in net/wall/racquet sports ($r = 0.33$). Negative correlations approaching moderate were observed for amateurs in aquatic boating, aquatic non-boating, and cycling sports (r of −0.31, −0.23, and −0.34). However, the cycling and aquatic boating sports results should be interpreted cautiously since their small sample sizes might cause bias.

The correlations were weak for all other sports groups and did not support significant associations between the examined variables (years of training and C-index) for amateurs nor professionals. Notably, the correlation coefficients differed significantly between amateur and professional athletes when considering all sports ($p = 0.0462$). C-index and years of training were positively correlated in professional athletes ($r = 0.06$), but negatively correlated in amateur athletes ($r = −0.07$), although both correlations were weak. A similar trend was observed when comparing female amateur and professional athletes ($p = 0.0210$). In cycling as well as in strength and fitness sports, the numbers of professional athletes were too small to calculate the correlation coefficients reliably.

Discussion

Sports can play a crucial role in fostering the sound development (including moral growth) of young people as research [30] focused on the potential benefits and factors that can negatively impact their development showed. Our study on levels of moral competency across various sports partially supports the hypothesis that moral reasoning differs by the type of sports and the mode of involvement only to some extent. The only interaction effects mediating the levels of moral competency were noticed between different sports and modes of involvement (amateur/professional). We found no clear nor strong associations between years of training and moral competency levels. This outcome concerns both sports in general, and those types of sport that have been predetermined in our study. This finding shows that the moral competency levels change regardless of the type of sports discipline practiced accordingly to developmental processes of moral growth [17]. It is contrary to what Miller and Jarman [10] and others [31, 32] have suggested, that sports differ by their individual characteristics and values that they contain and transmit and therefore might impact one's moral development differently. Our study does not support this and in this sense it forms a new perspective on that topic. It should be noted that the participants of a sport are

generally part of the whole society and, like others (nonathletes), they face similar social problems and everyday dilemmas daily. We believe that our results indicating that moral competency levels do not differ significantly across various sports or the studied groups (amateur/professional), may be partially explained by the research tool (MCT). This test has been generally designed to measure competency on the base of pre-determined two dilemmas from everyday life (work situation and life-saving medical dilemma), and as such were not specifically related to sport dilemmas. And although it is a universal assumption that the attitude to values and interhuman social relationships in sports should not differ from a life situation outside of sport, but perhaps using sport-related research tool on assessing the level of moral competency in sports could prove more differentiated results. For example, from the perspective of a sports referee, a good refereeing at an elite level of sport may be viewed as a combination of fairness in decision-making, accuracy of judgments, and consistency in actions [33, 34]. Conversely, a frequently observed phenomenon among athletes engaged in competitive sports is the rewarding of aggressive behaviors, even if they do not align with established social norms [35]. Furthermore, Webb [36] demonstrated that an increase in sport experiences among athletes leads to a shift in their previously held values towards those more oriented towards competition as their professionalism develops.

However, it should be noted that moral competencies and their development depend on various factors such as the environment and the moral atmosphere [37], type of sport [32], and nature of sport itself [38].

Nevertheless, Piaget [39] and Kohlberg [15] demonstrated much earlier that experiences gained via participation in sport may contribute to cognitive development, and consequently will result in better moral reasoning due to i.e., age, social encounters with adults, essentially with parents, but also coaches, other athletes (fellow players and opponents), and mates/friends character [40]. Therefore when analyzing C-index scores accordingly to the types of sports, we observed that they were higher in professional than amateur athletes for six types of sports. However, statistical significance was achieved only by four of those. Comparisons of C-index scores between amateur and professional athletes indicated significantly higher indices for amateurs in non-invasion games, martial arts and other fighting sports, aquatic boating sports, and for professionals in dance sports. Interestingly, most C-index scores in all groups indicated low moral competency (except for amateurs in aquatic boating sports). A broader understanding of the characteristics of the examined group might explain these findings [31, 32]. The abovementioned types of sports are all individual sports except for volleyball (a non-invasion game). One of the possible reasons for our results may be that in individual sports, athletes are responsible for their own performance and are not as reliant on the performance of other team members [41, 42]. The lack of a strong relationship between the years of training or mode of training (amateur/professional) with moral competency level in the final analysis confirms our previous findings [5]. The study was conducted on a group of youth aged 15–17 years, but the similarities have been noticed.

The characteristics of a given sport need to be considered when analyzing differences between types of sports. The analysis of mean C-index in the entire study population indicated that they ranged from 12.7 points for female professional athletes to 14.5 points for female amateur athletes but were similar in professional (13.9 points) and amateur (13.8 points) male athletes. Perhaps the situation is that the professional athletes' main goal is to compete well but focus on winning. If winning becomes their priority, other potential outcomes are dropped down on their hierarchy of motivations [43]. Pursuing victory may alter moral values in sports, as shown by many previous studies [44, 42, 45]. Some previous studies [12, 42, 5] have shown that professional individual-sport athletes have a higher moral competency level than team-sports athletes [42]. However, in our study, this expectation is counterbalanced by higher C-index in amateur athletes for five types of sports (invasion games, non-invasion games, martial arts and other fighting sports, aquatic boating sports, and cycling), some of which are also team sports (three were statistically significant).

This study's correlation analyses indicated a moderate positive relationship between years of training and C-index scores only for professional athletes in aquatic boating sports: the longer they trained, the higher their C-index. However, their average level was lower than that of amateurs in the same type of sport. This finding might be explained by the quality of novice trainees in these aquatic boating sports. An exclusive and prestigious nature of rowing [46] or sailing they still have the greatest power in shaping the moral and social habitus [47]. As Beauchamp & Vardaman [48] claim the rowing clubs can be seen as a site for moral and social education.

Those who stay and practice for a professional career start with a lower level of moral competency than their peers, but gradually increase their levels over time, although still within the low moral competency category. This hypothesis is consistent with Shields and Bredemeier [16], who found that in some sports the relationship between years of sports involvement and the levels of moral reasoning in has been generally negative. This result might also

be explained by Webb's prior observation [36], which suggests that with an increased years of involvement in sport practice athletes start presenting more professional approach (and more winning oriented) and their core set of values start to change as well. Therefore, this finding is intriguing and calls for more in-depth study in the future.

The only other positive correlation, approaching moderate strength (r = 0.33), was observed for professional athletes in net/wall/racquet sports. However, C-index scores did not differ significantly between professionals and amateurs in this type of sport. No other significant correlations were observed among types of sports beyond the weak strength level. The negative correlations approaching moderate strength observed for amateurs in cycling (r = −0.34) and aquatic boating sports (r = −0.31) were likely due to their relatively small subsample sizes, while the negative correlation for amateurs in aquatic non-boating sports (r = −0.23) was achieved with a reasonable subsample size.

Our study's respondents were university students aged around 19-23 years, which needs to be considered since they were all generally involved in sport-related high education. However, they appeared similar to the other peer age groups. Studies (with the use of the same research tool MCT) have shown that the moral competency levels of students have generally declined in many areas, such as business [49], medicine [50], and nursing [51]. Another study on Czech nursing students by Buźkova and Sikorová [52] found that the mean C-index was 14.2 points. In contrast, the mean C-index was found to change with years of study for Polish nursing students, who scored 12.8 points at the beginning the first year of studying to drop to 11.4 points in the fourth year [51]. Samanci [53] found the average C-index of Turkish students of primary education was 16 points, and was the same as for biology students at the same Turkish university. Interestingly, a study on young Czechs who were not university students (mean age = 24.3 years) [54] found a low median value for the scores by C-index to be 15.7 points. These findings are consistent with our earlier finding of a mean C-index of 12.6 for university students taking PE and Sports majors [3]. A good explanation of the situation in this age group has been offered by Rest [55] who noticed that after earlier stable increase a plateau appears in terms of moral growth in the early adulthood. Indeed, more recent data confirms this statement [56, 30].

Sports, with their regulations and intrinsic values, might pretend to be similar to a model of society, which involves all sorts of interactions and behaviors (cognitive, social, moral, and physical) between all parties and agents, including those among members of the same team and towards opponents, and can be embroidered with a wide scope of emotions, and filtered through a broad range of personal experiences [57]. It must be stressed that in sports, moral development and decision-making are generally influenced by various internal and external factors [17, 4]. In addition, participation modes may be a mediating factors in sports that could impact the patterns of individual moral development, as each sports and each sportsperson brings their own goals, principles, and values to the training process [16]. In this regard, some studies have indicated that professional competitions act as pivotal points at which moral choices most often occur to the individual sportsperson [58, 59]. Moreover, it is in the competitions when the athletes encounter stress (e.g., caused by physical contact and performing in front of crowds) and fatigue, which can act as drivers altering the levels of presenting of moral skills and behaviors in the heat of the real action [60, 61].

However, participation in sports alone does not lead to moral attitudes, judgments, and behaviors: it needs educational reinforcement [62]. Unfortunately, the traditional, universal set of values has been increasingly neglected, this process has become even more severe recently [63], supposedly also impacting all areas of sports [64, 65]. It is obvious that sport and real-life interact and penetrate each other space and thus it is impossible to avoid some social and cultural disturbances in human relationships, even at the universal social level. However, many indications show that sports can facilitate the moral development of youth [66, 67, 68] and thus becoming a socially valuable and highly demanded educational vehicle for transmitting moral values required for maintaining positive social interactions in the lifespan. Graupensparger, Jensen, and Evens [69] reported in their meta-analytic review that behaviors toward colleagues from one's team is moderately, but positively associated with behaviors of the same kind toward opponents. The opposite association was found in various studies on antisocial behaviors, where negative behaviors towards teammates were associated with similar behaviors towards opponents [11]. Interestingly, they also reported age as a moderator of social behaviors with a positive correlation in the adult population but a negative correlation in young athletes. However, some studies suggest that sport, specifically professional version, plays a crucial function in a dehumanization process of sports, and as such negatively influences the level of moral competency of those involved, athletes and coaches [58, 70] but can have disastrous consequences for the future of sport, and broader for social life in general.

Finally, it should be emphasized that our respondents showed a similarly low level of moral competency in life-concerning dilemmas to their peer-age group, regardless of their level of training and type of sport practiced. In our view, this may be attributed to the specific research tool used in this

study, which focuses only on dilemmas related to real-life and everyday problems rather than strictly on sport-related problems, a perception that could be more pronounced in this particular group.

Limitations and avenues for further research

To our knowledge, this is the first study examining associations between training modes, years of training, and moral competence levels across sports. Despite its limitations, it can provide a valuable initial assessment of the situation and become a valid foundation for further in-depth analyses. The cross-sectional nature of design, which despite a relatively large total sample size (N = 974), does not permit drawing cause-effect conclusions, could be considered a limitation of the study. In addition, our data collection based on the answers declared by university students may be subject to a bias. Two subgroups (type of sport) sizes were insufficient to perform a robust statistical analysis, and were omitted in the analysis process and skipped in the reporting. Some may find our division of types of sports somewhat arbitrary despite being based on a source-related review. However, we have found such typology convenient for this study's purpose. In the further studies more consideration should be given to education and sociocultural/socio-economic status and environmental influences that might affect the state of moral competency This dependency needs to be analyzed separately in detail and in a multidirectional manner. Also, other types of study designs, e.g., longitudinal designs, could be valuable in testing hypotheses on the changing levels of moral competency in young people with long-term involvement in sports.

Conclusions

All these new findings and theoretical approaches should direct the attention of the educational authorities (and especially PE teachers), including sports education system boards (and sport coaches), towards more comprehensive and combined strategies aimed at fostering the development of moral and social competencies during youth schooling and sporting processes.

The estimated moral competency level among the examined sport-related students (aged 19–23 years), measured using the standardized Lind's MCT, was generally similar to their age-matched peers from other countries as found in the relevant literature, and fell within the low-level category of competency. Differences (statistically significant) were noticed between training involvement modes and life-related moral competency levels. Amateurs had higher levels of moral competency than professionals in three types of sports (non-invasion games, martial arts and other fighting sports, aquatic boating sports). In contrast, professionals had higher moral competencies than amateurs in dance sports. No strong correlations were found between training modes. The only significant positive, moderate correlation between years of training and moral competency levels was found for the group of professional athletes in case of aquatic boating sports; the longer they trained, the higher their moral competency level was. However, it must be noted that the moral competency level of professional athletes from this type of sport (boating sport) was significantly lower than that of amateur athletes within the same sport. The correlation for professional athletes in net/wall/racquet sports approached moderate strength, and their moral competency level increased with years of practice.

Competing interests

We, the authors of this text, hereby declare that we have no conflict of interest related to any commercial or financial associations.

Funding

Please declare all the sources of funding including financial support. Please describe the role of the sponsor(s), if any, in any of the stages from study design to submission of the paper for publication.

References

1. Gary JM, Rubin NS. Sport promoting human development and well-being: Psychological components of sustainability. *UN Chronicle*. 2016;53(2): 30–32. https://doi.org/10.18356/f16c241e-en
2. Shields DL, Bredemeier BJ. Moral development and behavior in sport. In: Singer RN, Hausenblas HA, Janelle CM. (Eds.), *Handbook of sport psychology*. New-York: Wiley; 2001. P. 585-603.
3. Bronikowska M, Korcz A. The level of moral competences of pre-service PE teachers–a reason to worry? *Biomedical Human Kinetics*, 2019; 11(1), 19-27. https://doi.org/10.2478/bhk-2019-0003
4. Bronikowska M, Korcz A, Krzysztoszek J, Bronikowski M. How Years of Sport Training Influence the Level of Moral Competences of Physical Education and Sport Students. *Biomed Research International*, 2019; 11: 4313451. https://doi.org/10.1155/2019/4313451
5. Bronikowska M, Korcz A, Bronikowski M. The Role of Sports Practice in Young Adolescent Development of Moral Competence. *International Journal of Environmental Research and Public Health,* 2020; 24;17(15):5324. https://doi.org/10.3390/ijerph17155324
6. Peláez S, Aulls MW, Rossi A, Bacon SL. The coach as a contributor to the socio-moral context: A literature review. *Psychology Research*, 2013; 3(3): 113. https://doi.org/10.17265/2159-5542/2013.03.001

7. Johansson E, Brownlee J, Cobb-Moore C, Boulton-Lewis G, Walker S, Ailwood J. Practices for teaching moral values in the early years: a call for a pedagogy of participation. *Education, Citizenship and Social Justice,* 2011; 6(2): 109–124. https://doi.org/10.1177/1746197910397914
8. Peláez S, Aulls MW, Bacon SL. Morality in sport: The coach's perspective. International *Journal of Sports Science & Coaching*, 2016; 11(2): 237–249. https://doi.org/10.1177/1747954116637494
9. Jacobs F, Knoppers A, Webb L. Making sense of teaching social and moral skills in physical education. *Physical Education and Sport Pedagogy,* 2013; 18(1): 1–14. https://doi.org/10.1080/17408989.2011.621118
10. Miller RF, Jarman BO. Moral ethical character development views from past leaders. Journal of Physical Education, *Recreation and Dance*, 1988; 59: 72–78. https://doi.org/10.1080/07303084.1988.10609788
11. Kavussanu M, Boardley ID. The prosocial and antisocial behavior in sport scale. *Journal of Sport and Exercise Psychology*, 2009; 31(1): 97–117. https://doi.org/10.1123/jsep.31.1.97
12. Bredemeier B, Shields D. Moral growth among athletes and nonathletes: a comparative analysis. *Journal of Genetic Psychology*, 1986; 147: 7–18. https://doi.org/10.1080/00221325.1986.9914475
13. Nowak E. Demokracja zaczyna się w umyśle. Rozwijając osobowość demokratyczną [Democracy begins in the mind. Developing a democratic personality]. *Principia,* 2013; 57-58: 23–40. (In Polish). https://doi.org/10.4467/20843887PI.14.002.152
14. Lind G. *How to teach moral competence*. Logos Verlag Berlin; 2019.
15. Kohlberg L. Moral stages and moralization. The cognitive-developmental approach. In: Lickona T. (Ed.), *Moral development and behaviour. Theory, research and social issues*. New York: Holt, Rinehart and Winston; 1976. P. 31–53.
16. Shields DL, Bredemeier BJ. *Character development and physical activity*. Champaign, USA: Human Kinetics; 1995.
17. Proios M, Doganis G, Athanailidis I. Moral Development and Form of Participation, Type of Sport, and Sport Experience. *Perceptual and Motor Skills*, 2004; 99: 633–42. https://doi.org/10.2466/PMS.99.6.633-642
18. Pierce S, Gould D, Camiré M. Definition and model of life skills transfer. *International Review of Sport and Exercise Psychology*, 2017; 10:1: 186–211, https://doi.org/10.1080/1750984X.2016.1199727
19. Milstein N, Striet Y, Lavidor M, Anaki D, Gordon I. Rivalry and performance: A systematic review and meta-analysis. *Organizational Psychology Review*, 2022; 12(3): 332–361. https://doi.org/10.1177/20413866221082128
20. Nia ME, Besharat MA. Comparison of athletes' personality characteristics in individual and team sports. *Procedia - Social and Behavioral Sciences,* 2010; 5: 808–812. https://doi.org/10.1016/j.sbspro.2010.07.189
21. Collins English Dictionary. *Definition of "Amateurism"* [Internet]. 2020 [cited 2023 Apr 3]. Available from: https://www.collinsdictionary.com/dictionary/english/amateurism
22. Mareš L.'Good Sport': Different Dimensions and Their Constitutive Properties from the Ontological and Moral Point of View. Physical Culture and Sport. *Studies and Research*, 2023; 99(1): 27–42. https://doi.org/10.2478/pcssr-2023-0011
23. Matuszak A, Matuszak Z. Definition of the sample and its size in pedagogical research, In *General and Professional Education,* 2011; 2:33–39.
24. Schmidt SAJ, Serigne L, Hollestein, LM. Research Techniques Made Simple: Sample Size Estimation and Power Calculation. *Journal of Investigative Dermatology,* 2018; 138(8): 1678–82. https://doi.org/10.1016/j.jid.2018.06.165
25. Britannica. *Arts & Culture. Gymnastics* [Internet]. 2023 [cited 2023 Apr 3]. Available from: https://www.britannica.com/sports/gymnastics
26. Cambridge Dictionary. *Martial art* [Internet]. 2023 [cited 2023 Apr 3]. Available from: https://dictionary.cambridge.org/pl/dictionary/english/martial-art
27. Topen Sports. *Training for Strength and Fitness* [Internet]. 2023 [cited 2023 Apr 3]. Available from: https://www.topendsports.com/fitness/strength/index.htm
28. Kohlberg L. Stage and sequence: The cognitive developmental approach to socialization. In: Goslin DA. (Ed.), *Handbook of socialization theory and research*. Chicago: Rand McNally; 1969;. P. 380–437.
29. Schober PMD, Boer Ch, Schwarte LA. Correlation Coefficients: Appropriate Use and Interpretation. *Anesthesia & Analgesia,* 2018; 126(5): 1763-1768, https://doi.org/10.1213/ANE.0000000000002864
30. Volkova E, Miklyaeva A, Volkova I, Bezgodova S. Psychological well-being of adolescents gifted in math, humanities and sports: Comparative analysis. *Psychology in Education*, 2020; 2(4):358–365. https://doi.org/10.33910/2686-9527-2020-2-4-358-365
31. Bredemeier B, Weiss M, Shields D, Cooper B. The relationship of sport in development with children's moral reasoning and aggression tendencies. *Journal of Sport Sociology*, 1986; 8: 304–318. https://doi.org/10.1123/jsp.8.4.304
32. Tucker LW, Parks JB. Effects of gender and sport type on intercollegiate athletes' perceptions of the legitimacy of aggressive behaviors in sport. *Sociology of Sport Journal*, 2001; 18: 403–413. https://doi.org/10.1123/ssj.18.4.403
33. Weinberg RS, Richardson PA. *Psychology of officiating*. Champaign, IL: Leisure Press; 1990.
34. National Officiating Program. *Who are officials?* Canberra, Australia: Australian Coaching Council; 1999.
35. Stephens DG. Aggression. In: Duda JL. (Ed.), *Advances in sport and exercise psychology measurement*. Morgantown, WV: Fitness Information Technology; 1998. P. 277–294.
36. Webb H. Professionalization of attitudes towards play among adolescents. In G. S. Kenyon (Ed.),

Aspects of contemporary sport sociology. Chicago, IL: The Athletic Institute; 1969. P. 161–178.
37. Higgins A, Power C, Kohlberg L. The relationship of moral atmosphere to judgments of responsibility. In: Kurtines WM, Gewirtz J L. (Eds.), *Morality and moral behavior*. New York: Wiley; 1984. P. 52–73.
38. Stephens DE, Bredemeier B. Moral atmosphere and judgment about aggression in girls' soccer: relationships among moral and motivational variables. *Journal of Sport and Exercise Psychology*, 1996; 18: 158–173. https://doi.org/10.1123/jsep.18.2.158
39. Piaget J. *The moral judgment of the child*. New York: Free Press; 1965.
40. Weiss RM, Bredemeier B. Moral development in sport. *Journal of Exercise and Sport Sciences Reviews*, 1991; 18: 330-–. https://doi.org/10.1249/00003677-199001000-00015
41. Beller JM, Stoll SK. Moral reasoning of high school student athletes and general students: empirical study versus personal testimony. *Pediatric Exercise Science*, 1995; 7: 352–363. https://doi.org/10.1123/pes.7.4.352
42. Beller M, Stoll SK. *Myth versus reality: an examination of ethical gender issue in American collegiate athletic model*. Paper presented at the International Philosophic Society of Sport. Oslo: Norway; 1997.
43. Lumpkin A. *Physical education and sport: A contemporary introduction* (2nd edition). Times Mirror Magazine; 1990.
44. Allison MT. Sportsmanship: variation based on sex and degree of competitive experience. In: Dunleav A, Miracle A, Ress C. (Eds.), *Studies in the Sociology of Sport*. Fort Worth, TX: Texas Christian Press; 1982. P. 143–165.
45. Stephens DG. A correlational study on parental attachment and moral judgment competence of millennial generation college students [Doctoral dissertation]. University of Nebraska-Lincoln; 2009.
46. McDonald B. The university rowing club as a site of moral and social education in Japan. *International Sports Studies*, 2004; 26(2): 15-28.
47. Bourdieu P. *Distinction: A social critique of the judgement of taste*. Cambridge Mass: Harvard University Press; 1984.
48. Beauchamp ER, Vardaman Jr JM, Vardaman Jr JM. *Japanese Education since 1945*. Routledge; 2015. https://doi.org/10.4324/9781315703176
49. Bosco SM, Melchar DE, Beauvais LL, Desplaces DE. Teaching business ethics: The effectiveness of common pedagogical practices in developing students' moral judgment competence. *Ethics and Education*, 2010; 5(3): 263–280. https://doi.org/10.1080/17449642.2010.533049
50. Feitosa HN, Rego S, Bataglia PUR, Sancho KFCB, Rego G, Nunes R. Moral judgment competence of medical students: a transcultural study. *Advances in Health Sciences Education,* 2013; 18(5): 1067–1085. https://doi.org/10.1007/s10459-013-9449-5
51. Rzymska I, Musielak M. Evaluation of changes in moral preferences among midwifery students during university studies. *Nowiny Lekarskie*, 2011; 80(4): 272–276.
52. Bužgová R, Sikorová L. Moral judgment competence of nursing students in the Czech Republic. *Nurse Education Today*, 2013; 33(10): 1201–1206. https://doi.org/10.1016/j.nedt.2012.06.016
53. Samanci NK. A Study on the Link between Moral Judgment Competences and Critical Thinking Skills. *International Journal of Environmental and Science Education*, 2015; 10(2): 135–143. https://doi.org/10.12973/ijese.2015.236a
54. Chrenková P, Šukolová D. Nevera Vo Vzťahu K Morálnemu Usudzovaniu – Infidelity in Relation to Moral Reasoning [Infidelity in Relation to Moral Reasoning]. In: *Socialne Problemy a osobnost, Ústav experimentálnej psychológie* [Social Problems and Personality, Institute of Experimental Psychology], Bratislava: Center of Social and Psychological Sciences SAS; 2017. P. 186–193. (In Slovak).
55. Rest JR. *Development in judging moral issues*. Minneapolis, MN: Minnesota Press; 1979.
56. L. Simon R. *The Ethics of Coaching Sports: Moral, Social, and Legal Issues*.. 1st ed. Routledge; 2018. https://doi.org/10.4324/9780429496578
57. Costigan SA, Narelle E, Plotnikoff R, Hillman Ch, Lubans D. High-Intensity Interval Training for Cognitive and Mental Health in Adolescents. *Medicine & Science in Sports & Exercise*, 2016; 48(10): 1985–93. https://doi.org/10.1249/mss.0000000000000993
58. Bilohur V, Andriukaitiene R. Sports culture as a means of improving the integrity of sports personality: philosophical cultural and anthropological analysis. *Human Studies*, 2020; 6(83):136–152. https://doi.org/10.26661/hst-2020-6-83-10
59. Campbell MH, McNamee M. J. Ethics, genetic technologies and equine sports: the prospect of regulation of a modified therapeutic use exemption policy. *Sport Ethics Philosophy*, 2021;15(2):227–250. https://doi.org/10.1080/17511321.2020.1737204
60. Davis P. *Ethics, knowledge & truth in sports research*. Philosophy Now; 2018.
61. Graham DN, Burns GN. Athletic identity and moral development: An examination of collegiate athletes and their moral foundations. *International Journal of Sport Psychology*, 2020; 51(2):122–140. https://doi.org/10.7352/IJSP.2020.51.122
62. Andersson H, Svensson A, Frank C, Rantala A, Holmberg M, Bremer A. Ethics education to support ethical competence learning in healthcare: an integrative systematic review. *BMC Medical Ethics*, 2022; 23(1): 1–26. https://doi.org/10.1186/s12910-022-00766-z
63. Kinnier RT, Kernes JL, Dautheribes TM. A short list of universal moral values. Couns. *Values*, 2000; 45: 4–16. https://doi.org/10.1002/j.2161-007X.2000.tb00178.x
64. Parker A, Watson NJ. Sport, Religion, and Beliefs. In: Wenner LA (ed.) *The Oxford Handbook of Sport and Society*. 1st ed. Oxford University Press; 2022. P. 154–170. https://doi.org/10.1093/

oxfordhb/9780197519011.013.9
65. Robertson J, Constandt B. Moral disengagement and sport integrity: identifying and mitigating integrity breaches in sport management. *European Sport Management Quarterly*, 2021; 21(5): 714–730. https://doi.org/10.1080/16184742.2021.1945122
66. Wiggins DK. A history of highly competitive sport for American children. In: Smoll FL, Smith RE. (Eds.), *Children and youth in sport: A biopsychosocial perspective*. Madison, WI: Brown & Benchmark; 1996. P. 15–30.
67. Pennington C. Moral development and sportsmanship in interscholastic sports and physical education. *Journal of Physical Education, Recreation and Dane*, 2017; 88: 36–42. https://doi.org/10.1080/07303084.2017.1367745
68. Šukys S, Dargenė Ž, Karanauskienė D. Qualitative investigation of coaches' perspectives on moral education in sport. *Baltic Journal of Sport and Health Sciences,* 2017; 4(107): 46–56. https://doi.org/10.33607/bjshs.v4i107.39
69. Graupensperger SA, Jensen CJ, Evans MB. A meta-analytic review of studies using the Prosocial and Antisocial Behavior in Sport Scale: Associations among intergroup moral behaviors. *Sport, Exercise, and Performance Psychology*, 2018; 7(2): 186–204. https://doi.org/10.1037/spy0000121
70. Juengst ET. Annotating the Moral Map of Enhancement. In: Murray TH, Chuan VT (eds.) *The Ethics of Sports Technologies and Human Enhancement*. 1st ed. Routledge; 2020. P. 173–202. https://doi.org/10.4324/9781003075004-18

Information about the authors:

Małgorzata Bronikowska; (Corresponding author); https://orcid.org/0000-0002-0584-0725; bronikowska@awf.poznan.pl; Department of Recreation, University of Physical Education; Poznań, Poland.

Michał Bronikowski; https://orcid.org/0000-0002-4534-7345; bronikowski@awf.poznan.pl; Department of Didactics of Physical Activity, University of Physical Education; Poznań, Poland.

Cite this article as:
Bronikowska M , Bronikowski M. The association between the years and modes of sports training and levels of moral competence. *Physical Education of Students,* 2024;28(2):57–69.
https://doi.org/10.15561/20755279.2024.0202

Received: 04.02.2024

Accepted: 12.03.2024; **Published**: 30.04.2024

PHYSICAL EDUCATION OF STUDENTS

ORIGINAL ARTICLE

Participation motivation in disabled athletes

Bekir Furkan Tüzer[ABCDE], Havva Demirel[ABCDE]

Faculty of Sports Science, Selcuk University, Turkey

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim: Sports have significant effects on individuals of all ages and levels, particularly for those with disabilities. These effects are seen in terms of self-expression and competence skills. The aim of this study was to measure the motivation levels of disabled athletes in their participation in sports.

Material and Methods: The study involved 151 voluntary participants. The 'Motivation Scale for Participation in Sports for Disabled Individuals' was utilized. Independent t-tests and One-Way ANOVA multiple comparison tests were employed to compare differences between two independent groups and determine variations between variables.

Results: Significant differences were found in the motivation levels of disabled individuals in terms of gender, disability status, nationality, type of sport, and social status factors. Female participants were found to have higher levels of both internal and external motivation compared to males. It was determined that the internal motivation of individuals with hearing impairments is higher than those with visual and intellectual disabilities. Additionally, the external motivation levels of individuals with physical, visual, and hearing impairments are higher than those with intellectual disabilities. National athletes have been found to have high levels of external motivation. Furthermore, there is a significant difference in the internal and external motivations of individual sports participants compared to those participating in team sports. No significant differences were found in the duration of participants' athletic careers. Individuals who gained social status through sports were found to have high levels of external motivation.

Conclusions: Among the positive effects of sports in human life, it is observed that there are many positive values that sports bring to individuals. This includes the internal and external motivation it provides. Sports have significant effects on self-expression and self-sufficiency skills for individuals of all ages and levels, especially for individuals with disabilities. In this context, the participation of disabled individuals in sports becomes crucial in terms of their personal development and facilitating their lives, both physiologically, psychologically, and sociologically.

Keywords: motivation, disabilities, athletes, participation, sports

Introduction

The intersection of disability and sports presents complex challenges that extend beyond physical limitations. Despite the recognized benefits of sports for overall health and social integration, individuals with disabilities often face barriers to participation.

Sport is a significant tool for promoting overall health [1, 2] and fostering social connections [3]. Disability encompasses limitations in physical movement, exercise abilities, and intellectual skills. When disability and sports are considered together, the lack of exercise or participation among disabled individuals can increase the risk of chronic diseases such as obesity, hypertension, and diabetes [4]. Additionally, individuals with hearing, vision, or mobility impairments may experience psychological stress [5]. Mental health conditions are also recognized as significant factors in athletic success [6, 7]. Studies indicate that positive personality traits, motivation, confidence, focus, and perceived social support play crucial roles in preventing athletes from experiencing stress and achieving success in sports.

It should be noted that rewards, physical support, and various interactions can lead to significant outcomes for both disabled individuals and their families. These outcomes may include improvements in self-esteem, self-confidence, social skills, positive personal perceptions, and the development of physical and motor skills [9].

Motivation is the process that initiates, guides, and sustains goal-oriented behaviors. It is widely recognized as the driving force behind athletes' actions [10]. Particularly in sports, motivation plays a crucial role in fostering active participation and continuity [11]. Therefore, developing motivational strategies, especially tailored for disabled athletes, and providing ongoing support for these strategies is essential [12]. Motivation can stem from both internal and external sources, with the possibility of experiencing demotivation as well. Essentially, motivation encompasses three primary factors: intrinsic motivation (the enjoyment derived from autonomously performing an activity),

doi:10.15561/20755279.2024.0203

extrinsic motivation (engaging in an activity to motivate others or to attain external rewards), and demotivation (lack of intent to participate in a specific activity) [13]. Understanding the dynamics of intrinsic motivation, extrinsic motivation, and demotivation is beneficial not only for individuals with special needs involved in sports but also for coaches and families alike [14].

Clearly, there is a need for further investigation into the factors influencing the motivation of individuals with special needs to participate in sports. It is imperative to thoroughly assess the motivation levels of disabled individuals involved in sports and scientifically evaluate the resultant positive or negative behaviors stemming from motivation.

Hence, the primary objective of the study is to assess the motivation levels of disabled individuals. The secondary aim is to investigate potential associations between motivation states and various factors such as gender, disability, nationality, type of sport, duration of participation in sports, and the role of sports in social status attainment.

Materials and Methods

Participants

The population of the study consists of 151 disabled athletes (also university students), including 54 women and 97 men participating in sports in Konya province. This research was approved by the Ethics Committee of Selçuk University Faculty of Sports Sciences with the ethics committee report number 134 and the date 04.10.2022.

Research Design

In this study, the 'Motivation Scale for Participation in Sports for Disabled Individuals' was utilized. This scale consists of 22 items and includes three subscales: 'intrinsic motivation,' 'extrinsic motivation,' and 'demotivation' [15]. Since the demotivation subscale contains negative statements, it was reverse-coded. The items related to intrinsic and extrinsic motivation contain positive statements. The scale employs a 5-point Likert-type rating system, where higher scores indicate higher levels of motivation among individuals. The demographic information section comprised questions regarding gender, disability status, national athlete status, type of sport practiced, duration of involvement in sports, and the role of sports in social status attainment. A comparative model was employed for analysis.

Statistical Analysis

The Statistical Package for Social Sciences (SPSS) Version 22.0 was employed for data analysis in this study. Parametric tests were conducted due to the normal distribution of the data, as indicated by kurtosis and skewness values within the range of ±2 [16]. A significance level of $p < 0.05$ was considered statistically significant. The normality test applied to the data confirmed their normal distribution. Independent t-tests were used to analyze differences between independent groups, while One-Way ANOVA multiple comparison tests were employed for comparing more than two independent groups.

Results

Tables 1-8 present the results of the statistical analysis conducted on the data obtained from the research. Table 1 presents the descriptive statistical results obtained from the participants.

Table 1. Descriptive statistics results of the obtained data

Variable		N	%
Gender	Female	54	35.8
	Male	97	64.2
Disability Situation	Physically Disabled	45	29.8
	Blind	36	23.8
	Deaf	50	33.2
	Mentally disabled	20	13.2
National Sportsmanship	Yes	59	39.1
	No	92	60.9
Type of Sport	Individual	98	64.9
	Team	53	35.1
Year of Sportsmanship	1-3 Years	22	14.6
	3-6 Years	36	23.8
	6-9 Years	39	25.8
	9 Years and Over	54	35.8
Social Status	Yes	128	84.8
	No	23	15.2
	Total	151	100.0

Based on the data from Table 1, it is evident that there is a predominance of males among the participants, with physical disabilities and deafness being the most prevalent conditions. The majority of participants are not national athletes, prefer individual sports over team sports, and have been engaged in sports for 3 to 9 years, indicating a sustained interest in sports.

Upon comparing the data obtained from the participants based on gender, statistically significant differences were found in the intrinsic motivation and extrinsic motivation subscales (Table 2). Female participants demonstrated higher levels of intrinsic and extrinsic motivation compared to male participants. However, no significant difference was observed in the demotivation subscale ($p > 0.05$).

Multiple comparison results based on the participants' disability status are presented in Table 3.

Significant differences were observed in the

dimensions of intrinsic motivation, extrinsic motivation, and demotivation ($p < 0.05$). Tukey's test was conducted to identify specific group differences. The analysis revealed that in the intrinsic motivation dimension, participants with hearing impairments exhibited significantly different average scores compared to those with visual impairments and intellectual disabilities. Regarding the extrinsic motivation subscale, individuals with physical disabilities, visual impairments, and hearing impairments showed significantly higher average scores than those with intellectual disabilities. In terms of demotivation levels, a significant difference was found between individuals with hearing impairments and those with physical disabilities, with individuals with hearing impairments showing a more favorable outcome.

Table 4 provides comparison results based on the participants' status as national athletes.

Upon examining the analysis results, a significant difference was found favoring national athletes in the extrinsic motivation subscale ($p < 0.05$). However, no significant differences were observed in the intrinsic motivation and demotivation subscales.

The analysis results based on the types of sports practiced by the individuals are presented in Table 5. It indicates significant differences in the intrinsic and extrinsic motivation subscales ($p < 0.05$). Individuals engaging in individual sports demonstrated higher levels of intrinsic and extrinsic motivation compared to those engaging in team sports (this difference was found to be significant). Additionally, no significant difference was noted in the demotivation subscale.

Analysis results regarding the number of years individuals have been engaged in sports are presented in Table 6. According to the analyses, no statistically significant differences were found in the intrinsic motivation, extrinsic motivation, and demotivation subscales based on the duration of individuals' involvement in sports.

Significant differences were found in the analysis of data regarding whether sports provide individuals with social status in the extrinsic motivation subscale (Table 7). Upon examining the results, it was determined that individuals who answered «yes» to the question of whether sports provide social status had higher levels of extrinsic motivation compared to those who answered «no.» However, no statistically significant results were found in the intrinsic motivation and demotivation subscales.

The relationship between the subscales of the Sports Participation Motivation Scale is presented in Table 8. According to the analysis results, there is a moderate positive correlation between intrinsic motivation and extrinsic motivation, and a low negative correlation between intrinsic motivation

Table 2. Comparison of data according to gender variable

Motivation Types	Gender	N	x	Sd	t	p
Intrinsic Motivation	Female	54	51.8333	6.49746	5.368	.001*
	Male	97	44.0412	11.33938		
Extrinsic Motivation	Female	54	19.0185	4.11848	2.462	.015*
	Male	97	17.0412	5.03719		
Amotivation	Female	54	9.9815	3.57397	-1.343	.182
	Male	97	10.8866	4.59591		

Table 3. Multiple comparison results of data according to disability status

Disability Status		N	x	Sd	F	p	LSD
Intrinsic Motivation	A Physical	45	47.8000	11.96700	3.446	.018*	C> B-D
	B Blind	36	43.8611	10.58882			
	C Deaf	50	49.7000	7.37411			
	D Mentally	20	42.8000	11.92344			
Extrinsic Motivation	A Physical	45	18.6000	5.10526	6.048	.001*	A-B-C> D
	B Blind	36	17.0278	3.45159			
	C Deaf	50	18.9400	4.93802			
	D Mentally	20	14.1500	4.17102			
Amotivation	A Physical	45	9.2444	3.66901	3.218	.025*	C> A
	B Blind	36	10.6111	3.44987			
	C Deaf	50	11.8800	5.28625			
	D Mentally	20	10.1500	3.13344			

Table 4. Comparison results of data according to nationality variable

National Sportsmanship		N	x	Sd	t	p
Intrinsic Motivation	Yes	59	47.9322	11.65431	1.031	.304
	No	92	46.1196	9.77308		
Extrinsic Motivation	Yes	59	19.6780	4.41565	4.156	.001*
	No	92	16.5109	4.66338		
Amotivation	Yes	59	11.1525	4.97169	1.282	.203
	No	92	10.1848	3.72968		

Table 5. Comparison results of the data according to the type of sport practiced

Type of Sport		N	x	Sd	t	p
Intrinsic Motivation	Individual	98	48.0714	11.37210	2.170	.032*
	Team	53	44.5283	8.44804		
Extrinsic Motivation	Individual	98	18.7857	4.83170	3.758	.001*
	Team	53	15.8302	4.17288		
Amotivation	Individual	98	10.3061	4.25576	-1.005	.316
	Team	53	11.0377	4.29204		

Table 6. Multiple comparison results according to individuals' years of sport

Year of Sportsmanship		N	x	Sd	F	p
Intrinsic Motivation	1-3 Years	22	42.0455	10.43108	2.419	.069
	3-6 Years	36	47.7500	8.63010		
	6-9 Years	39	49.3077	9.14835		
	9 Years and Over	54	46.3704	12.15512		
Extrinsic Motivation	1-3 Years	22	16.2273	5.28188	1.411	.242
	3-6 Years	36	17.3056	4.88039		
	6-9 Years	39	18.7179	4.33437		
	9 Years and Over	54	17.9630	4.83682		
Amotivation	1-3 Years	22	9.9091	3.68923	1.466	.226
	3-6 Years	36	11.7222	3.89587		
	6-9 Years	39	10.7179	4.57078		
	9 Years and Over	54	9.9444	4.43578		

Table 7. Comparison results regarding the social status of sports

Sportsmanship	Social Status	N	x	Sd	t	p
Intrinsic Motivation	Yes	128	47.4375	10.90167	1.686	.094
	No	23	43.4348	7.63262		
Extrinsic Motivation	Yes	128	18.1094	4.76740	2.204	.029*
	No	23	15.7391	4.64384		
Amotivation	Yes	128	10.2969	4.29495	-1.821	.071
	No	23	12.0435	3.87859		

and demotivation. Therefore, it can be said that as intrinsic motivation increases, extrinsic motivation will also increase, and as intrinsic motivation decreases, extrinsic motivation will decrease. Additionally, it is observed that as intrinsic motivation increases, demotivation decreases. No significant relationship was found between extrinsic motivation and demotivation.

Discussion

The research on the participation motivations of disabled athletes included 59 national and 92 non-national athletes. Among them, 22 individuals reported engaging in sports for «1-3 years», 36 for «3-6 years», 39 for «6-9 years», and 54 for «9 years and above». Analysis of the data revealed

Table 8. The relationship between the sub-dimensions of the motivation to participate in sport scale

Sportsmanship		Intrinsic Motivation	Extrinsic Motivation	Amotivation
Intrinsic Motivation	r	1	.629	-.238
	p		.001*	.003*
Extrinsic Motivation	r	.629	1	-.028
	p	.001*		.735
Amotivation	r	-.238	-.028	1
	p	.003*	.735	

p<0.05

significant differences in several variables. In the gender-based comparison, significant differences were noted between female and male participants. Previous studies corroborate our findings. Moradi et al. [17] found higher levels of participation motivation in females compared to males. Similarly, another study examining gender differences in the participation motivation of disabled athletes also reported significant gender-based differences, favoring females [18]. While these findings align with our research, diverse outcomes have also been documented

Abdullah et al. [19] reported no significant difference in gender in their study investigating reasons for sports participation among disabled individuals. Similarly, in the study by Abdullah and colleagues [20] on the motivation of hearing-impaired individuals to participate in physical activities, gender did not show a significant difference. Another study examining participation motivations of disabled individuals in sports also found no significant gender difference [21].

Significant differences in internal motivation, external motivation, and amotivation dimensions based on types of disabilities were observed in this study [22]. Another study [22] evaluating participation among disabled individuals in physical activities found significant differences between those engaged in sports and those who were not, particularly favoring sports engagement among individuals with physical, visual, and hearing impairments. Similarly, in a study on disabled athletes [21], significant differences were noted based on types of disabilities, with individuals with physical disabilities exhibiting higher amotivation scores compared to those with visual and hearing impairments. These findings suggest that guiding disabled individuals towards suitable sports activities may help address motivation issues [21]. Accordingly, individuals with physical disabilities had higher levels of amotivation compared to individuals with visual impairments. It can be considered that addressing the motivation problem in disabled individuals can be resolved by directing them to suitable sports branches.

The social status acquired through sports can significantly influence an individual's position and perception in society. Factors such as the level of involvement, intensity, professional status, and national recognition in sports can directly impact one's social standing, reputation, and self-assurance. In this study, it was observed that individuals who are national athletes exhibit higher levels of external motivation compared to non-national athletes.

Polat et al. [23] investigated the relationship between motivation and sports participation frequency, revealing significant differences in both internal and external motivation dimensions. Their findings indicated that competitive athletes had higher average values compared to recreational sports participants. Similarly, Top and Akıl [24] identified significant disparities between elite and non-elite athletes. Their study concluded that elite athletes exhibited higher average values in individual, environmental, and causality factors compared to non-elite athletes. Furthermore, Mutlu et al. [21] explored participation motivations based on national athlete status, finding that individuals who are national athletes showed higher values in the internal motivation dimension than those who are not. In a separate study focusing on participation motivations among disabled individuals according to national athlete status, significant differences were detected in the external motivation dimension among disabled individuals who are national athletes [18]. Karakoç et al. [25] examined the self-esteem of deaf national athletes in their study and found significant results in favor of national athletes.

Undoubtedly, sports provide significant benefits to human life. Extensively researched for its proven efficacy in addressing challenges, building self-confidence, and fostering a solution-oriented mindset, sports influence various psychological factors.

Table 5 presents the analysis results concerning the types of sports practiced by disabled individuals. Individuals participating in individual sports exhibit higher levels of internal and external motivation compared to those engaged in team sports. These findings are supported by Moradi et al. [17], who

similarly found significantly higher average values among individuals involved in individual sports compared to team sports.

Yaşar [26] identified significant differences in motivational factors among various sports branches. Particularly, individuals in badminton scored higher in showing strength compared to football and basketball. Differences were also noted in the approach to success, where badminton players significantly differed from basketball, volleyball, and football players. Additionally, variations were observed in the avoidance of failure, particularly between badminton and basketball players. Further disparities were found between individuals in individual sports like weightlifting, shooting, and swimming, and those in basketball.

Tekkurşun and İlhan [27] found significant differences in the branch variable while studying the participation motivations of visually impaired athletes, with higher average values for individuals interested in judo compared to weightlifting regarding internal motivation. Moreover, they noted that individuals involved in judo significantly differed from those in goalball in terms of external motivation. In their study, Tekkurşun and İlhan [27] examined the participation motivations of disabled individuals and found that those with physical disabilities who engaged in individual sports exhibited higher levels of internal motivation compared to those who were visually or hearing impaired. Additionally, the external motivation levels of visually impaired individuals participating in individual sports significantly differed from those with physical and hearing impairments.

Sirin et al. [28] identified significant differences in the competition factor among high school students participating in sports, based on the branch variable. Notably, significant disparities were observed in the friend dimension between volleyball and basketball, as well as between football and basketball branches. In contrast, a study investigating the participation motivations of individuals with physical disabilities [29] found no significant difference in the branch variable.

The heightened levels of internal and external motivation seen in individuals participating in individual sports can be attributed to their heightened self-awareness of their motivations. In team sports, failures or challenges may be tolerated by other teammates, whereas in individual sports, success and failure rest solely on the athlete's shoulders. Consequently, internal motivation assumes greater significance in individual sports, as individuals equip themselves with the necessary tools to navigate challenges effectively.

The physical and physiological transformations resulting from sports participation are often acknowledged and praised by one's peers, further boosting internal motivation. Additionally, external praise for individual achievements directly bolsters internal motivation. Therefore, the development of internal motivation can foster external motivation, and vice versa, creating a mutually reinforcing cycle.

Development, characterized by psychological and physiological changes over time, plays a pivotal role in individuals' success in sports, often emerging from consistent effort. In this study, the sportsmanship periods of individuals were examined and are presented in Table 6. The results reveal that there was no statistically significant difference in the sports participation periods among individuals.

Mutlu et al. [21] discovered a low-level positive correlation between the years of sports participation and levels of amotivation. Additionally, Yaşar [26] identified significant differences in years of experience among disabled individuals, noting that individuals engaging in sports for 13 years and above exhibited very low levels of avoidance of failure motivation. Furthermore, Tekkurşun and İlhan [27] examined the relationship between years of sports participation and motivation levels among visually impaired individuals, revealing a high-level positive correlation between years of sports and levels of internal, external, and amotivation. As individuals' years of sports experience increased, their motivation levels also increased. However, in another study investigating this relationship, no significant differences were found [30].

Individuals with different social roles gain a certain place in society based on the respect they show to others and the respect they receive from others. This place that individuals occupy over time grants them a status. When analyzing the results, it is observed that those who answer «yes» to the question of whether sports bring social status have higher levels of external motivation compared to those who answer «no». However, upon examining the research in the literature, no study specifically addressing whether sports provide social status to individuals was found. Therefore, studies related to sports were examined, and it was observed the following facts

Ahmed et al. [31] «participation motivation scale» was used, and this scale includes the sub-dimensions of the «social status» factor. A significant difference was found in the gender factor within the social status sub-dimension. It was determined that female participants significantly differed from male participants.

Due to the lack of research in the literature regarding the social status of sports, the variable of «providing social status through sports» gains significant value for future studies to be pioneers. Furthermore, when examining the research findings, a positive significant relationship between intrinsic motivation and extrinsic motivation is observed. However, a negative significant relationship between demotivation and intrinsic motivation

was determined. As a result, it can be predicted that the feeling of demotivation that may arise due to individuals being able to self-motivate will decrease. Additionally, it can be said that positive opinions from one's environment can also increase intrinsic motivation. Therefore, it can be concluded that being motivated internally and externally has a significant impact in the face of feelings of demotivation.

Conclusions

In summary, sports offer numerous positive benefits to individuals, including both internal and external motivation, particularly impactful for those with disabilities. These activities foster self-expression and self-sufficiency across various age groups and skill levels. Notably, individuals competing at the national athlete level exhibit high external motivation, while those involved in individual sports demonstrate elevated internal and external motivation, underscoring the importance of sports engagement. Furthermore, participation in sports not only yields physiological advantages but also enhances psychological and sociological well-being, as evidenced by higher motivation levels among those attributing social status to sports. Encouraging participation in sports among people with disabilities can foster holistic development encompassing physiological, psychological, and sociological aspects, while bolstering internal and external motivation may mitigate levels of amotivation.

References

1. Akil M. Effect of acute exercises applied to sedentaries on various enzyme levels related to muscle damages. *Afri J Microbiol Res*. 2012; 6 (2): 284–287. https://doi.org/10.5897/AJMR11.1113
2. Dyer BT, Deans SA. Swimming with limb absence: A systematic review. *J Rehabil Assist Technol Eng*. 2017; 4: 1–10. https://doi.org/10.1177/2055668317725451
3. Jobling A. Life be in it: Lifestyle choices for active leisure. *Downs Syndr Res Pract*. 2001; 6 (3): 117–22. https://doi.org/10.3104/perspectives.102
4. *Disability and Health Overview* [Internet]. Centers for Disease Control and Prevention. 2021. [updated 2018 Jun; cited 2023 Sep 30]. Available from: https://www.cdc.gov/ncbddd/disabilityandhealth/disability.html
5. Carroll DD, Courtney-Long EA, Stevens AC. Vital signs: disability and physical activity--United States, 2009-2012. *MMWR Morb Mortal Wkly Rep*, 2014; 63 (18): 407–413.
6. Martin JJ. Determinants of Elite Disability Sport Performance. *Kinesiol. Rev*. 2015; 4: 91–98. https://doi.org/10.1123/kr.2014-0082
7. Samulski DM, Noce F, Da Costa VT. Mental Preparation. In: Vanlandewijck YC, Thompson WR (eds.) *The Paralympic Athlete*, 1st ed. Wiley; 2011. P. 198–213. https://doi.org/10.1002/9781444328356.ch11
8. Carlon S, Shields N, Dodd K. Differences in habitual physical activity levels of young people with cerebral palsy and their typically developing peers: A systematic review. *Disabil Rehabil*, 2013; 35(8):647–55. https://doi.org/10.3109/09638288.2012.715721
9. Farrell RJ, Crocker PRE, McDonough MH, Sedgwick WA. The driving force: Motivation in Special Olympics. *Adapted Physical Activity Quarterly*. 2004; 21, 153–166. https://doi.org/10.1123/apaq.21.2.153
10. Cottingham M, Phillips DH, Hall SA. Application of the motivation scale for disability sport consumption: An Examination of Intended Future Consumption Behavior of Collegiate Wheelchair Basketball Spectators. *J Sport Behav*. 2014; 37 (2): 117–133.
11. Deans S, Burns D, McGarry A. Motivations and barriers to prosthesis users participation in physical activity, exercise and sport: A review of the literature. *Prosthet Orthot Int*. 2012; 36 (3): 260–9. https://doi.org/10.1177/0309364612437905
12. Skatteboe S, Roe C, Perrin PB. Oneyear trajectories of motivation and physical activity in persons with disabilities. *J Rehabil Med*. 2016; 48 (4): 371-7. https://doi.org/10.2340/16501977-2071
13. Ryan RM, Deci EL. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*. 2000; 55 (1): 68–78. https://doi.org/10.1037//0003-066X.55.1.68
14. Vallerand RJ, Losier GF. An integrative analysis of intrinsic and extrinsic motivation in sport. *Journal of Applied Sport Psychology*. 1999; 11: 142–169. https://doi.org/10.1080/10413209908402956
15. Tekkurşun-Demir G, İlhan EL, Esentürk OK, Kan A. Sports Participation Motivation Scale in Disabled Individuals (ESKMS): Validity and reliability study. *Spormeter*. 2018; 16 (1): 95–106. https://doi.org/10.1501/Sporm_0000000347
16. George D, Mallery M. *SPSS for Windows Step by Step: A Simple Guide and Reference*, 17.0 update (10a ed.) Boston: Pearson; 2010.
17. Moradi J, Bahrami A, Amir D. Motivation for participation in sports based on athletes in team and individual sports. *Physical Culture and Sport*. 2020; 85(1), 14-21. https://doi.org/10.2478/pcssr-2020-0002
18. Tekkurşun-Demir G, İlhan EL. Motivation to participate in sports in disabled athletes. *Ankara University Faculty of Educational Sciences Journal of Special Education*, 2020; 21(1): 49–69. https://doi.org/10.21565/ozelegitimdergisi.490063
19. Abdullah NM, Shapie MNM, Lan NC, Pilus AM, Nazarudin MN. Persons with Disabilities and Their Motives for Participating in Sports. *Pertanika Journal Social Sciences & Humanities*, 2017; 25: 51–58.
20. Abdullah NM, Wateh N, Shapie MNM, Rahim MRA, Omar-Fauzee MS, Nazarudin MN. The motivation

factors to partıcıpate ın physıcal actıvıty (pa) among persons wıth hearıng ımpaıred. *International Journal of Accounting, Finance and Business*, 2019; 4(18): 21–31.
21. Mutlu Bozkurt T, Tekkurşun Demir G, Dursun M. Examination of sports participation motivations of physically, hearing and visually impaired athletes. *International Journal of Social Research*, 2019; 12(67): 721–28. https://doi.org/10.17719/jisr.2019.3760
22. Çelenk Ç. Motivation Affects Sports and Life Skills in Physical Disabled People. *Propósitos y Representaciones*, 2021;9(SPE3). https://doi.org/10.20511/pyr2021.v9nSPE3.1161
23. Polat E, Doğan B, Mutlu F. An Investigation of Sport Participation Motives of the Individuals Doing Recreative Sports and Competitive Sports. *International Journal of Social Science Research*, 2018; 7 (2): 175–187.
24. Top E, Akil M. Intermediary Role of Motivation and Social Support for Male Athletes with Physical Disabilities. *Journal of Teaching, Research, and Media in Kinesiology*, 2021; 7: 1–6.
25. Karakoç Ö, Çoban B, Konar N. Comparison of the self-esteem levels of hearing-impaired national athletes and hearing-impaired people who do not do sports. *Selçuk University Journal of Physical Education and Sport Science*, 2012; 14 (1): 12–17.
26. Yaşar Sönmez B. *Evaluation of sport-specific success motivations of physically disabled athletes*. [Master's Thesis]. Pain; Ağrı İbrahim Çeçen University, Institute of Social Sciences, Department of Physical Education and Sports; 2018.
27. Tekkurşun Demir G, İlhan EL. Motivation for Participation in Sports: A Research on Visually Impaired Athletes. *Gaziantep University Journal of Sports Sciences*. 2019; 4(1): 157–170. https://doi.org/10.31680/gaunjss.525455
28. Şirin EF, Çağlayan HS, Çetin MÇ, İnce A. Determination of factors affecting the sports participation motivation of high school students who do sports. *Niğde University Journal of Physical Education and Sports Sciences*. 2008; 2 (2): 98–110.
29. Yılmaz A, Gümüşay A, Akkaya CC. Examination of Elite Physically Disabled Athletes' Motivation Levels of Participation in Sports. *International Journal of Disabilities Sports and Health Sciences,* 2021; 4(2): 86–99. https://doi.org/10.33438/ijdshs.930603
30. Yılmaz A, Kırımoğlu H, Kaynak K. Examining the sport-specific success motivation levels of athletes participating in the Turkish visually impaired swimming championship. *Journal of Sports and Performance Research,* 2019; 10(3): 270–281. https://doi.org/10.17155/omuspd.481491
31. Ahmed MD, Ho WKY, Al-Haramlah A, Jose Mataruna-Dos-Santos L. Motivation to participate in physical activity and sports: Age transition and gender differences among India's adolescents. *Cogent Psychology*, 2020; 7(1): 1798633. https://doi.org/10.1080/23311908.2020.1798633

Information about the authors:

Bekir Furkan Tüzer; (Corresponding author); https://orcid.org/0000-0002-1665-7205; bekir.tuzer@selcuk.edu.tr; Faculty of Sports Science, Selcuk University; Konya, Turkey.

Havva Demirel; https://orcid.org/0000-0003-2805-4281; havvademirel@selcuk.edu.tr; Faculty of Sports Science, Selcuk University; Konya, Turkey.

Cite this article as:
Tüzer BF, Demirel H. Participation motivation in disabled athletes. *Physical Education of Students,* 2024;28(2):70–77.
https://doi.org/10.15561/20755279.2024.0203

Received: 14.02.2024

Accepted: 21.03.2024; **Published**: 30.04.2024

PHYSICAL EDUCATION OF STUDENTS

ORIGINAL ARTICLE

Harmonizing musculoskeletal health: transformative effects of 8-week intervention program on posture in music students

Stanislav Azor[1AB], Michal Marko[2BC], Štefan Adamčák[3CD], Pavol Bartík[3DE]

[1] *Institute of Physical Education and Sports, Technical University in Zvolen, Slovakia*
[2] *Faculty of Performing Arts, Academy of Arts in Banská Bystrica, Slovakia*
[3] *Faculty of Physical Education, Sport and Health, Matej Bel University in Banská Bystrica, Slovakia*

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim: Musculoskeletal complaints are common among music students, irrespective of gender. They develop due to intense practice over an instrument; spending long hours of practice may cause muscular imbalance, tension, and awkward posture. The repetitive nature of practice in music students may cause overuse and fatigue. This increases the risk of acute pain and can affect both quality of life and performance. Therefore, the present study aimed at evaluating the transformative effects of an 8-week intervention program on posture in music students.

Material and Methods: The 8-week intervention program with transformative effects was conducted over 8 weeks (from September 18 to November 12) on Mondays and Thursdays, for 45 minutes each session. The program aimed to benefit 25 music students, of whom (i) 15 were in the experimental group (with an average age of 24.20 years, average weight of 82.40 kg, and average height of 178.60 cm), and (ii) 10 were in the control group (with an average age of 24.60 years, average weight of 78.40 kg, and average height of 182.20 cm). All participants were enrolled in the second year of a master's degree program in Performing Arts. Standardized measures for evaluating posture (utilizing Klein and Thomas's method, as refined by Mayer) were conducted both before (Week 1, September 18) and after (Week 8, November 12) the intervention. The impact of the 8-week intervention program was assessed using the Wilcoxon Rank-Sum Test, Wilcoxon Signed-Rank Test, and Pearson's r.

Results: Significant differences ($p < 0.05$, < 0.01) between 25 music students (M); in particular experimental group ($n = 15$) and control group ($n = 10$), were in 4 (80%) segments of body in post-test: (i) Head and neck; (ii) Abdomen and pelvis; (iii) Curvature of spine; (iiii) Shoulders and scapulas. Insignificant differences ($p < 0.05$) between 25 music students (M) were in pre-test.

Conclusions: Significant differences ($p < 0.05$, < 0.01) indicated the transformative effects in the experimental group's ($n = 15$) posture. This emphasizes the potential of the 8-week intervention program in promoting musculoskeletal health of music students. Therefore, additional research is necessary to investigate the lasting resilience (sustainability) of advantages and enhance the intervention plan in music education.

Keywords: body posture, intervention program, musculoskeletal health, music students.

Introduction

Maintaining the posture (correct) is of upmost importance in promoting the well-being of music students, allowing to engage in music-making with comfort (ease); however, prevention of posture in not common in music students. Despite its importance, playing-related musculoskeletal disorders (PRMDs) persist in music students, leading to discomfort, pain, and career-limiting injury [1, 2, 3]. Recognizing the challenge, educators (researchers) turn attention to interventions (target) aimed at improving the posture in music students [1, 4, 5, 6].

Music-making (practice) is demanding because of intense practice over an instrument, i.e., spending long hours of practicing may cause muscular imbalance, tension, and awkward posture [7]. Maintaining the posture is important because of preventing the playing-related musculoskeletal disorders, maximizing the playing technique (routine), and understanding the importance of ergonomics [8, 9]; however, incorrect posture (awkward) may cause muscle tension, joint strain, and (even) chronic pain [9, 10, 11]. Incorrect posture in music students is common (± 58%), more in females [12]. ± 85% of first-year (freshman) music students enrolled in higher education (university, college) experience acute pain; ± 34% of them experience playing-related musculoskeletal disorders, either in advance of enrollment in bachelor's degree [13, 14, 15]. Prevalence of playing-related musculoskeletal disorders in music students may differ, depending on diverse factors; in particular, instruments played, intensity of practice, level of awareness, and preventive measures taken [1]. Responsibility

doi:10.15561/20755279.2024.0204

for health (musculoskeletal) in music students is low; therefore, raising awareness and offering the instructions (target) in preventing the playing-related musculoskeletal disorders while studying may influence the careers of music students [11].

Despite its importance (maintaining the posture), correcting the incorrect posture is challenging; in particular, in music students who develop maladaptive postural habits over years of practice [6, 16]. Demands of music-making (practice) prioritize mastering over an instrument and artistic expression over well-being of music students, leading to overlook and/or dismiss the signs of discomfort. Learning environment (itself) may worsen the playing-related musculoskeletal disorders because intense practice over an instrument happens in settings with inadequate support (ergonomics). Educators (may) lack the training and/or awareness in addressing posture effectively, focusing on musical instructions over principles of biomechanics [17]. Differences in disciplines (e.g., anatomy, ergonomics) necessitate tailored approaches in correcting the posture, making it challenging to devise universal interventions [1]. Despite the challenges, the imperative in promoting the posture (correct) and preventing the playing-related musculoskeletal disorders compels the educators (researchers) to explore the innovative interventions tailored to needs of music students [4, 5, 18, 19, 20].

Interventions aimed at improving posture in music students; in particular, enrolled in higher education, represent important areas of research (science) in music education; however, research in Slovakia about this topic is not as advanced as it is in other countries [21]. Because many gaps remain in literature, in terms of Slovak scale (the best of authors' knowledge), the present study was aimed at evaluating the transformative effects (impact) of 8-week intervention program on posture in music students.

Materials and Methods

Participants

Regarding the study aim (see Introduction), 25 music students (M = male) participated in: (i) Experimental group (60%, n = 15) (24.20 years, 82.40 kg, 178.60 cm); (ii) Control group (40%, n = 10) (24.60 years, 78.40 kg, 182.20 cm), attending the master's degree (2nd year) in Performing Arts (Faculty of Performing Arts, Academy of Arts in Banská Bystrica, Slovakia) (Table 1). 25 music students consisted of convenience sample, recruited by institutional emails (Control group; 40%, n = 10) and elective subjects - "Musculoskeletal System - Prevention 1 - 4" and aimed at selective sampling; regarding age, gender, and year of study. String instruments were the most played by music students (Table 2).

Evaluating the impact (transofrmative effects) of 8-week intervention program on pusture in music students was carried out in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. All subjects provided written informed consent [22].

Table 1. Antropometric data of music students (100%, n = 25)

Anthropometric Data	Experimental group (60%, n = 15)	Control group (40%, n = 10)
Age (years)	24.20	24.60
Body weight (kg)	82.40	78.40
Body height (cm)	178.60	182.20

Table 2. Instruments played by music students (100%, n = 25)

Types of Instruments	Experimental group (60%, n = 15)	Control group (40%, n = 10)
Wind	3	2
String	7	5
Keyboard	5	3

Research Design

Evaluating the impact (transformative effects) of 8-week intervention program on posture in music students was carried out 8 weeks (September, 18 - November, 12), 2x (Mon, Thu)/ week/ 45 minutes, aiming at music students (100%, n = 25), utilizing the true experimental design (experimental vs. control group). Random assignment (week 1) was carried out because of allocating 25 music students into 2 groups: (i) Experimental group (60%, n = 15); (ii) Control group (40%, n = 10).

15 music students (60%) of experimental group underwent 8-week intervention program [1] under the guidance of lecturer - M. Marko; who informed the experimental group (60%, n = 15) of principles of 8-week intervention program. 8-week intervention program was chosen because of supporting the musculature (muscular system) of spine, neck, abdomen, and shoulders [4], allowing the experimental group (60%, n = 15) to exercise (low-load; early stage), advancing to patterns of resistance [5]. 8-week intervention program consisted of 5-minute warm-up, 35-minute intervention, itself (3 sets of 12 reps and/ or 3 sets of 6 reps - 1 min), and 5-minute cool down. 15 music students (60%) of experimental group documented the progress of 8-week intervention program, recording details; in particular, number of sets/ reps and possible problems. Experimental group (60%, n = 15) informed the lecturer in case of musculoskeletal discomfort and/ or pain and he (lecturer), in turn, monitored the signs of

fatigue; in particular, shaking, loss of control [6]. Social (group) setting as method of delivery was choosen because of its cost effectiveness. 8-week intervention program (transformative effects) was aimed at alterations in neuromuscular patterns and improvements in strength, in consequence of physiological adaptations.

Standardized measure (Klein and Thomas/ Mayer) [23] to evaluate the posture (static) was carried out; in particular pre- (September, 18 - Week 1) and post-test (November, 12 - Week 8). Standardized measure evaluates (visual) 5 segments of body: (i) Head and neck; (ii) Shape of chest; (iii) Abdomen and pelvis; (iiii) Curvature of spine; (iiiii) Shoulders and scapulas. Numerical values (1 - 4) detone the positions of segments, concerning the quality (their), while posture is indicated by postural scores (scale): (i) Correct posture, 5 points; (ii) Good posture, 6 - 10 points; (iii) Bad posture, 11 - 15 points; (iiii) Incorrect posture, 16 - 20 points [24].

Statistical Analysis

Evaluating the impact (transformative effects) of 8-week intervention program on posture in music students was by Wilcoxon Rank-Sum Test (2 independent samples, non-parametric), Wilcoxon Signed-Rank Test (2 dependent samples, non-parametric), Pearson's r, and descriptive statistics (Ibm Spss Modeler). Significant differences ($p < 0.05$, < 0.01) between 2 independent samples (experimental vs. control group) were evaluated by Wilcoxon Rank-Sum Test, of which the significance level (α) was 0.01 and 0.05. Significant differences ($p < 0.05$, < 0.01) between 2 dependent samples (Week 1, Week 8) were evaluated by Wilcoxon Signed-Rank Test, of which the significance level (α) was 0.01 and 0.05 [25]. Measuring of linear correlation between 2 sets of data (variable) was evaluated by Pearson's r [26]. Descriptive statistics (arithmetic mean, percentage) described the features (basic) of 25 music students.

Results

Table 3 illustrates the differences ($p < 0.05$, < 0.01) in posture between 2 independent samples (experimental vs. control group). Average values (1 - 4) in terms of quality of posture (static) of experimental group (60%, n = 15) was as follows: (i) Pre- (Week 1)/ Post- (Week 8) - (i-i) Head and neck - 2.20/ 1.40; (i-ii) Shape of chest - 1.60/ 1.30; (i-iii) Abdomen and pelvis - 2.20/ 1.20; (i-iiii) Curvature of spine - 2.20/ 1.20; (i-iiiii) Shoulders and scapulas - 1.80/ 1.20. Average values in terms of quality of posture of control group (40%, n = 10) was as follows: (ii) Pre- (Week 1)/ Post- (Week 8) - (ii-i) Head and neck - 2.80/ 2.80; (ii-ii) Shape of chest - 1.80/ 1.80; (ii-iii) Abdomen and pelvis - 2.80/ 2.80; (ii-iiii) Curvature of spine - 2.20/ 2.20; (ii-iiiii) Shoulders and scapulas - 2.20/ 2.20.

Regarding the results of repeated measure analysis (after 8 weeks) of changes in quality of posture in experimental group (60%, n = 15), significant changes ($p < 0.05$, < 0.01) occurred in all (5) segments. Significant decrease ($p < 0.01$) in measured values was at week 8 (post-test) compared to baseline (pre-, week 1) in experimental group (60 %, n = 15), as confirmed by post hoc analysis. Decrease was at 3.60 in postural score (index) after the intervention of 8-week program, as demonstrated by Z-score of 3.42 ($p < 0.01$, $r = 0.62$) (Table 3).

Table 3. Differences ($p < 0.05$, < 0.01) in posture between 2 independent samples

Experimental group			
Parameters	**Pre-; Week 1**	**Post-; Week 8**	**Wilcoxon S-R Test**
Head and neck	2.20	1.40	$Z = 3.36$, $p < 0.01$, $r = 0.62^{**}$
Shape of chest	1.60	1.30	$Z = 2.24$, $p < 0.05$, $r = 0.40^{*}$
Abdomen and pelvis	2.20	1.20	$Z = 3.06$, $p < 0.01$, $r = 0.56^{**}$
Curvature of spine	2.20	1.20	$Z = 3.42$, $p < 0.01$, $r = 0.64^{**}$
Shoulders and scapulas	1.80	1.20	$Z = 2.82$, $p < 0.01$, $r = 0.52^{**}$
Postural score (index)	9.80	6.20	$Z = 3.42$, $p < 0.01$, $r = 0.62^{**}$
Control group			
Parameters	**Pre-; Week 1**	**Post-; Week 8**	**Wilcoxon S-R Test**
Head and neck	2.80	2.80	n/a
Shape of chest	1.80	1.80	n/a
Abdomen and pelvis	2.80	2.80	n/a
Curvature of spine	2.20	2.20	n/a
Shoulders and scapulas	2.20	2.20	n/a
Postural score (index)	12.60	12.60	n/a

* - Significance (α) = 0.05; ** - Significance (α) = 0.01; n/a - Not available.

Table 4. Differences ($p < 0.05, < 0.01$) in posture between 2 dependent samples

Pre-; Week 1			
Parameters	**Experimental group**	**Control group**	**Wilcoxon R-S Test**
Head and neck	2.20	2.80	Z = -1.86, p > 0.05, r = -0.36
Shape of chest	1.60	1.80	Z = -0.28, p > 0.05, r = -0.04
Abdomen and pelvis	2.20	2.80	Z = -1.82, p > 0.05, r = -0.38
Curvature of spine	2.20	2.20	Z = -0.14, p > 0.05, r = -0.02
Shoulders and scapulas	1.80	2.20	Z = -1.80, p > 0.05, r = -0.34
Postural score (index)	9.80	12.60	Z = -1.84, p > 0.05, r = -0.38
Post-; Week 8			
Parameters	**Experimental group**	**Control group**	**Wilcoxon R-S Test**
Head and neck	1.40	2.80	Z = -3.84, p < 0.01, r = -0.86**
Shape of chest	1.30	1.80	Z = -1.42, p > 0.05, r = -0.28
Abdomen and pelvis	1.20	2.80	Z = -4.22, p < 0.01, r = -0.82**
Curvature of spine	1.20	2.20	Z = -3.84, p < 0.01, r = -0.84**
Shoulders and scapulas	1.20	2.20	Z = -3.86, p < 0.01, r = -0.82**
Postural score (index)	6.20	12.60	Z = -3.84, p < 0.01, r = -0.84**

** - Significance (α) = 0.01.

Repeated measure analysis of changes in quality of posture in control group (40%, n = 10) was insignificant ($p > 0.05$) (n/a). There was no significant decrease ($p < 0.05, < 0.01$) in measured values at week 8 (post-test) compared to baseline (pre-, Week 1) in control group (40%, n = 10) as confirmed by post hoc analysis.

Table 4 illustrates the differences ($p < 0.05, < 0.01$) in posture between 2 dependent samples. Measure analysis of changes in quality of posture in pre- (Week 1) test of experimental (60%, n = 15) and control (40%, n = 10) group was insignificant ($p > 0.05$) (5 segments). There was insignificance ($p > 0.05$) in measured analysis at week 1 (pre-) as comparing the experimental (60%, n = 15) and control (40%, n = 10) group (post hoc analysis). Difference of 2.80 in favor of experimental group (60%, n = 15) in postural score (index) between 2 dependent samples before the intervention of 8-week program was insignificant ($Z = -1.84$, $p > 0.05$, $r = -0.38$) (Table 4).

Regarding the repeated measure analysis (after 8 weeks) of changes in quality of posture at week 8 (post-) between 2 dependent samples, significant changes ($p < 0.01$) occurred; in particular: (i) Head and neck ($Z = -3.84$, $p < 0.01$, $r = -0.86$); (ii) Abdomen and pelvis ($Z = -4.22$, $p < 0.01$, $r = -0.82$); (iii) Curvature of spine ($Z = -3.84$, $p < 0.01$, $r = -0.84$); (iiii) Shoulders and scapulas ($Z = -3.86$, $p < 0.01$, $r = -0.82$). Difference of 6.40 in favor of experimental group (60%, n = 15) in postural score (index) between 2 dependent samples after the intervention of 8-week pro-gram was significant ($Z = -3.84$, $p < 0.01$, $r = -0.84$).

Discussion

Regarding the impact (transformative effects) of 8-week intervention program on posture in music students (100%, n = 25), the incidence rate of research (available) is low [27]; and because many gaps remain in literature, in terms of Slovak scale [21] (the best of authors' knowledge), the present study was aimed at evaluating the transformative effects of 8-week intervention program on posture in music students.

Research carried out by authors [13-15] underlines the prevalence of playing-related musculoskeletal disorders in music students and harmful effects of incorrect posture (see Introduction). ± 84% of music students surveyed the playing-related musculoskeletal disorders, with the spine, neck, and arms emerging as the most affected areas [28].

Recognizing the challenges, authors pay attention (more) to interventions (target) aimed at improving the posture in music students [4-6, 18-20]. Repeated measure analysis (after 8 weeks) of changes in quality of posture at week 8 (post-) between 2 dependent samples was significant ($p < 0.01$); in particular, difference of 6.40 in postural score (index) was significant ($Z = -3.84$, $p < 0.01$, $r = -0.84$) and in favor of experimental group (60%, n = 15). Similar study [29] involved 10 participants (n = 10); clarinetists experiencing the playing-related musculoskeletal disorders during the intense practice over an instrument. 6-week (3x/ week) intervention program consisted of autonomous exercises aimed at enhancing the mobility of joints, strengthening the posture; in particular, focusing on scapular region and limbs (upper). Standardized

measures consisted of posture (evaluation) and subjective pain perception. Measure analysis of 10 clarinetists (n = 10) discovered the significant changes ($p < 0.05$, < 0.01) in perceived pain levels ($p < 0.01$) and alternations in spine ($p < 0.01$). Another study [4] consisted of 85 musicians (professional, n = 85), divided into: (i) Experimental group (n = 30); (ii) Control group (n = 25). Intervetions lasted 9 - 12 weeks with 16 sessions of 35 minutes, focusing on exercises aimed at specific muscle groups. Musicians (100%, n = 55) perceived instructions (detailed) and documentation of exercises. Results (after 12 weeks) showed the significant changes ($p < 0.05$, < 0.01) of playing-related musculoskeletal disorders; however, effects were not sustained after 6 months.

Educational institutions (music schools, higher education) are in charge of teaching music students; in particular, professional subjects; however, how to take care of musculoskeletal health (posture, in our case) is absent [21, 30]; therefore, education institutions must take measures (active) in addressing the absence in education [1]. Addressing the absence, education institutions may incorporate the education of musculoskeletal health into curriculum. By educating (instrument-specific ergonomics, autonomous exercises), it may address the demands placed on music students [31]. Music students who receive tailored assessments and/or guidance by health professionals improve awareness of posture [9, 32]. Integration of musculoskeletal health education into curriculum is not just important, but necessary too.

Using evidence (available) of interventions in cooperation with medical experience and current best practice [33], 8-week intervention program was effective at improving posture in experimental group (60%, n = 15). According to results of 8-week intervention program (see Results), we may recommend it for practical use of static load in music students; however, it must be kept in mind that types of instruments are important in terms of designing of interventions because demands are not always equal [29].

Conclusions

Transformative effects of 8-week intervention program on posture in music students (100%, n = 25; M) emphasize the important role of interventions (target) in terms of promoting the musculoskeletal health. Effectiveness of 8-week intervention program in promoting the posture (correct) suggests that interventions may result in significant benefits ($p < 0.05$, < 0.01) in musculoskeletal health. 8-week intervention program incorporates the combinations of target exercises, ergonomic alterations, and educational aspects aimed at enhancing the posture awareness. Such interventions are important because of minimizing the danger of musculoskeletal disorders (MSDs) and optimizing the performance and well-being in music students.

Significant differences ($p < 0.05$, < 0.01) underscore the importance of prevention (early) and active measures in addressing the musculoskeletal issues in music students (100%, n = 25). Given the demanding nature of practice over an instrument, music students are susceptible (particularly) to developing the playing-related musculoskeletal problems (PRMDs). Implementing of 8-week intervention program (early) in music students' practice may help in terms of preventing the musculoskeletal issues; however, additional research is necessary in terms of investigating the lasting resilience (sustainability) of advantages and enhancing the intervention plan in music education.

The research was carried out as preliminary research within the grant project VEGA 1/0512/24 "Epidemiology of Musculoskeletal Disorders among Students of Performing Arts."

Acknowledgement

The authors thank 25 music students (M) who agreed (voluntarily) to participate in our study, which received no specific grant from any funding agency in the public, commercial, and/or not-for-profit sectors.

Conflict of interest

The authors declare no conflict of interest.

References

1. Marko M, Adamčák Š, Azor S, Bartík P. 6-week intervention program and posture changes in music students. *European Journal of Contemporary Education*. 2023;12(4):1365–1373. https://doi.org/10.13187/ejced.2023.4 .1365
2. Cruder C, Falla D, Mangili F, Azzimonti L, Araujo L, Williamon A, Barbero M. Profiling the location and extent of musicians' pain using digital pain drawings. *Pain Practice*. 2018;18(1):63–66. https://doi.org/10.111 1/papr.12581
3. Kok L, Huisstede B, Voorn V, Schoones J, Nelissen R. Occurrence of musculoskeletal complaints among professional musicians: Systematic review. *International Archives of Occupational and Environmental Health*. 2016;89(3):373–396. https://doi.org/10.1007/s00420-015-1090-6
4. Chan C, Driscoll T, Ackerman B. Effects of musicians' exercise intervention on performance-related musculo-skeletal disorders. *Medical Problems of Performing Artists*. 2014;29(4):180–188. https://doi.org/10.21091/mp pa.2014.4038
5. Chan C, Driscoll T, Ackerman B. Development of specific exercise program for professional orchestral musicians. *Injury Prevention*. 2013;19(4):257–263. https://doi.org/10.1136/injuryprev-2012-040608
6. Kim D, Cho M, Park Y, Yang I. Effects of exercise program for posture correction on musculoskeletal pain. *Journal of Physical Therapy Science*. 2015;27(6):1790–1794. https://doi.org/10.1589/jpts.27.1791
7. Cruder C, Barbero M, Soldini E, Gleeson N. Patterns of pain location in music students: Cluster analysis. *BMC Musculoskeletal Disorders*. 2021;22(1):1–13. https://doi.org/10.1186/s12891-021-04046-6
8. Árnason K, Briem K, Árnason Á. Effects of education and prevention course for university music students on body awareness and attitude toward health and prevention. *Medical Problems of Performing Artists*. 2018;33 (2):131–136. https://doi.org/10.21091/mppa.2018.2021
9. Chan C, Ackermann B. Evidence-informed physical therapy management of performance-related musculo-skeletal disorders in musicians. *Frontiers in Psychology*. 2014;8(5):1–14. https://doi.org/10.3389/fpsyg.2014. 00706
10. Portnoy S, Cohen S, Ratzon N. Correlations between body postures and musculoskeletal pain in guitar players. *Plos One*. 2022;17(1):1–11. https://doi.org/10.1371/journal.pone.0262207
11. Stanhope J, Weinstein P. Should musicians play in pain? *British Journal of Pain*. 2021;15(1):82–90. https://doi .org/10.1177/20494 63720911399
12. Rousseau C, Barton G, Garden P, Baltzopoulos V. Development of injury prevention model of playing-related musculoskeletal disorders in orchestra musicians based on predisposing risk factors. *International Journal of Industrial Ergonomics*. 2021;81(2):1–10. https://doi.org/10.1016/j.ergon.2020.103026
13. Dommerholt J. Performing arts medicine - Instrumentalist musicians, part 2 – Examination. *Journal of Body-work and Movement Therapies*. 2010;14(1):65–72. https://doi.org/10.1016/j.jbmt.2009.02.004
14. Brandfonbrener A. History of playing-related pain in 330 university freshman music students. *Medical Problems of Performing Artists*. 2009;24(1):30–36. https://doi.org/10.21091/mppa.2009.1007
15. Spahn C, Voltmer E, Mornell A, Nusseck M. Health status and preventive health behavior of music students during university education. *Music and Science*. 2017;21(2):213–219. https://doi.org/10.1177/102986491769 8197
16. Blanco-Piñeiro P, Diáz-Pereira P, Martínez A. Common postural defects among music students. *Journal of Bodywork and Movement Therapies*. 2015;19(3):565–572. https://doi.org/10.1016/j.jbmt.2015.04.005
17. Rickert L, Barrett S, Ackermann B. Injury, and orchestral environment: Part 2. Organisational culture, behavioral norms, and attitudes to injury. *Medical Problems of Performing Artists*. 2015;29(2):94–100. https://doi. org/10.21091/mppa.2014.2020
18. Baadjou V, Ackermann B, Verbunt J, Eijsden-Besseling M, Bie R, Smeers R. Implementation of health education interventions at Dutch music schools. *Health Promotion International*. 2021;36(2):334–348. https://doi. org/10.1093/heapro/daaa050
19. Davies J. Alexander technique classes improve pain, performance factors in tertiary music students. *Journal of Bodywork and Movement Therapies*. 2020;24(1):1–7. https://doi.org/10.1016/j.jbmt.2019.04.006
20. Akbari-Chehrehbargh Z, Tavafian S. Impact of el-poems study: E-learning for postural education in music students: Randomized controlled trial protocol. *Trials*. 2022;23(1):1–8. https://doi.org/10.1186/s13063-022-0 6335-4
21. Strenáčiková, M. Health problems of professional musicians and music students. *University Review*. 2020;14 (3):27–30.
22. Harriss D, MacSween A, Atkinson G. Ethical standards in sports and exercise science research: 2022 update. *International Journal of Sports Medicine*. 2020;40(13):813–817. https://doi.org/10.1055/a-1015-3123
23. Mandzáková M, Slováková M. Intervention program on quality of children's posture at elementary education level. *Sport Mont*. 2023;21(3):57–63. https://doi.org/10.26773/smj.231009
24. Bendíková E, Marko M, Rozim R, Tomková Š. Effects of changes by physical program on muscular and skeletal systems of secondary school students. *Journal of Physical Education and Sports*. 2020;20(4):1681–1687. https://doi.org/10.7752/jpes.2020.04228
25. Nahm F. Nonparametric statistical tests for continuous data. Basic concept and practical use. *Korean Journal of Anesthesiology*. 2016;69(1):8–14. https://doi.org/10.4097/kjae.2016.69.1.8

26. Schober P, Boer C, Schwarte L. Correlation coefficients: Appropriate use and interpretation. *Anesthesia and Analgesia*. 2018;126(5):1763–1768. https://doi.org/10.1213/ANE.0000000000002864
27. Blanco-Piñeiro P, Diáz-Pereira P, Martínez A. Musicians, postural quality, and musculoskeletal health: Literature's Review. *Journal of Bodywork and Movement Therapies*. 2016;21(1):157–172. https://doi.org/10.1016/ j.jbmt.2016.06.018
28. Ackermann B, Driscoll T, Kenny D. Musculoskeletal pain and injury in professional orchestral musicians in Australia. *Medical Problems of Performing Artists*. 2012;27(4):171–187. https://doi.org/10.21091/mppa.2012 .4034
29. Gallego-Cerveró C, Ros C, Sanchis L, Martin J. Physical training for musicians: Systematic review. *Sportis Scientific Journal of School Sport Physical Education*. 2019;5(5):532–561. https://doi.org/10.17979/sportis.20 19.5.3.5536
30. Barton R, Feinberg J. Effectiveness of an educational program in health promotion and injury prevention for freshman music majors. *Medical Problems of Performing Artists*. 2008;23(2):47–53. https://doi.org/10.21091/ mppa.2008.2010
31. Lee S, Carey S, Dubey R, Matz R. Intervention program in college instrumental musicians with kinetics analysis of cello and flute playing. *Medical Problems of Performing Artists*. 2012;27(2):85–94. https://doi.org/10.21 091/mppa.2012.2016
32. Andersen N, Mann S, Jull-Kristensen B, Søgaard K. Comparing the impact of specific strength training vs. general fitness training on professional symphony orchestra musicians: Feasibility study. *Medical Problems of Performing Artists*. 2017;32(2):94–100. https://doi.org/10.21091/mppa.2017.2016
33. Kliziene I, Cibulskas G, Ambrase N, Cizauskas G. Effects of 8-month exercise program on physical activity and physical fitness for first grade students. *European Journal of Contemporary Education*. 2018;7(4):717–727. https://doi.org/10.13187/ejced.2018.4.717

Information about the authors:

Stanislav Azor; https://orcid.org/0009-0001-6586-1958; stanislav.azor@tuzvo.sk; Institute of Physical Education and Sports, Technical University in Zvolen; Slovakia.

Michal Marko; (Corresponding author); https://orcid.org/0000-0003-0054-0667; michal.marko@aku.sk; Faculty of Performing Arts, Academy of Arts in Banská Bystrica; Slovakia.

Štefan Adamčák; https://orcid.org/0000-0002-8002-6010; stefan.adamcak@umb.sk; Faculty of Physical Education, Sport and Health, Matej Bel University in Banská Bystrica; Slovakia.

Pavol Bartik; https://orcid.org/0000-0002-2087-7876; pavol.bartik@umb.sk; Faculty of Physical Education, Sport and Health, Matej Bel University in Banská Bystrica; Slovakia.

Cite this article as:
Azor S, Marko M, Adamčák Š, Bartík P. Harmonizing musculoskeletal health: transformative effects of 8-week intervention program on posture in music students. *Physical Education of Students,* 2024;28(2):78–84. https://doi.org/10.15561/20755279.2024.0204

Received: 16.02.2024

Accepted: 21.03.2024; **Published**: 30.04.2024

ORIGINAL ARTICLE

The perception on physical activity among students

Florin Valentin Leuciuc[ABCDE], Gheorghe Pricop[ABCD]

Faculty of Physical Education and Sport, Ștefan cel Mare University of Suceava, Romania

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim: Questionnaires are useful tools for assessing the level of physical activity in the general population due to their brevity, ease of understanding, and ease of application. The aim of our study is to subjectively assess the physical activity of participants using the self-report scale of the Godin–Shepard Leisure-Time Physical Activity Questionnaire.

Material and Methods: The study involved 299 undergraduate and graduate students from Stefan cel Mare University of Suceava (Romania). In their academic activities, they typically engage in between 4 and 6 hours of practice. Additionally, many respondents participate in various physical activities, totalling another 4 to 8 hours of physical activity per week. The questionnaire consists of three questions regarding the level of physical activity (intense, moderate, low). It aims to collect data for the past 7 days for each physical activity lasting at least 15 minutes.

Results: The intergroup analysis of the data showed statistical significance in the Wilcoxon rank-sum test for three out of six analyzed situations: graduate males versus graduate females, undergraduate males versus undergraduate females, and graduate males versus undergraduate males ($p < 0.001$). In the study, data concerning the level of physical activity among students were collected. Data analysis showed that over 80% (240 out of 299) of the respondents are moderately active or active. Statistically significant differences were observed only by study level and gender. While there was a notable difference of 10 points between males and females, it did not reach statistical significance.

Conclusions: We can conclude that physical activity is an important aspect of students' daily routines. However, awareness programs are necessary to encourage them to remain physically active. These programs also promote the benefits of physical activity for physical, mental, and social well-being, as well as overall quality of life.

Keywords: physical activity, questionnaire, students, assessment

Introduction

Questionnaires are valuable tools for assessing the level of physical activity in the general population. Other benefits of using questionnaires include their brevity, ease of understanding, and application, facilitated by technology. They also allow for fast analysis of results and enable appropriate actions based on the findings [1, 2]. In the field of physical education, various questionnaires are utilized, such as the International Physical Activity Questionnaire, Baecke Questionnaire, Physical Activity Index, Global Physical Activities Questionnaire, and Godin–Shepard Leisure-Time Physical Activity Questionnaire.

For good health and quality of life, the recommendation is to engage in various types of physical activities for at least 150 minutes per week with moderate and vigorous intensity [3, 4]. In recent years, many studies have revealed a low level of physical activity among youth and children, with more than half of the subjects recording insufficient physical activity [5, 6, 7, 8, 9]. Additionally, two meta-studies (involving over 3 million participants) present a concerning situation regarding adolescents and youths, with over 80% of respondents being insufficiently physically active [10, 11].

Previous studies have shown that the Godin–Shepard Leisure-Time Physical Activity Questionnaire is a valid tool for assessing the level of physical activity in the general population [12, 13, 14, 15]. The use of this questionnaire has revealed that physical activity is correlated with study level, profession (individuals with higher education and office jobs tend to have more physical activity during leisure-time), and gender (males being more active than females) [16].

A study conducted on Finnish adults showed that vigorously active individuals had better physical and health functioning compared to inactive and moderately active individuals, with those in the vigorously active category experiencing greater benefits and a higher quality of life [17]. Another study conducted on a Scandinavian population revealed that regular physical activity during leisure time improves bone mineral density and reduces the risk of osteoporosis [18]. The Godin–Shepard Leisure-Time Physical Activity Questionnaire is a useful tool for measuring changes in physical activity in response to an intervention, treatment, or medication for health issues [19, 20, 21, 22].

doi:10.15561/20755279.2024.0205

Questionnaires are considered reliable and valid tools for assessing the level of physical activity. Previous studies have shown a low level of physical activity among youths, but there is a lack of information concerning Romanian youth. The aim of our study is to subjectively assess the physical activity of participants using a self-report scale, specifically the Godin–Shepard Leisure-Time Physical Activity Questionnaire.

Materials and Methods

Participants

The study involved 299 undergraduate and graduate students from the Faculty of Physical Education and Sport at Stefan cel Mare University of Suceava (Romania): undergraduate males - 110, undergraduate females - 80; graduate males - 49, and graduate females - 60. In their academic activities, they typically engage in between 4 and 6 hours of practice. Additionally, many respondents participate in various physical activities, resulting in an additional 4 to 8 hours of physical activity per week.

Research Design

The questionnaire comprises 3 questions concerning the level of physical activity (intense, moderate, low) to collect data for the last 7 days, for each physical activity that lasts for at least 15 minutes. In the analysis of the results, each strenuous activity will be multiplied by 9, each moderate activity by 5, and each mild/light activity by 3. This questionnaire could be applied to healthy individuals as well as those with health issues. According to the author of this questionnaire [23], a healthy person is considered active if they accumulate 24 or more points or units within one week. Between 14 and 23 units is considered moderately active, and less than 14 is considered insufficiently active or sedentary. For students in the field of Sport Science, a different benchmark was established: a person will be considered active if they accumulate 48 or more points/units within one week; between 28 and 47 points/units is considered moderately active, and less than 28 is considered insufficiently active or sedentary. This is twice as high as compared to the general population.

Statistical Analysis

The study utilized descriptive statistics (mean, standard deviation) and the Wilcoxon rank-sum test (statistical significance set at $p < 0.05$) for each analyzed category (gender; study level; gender and study level). Statistical analysis was conducted using the IBM SPSS Statistics program (version 26).

Results

The intergroup analysis of the data (male–female, graduate–undergraduate, graduate male–graduate female, undergraduate male–undergraduate female, graduate male–undergraduate male, graduate female–undergraduate female) showed statistical significance at the Wilcoxon rank-sum test for three out of six analyzed situations (Table 1).

All analyzed groups in the study demonstrated a very good level of physical activity, with participants being classified as active individuals. Males achieved the highest average values, with scores exceeding 50 points, which were 10 points higher than those of females. However, at the individual level, the situation varied within each category. Among undergraduate males (110), 18 respondents were classified as sedentary, 32 as moderately active, and 60 as active. For undergraduate females (80), 13 respondents were sedentary, 33 were moderately

Table 1. Statistical significance at intergroup analysis

Statistical Parameters/Groups	X ± SD	Z	Asymptotic significance
Graduate male vs.	54.65±34.60	6.096	0.001*
Graduate female	39.47±27.78		
Ungraduate male vs.	51.99±26.72	6.346	0.001*
Ungraduate female	43.91±25.17		
Graduate male vs.	54.65±34.60	6.032	0.001*
Ungraduate male	51.99±26.72		
Graduate female vs.	39.47±27.78	0.356	0.722
Ungraduate female	43.91±25.17		
Graduate vs.	46.39±28.62	1.934	0.053
Ungraduate	48.59±23.40		
Male vs.	52.81±26.56	1.495	0.135
Female	42.08±22.81		

X = mean, SD = standard deviation, Z = standardized test statistic value from the Wilcoxon test,

* significance level 0.05.

active, and 33 were active. Among graduate males (49), 8 respondents were sedentary, 18 were moderately active, and 23 were active. For graduate females (80), 19 respondents were sedentary, 26 were moderately active, and 15 were active.

Statistical significance was observed in three out of six analyzed situations (graduate male vs. graduate female; undergraduate male vs. undergraduate female; graduate male vs. undergraduate male).

Discussion

The aim of our study was to subjectively assess the physical activity of participants using a self-report scale, specifically the Godin–Shepard Leisure-Time Physical Activity Questionnaire. Previous research has shown that the level of education influences adherence to regular physical activity [24], which is consistent with our findings where over 80% of respondents were classified as moderately active or active. Questionnaires are generally accepted to have moderate reliability and validity, making them accessible tools for quickly assessing the level of physical activity within a population, whether administered in written or online format [25]. In our research, we utilized a translated version of the Godin–Shepard Leisure-Time Physical Activity Questionnaire, which was deemed more appropriate for our participants, with response times similar to those reported in other studies [26].

A follow-up study revealed that individuals who graduated from a higher vocational school or university maintained their level of physical activity compared to those with lower levels of education, among whom a decrease in physical activity was observed alongside perceived changes in health status [27]. This finding is particularly relevant to our study, as it raises the question of whether, during a follow-up assessment, the same subjects will maintain or improve their level of physical activity when the questionnaire is administered again.

Leisure-time physical activity has benefits for life quality, health status, and life expectancy, with many of our respondents being active individuals experiencing multiple physical and psychological benefits due to regular physical exercise [28]. Education, occupation, and income are factors that influence perceptions of physical activity in leisure time, and over generations/years, these factors have remained constant in assessing the level of physical activity in the general population [29]. The Godin Leisure-Time Exercise Questionnaire is affordable and easy to apply to adolescents and youth, yielding reliable data for determining the level of physical activity [30, 31] and for developing intervention programs in specific situations based on the analyzed data. These findings are particularly relevant to our study, as they provide context and support for our own research into the subjective assessment of physical activity among our participants.

General recommendation is to practice regular physical exercise with moderate to vigorous intensity [32, 33], a vast majority of our respondents fits in this recommendation, meaning physical, psychological and social benefits. For our subjects was noticed a significant difference both by study level and gender in 3 out of 4 situations; also, only by gender, males average scores were better than females with over 20%, but without statistical significance. 240 out of 299 respondents are moderate active or active, the main goal being for the rest of the participants to practice regular physical activity for at least 150 minutes with moderate to vigorous intensity per week and muscle-strengthening activities at least 2 days per week [3].

The use of questionnaires to determine the level of physical activity had some limitations, primarily due to the subjective nature of respondents' self-reports. Additionally, all respondents were students in the field of Sport Science, which may limit the generalizability of the results. Our study included 299 participants from one university, serving as a benchmark for further research focused on the level of physical activity among Romanian students and its impact on health-related fitness. Furthermore, it is recommended to increase the number of participants in future studies to establish a more comprehensive understanding of the impact of physical activity on the daily routines of Romanian students.

Conclusions

The main challenge when using questionnaires to collect data on physical activity is to minimize subjectivity to obtain accurate information and facilitate appropriate data analysis. Our findings underscore the importance of physical activity in students' daily lives. Awareness programs are necessary to encourage them to remain physically active and promote the numerous benefits of physical activity, including physical, mental, and social well-being, and overall quality of life. Future studies should consider incorporating specific physical fitness tests alongside questionnaires to enhance objectivity in evaluation and establish a benchmark for this demographic of the Romanian population.

Funding

The APC was funded by Ștefan cel Mare University of Suceava.

Conflict of interest

The authors declare that there is no conflict of interest in writing this article.

References

1. Karolinska Institute. *International Physical Activity Questionnaire. Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (IPAQ)—Short and Long Forms*. Stockholm: Sweden; 2005.
2. Leuciuc FV, Ghervan P, Popovici IM, Benedek F, Lazar AG, Pricop G. Social and Educational Sustainability of the Physical Education of Romanian Students and the Impact on Their Physical Activity Level. *Sustainability* 2020; *12:* 9231. https://doi.org/10.3390/su12219231
3. World Health Organization. *WHO guidelines on physical activity and sedentary behavior: at a glance. Geneva* [Internet]. 2020 [updated 2022 Jun; cited 2022 Dec 12]. Available from: https://www.who.int/publications/i/item/9789240015128
4. World Health Organization. *Global status report on physical activity* [Internet]. 2022. Geneva [updated 2022 Jun; cited 2022 Dec 12]. Available from: https://www.who.int/publications/i/item/9789240059153
5. Dyrstad SM, Hansen BH, Holme IM, Anderssen SA. Comparison of self-reported versus accelerometer-measured physical activity. *Medicine & Science in Sports & Exercise*, 2014; 46: 99–106. https://doi.org/10.1249/MSS.0b013e3182a0595f
6. Pedisic Z, Rakovac M, Bennie J, Jurakic D, Bauman AE. Levels and correlates of domain-specific physical activity in university students: Cross-sectional findings from Croatia. *Kinesiology,* 2014; 46: 12–22.
7. Raddi LLD, da Silva JP, Ferrari GLD, de Oliveira LC, Matsudo VKR. Physical activity level and accumulation of sitting time among medical students. *Revista Brasileira de Medicina do Esporte*, 2014; 20: 101–104. https://doi.org/10.1590/1517-86922014200201350
8. Gabrys T, Nowak Z, Michalski C, Szmatlan-Gabrys U, Stanula A. Obesity in 18-25-year-olds in relation to their physical activity, and lifestyle. *Physical Activity Review*, 2018; 6: 64–72, https://doi.org/10.16926/par.2018.06.09
9. Nikolic M, Jovanovic R, Stankovic A. Characteristics of physical activity among healthy Serbian adolescents. *Revista Brasileira de Medicina do Esporte*, 2020; 26: 30–33. https://doi.org/10.1590/1517-869220202601187598
10. Guthold R, Stevens GA, Riley LM, Bull F.C. Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1.9 million participants. *Lancet Global Health*, 2018; 6(10): e1077–e1086. https://doi.org/10.1016/S2214-109X(18)30357-7
11. Guthold R, Stevens GA, Riley LM, Bull FC. Global trends in insufficient physical activity among adolescents: a pooled analysis of 298 population-based surveys with 1.6 million participants. *Lancet Child. Adolescent Health,* 2020; 4(1): 23–35. https://doi.org/10.1016/S2352-4642(19)30323-2
12. Kimm SY, Glynn NW, Kriska AM, Fitzgerald SL, Aaron DJ, Similo SL, McMahon RP, Barton BA. Longitudinal changes in physical activity in a biracial cohort during adolescence. *Medicine and Science in Sports and Exercise*, 2000; 32(8): 1445–1454. https://doi.org/10.1097/00005768-200008000-00013
13. Scerpella TA, Tuladhar P, Kanaley JA. Validation of the Godin-Shephard questionnaire in prepubertal girls. *Medicine and Science in Sports and Exercise*, 2002; 34(5): 845–850. https://doi.org/10.1097/00005768-200205000-00018
14. Amireault S, Godin G. The Godin-Shephard leisure-time physical activity questionnaire: validity evidence supporting its use for classifying healthy adults into active and insufficiently active categories. *Perceptual and Motor Skills*, 2015; 120(2): 604–622. https://doi.org/10.2466/03.27.PMS.120v19x7
15. João TM, Rodrigues RC, Gallani MC, Miura CT, Domingues GB, Amireault S, Godin G. Validity of the Brazilian version of the Godin-Shephard Leisure-Time Physical Activity Questionnaire. *Cadernos de Saude Publica,* 2015; 31(9): 1825–1838. https://doi.org/10.1590/0102-311X00189713
16. Seiluri T, Lahti J, Rahkonen O, Lahelma E, Lallukka T. Changes in occupational class differences in leisure-time physical activity: a follow-up study. *The International Journal of Behavioral Nutrition and Physical Activity*, 2011; 8: 14. https://doi.org/10.1186/1479-5868-8-14
17. Lahti J, Laaksonen M, Lahelma E, Rahkonen O. The impact of physical activity on physical health functioning--a prospective study among middle-aged employees. *Preventive Medicine*, 2010; 50(5-6): 246–250. https://doi.org/10.1016/j.ypmed.2010.02.007
18. Morseth B, Emaus N, Wilsgaard T, Jacobsen BK, Jørgensen L. Leisure time physical activity in adulthood is positively associated with bone mineral density 22 years later. The Tromsø study. *European Journal of Epidemiology*, 2010; 25(5): 325–331. https://doi.org/10.1007/s10654-010-9450-8
19. Amireault S, Godin G, Lacombe J, Sabiston CM. Validation of the Godin-Shephard Leisure-Time Physical Activity Questionnaire classification coding system using accelerometer assessment among breast cancer survivors. *Journal of Cancer Survivorship: Research and Practice*, 2015; 9(3): 532–540. https://doi.org/10.1007/s11764-015-0430-6
20. Amireault S, Godin G, Lacombe J, Sabiston CM. The use of the Godin-Shephard Leisure-Time Physical Activity Questionnaire in oncology research: a systematic review. *BMC Medical Research Methodology*, 2015; 15: 60. https://doi.org/10.1186/s12874-015-0045-7
21. Motl RW, Bollaert RE, Sandroff BM. Validation of the Godin Leisure-Time Exercise Questionnaire classification coding system using accelerometry in multiple sclerosis. *Rehabilitation Psychology*, 2018; 63(1): 77–82. https://doi.org/10.1037/rep0000162
22. Sikes EM, Richardson EV, Cederberg KJ, Sasaki JE, Sandroff BM, Motl RW. Use of the Godin leisure-time exercise questionnaire in multiple sclerosis research: a comprehensive narrative review.

Disability and Rehabilitation, 2019; 41(11): 1243–1267. https://doi.org/10.1080/09638288.2018.1424956
23. Godin G. The Godin-Shephard leisure-time physical activity questionnaire. *Health & Fitness Journal of Canada*, 2011; 4(1): 18–22.
24. Kružliaková N, Estabrooks PA, You W, Hedrick V, Porter K, Kiernan M, Zoellner J. The Relationship Between the Stanford Leisure-Time Activity Categorical Item and the Godin Leisure-Time Exercise Questionnaire Among Rural Intervention Participants of Varying Health Literacy Status. *Journal of Physical Activity & Health*, 2018; 15(4): 269–278. https://doi.org/10.1123/jpah.2017-0284
25. Helmerhorst HJ, Brage S, Warren J, Besson H, Ekelund U. A systematic review of reliability and objective criterion-related validity of physical activity questionnaires. *The International Journal of Behavioral Nutrition and Physical Activity*, 2012; 9: 103. https://doi.org/10.1186/1479-5868-9-103
26. São-João TM, Rodrigues RC, Gallani MC, Miura CT, Domingues GB, Godin G. Cultural adaptation of the Brazilian version of the Godin-Shephard Leisure-Time Physical Activity Questionnaire. *Revista de Saude Publica*, 2013; 47(3): 479–487. https://doi.org/10.1590/s0034-8910.2013047003947
27. Droomers M, Schrijvers CT, Mackenbach JP. Educational level and decreases in leisure time physical activity: predictors from the longitudinal GLOBE study. *Journal of Epidemiology and Community Health*, 2001; 55(8): 562–568. https://doi.org/10.1136/jech.55.8.562
28. Kujala UM, Kaprio J, Sarna S, Koskenvuo M. Relationship of leisure-time physical activity and mortality: the Finnish twin cohort. *JAMA,* 1998; 279(6): 440–444. https://doi.org/10.1001/jama.279.6.440
29. Mäkinen T, Borodulin K, Laatikainen T, Fogelholm M, Prättälä R. Twenty-five year socioeconomic trends in leisure-time and commuting physical activity among employed Finns. *Scandinavian Journal of Medicine & Science in Sports*, 2009; 19(2): 188–197. https://doi.org/10.1111/j.1600-0838.2007.00739.x
30. Koo MM, Rohan TE. Comparison of four habitual physical activity questionnaires in girls aged 7-15 yr. *Medicine and Science in Sports and Exercise*, 1999; 31(3): 421–427. https://doi.org/10.1097/00005768-199903000-00011
31. Eisenmann JC, Milburn NJ, Jacobsen LN, Moore SJ. Reliability and convergent validity of the Godin Leisure-Time Exercise Questionnaire in rural 5th-grade school-children. *Journal of Human Movement Studies,* 2002*; 43*: 135–149.
32. Prochaska JJ, Sallis JF, Long B. A physical activity screening measure for use with adolescents in primary care. *Archives of Pediatrics & Adolescent Medicine*, 2001; 155(5): 554–559. https://doi.org/10.1001/archpedi.155.5.554
33. Pardo A, Roman-Vinas B, Ribas-Barba L, Roure E, Vallbona C, Serra-Majem L. Health-enhancing physical activity and associated factors in a Spanish population. *Journal of Science and Medicine in Sport*, 2014; 17: 188–194, https://doi.org/10.1016/j.jsams.2013.04.002

Information about the authors:

Florin Valentin Leuciuc; (Corresponding author); https://orcid.org/0000-0002-9976-0397; florin.leuciuc@usm.ro; Faculty of Physical Education and Sport, Ștefan cel Mare University of Suceava; Suceava, Romania.

Gheorghe Pricop; https://orcid.org/0000-0003-4821-3374; itayfh@gmail.com; Faculty of Physical Education and Sport, Ștefan cel Mare University of Suceava; Suceava, Romania.

Cite this article as:
Leuciuc FV, Pricop G. The perception on physical activity among students. *Physical Education of Students,* 2024;28(2):85–89.
https://doi.org/10.15561/20755279.2024.0205

Received: 18.02.2024

Accepted: 21.03.2024; **Published**: 30.04.2024

PHYSICAL EDUCATION OF STUDENTS

ORIGINAL ARTICLE

Examining the effects of attention and concentration levels on reaction time in fencing

Ömer Aydın[ABDE], Erman Doğan[CD], Ezgi Sevilmiş[AD], Çiğdem Karagülmez Sağlam[AD]

Faculty of Sport Science, Girne American University, Cyprus

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim: Attention and concentration, fundamental psychological skills, are crucial in situations where the opponent moves rapidly and incessantly. Reaction time is also of paramount importance in winning a game in fencing, which requires both offensive and defensive actions. Understanding the factors that affect reaction time is essential for improving performance. This study aimed to investigate the impact of disruptions in attention and concentration on reaction time in fencing.

Material and Methods: Thirty-four healthy male and female fencers participated in two testing sessions. In the initial session, participants filled out a personal information form and took the d2 Attention Test to determine their attention levels. They also completed items representing the concentration disruption subscale of the Sport Anxiety Scale-2 (SAS-2) to measure concentration levels. In the second session, participants underwent the Favero Electronic Fencing Target (EFT-1) test to measure their reaction times. To analyze the obtained data, SPSS 20 was used. The Pearson correlation coefficient between attention, concentration disruption, and participants' reaction times was calculated. Then, linear regression analysis was employed to test whether attention and concentration scores could predict the reaction times.

Results: The findings indicated that there is a significant positive relationship between E ($r = .603$, $p < .01$), E% ($r = .628$, $p < .01$), E1 ($r = .584$, $p < .01$), E2 ($r = .533$, $p < .01$), and reaction time. Additionally, a significant negative relationship was revealed between concentration performance and reaction times ($r = -.456$, $p < .01$). A significant positive correlation was observed between fencers' concentration disruption and reaction times ($r = .416$, $p < .05$).

Conclusions: Our study results emphasize the importance of attention and concentration in disciplines that require quick reactions. These cognitive factors need to be considered in the development of sports performance.

Keywords: fencing, reaction time, attention, concentration.

Introduction

Fencing is an open-skill sport in which fast body movements, effective game strategies, and cognitive skills are used effectively [1]. In fencing, reaction time plays an important role in developing deceptive strategies against the opponent, attacking as soon as possible, and defending by anticipating the opponent's attack. The response to a visual, auditory, and tactile stimulus of athletes determines their reaction time [2]. Reaction time is one of the key factors in achieving peak performance in fencing, as it is closely related to decision-making and action [3]. Since it is accepted that reaction time directly affects performance in fencing, research has been conducted on various training methods to improve reaction time [4, 5]. Factors such as concentration and attention are known may affect reaction time.

Concentration, a basic psychological skill, is crucial to maintaining mental toughness, especially in situations where the rival moves quickly and continuously. According to Moran, concentration is defined as the mental effort one is willing to spend on the most important thing in any subject [6]. An athlete with a high level of concentration tries to compete in the best possible way to reach the goal, learns new skills faster and in a shorter time, increases self-confidence, keeps stress and anxiety under control at high levels of experience, and focuses on factors that are within the control [7]. Therefore, the high concentration levels of athletes before and during the competition may have a positive effect on their performance. The study by Mahardhika et al. [8] investigated the effect of concentration on football-playing skills and showed that there is a significant relationship between concentration and football performance. Donie et al. [9] examined the effect of concentration, eye coordination, and agility on badminton playing skills and showed that the badminton playing skills of athletes with high concentration were affected positively.

Attention is one of the most researched topics in the field of sports as it covers almost all aspects of perception, cognition, and action [10]. Attention is related to the process by which certain relevant information is processed while other information

doi:10.15561/20755279.2024.0206

is ignored [11]. High attention levels are required of athletes so that responses to stimuli can be provided efficiently. Athletes need to pay attention to resources under control while aiming to improve their performance effectively [12]. The studies point out the importance of attentional resources for succeeding in sports [13, 14, 15]. Hijazi [16] investigated the relationship between attention, visual perception, and sports performance in fencing and found that there is a significant relationship between high attention levels and the sports performance of fencers. The effect of attention on sports performance in football was investigated by Fetean et al. [17] and it was found that the attention-test program increased the performance of football players. A study conducted by Gutierrez-Davila et al. [18] on the effect of attention on offensive and defensive actions in fencing showed that attention processes play an important role in fencer performance in real competitions and positively affect success.

In light of this information, the present study aimed to investigate the relationship between attention, concentration, and reaction time of fencers. It was hypothesised that attention levels have a positive effect on reaction times in fencers. It was also expected that there is a significant positive relationship between concentration and reaction times.

Materials and Methods

Participants

34 healthy male and female fencers met the inclusion criteria and were selected for this study. The inclusion criteria were as follows (tabl. 1): (a) aged 18–25 years; (b) free of any acute or chronic neuromuscular diseases; (c) not having visual impairment; (d) not being a smoker and/or an alcohol user; (e) not using drugs; (f) body mass index (BMI) less than 30. The experimental procedures, including possible risks, were verbally explained to the participants after which they signed informed consent. Following the approval by the Committee for Scientific Research and Ethics of the Faculty of Sport Sciences at the Girne American University with 2022-2023/01 reference number, the research commenced and all data was collected by the Declaration of Helsinki.

Research Design

The test protocol consisted of two sessions (Figure 1). In the first test session, the personal information form, d2 attention test, and items representing the concentration disruption subscale of the Sport Anxiety Scale-2 (SAS-2) were applied for the psychometric evaluations. In the second test session which is 24 hours after the first test session, the warming up (running 12 minutes, dynamic stretching exercises, and standardized specific warm-up exercises for fencing) and the Favero Electronic Fencing Target (EFT-1) test to measure reaction time were performed.

Personal Information Form

To determine the characteristics of the participants, a form prepared by the researchers containing information on age, training experience year, weight, height, and gender was applied.

D2 Attention Test

The d2 attention test, developed by Brickenkamp and Rump in 1962 [19] and revised over the years was used [20]. The purpose of this test is to evaluate the continuous attention and visual screening ability of participants [21]. In this test, which is used to determine the structure of attention and concentration, participants are asked to constantly focus on selecting a stimulus [20]. The first page of the test contains an application line and a section where performance results are recorded. On the next page, there is a standardized test. The test page consists of 14 lines and each of these lines contains

Table 1. Descriptive statistics of the participants

Characteristics	Mean	SD	Min	Max
Age (year)	19.94	2.424	18	25
Fencing Experience (year)	7.35	2.984	3	17

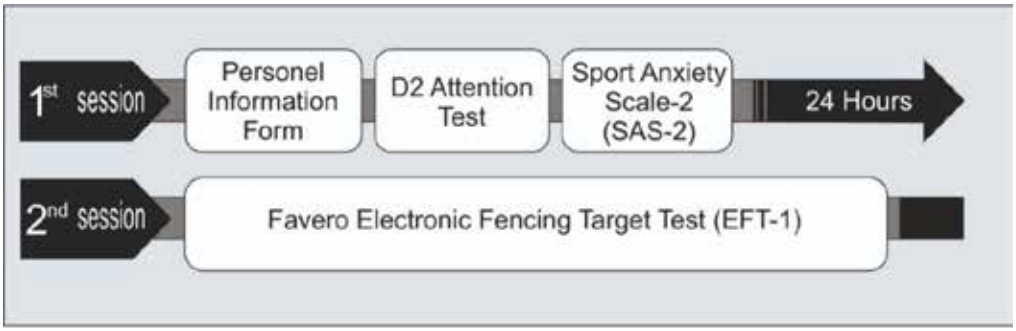


Figure 1. Schematic representation of the experimental setup

47 marked letters. There are a total of 16 different letters in each line, including the letters "p" and "d" and the one two three, and four signs above/below these letters. In the test participants must scan the lines and mark the letter the two-dotted "d" letters by ignoring non-relevant letters. Participants are given 20 seconds for each line. This test may applied individually or as a group. This test may applied individually or as a group [20, 21]. In our research, participants were gathered in the meeting room and the d2 test was applied as a group at a time.

Total Number of Items Processed (TN): The quantitative performance measurement for all processed items that are related and non-related.

Total Error (E): Indicates errors unmarked (E1) and mismarked letters (E2).

Error% (% E): It is a variable measures that the qualitative value of performance. Refers to the error rate across all items processed. The accuracy of the subject, the nature of the work, and the increase in the degree of attention depend on the decrease in the error rate.

Error 1 (E1): The number of mistakes due to omission.

Error 2 (E2): Errors of commission.

Total Norm-Error (TN-E): It is the score obtained by subtracting errors from the total number of items scanned. TN-E is a total performance score. TN–E shows normal distribution, it has a high level of reliability and provides a measure of the relationship between performance's accuracy and speed. In addition, TN–E focuses more on the quantitative part of performance and gives less importance to the qualitative part. In exceptional cases, if the quantitative and qualitative scores are (total score and error percentage) extremely high, TN–E, tends to indicate total performance more. Overestimations can be avoided by taking error scores or examining the concentration performance score.

Concentration Performance (CP): It is obtained by taking away E2 from the number of relevant items marked as true. Unlike TN-E, CP is not affected by marking all letters or skipping random test sections. This index is excellent for the accuracy of performance and coordination of speed.

Fluctuation Rate (FR): It indicates the difference between the line including the maximum number of items and the line including the minimum number of items. FR is one of the less reliable measurements of the test. Excessively high FR scores may create inconsistency in the speed of work and may be associated with low motivation [22].

Sport Anxiety Scale-2

The Sport Anxiety Scale-2 (SAS-2) was developed by Smith et al. [23] and was also revised by Smith et al. [24]. This scale has 3 subscales (somatic anxiety, worry, and concentration disruption) and consists of 15 items, 5 items each. This study used only the concentration disruption subscale of the SAS-2. Participants are asked to mark the number closest to them (1-not at all, 2-a little bit, 3-pretty much, 4 very much) to indicate how they felt before/during competitions and games. At the beginning of the study, the participants were asked about doubts about understanding the statements. The implementation of this questionnaire was carried out by the relevant rules and regulations.

Favero Electronic Fencing Target Test (EFT-1)

An electronic fencing target (Favero EFT-1) manufactured by Favero Electronic was used. There are five targets on the device, each equipped with an LED light. Two of the targets located at the bottom of the device are 90 cm above the ground, the other two are 130 cm above the ground, and the distance is 30 cm between these four targets. The fifth target is located in the middle of the device, at the point where the diagonals intersect.

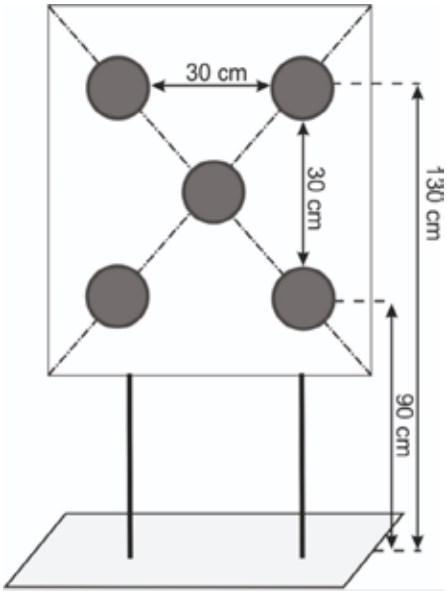


Figure 2. Electronic fencing target (Favero EFT-1) device.

The device has nine different programs however, this study was conducted using programme 1. All programs consist of 10 pokes and the minimum duration of these pokes is 0.01 seconds and the maximum duration is 1.30 seconds. If a target was missed or a poke sequence was not performed correctly, the poke is assumed to have been completed at maximum time and is considered 1.30 seconds. In addition, the fencers were not allowed to repeat the pokes they missed in the tests. Therefore, a clear determination of the speed and accuracy of the pokes made has been provided. In this program, the fencers were asked to poke randomly appearing red lights with the tip of the foil using their dominant hand. The turning red light to green at the end of the poking indicates the accuracy of the poke. During this test, the digital screen on the top of the device showed and recorded the duration of the poke. At the end of the test, the device showed the

average duration of the 10 pokes and the duration of the fastest one. In this study, we used the average duration of the 10 pokes.

Statistical Analysis

In order to analyze the obtained data set, we first calculated the Pearson correlation coefficient between attention, concentration disruption, and the reaction times of the participants. Then we tested whether attention and concentration scores may have an account for predicting the reaction times employing linear regression analysis.

Results

The correlation analyses were shown in Table 2 to determine the relationship between the d2 attention test and reaction times.

Correlation analyses were conducted to explore the relationship between d2 attention test scores and reaction times among fencers (Table 2). The results reveal significant positive correlations between various error metrics from the d2 test and reaction times. Additionally, a significant inverse relationship was found between concentration performance scores and reaction times.

The correlation between concentration disruption and reaction times among fencers is outlined in Table 3. A significant positive correlation was observed, suggesting that an increase in concentration disruption correlates with longer reaction times. This finding highlights the impact of concentration levels on the speed of fencers' responses.

Table 4 showcases the predictive power of the d2 attention test for fencers' reaction times. It reveals that error rates and concentration significantly affect reaction speeds, with detailed metrics like Total Error and Concentration Performance directly correlating with performance. The Adjusted R^2 value underscores the proportion of reaction time variability explained by these attentional factors. The predictive power of the regression model of fencers' d2 attention test and concentration level for reaction time was 32%.

Table 5 presents the regression analysis on the impact of concentration disruption on fencers' reaction times. The analysis indicates that concentration disruption inversely affects reaction times, with the Adjusted R^2 value revealing that this factor alone explains 15% of the variation in reaction speeds.

Table 2. The relationship between the d2 attention test and reaction times of fencers

Measurement	Reaction Time
Total Number of Items Processed (TN)	-.124
Total Error (E)	.603**
Error Percentage (%E)	.628**
Error Type 1 (E1)	.584**
Error Type 2 (E2)	.533**
Total Norm-Error (TN-E)	-.278
Concentration Performance (CP)	-.456**
Fluctuation Rate (FR)	-.120

*Note: **p<.01*

Table 3. The relationship between concentration disruption and reaction times of fencers

Measurement	Reaction Time
Concentration Disruption	.416*

*Note: *p<.05*

Table 4. Predictive abilities of d2 attention test for reaction time

Variable	B	Beta	t	R	Adjusted R^2
Constant	85.763		3.659		
Total Error (E)	-.607	-.986	-.076		
Error Percentage (E%)	.567	.167	.224	.651	.321
Error Type 1 (E1)	.765	1.103	.094		
Error Type 2 (E2)	1.298	.356	.163		
Concentration Performance (CP)	-.063	-.173	-.606		

Note: B: Unstandardized regression coefficient; Beta: Standardized regression coefficient; t: Test statistic for the regression coefficient; R: Correlation coefficient; Adjusted R^2: Adjusted R-squared, measures the proportion of variation explained by the model, adjusted for the number of predictors.

Table 5. Predictive abilities of concentration disruption for reaction time

Variable	B	Beta	t	R	Adjusted R^2
Constant	113.299		9.995	.416	.147
Concentration Disruption	-3.259	-.416	-2.586		

Note: B: Unstandardized regression coefficient; Beta: Standardized regression coefficient; t: Test statistic for the regression coefficient; R: Correlation coefficient; Adjusted R^2: Adjusted R-squared, measures the proportion of variation explained by the model, adjusted for the number of predictors.

Discussion

Fencers are believed to possess superior ability in selecting the correct motor response due to the physical nature of fencing as a reactive sport. In our study, it was observed that there was a significant positive correlation between the error numbers, error percentage and reaction time and that fewer errors in attention tests may be associated with faster reaction times. In addition, a significant negative relationship was found between concentration and reaction times. Therefore, high concentration shortens reaction time. Additionally, it revealed a significant positive correlation between concentration disruption and reaction times among fencers. This suggests that slower reaction times are associated with higher levels of concentration disruption.

The study results indicate that reaction times are linked to levels of attention and concentration, which is in line with Gutierrez-Davila et al. [18] research on the impact of attention on offensive and defensive actions in fencing. Their study demonstrated that attentional processes play a crucial role in fencers' performance in actual competitions and have a positive impact on their success.

Solanky et al. [25] found a significant correlation between reaction times and attention and concentration levels in their study of national gymnastics and hockey players, which is consistent with our findings. It is important to note that these studies highlight the importance of attention and concentration levels in reaction time in athletes. Similarly, Subramanyam et al. [26] reported a statistically significant relationship between attention control and reaction time in athletes at a sports training centre. Schmidt and Lee [27] concluded that reaction time is associated with the ability to make quick and accurate decisions based on sensory information.

In a recent study, Kıyıcı [28] investigated the attention and reaction levels of athletes across various sports. The results showed significant differences between sports in terms of the importance of attention and reaction time, with fencing being particularly noteworthy. These findings support the notion that attention levels are closely related to reaction times.

Podrigalo et al. [29]. found that the reaction speed of taekwondo athletes increased with age and training experience. Balko and Simonek [30] conducted research on the detection of differences in simple and selective reaction time during visual stimulation between elite, sub-elite, and beginner fencers. The findings indicate a significant difference in reaction time between beginners and elite fencers during different movement tasks, such as direct strike and lunge.

It is important to note that shorter reaction times were associated with higher levels of attention and concentration. The study conducted by Solanky et al. [25] found a significant relationship between reaction times and attention and concentration levels in national gymnastics and hockey players. These findings highlight the significance of attention and concentration levels concerning athletes' reaction time. Dereceli [31] investigated the concentration and mental endurance of professional basketball players and found that guards demonstrated better concentration abilities than players in other positions.

Athletic performance can be affected by reaction time which can help the athlete react to each situation better and reduce the risk of injuries. Furthermore, there is a close relationship between attention and reaction time. That is to say, the higher levels of attention result in a shorter reaction time, and the opposite is also true [32]. All these findings show, how our research can complement each other in understanding and improving the factors that influence athlete performance.

Conclusions

During the process of recognising the goals of individuals, the periods of arousal, perception, attention, and reaction are directly related to each other. In this context, as a result of our research aimed to determine the relationship of concentration, attention, and reaction time in fencing sport. These results show that a significant relationship was found between concentration levels and reaction time. There was also a significant relationship between attention levels and reaction time. This suggests that high levels of concentration and attention can have a direct effect on performance by improving reaction times. These effects of concentration and attention are important elements to consider in training strategies and performance enhancement studies. The results of this study once again confirm

the importance of attention, concentration, and reaction time in the field of sports science and may make an important contribution to research aimed at better understanding the role of these cognitive characteristics in sports performance.

Acknowledgement

We thank to all the students and coaches participating in the study.

References

1. Bianchedi D. The science of fencing. *Sports Medicine*, 2008;38(6):465–381. https://doi.org/10.2165/00007256-200838060-00003
2. Marcos PD. Ipsilateral and contralateral effects neuromuscular facilitation technigues on hip motion and electromyographic activity. *Physical Therapy*, 1979;59(11):1366–1373. https://doi.org/10.1093/ptj/59.11.1366
3. Borysiuk Z. The significance of sensorimotor response components and EMG signals depending on stimuli type in fencing. *Acta Universitatis Palackianae Olomucensis*, 2008;38(1):43–51.
4. Yao Q. The reaction speed of different types of training on fencing athletes. *Revista Brasileira de Medicina do Esporte*, 2022;28(2):141–143. https://doi.org/10.1590/1517-8692202228022021_0453
5. Magyar P, Faur M, Nita V, Dintica G. Developing the speed of fencers at the level of the lower and upper limbs through a combined program of non-specific and fencing-specific exercises. *Annals of Applied Sport Science*, 2023;11(4):1206–1217. https://doi.org/10.61186/aassjournal.1206
6. Moran A. *Sport and exercise psychology: A critical introduction.* London: Routledge; 2003. https://doi.org/10.4324/9780203380246
7. Goksel AG, Zorba E. The examination of sportsmanship behaviors of beach handball players in Turkey. *Sport Journal*, 2017;19:1–9.
8. Mahardhika K, Hidayat R, Nurhayati A, Riswanto AH. The role of concentration on football playing skills Cintasi FC. *Journal of Physical Education, Sport, Health and Recreation*, 2023;12(2):167–173.
9. Donie D, Shapie MNM, Okilanda A, Edmizal E, Suryadi D, Suganda MA. Concentration, eye coordination and agility: How they influence badminton playing skills. *Journal of Physical Education and Sport*, 2023;23(12):3309-3317. https://doi.org/10.7752/jpes.2023.12378
10. Abernethy B, Maxwell JP, Masters RSW, Kamp JVD, Jackson RC. Attentional Processes in Skill Learning and Expert Performance. In: Tenenbaum G, Eklund RC (eds.) *Handbook of Sport Psychology*, 1st ed. Wiley; 2007. P. 245–263. https://doi.org/10.1002/9781118270011.ch11
11. Williams AM, Davids K, Williams JG. *Visual perception and action in sport.* London: Routledge; 1999.
12. Faubert J, Sidebottom L. Perceptual cognitive training of athletes. *Journal of Clinical Sport Psychology*, 2012;6(1):85–102. https://doi.org/10.1123/jcsp.6.1.85
13. Bernier M, Thienot E, Codron R, Fournier JF. Mindfulness and acceptance approaches in sport performance. *Journal of Clinical Sport Psychology*, 2009;3(4):320–333. https://doi.org/10.1123/jcsp.3.4.320
14. Kaufman KA, Glass C. R, Arnkoff DB. Evaluation of mindful sport performance enhancement (MSPE): A new mental training approach to promote flow in athletes. *Journal of Clinical Sports Psychology*, 2009;3(4):334–356. https://doi.org/10.1123/jcsp.3.4.334
15. Moen F, Firing K, Wells A. The effects of attention training techniques on stress and performance in sports. *International Journal of Applied Sports Sciences*, 2016;28(2):213–225. https://doi.org/10.24985/ijass.2016.28.2.213
16. Hijazi MMK. Attention, visual perception and their relationship to sport performance in fencing. *Journal of Human Kinetics*, 2013;39(1):195–201. https://doi.org/10.2478/hukin-2013-0082
17. Fetean DG, Monea G, Rosca M. The influence of attention in increasing sports performance in football at the age of 7-10 years. *Health, Sports & Rehabilitation Medicine*, 2020;21(1):41–44. https://doi.org/10.26659/pm3.2020.21.1.41
18. Gutierrez-Davila M, Rojas FJ, Gutierrez-Cruz C, Navarro E. Effect of dual-attention task on attack and defensive actions in fencing. *European Journal of Sport Science*, 2017;17(8):1004–1012. https://doi.org/10.1080/17461391.2017.1332100
19. Brickenkamp R, Rump G. Die stabilitat des Aufmerksamkeits-Belastungs-Tests (Test d2) über langere Zeitabschnitte [The stability of the attention load test (test d2) over longer periods of time]. *Diagnostica*, 1966;12(1):17-24. (In German).
20. Brickenkamp R, Zillmer E. *The d2 test of attention*. Seattle, Washington: Hogrefe & Huber Publishers; , 1998. https://doi.org/10.1037/t03299-000
21. Spreen O, Strauss E. *A Compendium of neuropsychological tests: administration, norms and commentary: administration, norms and commentary.* (2th edition). New York: Oxford University Press; 1998.
22. Çağlar E, Koruç Z. Reliability and validity of d2 test of attention for athletes. *Hacettepe Journal of Sport Sciences*, 2006;17(2):58–80.
23. Smith RE, Smoll FL, Schutz RW. Measurement and correlates of sport-specific cognitive and somatic trait anxiety: The Sport Anxiety Scale. *Anxiety Research*, 1990;2(4):263–280. https://doi.org/10.1080/08917779008248733
24. Smith RE, Smoll FL, Cumming SP, Grossbard JR. Measurement of multidimensional sport performance anxiety in children and adults: The Sport Anxiety Scale-2. *Journal of Sport and Exercise Psychology*, 2006;28(4):479–501. https://doi.org/10.1123/jsep.28.4.479

25. Solanky A, Parade A, Khumanthem G, Kunte KP. Study on the relationship between reaction time, reactive stress tolerance, and attention in Ncoe athletes. *Sport Research*, 2022;11(1,2):35–41.
26. Subramanyam V, Jamuna D, Kalavathi P. A study of reaction time and attention control among athletes of sports training centers of sports authority of India. *International Journal of Sports Sciences and Fitness*, 2016;6(2):132–142.
27. Schmidt RA, Lee TD. *Motor control and learning: A behavioral emphasis*. Champaign, IL: Human Kinetics; 2011.
28. Kıyıcı F, Salihi M. Sporcularin Dikkat Ve Reaksiyon Düzeylerinin Branşlara Göre Karşilaştirilmasi [Comparison of Athletes' Attention and Reaction Levels by Branches]. *Akdeniz Spor Bilimleri Dergisi*, 2023;6(1): 1213–1226. (In Turkish). https://doi.org/10.38021/asbid.1373994
29. Podrigalo L, Romanenko V, Podrihalo O, Iermakov S, Huba A, Perevoznyk V, Podavalenko O. Comparative analysis of psychophysiological features of taekwondo athletes of different age groups. *Pedagogy of Physical Culture and Sports,* 2023;27(1):38–44. https://doi.org/10.15561/26649837.2023.0105
30. Balkó Š, Borysiuk Z, Šimonek J. The influence of different performance levels of fencers on simple and choice reaction time. *Revista Brasileira de Cineantropometria & Desempenho Humano,* 2016;18(4):391–400. https://doi.org/10.5007/1980-0037.2016v18n4p391
31. Dereceli C. An examination of concentration and mental toughness in professional basketball players. *Journal of Education and Training Studies*, 2019;7(1):17–22. https://doi.org/10.11114/jets.v7i1.3841
32. Karwowski W. The discipline of human factors and ergonomics. In: G. Salvendy (Eds.), *International Encyclopedia of Ergonomics and Human Factors*, 2006:3–37. https://doi.org/10.1201/9780849375477

Information about the authors:

Ömer Aydın; (Corresponding author); https://orcid.org/0009-0000-7692-6668; omer_aydin@msn.com; Faculty of Sport Science, Girne American University; Cyprus.

Erman Doğan; https://orcid.org/0000-0002-3214-0978; ermandogan82@gmail.com; Faculty of Sport Science, Girne American University; Cyprus.

Ezgi Sevilmiş; https://orcid.org/0000-0003-0895-6544; ezgi.sewilmis@gmail.com; Faculty of Sport Science, Girne American University; Cyprus.

Çiğdem Karagülmez Sağlam; https://orcid.org/0000-0002-6924-1326; cigdemkgsaglam@icloud.com; Faculty of Sport Science, Girne American University; Cyprus.

Cite this article as:
Aydın Ö, Doğan E, Sevilmiş E, Karagülmez Sağlam Ç. Examining the effects of attention and concentration levels on reaction time in fencing. *Physical Education of Students,* 2024;28(2):90–96. https://doi.org/10.15561/20755279.2024.0206

Received: 15.03.2024

Accepted: 16.04.2024; **Published**: 30.04.2024

2024
02

ORIGINAL ARTICLE

Kinesiophobia, exercise addiction and mindfulness in athletes

Sema Arslan Kabasakal[1ABCDE], Ezginur Çelik[2CDE], Burcu Güvendi[1ABE], Burçak Keskin[3BDE]

[1] *Faculty of Sport Science, Department of Sport Health Science, Yalova University, Turkey*
[2] *Faculty of Humanities and Social Sciences, Department of Psychology, Yalova University, Turkey*
[3] *Faculty of Sport Science, Department of Movement Training Science, Yalova University, Turkey*

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim: Since athletes tend to be addicted to exercise, they are at a higher risk of experiencing sports injuries compared to others. Exercise addiction and kinesiophobia, which is the fear of (re)injury and movement after an injury, are distinct but related concepts for athletes. It has been stated that mindfulness helps individuals to diminish their kinesiophobia. However, little is known about the relationship between exercise addiction, kinesiophobia, and mindfulness among athletes. Therefore, the aim of the study was to investigate kinesiophobia, exercise addiction, and mindfulness among athletes and to examine the effect of certain variables on these three concepts.

Material and Methods: The sample of the study consisted of 313 athletes over the age of 18. Participants were included in the study on a voluntary basis, using the convenience sampling method. Study data were collected with the 'Demographic Form', the 'Tampa Scale for Kinesiophobia', and the 'Exercise Addiction Scale'.

Results: The study discovered that national athletes exhibited statistically higher levels of exercise addiction compared to non-national athletes. Similarly, athletes suffering from chronic pain showed higher exercise addiction scores than those without chronic pain. Furthermore, athletes who had sustained sports injuries demonstrated higher exercise addiction levels compared to those who had not. It was also determined that athletes with pain or movement limitations due to sports injuries exhibited increased levels of kinesiophobia compared to those without such limitations. In addition, athletes with chronic pain reported higher levels of kinesiophobia compared to their counterparts without chronic pain. Female athletes were found to have higher levels of mindful awareness compared to male athletes. Additionally, when analyzing the relationship between these three parameters, a negative correlation was observed between kinesiophobia and mindfulness among athletes.

Conclusions: While kinesiophobia and exercise addiction are not directly related, there is a negative relationship between kinesiophobia and mindfulness. Furthermore, chronic pain and limitations in movement after a sports injury are identified as risk factors for kinesiophobia. Additionally, being a national athlete, experiencing chronic pain, and sustaining sports injuries are considered risk factors for exercise addiction.

Keywords: kinesiophobia, exercise addiction, mindfulness, athletes

Introduction

In some sports disciplines, individuals' desire for success leads to high competition both on and off the field. This is particularly true among athletes, creating pressures [1]. Such environments of high competition and pressure can lead to various negative consequences, including sports injuries. Athletes inevitably face sports injuries throughout their careers [2]. Maladaptive psychological factors, such as excessive fear, can lead to long-term pain and dysfunction after an injury [3]. Kinesiophobia is defined as the avoidance of physical movement and fear of performing activities due to the risk of re-injury [4]. This fear of re-injury and the subsequent fear of movement can negatively impact injury recovery and the ability to return to sports [5]. Studies have reported that kinesiophobia can lead to chronic musculoskeletal disorders [6], as well as pain, injury, and reduced quality of life [3, 7]. Related interventions can encourage individuals to engage in functional exercises and physical activities by alleviating their kinesiophobia. For example, Su et al. [8] found that a 12-week exercise intervention showed promising results in decreasing the level of kinesiophobia. Similarly, Chen et al. [9] discovered that regular exercise reduced anxiety-related amygdala activation.

Exercise addiction [10], characterized by excessive physical activity and a loss of control over this activity, can adversely affect individuals' functionality. It is distinct from kinesiophobia, which is defined as a fear of movement. This distinction raises the question of whether exercise addiction in athletes can prevent or, conversely, contribute to the development of kinesiophobia [11, 12, 13, 14]. However, a review of the relevant literature reveals that the relationship between exercise addiction and

doi:10.15561/20755279.2024.0207

kinesiophobia has not been explicitly established.

Cognitive Behavioral Therapy (CBT) is a psychotherapeutic approach employed to address kinesiophobia [15, 16]. It focuses on identifying and modifying maladaptive thought patterns that negatively influence an individual's emotions and behaviors, replacing them with more adaptive ones [17]. Research has demonstrated that CBT is more effective in reducing agoraphobia compared to traditional exercise methods [18]. Moreover, studies have established a link between the level of mindfulness and the severity of pain and kinesiophobia [19]. As a result, Mindfulness-Based Therapies, which represent a type of third-wave CBT, have proven effective in diminishing kinesiophobia, especially when integrated with exercise treatments [20, 21]. Despite these findings, the relationship between mindfulness and kinesiophobia has yet to be thoroughly explored within the athlete population.

This study aimed to investigate the relationship between kinesiophobia, mindfulness, and exercise addiction among athletes. The current study was formulated around two main hypotheses:

H1a: There is a negative relationship between kinesiophobia and exercise addiction among athletes. This hypothesis seeks to explore whether exercise addiction, characterized as a form of addiction, can act as a protective factor against kinesiophobia. Such a relationship could potentially facilitate a smoother treatment process after injury and expedite the return to sports activities.

H1b: There is a negative relationship between kinesiophobia and mindfulness among athletes. This hypothesis underscores the need to assess mindfulness levels in athletes with kinesiophobia. Additionally, it aims to highlight the significance of cultivating awareness among athletes to ensure that acute injuries do not adversely impact their lives.

Materials and Methods

Participants

The sample of the current study comprised 313 athletes, all over the age of 18. The majority were male (65.2%) and university students (83.1%), with football being the most common sport among participants (31.6%). Among them, 17.3% were national athletes, with the majority (89.3%) having held this status for between 1 and 10 years. Additionally, 17.6% of the participants reported experiencing chronic pain. A significant portion of the sample had suffered sports injuries (68.7%), with 43.26% experiencing pain or movement restrictions as a result. Detailed demographic characteristics of the sample are presented in Table 1.

Research Design

All procedures in this study involving human participants were conducted in accordance with the ethical standards of the Yalova University Human Research Ethics Committee, approved on 08.05.2023 under approval number 2023/78. Following ethical approval, data were collected using a convenience sampling method. Participants provided their informed consent before voluntarily participating in the study. As part of the study, participants were asked to complete a demographic form and various scales. The entire process took approximately 15 minutes.

Demographic Form

Participants' age, gender, educational level, weight, height, and sports discipline were collected through a demographic form. Additionally, information regarding their status as national athletes, the duration of being national athletes, the presence of chronic pain, experience of sports injuries, and any pain or movement restrictions caused by injuries were also gathered from the participants.

Tampa Scale for Kinesiophobia

The Tampa Scale for Kinesiophobia (TSK) was developed to measure the fear of movement/(re) injury [22], although its publication occurred later. After obtaining the necessary permissions, Vlaeyen et al. [23] published the scale. The scale comprises 17 items on a 4-point Likert scale ranging from 1 (Strongly Disagree) to 4 (Strongly Agree), where higher scores indicate a higher level of fear of movement/(re)injury. Additionally, a cut-off score of 37 is used to categorize individuals regarding their fear of movement, with scores higher than 37 indicating a significant fear of movement [24]. The scale was adapted to Turkish by Tunca-Yılmaz and colleagues [25], with a test-retest reliability of .81. In the current study, its internal consistency was found to be .77.

Exercise Addiction Scale

The Exercise Addiction Scale (EAS) was designed to assess the level of sports addiction [26]. This scale includes three subscales and features 17 items, each rated on a 5-point Likert scale (1 = Strongly Disagree; 5 = Strongly Agree). Scoring is categorized as follows: 1-17 indicates a normal group; 18-34 indicates a low risk group; 35-51 indicates a medium risk group; 52-69 indicates an addicted group; and 70-85 indicates a highly addicted group. The scale's Cronbach alpha was found to be .88 for the total scale, with subscale values ranging from .77 to .88. In the current study, the total score of the scale was utilized, and its Cronbach alpha was determined to be .87.

Athlete Mindfulness Scale

The Athlete Mindfulness Scale (AMS) was designed to assess the level of mindfulness skills in athletes [27]. This scale features three subscales — Awareness, No Judgment, and Refocusing — and includes 15 items, each rated on a 6-point Likert scale (1 = Almost Never; 6 = Almost Always). Higher

Table 1. Demographic Characteristics of the Sample (n=313)

Variables		x̄	Min.	Max.
Weight (kg)		69.11 ± .77	40.0	114.0
Height (cm)		174.41 ± .59	140.0	208.0
Characteristics			**n**	**%**
Gender		Male	204	65.2
		Female	109	34.8
Educational Level		Primary School	1	.3
		High School	39	12.5
		University	260	83.1
		Master's Degree	12	3.8
		Doctorate Degree	1	.3
Branches of Sport		Football	99	31.6
		Basketball	29	9.3
		Volleyball	30	9.6
		Wrestling	33	10.5
		Other	142	39.0
National Athlete		Yes	54	17.3
		No	259	82.7
Duration of Being National Athlete		1-10 Years	48	89.3
		11-20 Years	3	5.6
		21-30 Years	1	1.9
		+30 Years	2	3.7
Chronic Pain		Yes	55	17.6
		No	258	82.4
Sport Injury		Yes	215	68.7
		No	98	31.3
Pain/Movement Restriction Caused by Sport Injury		Yes	93	43.3
		No	122	56.7

scores indicate a higher level of mindfulness. The scale was adapted to Turkish by Tingaz in 2020 [28]. Its test-retest reliability was established at .89, and its Cronbach alpha was initially calculated at .82. In the current study, the scale's Cronbach alpha was determined to be .84

Statistical Analysis

The data were analyzed using SPSS Version 25. Before proceeding with descriptive and inferential analyses, the normal distribution of the variables was assessed using skewness and kurtosis values, with a cutoff point of -1.5 and +1.5 [29]. Following this preliminary check, descriptive analyses of the continuous variables were conducted. Correlational analyses were then performed to examine the relationships among variables. To analyze group differences in the levels of kinesiophobia, exercise addiction, and mindfulness, independent t-tests were conducted based on independent variables such as gender, national athlete status, chronic pain, sports injury, and pain/movement restriction caused by sports injury. In these independent t-tests, the results of Levene's Test for Equality of Variances – Equal Variances Not Assumed – were reported, as the variances between the groups were not equal.

Results

Descriptive characteristics of the continuous variables are presented in Table 2. As indicated in Table 2, based on the skewness and kurtosis values, the assumption of normality for all continuous variables was satisfied.

Utilizing the cutoff score of 37 for kinesiophobia, 69% of the participants exhibited a fear of movement/(re)injury (Table 3). Additionally, with respect to exercise addiction scores, not a single participant was classified as having a normal level of exercise; furthermore, more than half of them (58.1%) were identified as being addicted to exercise. This is further corroborated by the data in Table 2, where the total mean score for exercise addiction was 59.28, indicating a prevalent experience of exercise

Table 2. Descriptive Characteristics of the Continuous Variables (n = 313)

Variables	$\bar{X}$ ± SD	S. E. Mean	Min.	Max.	Skewness	Kurtosis
Kinesiophobia	38.61 ± 5.47	.31	19.00	57.00	-.33	.62
Exercise Addiction	59.28 ± 12.14	.69	18.00	90.00	-.36	.39
Mindfulness	60.86 ± 7.02	.40	37.00	88.00	.22	1.04

Note. SD = Standard Deviation, S. E. Mean = Mean of Standard Error, Min. = Minimum Value, Max. = Maximum Value.

Table 3. Grouping Participants Regarding Continuous Variables (n = 313)

Variables		n	Percentage
Kinesiophobia	No	97	31.0
	Yes	216	69.0
Variables	**Group**	**n**	**Percentage**
Exercise Addiction	Normal Group	0	0
	Low Risk Group	12	3.8
	Middle Risk Group	60	19.2
	Addicted Group	182	58.1
	Highly Addicted Group	59	18.8

Note. By grouping participants, the cut-off scores given at the section of measurement tools were used.

Table 4. Correlations Between Variables (N = 313)

Variables		1	2	3
1.Kinesiophobia	r	1	-.03	-.18
	p		.65	.001**
2.Exercise Addiction	r		1	.04
	p			.45
3. Mindfulness	r			1

Note. **p = .001

addiction among the participants.

As shown in Table 4, kinesiophobia was found to be negatively associated with mindfulness (r = -.18, p = .001), with other associations being non-significant (p > .05).

Following the data presented in Table 5, female athletes exhibited a higher level of mindfulness compared to male athletes [t(311) = 2.42, p < .05]. National athletes displayed a higher level of exercise addiction than non-national athletes [t(311) = 2.13, p < .05]. Athletes suffering from chronic pain showed higher levels of kinesiophobia and exercise addiction compared to those not suffering from chronic pain [t(311) = 2.75, p < .05; t(311) = 2.41, p < .05, respectively]. Additionally, athletes who had experienced a sports injury had a higher level of exercise addiction than those who had not [t(154.18) = 2.20, p < .05]. Athletes with pain/movement restrictions caused by a sports injury also had a higher level of kinesiophobia than those without such restrictions [t(311) = 3.57, p < .001]. Differences in other groups regarding the dependent variables were not significant (p > .05).

Discussion

The study aimed to investigate the relationship between kinesiophobia, mindfulness, and exercise addiction among athletes, with an additional focus on how these factors vary according to gender, national athlete status, presence of chronic pain, history of sports injuries, and injury-related pain and movement restrictions.

Significantly, the study revealed that a considerable portion of participants reported experiencing fear of movement (kinesiophobia) as well as exercise addiction. Previous research on kinesiophobia among athletes has indicated that those who have sustained sports injuries tend to exhibit higher levels of this fear [30]. Furthermore, there is evidence suggesting that athletes might be more susceptible to exercise addiction [12, 13, 14].

Mindfulness, a skill designed to alter individuals' relationship with their thoughts and emotions without directly changing them [31], has been demonstrated to positively affect athlete performance. This includes reductions in anxiety levels and enhancements in motor control [32]. In this study, it was discovered that female athletes

Table 5. Descriptive Statistics of the Variables and the Results of Independent T-test Analyses

DV			KP			EA			MIND		
IV	**Groups**	**n**	**$\bar{X}$ ± SD**	**t**	**p**	**$\bar{X}$ ± SD**	**t**	**p**	**$\bar{X}$ ± SD**	**t**	**p**
Gender	Female	109	39.12 ± 5.33	1.12	.23	58.96 ± 11.89	-.34	.74	62.17 ± 6.95	2.42	.02*
	Male	204	38.34 ± 5.54			59.44 ± 12.29			60.17 ± 6.98		
National Athlete	No	259	38.34 ± 5.48	1.95	.05	58.61 ± 12.20	2.13	.03*	60.87 ± 7.36	-.04	.98
	Yes	54	39.93 ± 5.28			62.46 ± 11.40			60.83 ± 5.11		
Chronic Pain	No	258	38.23 ± 5.41	2.75	.01*	58.52 ± 11.98	2.41	.02*	60.93 ± 7.13	-.37	.72
	Yes	55	40.44 ± 5.45			62.84 ± 12.35			60.55 ± 6.54		
Sport Injury	No	98	38.15 ± 5.05	1.01	.32	56.86 ± 14.00	2.20	.03*	60.80 ± 7.11	.11	.91
	Yes	215	38.82 ± 5.65			60.38 ± 11.04			60.89 ± 7.00		
Pain & Movement Restriction	No	220	37.91 ± 5.22	3.57	.00**	58.45 ± 12.37	1.87	.06	60.94 ± 7.30	-.30	.77
	Yes	93	40.28 ± 5.72			61.25 ± 11.39			60.68 ± 6.35		

Note. KP = Kinesiophobia, EA = Exercise Addiction, MIND = Mindfulness, IV = Independent Variables, DV = Dependent Variables, N = Number of Samples, SD = Standard Deviation. *p < .05, **p < .001

exhibit higher levels of mindfulness compared to their male counterparts, a finding echoed by similar research [33, 34]. Conversely, research focused on elite athletes identified no significant gender differences in mindfulness levels [35], a conclusion also reached in studies involving university student-athletes [36]. The variation in these findings could be attributed to factors such as the specific sports disciplines involved and the average age of the participants in the sample groups.

One notable finding from the study is that national athletes exhibit higher levels of exercise addiction compared to non-national athletes. Factors such as dedication to exercise routines and participation in intense training programs have been identified as contributors to the risk of developing exercise addiction among athletes [37, 38]. Furthermore, it has been reported that athletes with higher status and who compete at more competitive levels are at an increased risk for exercise addiction [39]. Athletes engaged in international competitions also face a greater risk of developing exercise addiction compared to their counterparts who compete in local or regional competitions or those who exercise recreationally [40]. In summary, the elevated status and competitive environment of national athletes, along with their involvement in international competitions and rigorous training schedules, may significantly contribute to a heightened risk of exercise addiction.

In this study, it was also found that athletes suffering from chronic pain exhibited higher levels of exercise addiction and kinesiophobia compared to those without chronic pain, while their mindfulness scores remained similar. This observation aligns with findings from previous research. For instance, Caru et al. [41] identified elevated levels of exercise addiction in athletes dealing with chronic pain. Contrarily, Lichtenstein et al. [42] suggested that pain does not significantly affect the continuity of exercise among athletes. Moreover, Bordeleau et al. [43] discovered a correlation between kinesiophobia and pain intensity in individuals with chronic pain, further corroborating this study's results. Hence, athletes reporting chronic pain also demonstrated increased levels of kinesiophobia and exercise addiction.

Observing exercise addiction alongside movement avoidance in individuals with chronic pain presents an unusual phenomenon. The precise reason behind this result remains unclear, primarily because the level of chronic pain was not measured in this study, nor was it directly correlated with kinesiophobia. A critical factor to consider is the potential for sports injuries to lead to chronic pain. In our study, participants were simply asked whether they experienced chronic pain, without further inquiry into the pain's origin, which constitutes a limitation of our research. It's possible that the chronic pain reported by participants was not a result of exercise and thus did not influence their exercise commitment. Furthermore, the chronic pain they experienced might have been related to daily life activities rather than exercise-specific movements, potentially leading to the avoidance of certain movements. Future research exploring the relationship between exercise addiction and kinesiophobia should thoroughly investigate chronic pain and its impacts.

In the investigation of exercise addiction in relation to sports injuries, it was discovered that athletes who had sustained an injury exhibited higher levels of exercise addiction compared to their uninjured counterparts. This suggests that athletes prone to exercise addiction may be at a greater risk of sustaining injuries and are likely to continue exercising despite pain or injury [44]. Given that all study participants were potentially at risk of developing exercise addiction, this finding was anticipated. However, this study also found that levels of kinesiophobia and mindfulness were

similar among athletes, regardless of whether they had experienced sports injuries. This observation is consistent with other research indicating that sustaining an injury does not necessarily correlate with levels of kinesiophobia and mindfulness [28, 45].

In this study, it was observed that athletes experiencing movement restrictions and pain due to sports injuries exhibited higher levels of kinesiophobia compared to those without such limitations. Interestingly, the levels of exercise addiction and mindfulness were similar between the two groups. Additionally, athletes with chronic pain demonstrated higher levels of kinesiophobia than those without chronic pain. Research has shown that an increase in kinesiophobia levels correlates with a heightened risk of pain and injury [3]. The pain fear-avoidance model [23, 46] suggests that catastrophizing thoughts about pain and the fear of its recurrence lead to avoidance behaviors, an overreaction to potential threats, and ultimately, movement avoidance [46, 47]. Individuals who engage in avoidance behaviors are more likely to suffer from chronic musculoskeletal pain after an injury [46]. The findings of this study lend support to the pain fear-avoidance model. It is posited that negative perceptions of pain may cause acute pain from sports injuries to evolve into chronic pain in athletes who develop kinesiophobia. Moreover, the avoidance of movement, stemming from these fears, may lead to reduced levels of physical activity.

Another result of the study was that as athletes' levels of mindfulness increased, their levels of kinesiophobia decreased. Mindfulness is a mental state that enables individuals to focus on the present moment without judgment, experiencing it in its purest form [48, 49]. It is a skill that assists individuals in recognizing negative emotions and understanding that these are temporary experiences [50, 51]. Kabat et al. [52] conducted the first trials on mindfulness and meditation practices, which have been supported as effective in reducing pain. Furthermore, studies have demonstrated that mindfulness-based therapy can reduce kinesiophobia [20, 21, 53]. These findings support the results of the present study. The absence of previous research directly investigating the relationship between mindfulness and kinesiophobia levels in athletes underscores the unique contribution of this study.

Contrary to the hypothesis, this study found no negative relationship between exercise addiction and kinesiophobia. This suggests that the level of movement avoidance does not necessarily correlate with high or low levels of exercise addiction in athletes. This finding is in contrast to previous studies [11] that posited exercise addiction and kinesiophobia as opposing concepts. The lack of additional studies examining the relationship between kinesiophobia and exercise addiction in athletes limits the discussion of this result.

Furthermore, the study revealed no relationship between exercise addiction and mindfulness. This finding suggests that exercise addiction in athletes may reflect their intense passion and commitment to their sport, which forms a significant part of their identity, rather than a pathological tendency. This aligns with the findings of Juwono et al. [54], which recommend a re-evaluation of the concept of exercise addiction in athletes. The inconsistencies observed in this study regarding exercise addiction may stem from the ambiguous definition of addiction within the athletic population.

Future research should explore the implementation of mindfulness-based practices among athletes to investigate their impact on reducing levels of kinesiophobia. Such studies could provide valuable insights into effective interventions for managing fear of movement and injury in sports settings.

Conclusions

The study explored the relationship between kinesiophobia, exercise addiction, and mindfulness in athletes aged 18 and older, considering various risk factors. It was found that chronic pain and pain or movement restriction due to sports injuries are significant risk factors for kinesiophobia. Meanwhile, being a national athlete, experiencing chronic pain, and sustaining sports injuries emerged as risk factors for exercise addiction. Importantly, athletes in this group displayed high levels of both exercise addiction and kinesiophobia. However, an increase in mindfulness levels was associated with a decrease in kinesiophobia levels. Thus, organizing mindfulness practices or interventions could enhance athletes' mindfulness and mitigate kinesiophobia. Implementing mindfulness practices proactively, before athletes suffer injuries, could positively alter their attitudes towards sports injuries and enhance the quality of rehabilitation post-injury, facilitating a quicker return to sports, reducing the costs associated with sports injuries, and discouraging athletes from quitting sports altogether. Additionally, no support was found for a relationship between exercise addiction and either kinesiophobia or mindfulness. It is possible that high levels of exercise addiction among athletes stem from a competitive drive, passion for their sport, and professional commitments rather than being indicative of a pathological addiction. This suggests that the addiction observed may align more closely with the principles of sportsmanship.

Funding

No financial support was used for the study.

Conflict of Interest

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

References

1. Karaman T. Teknik Dırektörlerin Futbolculuk Kariyerleri Üzerinden Kulüp İstikrar Düzeylerinin İncelenmesi [Examining Club Stability Levels of Coaches Based on Their Football Careers]. *SPORMETRE Beden Eğitimi ve Spor Bilimleri Dergisi*, 2023;21(100. Years Special Issues):91–100. (In Turkish . https://doi.org/10.33689/Spormetre.1285551
2. Moss RA, Slobounov S. Neural, behavioral and psychological effects of injury in athletes. *Foundations of Sport-Related Brain Injuries*. 2006: 407–430. https://doi.org/10.1007/0-387-32565-4_18
3. Luque-Suarez A, Martinez-Calderon J, Falla D. Role of kinesiophobia on pain, disability and quality of life in people suffering from chronic musculoskeletal pain: A systematic review. *British Journal of Sports Medicine,* 2019;53(9):554–5. https://doi.org/10.1136/bjsports-2017-098673
4. Kori S, Miller R, Todd D. Kinesiophobia: a new view of chronic pain behavior. *Pain Manage*. 1990;3:35–43.
5. Hsu CJ, Meierbachtol A, George SZ, Chmielewski TL. Fear of reinjury in athletes: implications for rehabilitation. *Sports Health*. 2017;9(2):162–167. https://doi.org/10.1177/1941738116666813
6. Domenech J, Sanchis-Alfonso V, López L, Espejo B. Influence of kinesiophobia and catastrophizing on pain and disability in anterior knee pain patients. Knee Surg. *Sports Traumatol Arthrosc* 2013;21:1562–158. https://doi.org/10.1007/s00167-012-2238-5
7. Oskay D, Tuna Z, Düzgün İ, Elbasan B, Yakut Y, Tufan A. Relationship between kinesiophobia and pain, quality of life, functional status, disease activity, mobility, and depression in patients with ankylosing spondylitis. *Turkish Journal of Medical Sciences*. 2017;47(5):1340–1347. https://doi.org/10.3906/sag-1702-93
8. Su Y, Huang L, Liu H, Chen S, Peng L. The Effect of Exercise Intervention on Disability and Kinesiophobia in a Retired Athlete With Old Patella Fracture: A Case Report. *Frontiers in Psychology*. 2021;12:744433. https://doi.org/10.3389/fpsyg.2021.744433
9. Chen YC, Chen C, Martínez RM, Etnier JL, Cheng Y. Habitual physical activity mediates the acute exercise-induced modulation of anxiety-related amygdala functional connectivity. *Scientific Reports*. 2019;9(1):19787. https://doi.org/10.1038/s41598-019-56226-z
10. Szabo A, Demetrovics Z. *Passion and Addiction in Sports and Exercise*. New York (NY): Routledge, 2022. https://doi.org/10.4324/9781003173595
11. Hasenbring MI, Chehadi O, Titze C, Kreddig N. Fear and anxiety in the transition from acute to chronic pain: there is evidence for endurance besides avoidance. *Pain Management*. 2014;4(5):363–374. https://doi.org/10.2217/pmt.14.36
12. Smith D, Wright C, Winrow D. Exercise dependence and social physique anxiety in competitive and non-competitive runners. *International Journal of Sport and Exercise Psychology*. 2010;8(1):61–69. https://doi.org/10.1080/1612197X.2010.9671934
13. De La Vega R, Parastatidou IS, Ruíz-Barquín R, Szabo A. Exercise addiction in athletes and leisure exercisers: The moderating role of passion. *Journal of Behavioral Addictions*. 2016;5(2):325-331. https://doi.org/10.1556/2006.5.2016.043
14. Szabo A, De La Vega R, Ruiz-Barquín R, Rivera O. Exercise addiction in Spanish athletes: Investigation of the roles of gender, social context and level of involvement. *Journal of Behavioral Addictions*. 2013;2(4):249–252. https://doi.org/10.1556/jba.2.2013.4.9
15. Archer KR, Devin CJ, Vanston SW, et al. Cognitive-behavioral–based physical therapy for patients with chronic pain undergoing lumbar spine surgery: a randomized controlled trial. *The Journal of Pain*. 2016;17(1):76–89. https://doi.org/10.1016/j.jpain.2015.09.013
16. Cai L, Gao H, Xu H, Wang Y, Lyu P, Liu Y. Does a program based on cognitive behavioral therapy affect kinesiophobia in patients following total knee arthroplasty? A randomized, controlled trial with a 6-month follow-up. *The Journal of Arthroplasty*. 2018;33(3):704–710. https://doi.org/10.1016/j.arth.2017.10.035
17. Hofmann SG, Asnaani A, Vonk IJ, Sawyer AT, Fang A. The efficacy of cognitive behavioral therapy: a review of meta-analyses. *Cognitive Therapy and Research.* 2012;36:427–40. https://doi.org/10.1007/s10608-012-9476-1
18. Monticone M, Ambrosini E, Rocca B, Cazzaniga D, Liquori V, Foti C. Group-based task-oriented exercises aimed at managing kinesiophobia improved disability in chronic low back pain. *European Journal of Pain*. 2016;20(4):541–551. https://doi.org/10.1002/ejp.756
19. Rezaei S, Hassanzadeh S. Are mindfulness skills associated with reducing kinesiophobia, pain severity, pain catastrophizing and physical disability? Results of Iranian patients with chronic musculoskeletal pain. *Health Psychology Report*. 2019;7(4):276–285.
20. Bagheri S, Naderi A, Mirali S, Calmeiro L, Brewer BW. Adding mindfulness practice to exercise therapy for female recreational runners with patellofemoral pain: A randomized controlled trial. *Journal of Athletic Training*. 2021;56(8):902–911. https://doi.org/10.4085/1062-6050-0214.20
21. Yumeng Z, Juan M. Effects of mindfulness therapy on patients with kinesiphobia after total hip replacement. *MEDS Public Health and Preventive Medicine.* 2023;3(5):66–72. https://doi.org/10.23977/phpm.2023.030510
22. Miller RP, Kori SH, Todd DD. The Tampa Scale: A measure of kinesiophobia. *The Clinical Journal of Pain*. 1991;7(1):51–52. https://doi.org/10.1097/00002508-199103000-00053
23. Vlaeyen JW, Linton SJ. Fear-avoidance and its consequences in chronic musculoskeletal pain: a state of the art. *Pain*. 2000;85(3):317–332. https://doi.org/10.1016/S0304-3959(99)00242-0

24. Heuts PHT, Vlaeyen JW, Roelofs J, et al. Pain-related fear and daily functioning in patients with osteoarthritis. *Pain.* 2004;110(1):228–235. https://doi.org/10.1016/j.pain.2004.03.035
25. Tunca-Yılmaz Ö, Yakut Y, Uygur F, Uluğ, N. Tampa Kinezyofobi Ölçeği'nin Türkçe versiyonu ve test-tekrar test güvenirliği. *Fizyoterapi Rehabilitasyon*. 2011;22(1):44–9.
26. Tekkurşun-Demir G, Hazar Z, Cicioğlu Hİ. Egzersiz bağımlılığı ölçeği (EBÖ): Geçerlik ve güvenirlik çalışması [Exercise addiction scale (EDS): Validity and reliability study]. *Kastamonu Eğitim Dergisi*. 2018;26(3):865-874. (In Turkish). https://doi.org/10.24106/kefdergi.413383
27. Thienot E, Jackson B, Dimmock J, Grove JR, Bernier M, Fournier JF. Development and preliminary validation of the mindfulness inventory for sport. *Psychology of Sport and Exercise*. 2014;15(1), 72–80. https://doi.org/10.1016/j.psychsport.2013.10.003
28. Tingaz EO, Ekiz MA, Çakmak S. Examination of mindfulness and impulsiveness in university student-athletes in terms of sports injury development history. *Current Psychology*. 2020:41(8):1–9. https://doi.org/10.1007/s12144-020-01024-4
29. Tabachnick BG, Fidell LS. *Using Multivariate Statistics* (5th ed.). Boston, MA: Pearson; 2007.
30. Çevi K, Saldiran T, Atici E, Öztürk Ö, Akgöl AC, Özkeski NM, Aydin G, et al. Lower Limb Injury History in Elite Athletes: Relationship with Kinesiophobia and Effect on Physical Performance. *Turkiye Klinikleri Journal of Sports Sciences*, 2020;12(1): 1–8. https://doi.org/10.5336/sportsci.2019-70271
31. Anderson SA, Haraldsdottir K, Watson D. Mindfulness in athletes. *Current Sports Medicine Reports*. 2021;20(12):655-660. https://doi.org/10.1249/JSR.0000000000000919
32. Bühlmayer L, Birrer D, Röthlin P, Faude O, Donath L. Effects of mindfulness practice on performance-relevant parameters and performance outcomes in sports: A meta-analytical review. *Sports Medicine*. 2017; 47:2309–2321. https://doi.org/10.1007/s40279-017-0752-9
33. Bulğay C, Tingaz EO, Bayraktar I, Çetin E. Athletic performance and mindfulness in track and field athletes. *Current Psychology*. 2022;41(7):4482–4489. https://doi.org/10.1007/s12144-020-00967-y
34. Nicholls AR, Polman RC, Levy AR, Backhouse SH. Mental toughness in sport: Achievement level, gender, age, experience, and sport type differences. *Personality and İndividual Differences*. 2009;47(1):73–75. https://doi.org/10.1016/j.paid.2009.02.006
35. Cathcart S, McGregor M, Groundwater E. Mindfulness and flow in elite athletes. *Journal of Clinical Sport Psychology*. 2014;8(2):119–141. https://doi.org/10.1123/jcsp.2014-0018
36. Metin SN, Uzgur K, Akkoyunlu Y, Konar N. The relationship between burnout levels and mindfulness of university students-athletes. *Physical Education of Students*. 2023;27(3):97–103. https://doi.org/10.15561/20755279.2023.0301
37. Szabo A. *Addiction to exercise: A symptom or a disorder?* New York, NY: Nova Science Publishers; 2010.
38. Lichtenstein MB, Hinze CJ, Emborg B, Thomsen F, Hemmingsen SD. Compulsive exercise: links, risks and challenges faced. *Psychology research and behavior management*. 2017;10:85–95. https://doi.org/10.2147/PRBM.S113093
39. Conesa MDPV, Plaza FJP, Palacios CDF. Can motives lead athletes to suffer from exercise dependence? Risk of exercise dependence according to motives for practice. *Journal of Physical Education and Sport.* 2017;17(4):2405–2411. https://doi.org/10.7752/jpes.2017.04266.
40. Weinstein A, Maayan G, Weinstein Y. A study on the relationship between compulsive exercise, depression and anxiety. *Journal of Behavioral Addictions.* 2015;4(4):315–318. https://doi.org/10.1556/2006.4.2015.034.
41. Caru M, Poulnais S, Gorwood P, Kern L. Exercise addiction, pain and injuries in amateur athletes. *Sport Sciences for Health*. 2022;18(4):1253–1261. https://doi.org/10.1007/s11332-022-01004-0
42. Lichtenstein MB, Nielsen RO, Gudex C, Hinze CJ, Jørgensen U. Exercise addiction is associated with emotional distress in injured and non-injured regular exercisers. *Addictive behaviors reports*. 2018;8:33–39. https://doi.org/10.1016/j.abrep.2018.06.001
43. Bordeleau M, Vincenot M, Lefevre S, et al. Treatments for kinesiophobia in people with chronic pain: A scoping review. *Frontiers in Behavioral Neuroscience*. 2022;16:933483. https://doi.org/10.3389/fnbeh.2022.933483
44. Lichtenstein MB, Christiansen E, Elklit A, Bilenberg N, Støving RK. Exercise addiction: a study of eating disorder symptoms, quality of life, personality traits and attachment styles. *Psychiatry Research*. 2014;215(2):410–416. https://doi.org/10.1016/j.psychres.2013.11.010
45. Ünver G, Kara E, Yoldaş A. Investigation of Sports Injuries and Kinesiophobia in Volleyball Players. *Gaziantep Üniversitesi Spor Bilimleri Dergisi*. 2020;5(4):443–455. https://doi.org/10.31680/gaunjss.779513
46. Leeuw M, Goossens ME, Linton SJ, Crombez G, Boersma K, Vlaeyen JW. The fear-avoidance model of musculoskeletal pain: current state of scientific evidence. *Journal of Behavioral Medicine*. 2007;30:77–94.https://doi.org/10.1007/s10865-006-9085-0
47. Lundberg M, Grimby-Ekman A, Verbunt J, Simmonds MJ. Pain-related fear: a critical review of the related measures. *Pain Research and Treatment*. 2011; 494196. https://doi.org/10.1155/2011/494196
48. Segal ZV, Williams JMG, Teasdale JD. *Mindfulness-based cognitive therapy for depression*. New York: Guilford Press; 2013.
49. Desbordes G, Gard T, Hoge EA et al. Moving beyond mindfulness: Defining equanimity as an outcome measure in meditation and contemplative research. *Mindfulness*. 2015;6:356–372. https://doi.org/10.1007/s12671-013-0269-8
50. Bishop SR, Lau M, Shapiro S, et al. Mindfulness: A proposed operational definition. *Clinical Psychology: Science and Practice*. 2006;11:230–241. https://doi.

org/1.1093/clipsy.bph077
51. Azad Marzabadi E, Hashemi Zadeh SM. The effectiveness of mindfulness training in improving the quality of life of the war victims with post-traumatic stress disorder (PTSD). *Iranian Journal of Psychiatry*. 2014;9(4):228–236.
52. Kabat-Zinn J. *Full catastrophe living, revised edition: how to cope with stress, pain and illness using mindfulness meditation*. UK: Hachette; 2013.
53. Demirci C, Oksul M, Ozer N, Ozdemir, L. Effect of mindfulness on fatigue, kinesiophobia and quality of life in patients with acute myocardial infarction. *Annals of Clinical and Analytical Medicine*. 2023;14(2):110–11. https://doi.org/10.4328/ACAM.21365
54. Juwono ID, Tolnai N, Szabo A. Exercise addiction in athletes: A systematic review of the literature. *International Journal of Mental Health and Addiction*. 2022;20(5):3113–3127. https://doi.org/10.1007/s11469-021-00568-1

Information about the authors:

Sema Arslan Kabasakal; (Corresponding author); https://orcid.org/0000-0002-4552-9640; sema.kabasakal@yalova.edu.tr; Faculty of Sport Science, Department of Sport Health Science, Yalova University; Yalova, Turkey.

Ezginur Çelik; https://orcid.org/0000-0002-5399-9255; ezginur.celik@yalova.edu.tr; Faculty of Humanities and Social Sciences, Department of Psychology, Yalova University; Yalova, Turkey.

Burcu Güvendi; https://orcid.org/0000-0002-6170-9107; burcu.guvendi@yalova.edu.tr; Faculty of Sport Science, Department of Sport Health Science, Yalova University; Yalova, Turkey.

Burçak Keskin; https://orcid.org/0000-0003-4313-7720; burcak.keskin@yalova.edu.tr; Faculty of Sport Science, Department of Movement Training Science, Yalova University; Yalova, Turkey.

Cite this article as:
Arslan Kabasakal S, Çelik E, Güvendi B, Keskin B. Kinesiophobia, exercise addiction and mindfulness in athletes. *Physical Education of Students,* 2024;28(2):97–105.
https://doi.org/10.15561/20755279.2024.0207

Received: 12.03.2024

Accepted: 17.04.2024; **Published**: 30.04.2024

ORIGINAL ARTICLE

Applied biomechanics within the Kinesiology discipline in higher education

Vladimir Potop[1,2,3ABCDE], Liviu Emanuel Mihailescu[1ABCDE], Ion Mihaila[1,2ABCDE], Monika Zawadka-Kunikowska[4CDE], Wladyslaw Jagiello[5CDE], Andrii Chernozub[6ACDE], Mihai Sebastian Baican[7ADE], Olivia Carmen Timnea[8DE], Carmen Ene-Voiculescu[9DE], Alexandru Acsinte[10ADE]

[1] *Department of Physical Education and Sport, National University of Science and Technology Politehnica Bucharest, University Center Pitesti, Pitesti, Romania*
[2] *Doctoral School of Sports Science and Physical Education, National University of Science and Technology Politehnica Bucharest, University Center Pitești, Pitesti, Romania*
[3] *State University of Physical Education and Sport, Chisinau, Republic of Moldova*
[4] *Department of Human Physiology, Nicolaus Copernicus University, Poland*
[5] *Sports Department, Gdansk University of Physical Education and Sport, Poland.*
[6] *Lesya Ukrainka Volyn National University, Lutsk, Ukraine*
[7] *Swiss Med Clinic, Buchareast, Romania*
[8] *Romanian-American University, Buchareast, Romania*
[9] *„Ovidius" University of Constanta, Constanta, Romania*
[10] *"Vasile Alecsandri" University of Bacau, Bacau, Romania*

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim: Biomechanics is a fundamental component of Kinesiology, offering critical insights into the mechanics of human movement. As the demand for comprehensive educational programs in Kinesiology grows, understanding the role and effectiveness of biomechanics within these programs becomes increasingly important. The aim of the study is to investigate and highlight the role and importance of biomechanics in the context of higher education, with an emphasis on the discipline of Kinesiology.

Material and Methods: This study involved 71 students from the Department of Physical Education and Sport at Pitești University Center. It included 43 students specializing in Physical Education and Sport (PES) and 28 in Sports and Motor Performance (SMP). The research utilized the university's e-learning platform to monitor teaching and evaluation activities within the Kinesiology discipline. The evaluation of fundamental Kinesiology knowledge was assessed through various indicators. Google Forms-Questionnaire sought to gauge student opinions on the thematic content of Biomechanics as applied to Kinesiology and to evaluate the teaching staff. The nonparametric Kruskal-Wallis Test was employed to analyze differences in means across the groups.

Results: The study revealed a diverse interest in sports across the Physical Education and Sport (PES) and Sports and Motor Performance (SMP) programs. Soccer, basketball, and handball were the most popular among students. Comparative analysis of academic performance showed no significant differences between the groups in various assessments ($p>0.05$). The overall student feedback on the "Fundamentals of Biomechanics of Physical Activities and Sports" course was predominantly positive. Over 50% of the students rated it as very good. Areas for improvement in teaching methods were also identified to enhance the academic experience.

Conclusions: This study highlights the effective integration of biomechanics within the Kinesiology discipline at the higher education level. Findings suggest that well-structured educational programs can enhance students' understanding and application of biomechanics. This contributes positively to their academic and professional development in sports sciences. Continuous curriculum assessment and refinement are crucial for maintaining the relevance and effectiveness of such programs.

Keywords: comparative analysis, teaching activity, thematic content, evaluation, opinions, performance standards.

Introduction

The integration of biomechanics within kinesiology programs in higher education is increasingly significant, playing a crucial role in enhancing the understanding and application of physical activity principles. This interdisciplinary approach not only enriches the academic landscape by fostering a deeper comprehension of movement mechanics but also equips students

doi:10.15561/20755279.2024.0208

with analytical skills crucial for addressing complex challenges in sports and health sciences. In the context of higher education, kinesiology acts as an essential bridge between theoretical knowledge and practical application in physical activities, sports, and health, making it a pivotal area of study [1]. Kinesiology, as an expansive academic discipline, supports various professions and tackles significant public health concerns through its comprehensive content [2, 3, 4]. The concept of "pedagogy" in kinesiology, particularly sports pedagogy, has recently gained recognition in the English-speaking academic community, aligning with its longstanding acknowledgment in Europe [5]. Research in physical education and sports pedagogy, central to kinesiology, demands rigorous academic inquiry to maintain its relevance and efficacy [6]. The commitment to integrating research, physical activity, and professional practice within kinesiology programs underscores the importance of inclusion and public service in higher education [7]. Biomechanics, as a fundamental aspect of kinesiology, plays a pivotal role in grounding theoretical knowledge into practical applications [8].

The integration of biomechanics within kinesiology programs in higher education is increasingly significant, playing a crucial role in enhancing the understanding and application of physical activity principles. The profound impact of biomechanics in kinesiology underscores its indispensability in bridging theoretical knowledge with practical applications in physical activities, sports, and health.

Biomechanics courses are commonly offered at the undergraduate level, particularly within engineering (e.g., mechanical and biomedical) and health sciences fields. As an introductory course, it applies mechanical principles to human movement analysis, providing a foundational understanding of the interactions between human movement and the physical environment. This knowledge is crucial for optimizing efficiency in daily activities, the work environment, sports, and physical exercises [9]. Students learn to apply and integrate anatomical and biomechanical concepts across a diverse range of activities and populations, including various ages, abilities, and conditions ranging from acute injuries to chronic disabilities and differing fitness levels [10]. Essential for the professional development of specialists in physical education, a robust foundation in biomechanics enhances their practical applications. However, deficiencies in this foundational knowledge can lead to challenges in its practical application, indicating a potential need for enhancements in the pedagogical approaches used to teach biomechanical concepts in undergraduate courses [11, 12, 13]. Given its broad applications and impact on professional practice, the study of biomechanics is fundamental in preparing students for real-world challenges in physical activities and health-related fields.

Biomechanics, an interdisciplinary field, is fundamentally concerned with the dynamics of movement and the forces applied to the human body [14, 15, 16]. Over the past decade, the domain has expanded to include the observation, measurement, analysis, evaluation, and interpretation of human movement [17]. A critical examination of the pedagogical history in biomechanics is crucial, highlighting the need to balance functional anatomy with mechanics and emphasizing the importance of both qualitative and quantitative analyses. Interdisciplinary cooperation is essential to develop biomechanical principles that integrate smoothly with other subdomains of kinesiology and physical education [18, 19]. Additionally, addressing methodological and statistical issues highlighted in early articles and commentaries is vital to bolster confidence and advance knowledge within the field [20]. This enhanced understanding underscores the need for ongoing collaboration and refinement within biomechanics education to effectively translate complex theoretical concepts into practical applications.

The National Association for Sport and Physical Education has established learning objectives for biomechanics at the undergraduate level. However, teaching methods that overly emphasize applied physics could potentially discourage student interest in biomechanics. Thus, it is critical to balance the focus on mechanics to engage students effectively [21]. Evidence suggests that active learning approaches significantly enhance student engagement and mastery of biomechanical concepts within the introductory courses [22]. Moreover, advancements in sports biomechanics training not only benefit the field but also enhance the practical application of this knowledge in professional settings. Graduates from diverse sports backgrounds who enroll in the Postgraduate Certificate in Education (PGCE) in Physical Education often face challenges in covering all areas of the National Curriculum for Physical Education. Specifically, there is a need for these student-teachers to improve their understanding and application of biomechanical principles within the PGCE program [23]. Addressing these educational gaps is crucial for equipping future physical education teachers with the necessary biomechanical expertise to enhance their teaching effectiveness and ensure comprehensive educational outcomes.

Technological advances in motion research over the past 40 years have significantly transformed biomechanics into an integral subdiscipline within kinesiology. These advancements have not only diversified research focus but also expanded the knowledge base by intersecting with other domains [24, 25]. This evolution highlights the

revolutionary potential of integrating natural laws with biomechanical and motor control principles, fostering strong deductions and interdisciplinary collaborations that reshape our understanding of human movement [26].

Such advancements underscore the fundamental importance of biomechanics in assessing and improving athletic performance, preventing injuries, and enhancing quality of life through physical activity. Despite the reliance on advanced technologies to study movement, there remains a tendency to overly focus on static and kinetic aspects, often neglecting the crucial dynamic component of movement. This dynamic aspect adds a holistic perspective by considering integrated stresses and individual decision-making processes that influence each person's movement, thus emphasizing the need for a balanced approach in biomechanical research [27].

To address these educational challenges, the "Fundamentals of Biomechanics" course is designed to provide deep, conceptual understanding of both biological and mechanical domains involved in movement. Engaging students in active learning and laboratory activities helps them connect personal experience with biomechanical concepts, thereby enhancing movement efficiency and reducing injury risks. It is crucial that biomechanics education fosters not only theoretical knowledge but also practical application, ensuring that future specialists can effectively translate academic insights into real-world benefits [28, 29].

Biomechanics and kinesiology are pivotal in understanding and enhancing human movement. These disciplines equip professionals with critical insights into movement patterns and their origins in living organisms, enabling effective application in various health-related fields [30]. Physical therapy students, for instance, rely heavily on principles of biomechanics and kinesiology to evaluate joint function, diagnose issues, and monitor rehabilitation progress [31].

Despite their growing importance in both academia and industry, there is evidence that many graduates from biomechanics and exercise science programs lack adequate preparation for professional challenges. This gap highlights the need for enhanced educational practices in the classroom to improve learning outcomes and ensure that students are well-equipped to apply their knowledge practically [32]. Addressing this issue requires effective strategies for teaching and applying biomechanical concepts that could significantly benefit students and professionals in the field [33].

This focus aligns closely with the curriculum of the "Kinesiology" course [34], which has been continuously developed to incorporate both theoretical and practical perspectives [35]. The course emphasizes the application of biomechanics as a scientific research approach at the undergraduate level, making it a fundamental component of sports science education. Students explore biomechanical aspects of specific movements tailored to various sports disciplines such as basketball [36, 37], dance sport [38, 39], handball [40, 41], judo [42, 43], football [44], gymnastics [45], kayak [46, 47], and swimming [48, 49]. This comprehensive study equips them with the necessary knowledge to pursue careers as coaches, kinesiotherapists, or researchers in the fields of sports and human performance.

The relevance of biomechanics within the kinesiology curriculum highlights the crucial need to understand and correctly apply biomechanical principles. This understanding is essential not only for academic purposes but also for the practical application in the professional training of future health and physical performance specialists. This integration ensures that graduates are well-prepared to contribute effectively to the field.

Despite the extensive integration of biomechanics into kinesiology education, gaps remain in understanding how effectively these principles are applied in real-world scenarios, particularly in educational settings. Current literature often lacks comprehensive evaluations that connect theoretical biomechanics training to tangible outcomes in student proficiency and professional readiness. This indicates a critical need for further empirical investigation to bridge these gaps, ensuring that biomechanical training effectively meets the evolving demands of health and sports science professions.

Purpose of the Study. The purpose of the study was to investigate and highlight the role and importance of biomechanics in the context of higher education, with an emphasis on the discipline of kinesiology.

Materials and Methods

Participants

The study involved students from the Department of Physical Education and Sports at the Faculty of Science, Physical Education, and Informatics within the University Center of Pitești, National University of Science and Technology Politehnica Bucharest. A total of 71 subjects (79.8% of enrolled students) participated, with 43 specializing in Physical Education and Sports (PES) and 28 in Sports and Motor Performance (SMP). All participants provided informed consent to voluntarily participate in the study, in accordance with the Helsinki Declaration. The research was approved by the Ethics Committee of the Doctoral School of Sports Science and Physical Education at the University Center of Pitești (ID: 13/16.02.2024).

Research Design

The study was designed to assess the integration of Applied Biomechanics within the Kinesiology discipline. It specifically focused on its application in Sports Science and Physical Education programs. Conducted from October 2022 to September 2023, the research involved undergraduate students. They specialized in Physical Education and Sports (PES) and Sports and Motor Performance (SMP) at the University Center of Pitești.

The academic structure of the course during the 2022-2023 year included 14 weeks of instruction, with each week comprising 2 hours of lecture and 2 hours of seminar. The course evaluations were conducted in two phases: the initial examinations in February 2023 and re-examinations in September 2023. Course monitoring and content delivery were supported by the university's e-learning platform.

Each semester was structured to provide 125 hours of total engagement: 56 hours as per the curriculum (split equally between lectures and seminars) and 69 hours dedicated to individual study. The course was credited with 5 academic credits.

Specifically, the topic "Fundamentals of Biomechanics in Physical Activities and Sports" was allocated 2 hours of lecture and 2 hours of seminar per week. The discipline codes for the courses were UP.01.F.3.O.11.01 for PES and UP.00.F.3.O.12.01 for SMP, ensuring structured and detailed academic delivery focused on the core aspects of biomechanics within physical education.

To enhance the theoretical understanding of the "Applied Biomechanics" course, the curriculum incorporated examples from a variety of specialized journals. These included Applied Sciences by MDPI, Springer Nature publications, the Brazilian Journal of Physical Therapy, the International Journal of Environmental Research and Public Health by MDPI, the International Journal of Sports Physiology and Performance published by Human Kinetics, the Journal of Athletic Training, the British Medical Bulletin from Oxford, and Sensors by MDPI.

During seminar sessions, practical application of biomechanical principles was emphasized through the analysis of exercises from diverse sports disciplines such as women's and men's artistic gymnastics, football, weightlifting, and swimming starts. This analysis was facilitated by the use of specialized software like Kinovea and Physics ToolKit. Techniques were further examined through the application of the postural orientation method, providing a comprehensive approach to movement analysis within the discipline [45].

Seminar activities included the preparation of two thematic papers to deepen students' engagement and application of biomechanics in sports disciplines:

Paper 1 (Requirements):

1. Cover Page: Last name, first name, specialization, chosen sport discipline, and topic.
2. Content:
   - Introduction: Argumentation about the chosen topic, including its importance, topicality, and motivation, supported by 2-3 recent sources (from 2022) from Google Scholar.
   - Biomechanics of the Chosen Sport Branch: Overview using 3-4 recent sources from Google Scholar (from 2022).
   - Biomechanics of the Chosen Sport Event: Detailed analysis.
   - Biomechanical Analysis of a Technical Skill/Element: In-depth examination.
3. Conclusions: Summary of insights and findings.
4. Bibliography: Formatted in APA style, sourced primarily from Google Scholar.

Paper 2 (Requirements):

1. Motivation for Sport Selection or Practice: Explanation of choice and its significance.
2. Specific Motor Fitness: Description and exemplification of general and specific physical training, including events/ exercises for testing/verification.
3. Technical Training: Systematization and exemplification of training processes.
4. Therapeutic/Medical Kinesiology: Focus on prophylaxis, traumatology with a bibliography of at least 5 sources.
5. Bibliography: Comprehensive listing of all sources used.

This formatting enhances readability and ensures that the academic requirements are clearly articulated for students, aligning with the educational goals of the kinesiology program.

Evaluation Methods and Assessment Criteria:

To assess students' fundamental knowledge in the discipline, the course adhered to the specified requirements and evaluation rules within the credit system and class grading protocol:

- *S1 (60% of Final Grade):* This is the aggregate of fractions from periodically evaluated activities. It includes:
  - A1 (20%)**:** Paper 1;
  - A2 (20%)**:** Paper 2;
  - A3 (20%)**:** Minimum 60% attendance in practical activities (Seminars). Each paper is graded on a scale of 1 to 10 points, with the final contribution calculated by multiplying the obtained score by the respective percentage.
- *Final Evaluation (FE) (40%):* Consists of a written examination assessing correctness, complexity of knowledge, logical coherence,

and assimilation of specialized language.

- *Final Grade (FG):* Computed by summing fractions from periodic evaluations (S1) and the final examination (FE). The final score is rounded off in favor of the student, ensuring that the minimum grade for the final evaluation is 5 points.

Additionally, to gather feedback on the course content "Fundamentals of Biomechanics of Physical Activities and Sports," a Google Forms questionnaire was administered. The survey, comprising six indicators, was also used to evaluate the teaching staff's effectiveness, providing insights into the teaching and evaluation processes [35].

Statistical Analysis

Statistical indicators such as mean and standard deviation were computed using KyPlot version 6.0 software (©1997-2020, KyensLab Inc). To assess mean differences between multiple irregular samples, the nonparametric Kruskal-Wallis Test was employed. A p-value of less than 0.05 was considered statistically significant.

Results

The study assessed the fundamental knowledge in the discipline of Kinesiology among 71 students, divided into two programs: Physical Education and Sports (PES), consisting of 43 students (37.2% female, 62.8% male), and Sports and Motor Performance (SMP), with 28 students (35.7% female, 64.3% male). Analysis of seminar participation and periodic evaluations indicated active engagement with the teaching activities, specifically through contributions to Paper 1 (A1), Paper 2 (A2), and seminar attendance (A3).

In terms of sports involvement, 37.3% of the students participated in recreational sports, while 62.7% were involved in competitive sports. Experience levels varied significantly: 29.1% of the participants had more than ten years of experience, 18.2% between eight to ten years, 20% for seven to eight years, and 10.9% for six years or fewer.

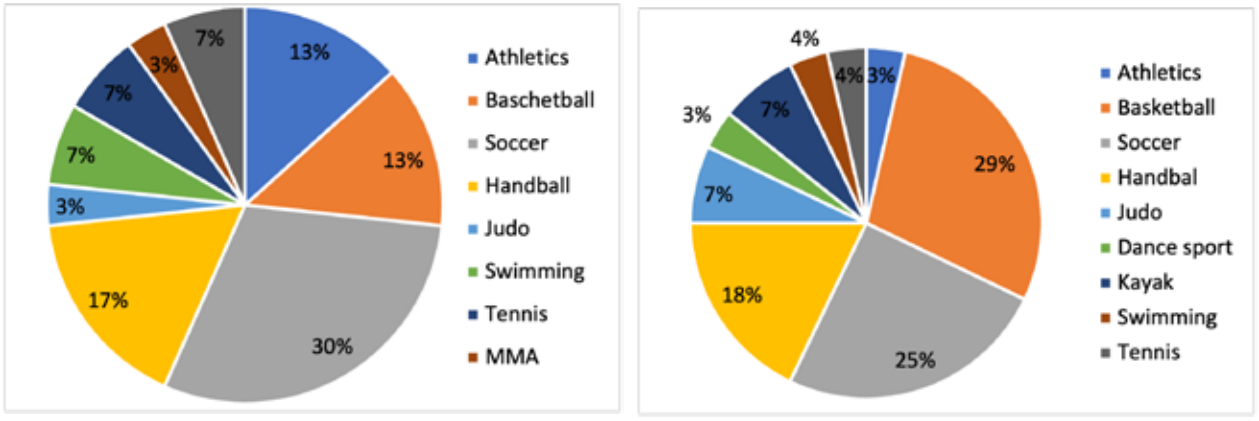
A survey was conducted among 30 students from two programs, Physical Education and Sports (PES) and Sports and Motor Performance (SMP), to gather opinions on the "Fundamentals of Biomechanics in Physical Activities and Sports" course. The distribution of sports interests varied between programs. In PES, the focus was more varied with 30% of students interested in football, 17% in handball, 13% in athletics and basketball, 7% each in tennis, swimming, and karate, and 3% in combat sports like judo and MMA. In contrast, SMP students showed a preference for basketball (29%), football (25%), handball (18%), and minor interests in kayaking, judo, athletics, tennis, and swimming (Figures 1A and 1B).

The evaluation of students' knowledge in Kinesiology adhered to the subject matter program's requirements and evaluation rules within the credit system. The results, which are presented in Table 1, highlight comparative performance across the study programs, indicating the level of knowledge assimilation and compliance with the academic standards.

Comparative Analysis of Student Performance

The statistical analysis of the course evaluations revealed subtle differences in academic performance between the Physical Education and Sports (PES) and Sports and Motor Performance (SMP) programs. For Paper 1 (A1), SMP students achieved a slightly higher average score by 3.5%, with 77% meeting the requirements, although this was not statistically significant ($p > 0.05$). Similarly, for Paper 2 (A2), SMP again scored higher by 1.5%, with 67% meeting the requirements ($p > 0.05$).

Attendance (A3) showed a higher average participation rate at PES by 8%, which may be attributed to the less intensive sports activities engaged by these students compared to those at SMP ($p > 0.05$). Overall, PES students slightly



A. PES B. SMP

Figure 1. Weight of sports events used within the course theme: PES - Physical Education and Sports; SMP - Sports and Motor Performance.

Table 1. Results of the evaluation of fundamental knowledge in the discipline of Kinesiology, n = 71

Variables		PES (n = 43)	SMP (n = 28)	Chi - Square	p-Value
A1 (20%)	pts	1.47 ±0.25	1.54 ±0.05	1.03	0.309
A2 (20%)	pts	1.31 ±0.40	1.34 ±0.47	0.18	0.668
A3 (20%)	pts	1.14 ±0.41	0.98 ±0.37	1.57	0.209
S1	pts	3.91 ±0.83	3.86 ±0.90	0.03	0.868
FE (E, 40%)	pts	2.95 ±0.42	3.00 ±0.54	0.21	0.649
S2	pts	6.89 ±1.14	6.87 ±1.26	0.08	0.781
Final grade	grade	7.25 ±0.96	7.04 ±1.35	0.03	0.855

Values are expressed as means ± standard deviations. Nonparametric Kruskal-Wallis Test

outperformed SMP in periodically evaluated activities (S1), with 65.2% achieving the required standards compared to 64.3% at SMP ($p > 0.05$).

The final examination scores averaged 7.5 points, with SMP scoring marginally higher by 0.13 points ($p > 0.05$). When considering both periodic evaluations and final examination scores (S2), the differences were minimal, showing only a 0.02 point difference ($p > 0.05$). The final grades reflected a higher mean score at PES by 0.21 points ($p > 0.05$), indicating better overall performance, possibly due to greater seminar participation and fewer absences at PES compared to SMP.

Assessment of Minimum and Maximum Performance Standards

An analysis of performance standards revealed minor differences between the Physical Education and Sports (PES) and Sports and Motor Performance (SMP) programs. For achieving minimum performance standards, 11.6% of PES students and 14.3% of SMP students met the criteria. In terms of maximum performance standards, 34.9% of PES students and 32.1% of SMP students reached the highest benchmarks. While there are variations, the overall performance and adherence to requirements show substantial equivalence between the two programs.

Student Opinions on Course Content

To gauge student perceptions of the "Fundamentals of Biomechanics in Physical Activities and Sports" course, a questionnaire was conducted. The summarized opinions on the course content are detailed in Table 2. This feedback is crucial for understanding student satisfaction and areas for improvement in the curriculum delivery.

The student feedback on the course content was largely positive. A substantial 50.9% of the participants rated the course as very good. Specifically, 63.3% praised the application of general principles of mechanics and biomechanics highly, and 52% were very satisfied with the teachings on kinematic and dynamic characteristics.

47% of the respondents found the applied biomechanics content in the Kinesiology discipline to be very good, highlighting the relevance and quality of the information provided. Additionally, 50% of the students noted that the integration of sports biomechanics and physical exercises was very beneficial for enhancing adaptive effects, and 46.7% believed it significantly reduced risks associated with physical activities.

The relevance of biomechanical knowledge across various disciplines was highly regarded by 49.9% of the students, who acknowledged its importance in optimizing sports performance and preventing injuries. Furthermore, 66.7% of the respondents found the use of quantitative and qualitative methods in movement analysis to be very efficient. The use of video techniques and image analysis was rated very good by 43.3% of the students, appreciating both the quantitative tools (software) and qualitative aspects (feedback to athletes).

Overall, the feedback indicates strong student appreciation for the course content and teaching methodologies, underscoring their significance in professional training within the Kinesiology discipline.

Evaluation of Course Effectiveness and Teaching Quality

In assessing performance standards within the course "Fundamentals of Biomechanics in Physical Activities and Sports," 37.7% of students rated their achievement of minimum performance standards as "very well," while nearly half of the participants (49.9%) rated their achievement of maximum performance standards similarly. These findings indicate that both the content and teaching methodologies of the course are highly regarded by students and deemed essential for their professional training in kinesiology.

Furthermore, to evaluate the effectiveness of teaching activities within the Kinesiology discipline, a questionnaire was distributed among students who interacted with the teaching staff during lectures and seminars throughout the semester. The overwhelmingly positive feedback is detailed in Figure 2, suggesting that the educational approaches employed are well-received and contribute significantly to student learning outcomes.

Table 2. Weight of the opinions of subjects regarding the content of the course "Fundamentals of Biomechanics of Physical Activities and Sports" in the Kinesiology discipline (n=30).

No.	Content		Grades (%)		
			3	4	5
1	General foundations of mechanics and biomechanics		16.7	13.3	63.3
2	Kinematic characteristics of motion	linear	16.7	23.3	50
		angular	16.7	16.7	60
3	Dynamic characteristics of motion	inertial	20	20	46.7
		force	23.3	13.3	53.3
		energetic	16.7	23.3	50
4	Basic knowledge of biomechanics applied in Kinesiology		16.7	33.3	63.3
5	Scientific disciplines used in biomechanics	mathematics	33.3	16.7	66.7
		physics	16.7	26.7	43.3
6	Qualitative and quantitative analysis in scientific research		33.3	16.7	66.7
7	The content of biomechanics	linear	23.3	20	50
		angular	20	30	43.3
8	Elements of sports biomechanics and exercise biomechanics	favoring factor ...	6.7	40	50
		elimination factor ...	13.3	33.3	46.7
9	Disciplines that utilize knowledge from biomechanics, aiming at	performance increase...	6.7	26.7	53.3
		prevention of accidents...	33.3	30	53.3
		reducing decline...	33.3	36.7	43.3
10	Which of the presented options do you consider more effective in analyzing movement?	qualitative	22.2		
		quantitative	11.1		
		qualitative and quantitative	66.7		
11	Video techniques and image analysis	quantitative (software)	20	36.7	43.3
		qualitative (feed-back)	20	36.7	43.3
12	The importance of the content of the discipline taught and its necessity in professional training		3.3	36.7	60
13	Assessment of the level of meeting the minimum performance standard	definition of basic notions	16.7	33.3	50
		systematization and general classifications	3.3	66.7	30
		limited operationalization	26.7	40	33.3
14	Assessment of the level of meeting the maximum performance standard	integrative concepts ...	6.7	30	63.3
		presentation of information ...	20	36.7	43.3
		identifying and presenting models	10	36.7	53.3

Notes. 3 – moderate opinion, 4 – good and 5 – very good

These results reflect a robust foundation within the study program, although continuous improvements and adjustments are necessary to enhance educational delivery and student satisfaction.

Student Feedback on Kinesiology Teaching Practices

The study surveyed 36 students from the Physical Education and Sports (PES) and Sports and Motor Performance (SMP) programs. The participants demonstrated a high level of satisfaction with the teaching practices in the Kinesiology discipline. Specifically, 68.6% positively rated the quality of teaching activities, 66.7% were satisfied with the use and efficiency of teaching methods, and 61.1% appreciated the teacher-student relationship and efforts in training students for their personal development. Furthermore, 66.7% praised the objectivity and transparency of evaluations, and 72.2% noted the effective training in extracurricular activities provided by the faculty.

These results indicate strong aspects of the educational approach within the Kinesiology program. However, they also suggest areas for improvement to enhance the academic experience comprehensively. Actively incorporating student feedback into educational strategies is crucial for continual enhancement of the teaching and learning process.

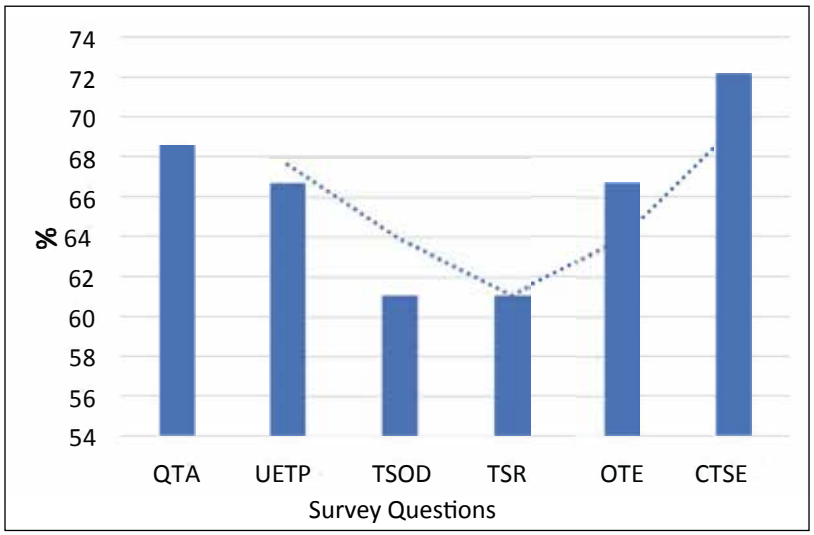


Figure 2. Students' assessment regarding the teaching activity conducted in the Kinesiology discipline: QTA - Quality of Teaching Activity; UETP - Use and Efficiency of Teaching Tools in the Learning Process; TSOD - Training the Student for Their Own Development; TSR - Teacher-Student Relationship; OTE - Objectivity and Transparency in Evaluation; CTSE - Capacity to Train the Student in Extracurricular Activities.

Discussion

The primary aim of this study was to assess the fundamental knowledge of Kinesiology among university students and to explore its impact on the quality of education within the disciplines of Physical Education and Sports (PES) and Sports and Motor Performance (SMP). Our findings reveal significant differences in thematic preferences between the two study programs, which could have profound implications for educational strategies.

The analysis of covered topics indicates a higher proportion of sports events in PES, with 30% of students participating in soccer, 17% in handball, 13% in athletics and basketball, 7% in tennis, swimming, and karate, and 3% in combat sports such as judo and MMA. Conversely, in the SMP program, 29% of subjects are interested in basketball, 25% in soccer, 18% in handball, 7% in kayaking and judo, and 4% in athletics, tennis, and swimming. These data reveal significant differences in thematic preferences between students from the two study programs, reflecting the diversity of interests and specific focus in the field of kinesiology (Fig. 1).

Additionally, concerns related to the content of the topics were addressed by studying the biomechanical aspects of movements specific to certain sports, practiced and preferred by the research subjects. Basketball, one of the most popular and widely viewed sports globally, provides a case in point. To enhance players' shooting accuracy, efficiency, and running speed before shots, it is crucial to analyze some biomechanical principles. Furthermore, modifications to footwear are suggested to reduce the risk of injury and improve sports performance in basketball [36, 37].

Proprioceptive training has shown significant benefits in improving agility skills in dance sports, particularly evident in tests like the "Eight" Figure with Flexion and Lateral Steps. These findings support the integration of this training type into regular dance practice to enhance performance and reduce injury risks [38, 39]. In sports biomechanics, similar emphasis on optimal performance and injury prevention is observed in different sports contexts.

A study on handball goalkeepers revealed that expert goalkeepers anticipate and initiate movement earlier than their less experienced counterparts during long-distance throws, demonstrating the importance of experience and training in reaction times and kinematics [40]. Another research found that training for vertical (VDJ) and horizontal jumps (HDJ) significantly enhances sprint and change of direction (COD) performance. Notably, VDJ was more effective in improving vertical jump abilities, whereas HDJ was beneficial for short-distance and COD performance improvements [41].

In judo, biomechanical assessments and skill-specific evaluations have been crucial. Detailed measurements and targeted tests help refine training control and enhance performance. Studies have also emphasized the critical role of biomechanical factors like flexibility and Kumikata in selecting and performing specific judo techniques [42, 43].

The advancement of technology has made biomechanical analysis a crucial component in competitive football training, highlighting the need for precise biomechanical studies to better understand the impact of mechanics on football performance [50]. Future research should continue to delineate the role of biomechanics in sports, aiming to clarify its contributions to

enhancing athletic performance and reducing injuries.

In the teaching of the Kinesiology course, a pivotal study was introduced that applied macro-learning methods to train female gymnasts [45]. This study utilized video-computerized methodologies and postural reference points to significantly enhance kinematic and dynamic parameters across gymnastics apparatus like vaults and uneven bars. The effectiveness of this approach was validated through scientific citations and increased academic interest, suggesting its applicability across various sports disciplines [45].

Further, an innovative observational model for analyzing kayaking sprint techniques was proposed, breaking down the motion into distinct phases for more nuanced analysis. This model was beneficial in identifying performance discrepancies related to the spinal column's sagittal position and hamstring extensibility among rowers of varying skill levels, underscoring the influence of individual and anthropometric factors on equipment setup [46, 47].

In swimming, a study focused on the biomechanics of dive starting revealed that regular practice significantly boosts performance, emphasizing the necessity for coaches to incorporate dive start drills in training regimes. This research also explored various biomechanical variables like stroke length, rate, and kinematics, and their interplay in optimizing swimming performance. Understanding these variables offers students and professionals insights into strategic performance enhancement [48, 49].

These examples highlight how biomechanics is integrated into sports science education, providing students with the tools to become knowledgeable coaches, kinesiotherapists, or researchers, equipped to apply biomechanical principles effectively in sports and human performance contexts.

The high participation rate of 79.8% from the enrolled students provides a robust basis for evaluating performance within the Kinesiology programs. The sample's gender balance and diverse involvement in grassroots and performance sports enhance the relevance and diversity of the analysis. By assessing fundamental competencies through seminar activities and indicators A1 (Paper 1), A2 (Paper 2), and A3 (attendance and seminar activity), we gain a comprehensive view of the students' understanding and skills in Kinesiology (Table 1).

The comparative analysis of statistical results shows no significant differences in performance and academic requirements fulfillment, although there are noteworthy trends. In SMP, students showed slightly higher averages in Paper 1 and Paper 2, yet these differences were not statistically significant. Similarly, PES students exhibited a higher average in attendance by 8%, which also lacked statistical significance. This pattern may reflect the more intensive engagement of PES students in elite sports activities.

In terms of periodic evaluations (S1) and final evaluations (FE), both programs demonstrated comparable achievements. Notably, even though SMP students had marginally higher averages in final evaluations, these differences were not statistically significant. However, PES students achieved marginally higher final grades, likely due to their lower absence rates and more active participation in practical seminar activities.

The analysis of minimum and maximum performance standards shows only slight variations between the programs, with a marginally higher percentage of PES students achieving the maximum standard. These findings suggest that while both programs perform well, there are subtle differences in how students meet academic and practical requirements, underlining the need for tailored educational strategies to optimize learning outcomes and practical applications in the field of Kinesiology.

Innovative teaching methodologies in biomechanics have shown promising results in enhancing student learning outcomes. Bagesteiro [9] highlights an active-experimental learning approach for undergraduate kinesiology students, which significantly improved their critical thinking skills and proficiency with biomechanical analysis tools. This method facilitated better data interpretation and understanding of human movement mechanics, demonstrating the value of hands-on, experiential learning in this field.

Similarly, Hsieh and Knudson [12] identified key factors influencing the success in learning biomechanical concepts, including exam performance, interest in the subject, and prior knowledge in physics. These factors underscore the importance of engaging and well-structured coursework that aligns with students' academic backgrounds and interests.

Further, Ives and Knudson [51] advocate for a more integrated approach within physical exercise science programs, emphasizing the need to incorporate diverse academic disciplines of kinesiology, such as biomechanics and motor behavior. This integration is crucial for preparing students comprehensively, enhancing their professional capabilities in various sports and health-related domains.

Esposito et al. [52] delve into students' perceptions of their training in kinesiology, revealing a general appreciation for academic training despite some reported discrepancies in the knowledge and skills acquired. The study points out that while a significant portion of students attain qualifications from national sports federations, a smaller percentage obtain credentials from other institutions, indicating a

variance in certification standards and possibly in educational content and quality.

Knudson and Wallace [19] explore student perceptions and epistemological beliefs about active learning exercises in biomechanics. While most students view these methods positively, the link between these perceptions and actual mastery of biomechanical concepts remains unclear, suggesting an area for further research.

These studies collectively highlight the critical need for educational strategies that not only provide robust theoretical knowledge but also emphasize practical, applied learning. By enhancing curricular offerings and pedagogical approaches in biomechanics within kinesiology programs, educational institutions can better equip students to meet the challenges of professional practice in sports and health sciences.

The feedback from students on the "Fundamentals of Biomechanics in Physical Activities and Sports" course reflects a generally positive reception and substantial appreciation for the material presented. Notably, 50.9% of students rated the course content as "very good," and 29.7% deemed it "good," indicating strong approval of the curriculum's relevance and value in the field of kinesiology (Table 2).

Students particularly praised the course's effective teaching of general mechanics and biomechanics principles, with 63.3% labeling it "very good." The kinematic and dynamic aspects of the course were also well-received, with 52% of responses rating these components highly. This positive feedback underscores the course's success in conveying complex concepts in a manner that enhances students' understanding and application in sports and physical activities.

Additionally, nearly half of the students (47%) expressed a "very good" opinion about the specific content related to applied biomechanics within the discipline, highlighting its essential role and coherent integration into the curriculum. The application of sports biomechanics and physical exercises was particularly appreciated for its role in augmenting adaptive effects and mitigating risks associated with physical activities, with 50% and 46.7% of students, respectively, finding these aspects highly beneficial.

The use of motion analysis methods, including video techniques and image analysis, was also favorably reviewed, with 43.3% of students recognizing the quantitative and qualitative value of these tools in enhancing athletic performance. This feedback suggests that such technologies are crucial for a deeper understanding and improvement of sports techniques and strategies.

These findings collectively demonstrate the course's effectiveness in delivering biomechanics education that is not only academically rigorous but also practically relevant, thereby supporting students' professional development in the field of kinesiology.

The results from the questionnaire offer insightful evaluations of the teaching staff within the Kinesiology discipline, illustrating a generally positive student perception of educational quality and engagement (Figure 2) [35]. Notably, the high ratings for "Quality of Teaching Activity" (QTA) and "Use and Efficiency of Teaching Tools in the Learning Process" (UETP) affirm the teaching staff's commitment to delivering content effectively using appropriate methodologies and educational tools. These efforts clearly resonate with the students, enhancing their learning experience.

Moreover, the appreciation shown for "Training the Student for Their Own Development" (TSOD) and "Capacity to Train the Student in Extracurricular Activities" (CTSE) underscores the proactive engagement of faculty in fostering not only academic but also personal and professional growth among students. This holistic approach to education is crucial for preparing students to meet real-world challenges.

Another positive aspect reflected in the feedback is the "Objectivity and Transparency in Evaluation" (OTE), where a significant majority perceive the evaluation processes as fair and transparent. This perception is vital for maintaining trust and integrity within the academic framework.

However, the relatively lower scores for "Teacher-Student Relationship" (TSR) suggest an area that could benefit from enhanced interaction and communication. Improving this dynamic could foster a more inclusive, supportive, and collaborative educational environment, which is essential for maximizing student engagement and satisfaction.

Overall, while the feedback is predominantly positive, highlighting the effectiveness and dedication of the teaching staff, there remains an opportunity to strengthen the teacher-student relationship, further enhancing the educational experience within the Kinesiology discipline.

The evaluation of diverse teaching models within biomechanics has underscored the pivotal role of physical education and sports pedagogy within the broader context of kinesiology [33]. These studies advocate for an expansive view of pedagogy that not only enriches the academic discipline but also enhances the practical application of biomechanical principles [6]. Such an approach is particularly crucial for students who aim to become physical education teachers, highlighting the need for improved pedagogical strategies to enhance their understanding and application of biomechanical concepts [23].

Tinning emphasizes the significance of sports pedagogy in kinesiology, advocating for a generative approach to pedagogy that

facilitates both the production and reproduction of knowledge across various subdomains of this field [5]. Additionally, the study by Woods et al. explores how well the interests and competencies of doctoral students in kinesiology align with the demands of academic roles in higher education. This study reveals the necessity for a comprehensive set of skills that prepare students for diverse academic responsibilities [53].

In summary, the integration of research findings and relevant literature emphasizes the crucial role of biomechanics in kinesiology within higher education settings. It highlights the need for a profound understanding of biomechanical principles and their effective implementation to improve educational outcomes and student performance in physical education and sports. This comprehensive approach is essential for developing well-rounded professionals capable of contributing to the advancement of kinesiology as an academic and practical discipline.

Conclusions

This research has highlighted the crucial role of fundamental knowledge in Kinesiology in shaping the quality of higher education within the fields of Physical Education and Sports (PES) and Sports and Motor Performance (SMP). The study has successfully utilized a detailed analytical approach based on the curriculum and evaluation criteria to assess and enhance the educational process effectively.

Our findings underscore the importance of adapting educational strategies to the diverse needs of students across different study programs. While the data suggest no significant disparities in performance across these programs, the variability observed points to the potential benefits of personalized educational interventions. These tailored strategies could better address individual academic needs and promote more equitable learning outcomes.

Feedback from students regarding the course content and instructional methods in Kinesiology has been predominantly positive, reflecting the curriculum's relevance and effectiveness in conveying complex biomechanical concepts and their applications in sports and health sciences. The appreciation noted for the teaching methodologies further emphasizes the impact of innovative pedagogical approaches on student engagement and comprehension.

Nonetheless, the insights gathered also indicate areas that could benefit from further refinement, particularly in enhancing interactive and communicative aspects of teaching to foster a more engaging and supportive learning environment. Strengthening the professor-student relationship and incorporating a broader array of teaching methods may better accommodate the varied learning styles and preferences within the student body.

Overall, the study advocates for ongoing efforts to refine educational practices in Kinesiology, ensuring they remain dynamic and responsive to both the academic and practical needs of students preparing for careers in physical education and sports science.

Acknowledgement

This study is part of the research theme of the Department of Physical Education and Sports at the University Center of Pitești, within the National University of Science and Technology "Politehnica" of Bucharest, for the academic year 2023-2024. We would like to express our gratitude to Professor Crețu Marian for the support provided in using the course theme in the "General Kinesiology" discipline across all investigated study programs. We also thank the subjects who participated in this research.

Conflict of interest

There is no conflict of interest to declare.

References

1. Armour KM, Chambers FC. 'Sport & Exercise Pedagogy'. The case for a new integrative sub-discipline in the field of Sport & Exercise Sciences/ Kinesiology/Human Movement Sciences. *Sport, Education and Society*, 2014;19(7):855–868. https://doi.org/10.1080/13573322.2013.859132
2. Hoffman SJ. *Introduction to kinesiology: studying physical activity*. Human Kinetics; 2009.
3. Dzewaltowski DA, McElroy M, Musch TI, Poole DC, Harms CA. Kansas State University physical activity systems framework: Integration of the discipline of kinesiology and public health. *Kinesiology Review*, 2015;4(4):346–354. https://doi.org/10.1123/kr.2015-0034
4. Knudson DV, Brusseau TA. (Eds.). *Introduction to kinesiology: studying physical activity*. Human Kinetics; 2021.
5. Tinning R. Pedagogy, sport pedagogy, and the field of kinesiology. *Quest,* 2008;60(3):405–424. https://doi.org/10.1080/00336297.2008.10483589
6. Solmon MA. Physical education and sport pedagogy: The application of the academic discipline of kinesiology. *Kinesiology Review*, 2021;10(3):331–338. https://doi.org/10.1123/kr.2021-0026
7. Gill DL. Integration: The key to sustaining kinesiology in higher education. *Quest*, 2007;59 (3):269–286. https://doi.org/10.1123/kr.2021-0029
8. Medved V. From research to teaching human kinesiological biomechanics: a Zagreb experience. In Challenges in Remote Sensing. In: *Proceedings of the 3rd WSEAS International Conference on Remote Sensing* (REMOTE 07), 2007. P. 43–46.

9. Bagesteiro LB. Practical experiential learning: a methodology approach for teaching undergraduate biomechanics. *Journal of Kinesiology & Wellness*, 2020;9:58–68. https://doi.org/10.56980/jkw.v9i.80
10. McLester J, St Pierre P. *Applied biomechanics: concepts and connections*. Second edition. Burlington, MA: Jones & Bartlett Learning; 2020.
11. Belmont RS, Lemos EDS. Biomechanics in physical education courses: a pedagogical view. *Aprendizagem Significativa em Revista/Meaningful Learning Review*, 2018;8(2):19–30.
12. Hsieh C, Knudson D. Important learning factors in high-and low-achieving students in undergraduate biomechanics. *Sports biomechanics*, 2018;17(3):361–370. https://doi.org/10.1080/14763141.2017.1347194
13. Wallace B, Knudson D. The effect of course format on student learning in introductory biomechanics courses that utilise low-tech active learning exercises. *Sports Biomechanics*, 2024;23(2):156–165. https://doi.org/10.1080/14763141.2020.1830163
14. Drewlinger DM. *Biomechanics: emergence of an academic discipline in the United States*. Texas Woman's University; 1996.
15. Abernethy B, Kippers V, Hanrahan SJ, Pandy MG, McManus AM, Mackinnon LT. *Biophysical Foundations of Human Movement*. 3rd ed. Human Kinetics; 2013. https://doi.org/10.5040/9781492595304.part-003
16. Alderink GJ, Ash BM. *Clinical kinesiology and biomechanics: a problem-based learning approach*. Cham: Springer; 2023.
17. Thomas SJ, Zeni JA, Winter DA. *Winter's Biomechanics and Motor Control of Human Movement*. John Wiley & Sons; 2022.
18. Knudson D. *Fundamentals of Biomechanics*. Boston, MA: Springer US; 2003. https://doi.org/10.1007/978-1-4757-5298-4
19. Knudson D, Wallace B. Student perceptions of low-tech active learning and mastery of introductory biomechanics concepts. *Sports Biomechanics,* 2021;20(4):458–468. https://doi.org/10.1080/14763141.2019.1570322
20. Vagenas G, Palaiothodorou D, Knudson D. Thirty-year trends of study design and statistics in applied sports and exercise biomechanics research. *International Journal of Exercise Science*, 2018;11(1):239–259.
21. Hamill, J. Biomechanics curriculum: its content and relevance to movement sciences. *Quest,* 2007;59(1):25–33. https://doi.org/10.1080/00336297.2007.10483533
22. Keogh JW, Moro C, Knudson D. Promoting learning of biomechanical concepts with game-based activities. *Sports Biomechanics*, 2024;23(3):253–261. https://doi.org/10.1080/14763141.2020.1845470
23. Stiles VH, Katene WH. Improving physical education student teachers' knowledge and understanding of applied biomechanical principles through peer collaboration. *Physical Education and Sport Pedagogy*, 2013;18(3):235–255. https://doi.org/10.1080/17408989.2012.666788
24. Gregor RJ. Interdisciplinary vertical integration: The future of biomechanics. *Quest*, 2008;60(1):31–44. https://doi.org/10.1080/00336297.2008.10483567
25. Hamill J, Knutzen KM, Derrick TR. Biomechanics: 40 years on. *Kinesiology Review*, 2021;10(3): 228–237. https://doi.org/10.1123/kr.2021-0015
26. Brink KJ, Likens A, Stergiou N. The Evolution of Scholarship of Biomechanics and Motor Control Within the Academy: The Past, the Present, and the Future. Kinesiology Review, 2023;13(1): 42–54. https://doi.org/10.1123/kr.2023-0054
27. Di Domenico F. From biomechanics to learning: Continuum for the theory of physical and sports education. *Journal of Human Sport and Exercise*, 2020;15(2proc):S268–S278. doi:https://doi.org/10.14198/jhse.2020.15.Proc2.18
28. Nigg BM, MacIntosh BR, Mester J. *Biomechanics and biology of movement*. Human Kinetics; 2000.
29. Knudson D. *Fundamentals of biomechanics*. Springer Nature Switzerland AG; 2021. https://doi.org/10.1007/978-3-030-51838-7
30. Knudson D. An integrated approach to the introductory biomechanics course. *Physical Educator*, 2003;60(3):122–133.
31. Hazari A, Maiya AG, Nagda TV. *Conceptual Biomechanics and Kinesiology*. Singapore: Springer Singapore; 2021. https://doi.org/10.1007/978-981-16-4991-2
32. Anderson DI, van Emmerik RE. Perspectives on the academic discipline of kinesiology. *Kinesiology Review*, 2021;10(3):225–227. https://doi.org/10.1123/kr.2021-0029
33. Riskowski JL. Teaching undergraduate biomechanics with just-in-time teaching. *Sports Biomechanics*, 2015;14(2):168–179. https://doi.org/10.1080/14763141.2015.1030686
34. Creţu M. *Kinesiologie generală* [General Kinesiology]. University of Pitesti Press; 2013. (In Romanian).
35. Manolachi V, Potop V, Chernozub A, Khudyi O, Delipovici I, Eshtayev S, Mihailescu LE. Theoretical and applied perspectives of the kinesiology discipline in the field of physical education and sports science. *Physical Education of Students*, 2022;26(6):316–324. https://doi.org/10.15561/20755279.2022.0606
36. Chakraborty S, Mondal P. Importance of biomechanics in Basketball layup shot. *International Journal of Physical Education, Sports and Health*, 2020; 7(5):237–239.
37. Lam WK, Kan WH, Chia JS, Kong PW. Effect of shoe modifications on biomechanical changes in basketball: A systematic review. *Sports Biomechanics*, 2022;21(5):577–603. https://doi.org/10.1080/14763141.2019.1656770
38. Ljubojevic A, Popovic B, Bijelic S, Jovanovic S. Proprioceptive training in dance sport: effects of agility skills. *Turkish Journal of Kinesiology*, 2020;6(3):109–117. https://doi.org/10.31459/turkjkin.742359
39. Cantergi D, Moraes LR, Loss JF. Applications

of Biomechanics Analysis in Dance: In: Pessali-Marques B (ed.) *Advances in Media, Entertainment, and the Arts*, IGI Global; 2021. P. 25–44. https://doi.org/10.4018/978-1-7998-4261-3.ch002
40. Rojas FJ, Gutiérrez-Davila M, Ortega M, Campos J, Párraga J. Biomechanical analysis of anticipation of elite and inexperienced goalkeepers to distance shots in handball. *Journal of Human Kinetics*, 2012;34(1):41–48. https://doi.org/10.2478/v10078-012-0062-0
41. Iacono AD, Martone D, Milic M, Padulo J. Vertical- vs. horizontal-oriented drop jump training: chronic effects on explosive performances of elite handball players. *The Journal of Strength & Conditioning Research*, 2017;31(4):921–931. https://doi.org/10.1519/JSC.0000000000001555
42. Boguszewska K, Boguszewski D, Buśko K. Special Judo Fitness Test and biomechanics measurements as a way to control physical fitness in young judoists. *Archives of Budo,* 2010;6(4):205–209.
43. Brabec L, Aedo-Muño, E, Brito CJ, Miarka B, Bustamante-Garrido A, Ariagada D, et al. Physical and biomechanical aspects that can influence the preference for the uchimata technique in judo: A case study. *ISBS Proceedings Archive*, 2023;41(1):13.
44. Nunome H, Hennig E, Smith N. (Eds.). *Football biomechanics*. New York, NY: Routledge; 2017. https://doi.org/10.4324/9781315638553
45. Potop V, Manolachi V. The scientific impact of applied biomechanics research in artistic gymnastics. *Revista Romaneasca pentru Educatie Multidimensionala*, 2020;12(3):213–218. https://doi.org/10.18662/rrem/12.3/318
46. McDonnell LK, Hume PA, Nolte V. An observational model for biomechanical assessment of sprint kayaking technique. *Sports Biomechanics*, 2012;11 (4):507–523. https://doi.org/10.1080/14763141.2012.724701
47. Abelleira-Lamela T, Vaquero-Cristóbal R, Esparza-Ros F, Marcos-Pardo PJ. Biomechanical adaptations in kayakers of different competitive levels and the relationship with the kayak elements. *Applied Sciences*, 2020;10 (23),8389. https://doi.org/10.3390/app10238389
48. Blanksby B, Nicholson L, Elliott B. Swimming: Biomechanical analysis of the grab, track and handle swimming starts: an intervention study. *Sports Biomechanics*, 2002;1(1):11–24. https://doi.org/10.1080/14763140208522784
49. Barbosa TM, Marinho DA, Costa MJ, Silva AJ. Biomechanics of Competitive Swimming Strokes. In: Klika V (ed.) *Biomechanics in Applications*, InTech; 2011. https://doi.org/10.5772/19553
50. Mihailović B, Lilić L, D'Onofrio R, Koliopoulos T, Pal M, Iacob GS. Biomechanics of Kicks in Football: A Review. *Ita J Sports Reh Po*, 2023;10(9):2779–2791.
51. Ives JC, Knudson D. The need for greater disciplinarybalance.*SportsMedicine*,2007;37:103–115. https://doi.org/10.2165/00007256-200737020-00002
52. Esposito G, Di Domenico F, Ceruso R, Aliberti S, Raiola G. Perceptions/opinions about the formation of the bachelor program in exercise and sports science by students aimed at the new professional profile of the basic kinesiologist. *Sport Sciences for Health*, 2024; 1–6. https://doi.org/10.1007/s11332-023-01139-8
53. Woods ML, Karp GG, Feltz DL. Positions in kinesiology and physical education at the college or university level. *Quest,* 2003;55(1):30–50. https://doi.org/10.1080/00336297.2003.10491787

Information about the authors:

Vladimir Potop; https://orcid.org/0000-0001-8571-2469; vladimir_potop@yahoo.com; Doctoral School of Sports Science and Physical Education, National University of Science and Technology Polytechnic Bucharest, University Center Pitești (Pitesti, Romania); Department of Physical Education and Sport, National University of Science and Technology Polytechnic Bucharest, University Center Pitești (Pitesti, Romania); State University of Physical Education and Sport (Chisinau, Republic of Moldova).

Liviu E. Mihailescu; (Corresponding author); https://orcid.org/0000-0001-9501-7953; liviumihailescu2006@yahoo.com; Department of Physical Education and Sport, National University of Science and Technology Polytechnic Bucharest, University Center Pitești; Pitesti, Romania.

Ion Mihaila; https://orcid.org/0000-0001-6173-9771; paulmihaila@yahoo.com; Doctoral School of Sports Science and Physical Education, National University of Science and Technology Politehnica Bucharest, University Center Pitești (Pitesti, Romania); Department of Physical Education and Sport, National University of Science and Technology Polytechnic Bucharest, University Center Pitești (Pitesti, Romania).

Monika Zawadka-Kunikowska; https://orcid.org/0000-0003-3861-7113; m.zkunikowska@cm.umk.pl; Department of Human Physiology, Nicolaus Copernicus University; Torun, Poland.

Wladyslaw Jagiello; https://orcid.org/0000-0001-7417-4749; wjagiello1@wp.pl; Sports Department, Gdansk University of Physical Education and Sport; Gdansk, Poland.

Andrii Chernozub; https://orcid.org/0000-0001-6293-8422; chernozub@gmail.com; Lesya Ukrainka Volyn National University; Lutsk, Ukraine.

Mihai Sebastian Baican; https://orcid.org/0009-0009-7845-9392; dr_mihaib@yahoo.com; Swiss Med Clinic; Bucharest, Romania.

Olivia Carmen Timnea; https://orcid.org/0000-0002-7308-5709; oliviatimnea@yahoo.com; Romanian-American University; Bucharest, Romania.

Carmen Ene-Voiculescu ; https://orcid.org/0009-0009-1176-1706; carmenenevoiculescu@gmail.com; „Ovidius" University of Constanta; Constanța, Romania.

Alexandru Ascinte; https://orcid.org/0000-0001-6401-4506; alexandruacsinte@hotmail.com; "Vasile Alecsandri" University of Bacau; Bacau, Romania.

Cite this article as:
Potop V, Mihailescu LE, Mihaila I, Zawadka-Kunikowska M, Jagiello W, Chernozub A, Baican MS, Timnea OC, Ene-Voiculescu C, Acsinte A. Applied biomechanics within the Kinesiology discipline in higher education. *Physical Education of Students,* 2024;28(2):106–119.
https://doi.org/10.15561/20755279.2024.0208

Received: 10.03.2024

Accepted: 28.04.2024; **Published**: 30.04.2024

PHYSICAL EDUCATION OF STUDENTS

ORIGINAL ARTICLE

Interaction of integral parameters of physical state and biological age of students aged 17-19 years old in the process of adaptation to standard and experimental physical education programs

Oleksandr Pryimakov[1,2ABCDE], Marek Sawczuk[3CDE], Stanislav Prysiazhniuk[4CDE], Georgy Korobeinikov[5ADE], Nataliya Mazurok[1,2CDE]

[1] *Faculty of Physical Culture and Health Promotion, Szczecin University, Poland*
[2] *Mykhailo Drahomanov Ukrainian State University, Ukraine*
[3] *Gdansk University of Physical Education and Sport, Gdansk, Poland*
[4] *The National Defence University of Ukraine named after Ivan Cherniakhovskyi, Ukraine*
[5] *Uzbek State University of Physical Education and Sports, Tashkent, Uzbekistan*

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim: The process of adaptation to physical education programs is a critical factor influencing the health and physical development of students. Understanding how these programs affect both the physical state and biological age of students can significantly improve their effectiveness. The aim of the study is to investigate the interaction between integral parameters of physical state (PS) and biological age (BA) of students aged 17-19 years old in the process of adaptation to standard and experimental physical education (PE) programs.

Material and Methods: The study involved 140 first-year students of the National University of Telecommunications - 80 males and 60 females. In the course of the research, the indices of functional state, physical fitness (PF) and physical development (PD), biological age (BA) were recorded in young men and women of the control (CG) and experimental (EG) groups. To process the experimental material, methods of dispersion and canonical analysis were used and multiple correlation and determination coefficients were calculated.

Results: It was revealed that the impact of PS integral parameters on students' BA is stronger than the inverse influence of BA on PS parameters. The degree of BA reduction under the influence of the studied factors is most pronounced in the EG of girls and boys. The variability of the group of PD and PF indices is accompanied by the variability of most of the BA parameters' dispersion in all studied groups of students. The factor of gender has the greatest impact on the BA of students. Girls have lower initial values of BA and it's a more pronounced decrease by the end of the experiment. The effectiveness of the impact of an aerobically oriented experimental program on the improvement of students' PS and reduction of BA was confirmed. Under the influence of the experimental program, the BA of EG girls decreases to a greater extent in comparison with EG boys and students of both control groups. Changes and differences in BA of boys and girls of EG and CG are due to the combined impact of the factor of PE software and that of adaptation changes of students' PS in the annual process of PE. In the group of boys and girls more pronounced influence on BA in the course of the experiment was produced by the factor of software and adaptation changes, respectively.

Conclusions: The gender factor has the strongest impact on students' BA - girls have lower initial values of BA and it's a more pronounced decrease by the end of the experiment in comparison with boys. Adaptation changes of PS in the process of software implementation are accompanied by a decrease in BA in the experimental groups. One of the criteria and confirmations of the effectiveness of the developed PE program is the degree of mutual influence of PS integral parameters, which is most pronounced in the reduction of BA in the experimental groups of girls and boys.

Keywords: students, gender, physical education, biological age, physical state, mutual influence.

Introduction

Accurately assessing the impact of physical education programs on student well-being and performance is increasingly recognized as a vital component of educational strategies. Understanding the physiological adaptations of students to physical education programs is crucial for optimizing health and performance outcomes. In this context, biological age (BA) provides a unique lens through which these adaptations can be assessed, highlighting variations in physical development that are not evident from chronological age alone.

Biological age is an integral parameter of a

doi:10.15561/20755279.2024.0209

human's physical state, encompassing physical development (PD), functional and physical fitness (PF), somatic health, and physical work capacity. These factors together provide a comprehensive measure of an individual's health and capabilities relative to their age group [1, 2, 3]. It is noted in the publications of several authors that the BA of modern youth significantly exceeds the chronological age [4, 5, 6]. Researchers believe that one of the reasons for this phenomenon is the insufficient level of motor activity of modern youth. The motor activity deficit of modern youth is accompanied by the deterioration of somatic health and accelerated rates of aging [4, 7, 8]. On the other hand, regular motor activity and sports engagement improve the PS and somatic health of a person [5, 7, 9], reduce BA [3, 10, 11] of persons of different ages.

Experimental material presented in the publications of a number of authors indicates that the improvement of PS and somatic health as a result of regular motor activity leads to physical work capacity increase [12, 13, 14], a decrease in BA, and the rate of aging [3, 10, 11], and increase in human life expectancy [15, 16]. In publications on the motor activity of students, it is noted that the insufficient number of physical education (PE) classes in universities is associated with an increase in BA and the rate of aging of students, deterioration of their functional status, and a decrease in physical and mental work capacity [4, 6, 13]. Different values of BA in persons of different sexes, and ages, showing different motor activity and having different levels of somatic health are indicative of the variety of factors influencing BA [2, 10, 17].

The analysis of mechanisms and factors influencing BA is complicated by the fact that the authors of numerous publications used for this purpose more than 300 heterogeneous PS parameters in total. Despite the study of the interrelations of many individual and a number of integral parameters of the PS with BA, the presented material is heterogeneous, difficult to compare, and does not allow to offer insight into the key factors and mechanisms determining BA. The majority of researchers used a limited number of PS indices to determine BA: anthropometric, morphological, functional, genetic, physical work capacity [18, 19, 20, 21]. Despite the fact that the publications of many authors reflect the dependence of BA on individual and integral PS parameters [2, 10, 17, 22], the specifics of the mutual influence of integral PS parameters on BA and BA on individual and integral parameters of students' PSs is not adequately investigated. It is characteristic that based on the analysis of a relatively limited number of human PS indices, researchers have developed mathematical models of BA dependence on the individual, most informative, indices of PD, PF, and functional state [3, 10, 17, 23].

A relatively small set of informative indices in the developed models, available methods of their determination, and high coefficients of determination allowed the authors to recommend mathematical models for assessing, modeling, and predicting youth BA depending on the partial weight, ratio, and variability of regression model parameters [10, 17, 18]. It is noteworthy that the mathematical models recommended by most authors for assessing and predicting youth BA were based primarily on functional indices. In some models, PD and PF indices were also considered as components determining a person's BA: body mass and length, static balancing in an upright posture, hand muscle strength, speed, endurance, and other parameters [2, 17, 23].

However, the available publications do not sufficiently reflect the relationship of BA with individual key and integral indices of PD, functional and physical fitness of individuals of different ages and genders.

The issues of mutual influence of integral parameters of students' PS and BA represent one of the least covered aspects of the problem under consideration. Even though the majority of authors analyzed the interrelationships of BA with individual indices of PD, PF, and functional state, the issues of mutual influence of PS integral parameters on youth BA and BA on integral parameters of PS remain insufficiently covered. The impact of different PE programs on students' BA, causing specific adaptation changes in the PS in the annual cycle of university PE, should also be referred to as the insufficiently covered aspect of the problem.

The effective solution of the set tasks is possible on the basis of complex research using adequate mathematical apparatus and based on the methodological principles of the system approach. The system approach, as a methodological principle, necessitates the study of the structure and interrelationships of integral components of PS, mechanisms of their improvement, mutual influence and impact on students' BA in the process of adaptation to physical loads in the annual cycle of university PE.

Incomplete coverage and relevance of the problem of interaction and mutual influence of integral indices of PS and BA structure of students determined the *objective of this work*: the study of the interaction of physical state and biological age integral parameters of 17-19 years old students in the process of adaptation to the standard and experimental physical education programs.

Materials and Methods

Participants

The study involved first-year students of the State University of Telecommunications aged 17-

19 years old (80 males and 60 females). The study protocol was approved by Ethic Committee State University of Telecommunications (Kyiv, Ukraine). The research was fulfilled in compliance with WMA Declaration of Helsinki – Ethical Principles for Medical Research Involving Human Subjects [24].

Research Design

The studies were conducted in physical education classes. To solve the tasks set in the study, students were divided into control (CG) and experimental (EG) groups of boys and girls. The teaching and learning process of physical education with students of the control and experimental groups was carried out in accordance with the schedule of classes - once a week for two academic hours. Classes in the CG were conducted according to the generally accepted methodology in conformity with the program of physical education in higher educational institutions of the Ministry of Education and Science of Ukraine [25].

In the EG, in addition to the physical education classes provided by the schedule (once a week), 3 times a week additional independent classes were held according to the experimental method developed by us [2, 4]. Additional classes were held at the stadium of the university, as well as in the landscape park during non-study time. They included recreational running and physical exercises performed by the method of circuit training. In accordance with the author's program, EG students performed dosed physical loads with a large number of physical exercises mainly of moderate intensity and different in coordination structure. The training process included exercises with elements of athletics, sports games, artistic gymnastics. In the gym, an individual method was applied using complexes of exercises of the basic CrossFit program. Besides, students performed specially selected complexes of physical exercises of small forms of active recreation in theoretical classes in other subjects.

Students' physical state (PS) was assessed by individual indices of physical development, functional and physical fitness. A total of 55 indices of PS and BA were recorded. Biological monitoring of PS was conducted in the forms of stage (at the beginning and the end of the academic year), current (during several classes in a certain period), and operational (during a single class) control.

The following methods, tests, and indices were used to *assess the level of physical fitness* (PF) of students: a) *dynamometry* - the maximum strength of the hand muscles was registered;

b) *60 m running with maximum speed* (the quality of quickness was evaluated according to the result);

c) *standing long jump* (the explosive power of the leg muscles was evaluated according to the result);

d) *arm flexion-extension in a supine position for 30 s* (the speed-strength endurance of the shoulder girdle muscles was evaluated according to the number of performed movements);

e) *sit-ups* with hands behind the head for 30 s (speed-strength endurance of the abdominal muscles was assessed by the number of performed movements);

f) *4 x 9 m shuttle run* (to characterize the physical qualities of agility and coordination of movements);

h) *500 m (girls) and 1000 m (boys) running* (to characterize the motor quality of general (aerobic and anaerobic endurance).

The functional fitness level of students was assessed according to the indices of cardiovascular, respiratory, and central nervous system activity: systolic and diastolic pressure, heart rate, vital capacity, inspiration breath-hold time (Stange's test, sec.) and expiration breath-hold time (Genchi's test, sec), vital index (Vital Index (VL/MT, where MT - body mass, kg), Skibinski index (0.01 VC·IBH/ HR), vegetative Kerdo index (1-DBP/ HR)·100), Robinson index (HR·SBP/100), static balancing on the left leg (motor coordination was evaluated by the time of keeping balance (sec) [2].

The *level of physical development* (PD) of students was assessed by body mass (kg) and length (cm), as well as body mass index (BMI).

Students' BA was calculated according to the method developed by Voitenko [17]. This method was based on the generally accepted methods of recording the activity indices of the cardiovascular, respiratory, and central nervous systems, and a specially developed method of health subjective estimation. The values of students' BA were calculated according to the following formulas [17]:

For men:

$$BA = 44.3+0.68 \cdot HSE+0.40 \cdot SBP-0.22 \cdot DBP-0.22 \cdot PP-0.004 \cdot VC-0.11 \cdot IBH+0.08 \cdot EBH- 0.13 \cdot SB.$$

For women:

$$BA = 17.4+0.82 \cdot HSE+0.005 \cdot SBP+0.16 \cdot DBP+0.35 \cdot PP-0.004 \cdot VC+0.04 \cdot IBH-0.06 \cdot EBH- 0.11 \cdot SB.$$

where: *HSE* – health subjective estimation in c.u., *SBP* – systolic blood pressure in mm Hg, *DBP* – diastolic blood pressure in mm Hg, *PP* – pulse pressure in mm Hg, *VC – vital capacity, IBH* – inspiration breath-hold in sec, *EBH* – expiration breath-hold in sec, *SB* – static balancing on the left leg in sec.

Statistical Analysis

Processing of the experimental material was carried out using the statistical software package STATISTICA 14.01.25 and Excel. To determine the degree of mutual influence of various factors on students' BA and biological age on individual integral parameters of PS, methods of dispersion analysis of one-, two- and three-factor complexes, as well as canonical analysis were used. Multiple correlation

coefficients and coefficients of determination were calculated. To determine the significance of differences between the registered parameters in the dynamics of the experiment, Fisher's criterion was calculated between the studied groups.

The algorithm of research results processing was as follows: first, the research materials were processed in the combined group of students (n=140), then in the EG (n=70), and CG (n=70) of students participating in the implementation of the developed (experimental) and standard (university) PE programs. The processing was completed in 4 groups of students: in experimental (n=40) and control (n=40) groups of boys, and in experimental (n=30) and control (n=30) groups of girls.

Results

Dispersion analysis of research results

Dispersion analysis of the research results obtained on EG and CG students enabled determining the degree of influence of the following integral factors on BA:

1) students' gender;

2) specificity of the software;

3) adaptation changes of physical state in the one-year pedagogical process in PE.

Table 1 presents the results of the dispersion analysis of the influence of 3 integral factors on students' BA (Table 1).

Dispersion analysis coefficients presented in Table 1 reflect the different degrees of influence of the studied factors on the BA. Of the three factors under consideration, that of gender has the greatest impact on students' BA.

The gender factor determines the variability of 47.2% ($p<0.0000$) of the BA dispersion. Gradations of the factor:

1) girls performing experimental and control programs;

2) boys performing experimental and control programs (Table 1).

The software specificity factor determines the variability of 6.84% ($p<0.0000$) of the BA dispersion. Gradations of the factor:

1) the combined group of girls and boys performing the experimental program (EP);

2) the combined group of girls and boys performing the standard (university) PE program.

The factor of adaptation changes of physical state in the annual cycle of the pedagogical process determines the variability of 1.45% ($p<0.004$) of the BA dispersion. Gradations of the factor:

1) beginning of the experiment;

2) end of the experiment.

Figure 1 graphically presents the changes in BA under the influence of three factors taken into account in the experiment:

1) gender - regardless of the impact of software and adaptation changes of students' PS (Fig. 1a);

2) *specificity of software* - regardless of the influence of gender and adaptation changes of PS (Fig. 1b);

3) *adaptation changes of PS* in the annual cycle of the pedagogical process - regardless of the impact of gender and software (Fig. 1c).

The coefficients of multiple correlation ($r=0.746$, $r<0.00001$) and determination ($d=0.555$, $p<0.0000$) indicate that changes of 55.5% ($p<0.0000$) of the total variation of students' BA are due to the influence of the above presented 3 factors, whereas 44.5% of variations in the BA dispersion are conditioned by factors not considered in this experiment.

The data presented in Figure 1 indicate that each of the factors under consideration has a statistically significant impact on students' BA. Among them, the strongest influence is exerted by the factor of gender ($d = 0.472$, $p<0.0000$), determining the variability of 47.2% ($p<0.0000$) of the dispersion of students' BA.

The graphical analysis of BA changes under the influence of adaptation changes in the physical state of boys (Fig. 2a) and girls (Fig. 2b) in the annual cycle of the PE process (without each group differentiation into CG and EG) is presented below.

The results presented in Figure 2 show the decrease in BA in boys (Fig. 2a) and girls (Fig. 2b) in the process of changes in their PS by the end of the academic year. The decrease in BA in both groups occurs regardless of the content of the software. This is explained by the fact that the students' BA was considered in this analysis in the combined group of

Table 1. Dispersion analysis of the influence of various factors on the biological age of students in the process of physical education in the first year of study

No.	Factors	Influence, %	F	p
1.	Gender (females – males)	47.2	243.8	<0.000000
2.	Specificity of PE software (content of EP and SP)	6.84	40.9	<0.000000
3.	Adaptation changes of physical state in the process of PE (*beginning – end of the experiment*)	1.45	8.7	<0.0035
4.	Factors not considered in the experiment	44.51		
	General	100.0		

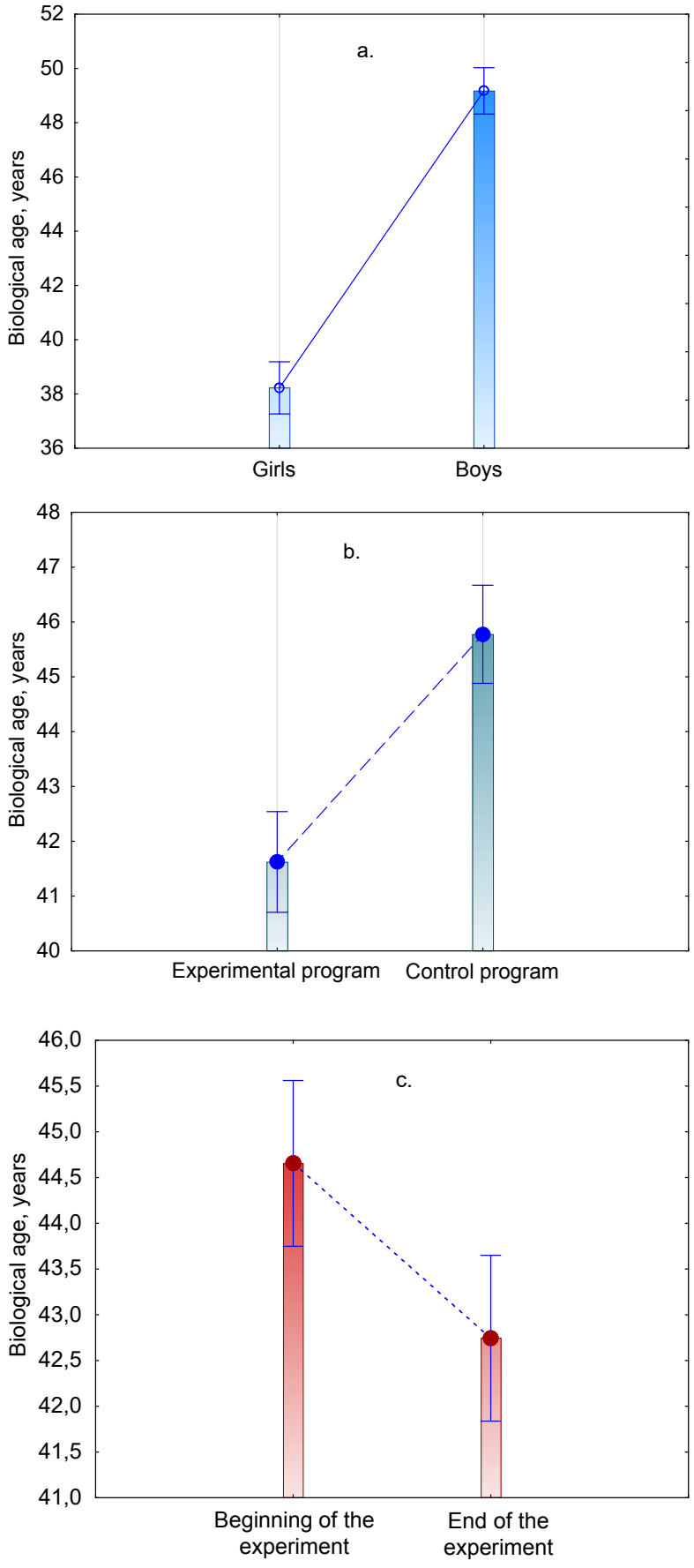


Figure 1. Changes in BA of students depending on gender (a), specificity of experimental (EP) and control (CP) PE programs (b), adaptation changes in PS during PE (c).

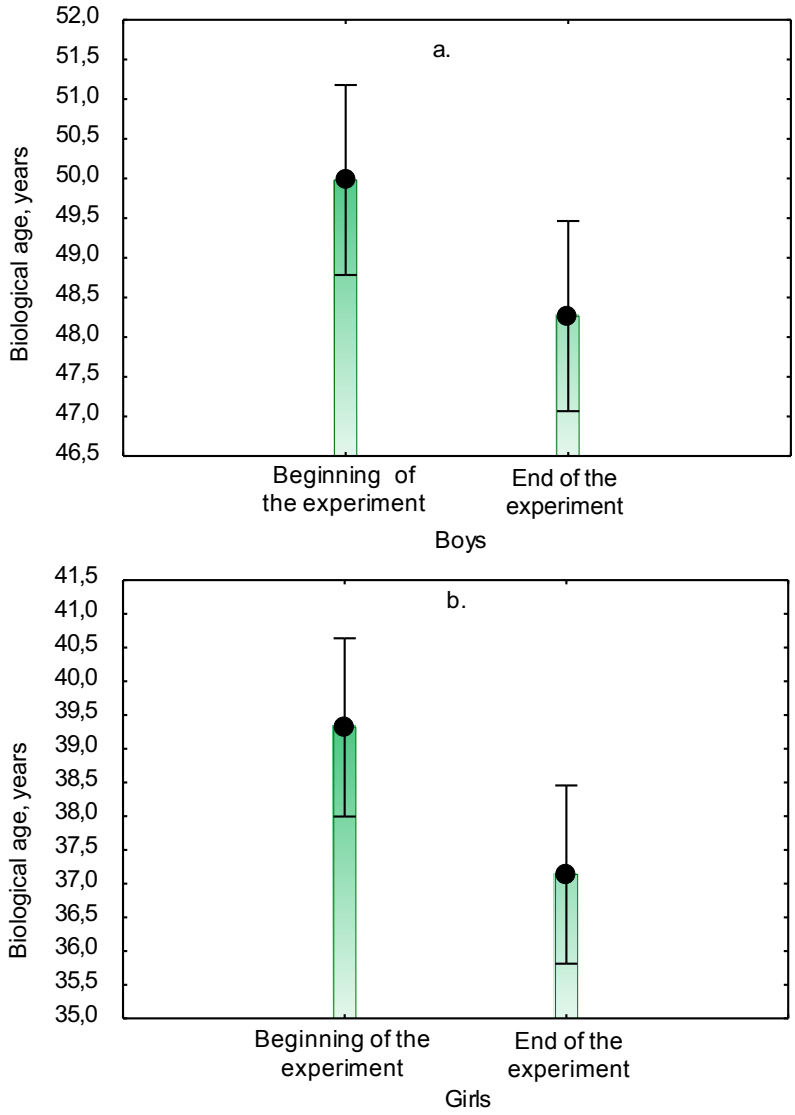


Figure 2. Changes in BA under the influence of adaptation changes of PS of boys (a) and girls (b) during the implementation of PE programs in the annual cycle of the pedagogical process.

boys (n=80) and girls (n=60) without differentiating them into EG and CG. The changes in the process of PE reflect the influence of adaptation changes of PS on the BA of students. Their impact determines the variability of 1.98 % ($p<0.05$) and 4.15 % ($p<0.02$) of BA dispersion in boys and girls, respectively.

The dispersion analysis allowed us to identify, quantify, and compare the impact of different factors on the BA of students of different genders (girls and boys) in the process of PE in the first year of study (Table 2).

The calculations presented in Table 2 and Fig. 1b indicate that software also contributes to a pronounced decrease in students' BA. The influence of the software factor of PE explains the variability of 24.83 % ($p<0.0001$) and 6.03 % ($F=11.0$, $p<0.001$) of BA variation in boys and girls, respectively. The influence of the factor of physical state adaptation changes in the process of PE explains the variability of 1.98 % ($p<0.0001$) and 24.11 % ($F=43.8$, $p<0.000000$) of BA variation in boys and girls, respectively.

Fig. 3 graphically presents the changes in BA in girls and boys of EG and CG during the implementation of standard (in CG) and experimental (in EG) PE programs at the beginning and the end of the experiment. The specifics of the PE software in the CG and EG were considered as factors influencing the BA in the groups of boys and girls (Fig. 3).

The curves presented in Figure 3a, indicate that the differences in BA of the two groups of girls are due to the differences in the training programs during the experiment. In the experimental group of girls, a statistically significant decrease in BA ($p<0.04$) is observed, whereas in the CG only a tendency to its decrease ($p>0.05$) is noted. In the boys of EG and CG, a positive dynamics to the decrease of BA was revealed under the influence of the studied factors with the most pronounced in the boys of EG (Fig. 3).

The dispersion analysis showed that the influence of the software factor on BA was more pronounced

Table 2. Results of dispersion analysis of different factors impact on the BA of boys and girls in the process of pedagogical experiment

Group	Factors of impact	Impact, %	F	p
Boys	Specifics of PE software (content of EP and SP)	24.83	50.25	0.0000
	Adaptation changes in physical state in the process of PE (beginning - end of the experiment)	1.98	4.00	0.05
Girls	Specifics of PE software (content of EP and SP)	6.03	11.0	0.001
	Adaptation changes in physical state in the process of PE (beginning - end of the experiment)	24.11	43.8	0.000000

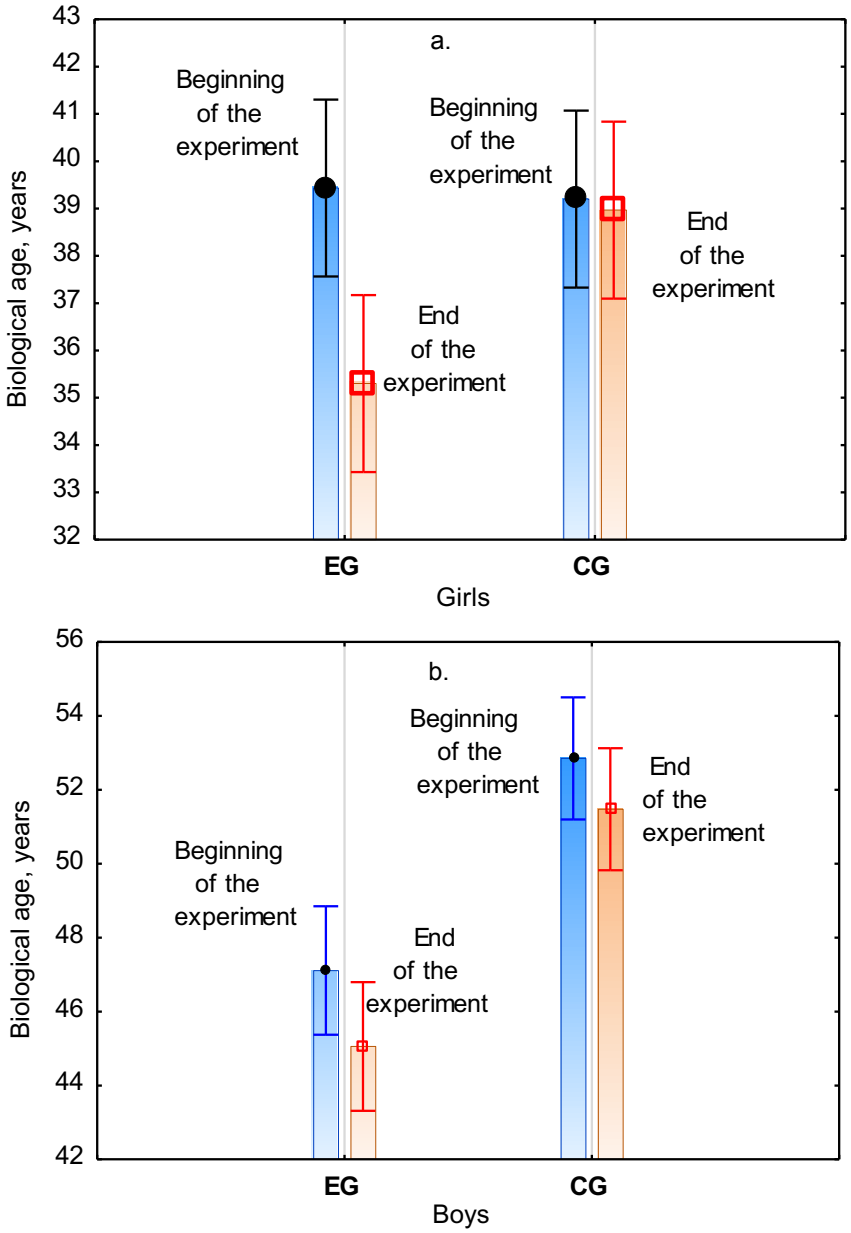


Figure 3. Change of biological age of girls and boys of the control (CG) and experimental (EG) groups in the pedagogical experiment. Gradations of the factor: beginning of the experiment, end of the experiment.

in the group of boys, whereas in girls the factor of adaptation to physical loads turned out to be more pronounced (tabl. 2).

Differences in the software of boys and girls of EG and CG caused differences in adaptation changes of their PS. The influence of the factor of PS adaptation changes determines the variability of 24.11% ($P < 0.000$) and 1.98% ($P < 0.05$) of BA dispersion in girls and boys, respectively.

The coefficients presented in Table 2 indicate that the differences in the biological age of boys and girls of the EG and CG are due to the combined

influence of the factor of PE software and that of adaptation changes in the physical state in the process of PE. That is, the factors of software of PE classes, determining the specificity of PS adaptation changes of boys and girls, contribute to the reduction of their BA by the end of the experiment. The degree of cumulative impact of two analyzed factors on the BA variation constitutes 26.9% ($P < 0.000$) and 30.14% ($P < 0.000$) in boys and girls, respectively.

The relatively low percentage of BA variability in boys and girls under the influence of the studied factors indicates that most of the variability of the total dispersion of BA is determined by factors not taken into account in this analysis.

Differences in the BA of the students of EG and CG throughout the experiment, while characterizing the average biological age in each combined group (females and males), reflect the impact of the specifics of the experimental and standard programs in the process of physical education and adaptation changes in the physical state in the dynamics of the annual cycle in PE.

Canonical analysis of the research results. To determine the specificity of the mutual influence of the studied groups of indices and BA, *canonical analysis* was undertaken. The conducted *canonical analysis* showed the different character of interaction of the following groups of variables:

1) functional state (7 parameters);
2) physical development and physical fitness (11 parameters);
3) biological age (2 parameters);
4) the combined group of all parameters (18 indices) of students' physical state (n=140).

The correlations between the following sets of indicators were investigated:

1) between functional indices (7 indices) and PD and PF indices (11 indices) (Table 3);
2) between BA variables (2 indices) and functional indices (7 indices) (Table 4);
3) between BA variables (2 indices) and PD and PF variables (11 indices) (Table 5);
4) between *all investigated parameters of physical state* (18 indices) and BA parameters (2 indices).

The analysis of the results of the mutual influence of the studied pairs of group indices is presented below.

The mutual influence of the group of functional indices and that of PD and PF indices. The parameters of the canonical analysis presented in Table 3 reflect different mutual variability of the group of functional indices and the combined group of PD and PF indices in the whole population of students.

The statistics presented in Table 3 reflect the proportions of dispersions determined by the canonical variables.

Sufficiently high values of the canonical correlation coefficient (R=0.679) and chi-square ($\chi 2$=246.9, p=0.0000001) between the two groups of PS variables in the combined group of students indicate a sufficiently high correlation between the group of functional indices and the group of PD and PF indices.

The data indicate that 14.68% of the dispersion of functional fitness indices is determined by the impact of canonical variables of PD and PF. Similarly, 23.18% of the dispersion of PD and PF indices is determined by the impact of the group of functional indices.

The results of interaction between two groups of physical state variables indicate that in EG boys and girls PD and PF indices have a stronger influence on functional indices than functional indices on PD and PF indices. In the control groups of boys and girls, on the contrary, the influence of functional

Table 3. Results of canonical correlation analysis of the relationship between the group of functional indices and the group of physical development and physical fitness indices

Groups		Statistical characteristics;	Functional indices (7)	Physical development and physical fitness indices (11)
All students	EG and CG (N=140)	Canonical correlation, χ^2	r=0.679 Chi2=246.9 p=0.0000	
		General variation	14.68%	23.18%
Girls	EG (N=30)	Canonical correlation, χ^2	r= 0.830 Chi2=123.0 p=0.0007	
		General variation	31.47%	26.18%
	CG (N=30)	Canonical correlation, χ^2	r= 0.586 Chi2=51.17 p=0.990	
		General variation	14.32%	8.55%
Boys	EG (N=40)	Canonical correlation, χ^2	r= 0.740 Chi2=133.73 p=0.00007	
		General variation	26.63%	15.32%
	CG (N=40)	Canonical correlation, χ^2	r= 0,647 Chi2=107,00 p=0,02	
		General variation	19,62%	14,87%

Table 4. Results of canonical correlation analysis of interaction between BA indices and functional indices

Groups		Statistical characteristics	BA indices (2)	Functional indices (8)
All students	EG and CG (N=140)	Canonical correlation, χ^2	r=0.795 Chi2=351.9 p=0.0000	
		General variation	34.4%	14.5%
Girls	EG (N=30)	Canonical correlation, χ^2	r= 0.827 Chi2=65.2 p=0.0000..	
		General variation	39.02%	11.9%
	CG (N=30)	Canonical correlation, χ^2	r= 0.989 Chi²212.6 p=0.0000..	
		General variation	56.1%	17.7%
Boys	EG (N=40)	Canonical correlation, χ^2	r= 0.873 Chi2=104.7 p=0.0000..	
		General variation	48.02%	18.4%
	CG (N=40)	Canonical correlation, χ^2	r= 0.878 Chi2=133.7 p=0.0000..	
		General variation	19.62%	14.87%

Table 5. Results of canonical correlation analysis of interaction between the group of BA and the group of PD and PF indices

Group		Statistical characteristics	BA indices (2)	Physical development and physical fitness indices (10)
All students	EG and CG (N=272)	Canonical correlation, χ^2	r=0.881 Chi2=468.6 p=0.0000	
		General variation	65.6%	40.9%
Girls	EG (N=30)	Canonical correlation, χ^2	r= 0.641 Chi2=40.8 p=.004	
		General variation	31.47%	26.18%
	CG (N=30)	Canonical correlation, χ^2	r= 0.570 Chi2=37.3 p=0.01	
		General variation	29.22%	6.90%
Boys	EG (N=40)	Canonical correlation, χ^2	r= 0.645 Chi2=49.3 p=0.0003	
		General variation	29.0%	11.0%
	CG (N=40)	Canonical correlation, χ^2	r= 0.392 Chi2=17.6 p=0.61	
		General variation	11.8%	2.4%

indices on PD and PF indices is stronger than that of PD and PF indices on functional indices.

Interaction of the group of functional indices (8 indices) *with those of BA* (2 indices) (Table 4). The parameters of the canonical analysis presented in Table 4 indicate that the influence of functional indices on BA is stronger than the inverse impact of BA on functional indices. This specificity of interaction between the *two groups of variables* is characteristic of all examined groups (girls and boys of EG and CG). It is confirmed by high values of canonical correlation coefficients (0.827-0.989 (p=0.0000)), percentage of variability of indices, as well as chi-square values (χ2) in all groups of students.

Table 5 presents canonical correlation coefficients, chi-square, and percentage of mutual influence of BA indices (2 indices) and PD and PF indices (11 indices) in all analyzed groups of students.

The results presented in Table 5 indicate that the variability of the group of PD and PF indices determines that of most of the dispersion of the group of BA indices in all groups of students. At the same time, the influence of the group of BA indices on the dispersion of PD and PF indices is much smaller. It is characteristic that in the CG of girls and boys, the mutual influence of BA variables and those of PD and PF is low and statistically insignificant.

The canonical analysis of interacting all parameters of students' physical state (18 parameters) with BA parameters (2 parameters) in the combined group of students (n=140) showed that the variability of 79.5 % (p=0.0000...) of dispersion of students' BA variables is determined by the influence of all variables of students' PS (18 parameters). On the other hand, the impact of BA variables on the total dispersion of PS indices is significantly lower and amounts to 29.2 % (p=0.0000...).

This regularity significance in the interaction between the two groups of parameters is evidenced by the high values of the canonical correlation coefficient (R = 0.909, p=0.0000001) and chi-square (χ^2 = 728.4, p=0.0000001). These calculations confirm the high dependence between PS indices and BA of students. At the same time, the combined effect of all PS indices on BA is higher than the BA effect on PS parameters.

The revealed interrelations reflect the presence of a certain positive cross-transfer between the groups of indices of functional state, PD, PF, and BA of students. The degree of mutual influence is most pronounced in the experimental groups of girls and boys, which is one of the confirmations of the positive influence of the experimental program on students' BA.

Therefore, the canonical analysis demonstrated that BA not only depends on the functional state, physical development, and physical fitness of students but also differently affects these components of the physical state of both boys and girls of EG and CG.

Discussion

Despite the fact that a large number of works have been devoted to the problem of BA and its interrelations with the indices of human physical state (PS), some aspects of the problem under consideration require more in-depth coverage.

The inadequately treated aspects of the problem under consideration include the issues of mutual influence of PS parameters and BA of persons of different ages. The analysis of works by various authors indicates that most of them are devoted to analyzing the influence of different PS parameters on BA and human aging [10, 13, 27]. At the same time, the inverse effect of BA on PS parameters has been studied comparatively less. Although specialists who have been dealing with the problem of human BA suggested using it as an index for assessing the general state of health and aging, as well as for predicting the main age-related diseases and mortality [21, 28, 29].

The object of study in the works of most authors addressing the relationships between BA and different forms of motor activity was middle-aged, elderly persons or athletes as a rule [3, 11, 16]. The authors studied mainly the relationships of BA with individual or integral indices of PF of individuals of different sex [10, 27, 30], somatic health [30], and motor activity levels [16, 23]. The influence of different forms of motor activity on the PS and BA of students has been studied to a much lesser extent, even though some studies have noted the low effectiveness of the impact of university physical education programs on the physical state, somatic health, and BA of students [2, 4, 23, 27, 30].

Insufficient study of the influence of different motor activity programs on students' BA, as well as the issue of the mutual influence of PS parameters and BA prompted us to conduct the present research. The research was aimed at studying the specifics of the mutual influence of BA parameters and 3 groups of PS parameters of boys and girls aged 17-19 years old in the process of their adaptation to standard [university] and experimental PE programs.

The experimental program of motor activity for students 17-19 years old was developed and published by us earlier [1, 2, 4, 23]. The diversity of factors affecting human BA, a large number of heterogeneous indices used by researchers to assess it, served as an argument for selecting methods of a complex approach and adequate mathematical apparatus to determine the factors and mechanisms influencing BA and its interrelationships.

To solve the tasks of the present research, standard methods of registration and estimation of students' PS parameters, as well as methods of dispersion and canonical analysis of experimental results were applied.

As a result of the conducted complex research, the effectiveness of the experimental PE program, as well as the used methods of mathematical processing and analysis - dispersion and canonical analysis - was confirmed.

The methods of dispersion and canonical analysis enabled to obtain material for analysis, which is an addition to our previously published results [2, 4, 23].

The dispersion and canonical analysis were used to determine the degree of influence of the following integral factors on students' BA:

1) PE software;
2) gender;
3) adaptation changes of students' body PS in the dynamics of the annual PE process;
4) group of PS functional parameters;
5) group of PD and PF parameters;
6) combined group of all studied PS parameters.

The canonical analysis also permitted to study the degree of mutual influence of integral parameters of students' PS and BA.

The dispersion analysis revealed that under the influence of the factors of PE software, gender, adaptation changes of students' body PS in the annual cycle of PE most part of students' BA dispersion changed (55.5%, $p<0.0000$). A lesser part of BA dispersion changed due to the influence of factors not considered in this analysis. The influence of some other integral factors on students' BA was considered in one of the previous publications [2].

Of the factors analyzed in this article, the factor of gender had the greatest influence on the BA of students in the first year of study. As our research has shown, its influence determines 47.2 % ($p<0.0000$) of BA variability in the studied students. Significantly lower values of BA are observed in girls as compared to boys.

It is noteworthy that the influence of the software factor on the BA is higher in the group of boys, whereas that of adaptation changes in the course of the experiment - in the group of girls. The results indicate that the difference between the BA of girls and boys in the EG and CG is due to the combined impact of the factor of software specificity and that

of adaptation changes in the PS in the course of the experiment.

This result can be explained in the following way: the specificity of the PE classes' software through adaptation changes of the body PS of boys and girls, determined BA decrease by the end of the experiment in both groups unevenly. The most pronounced changes in BA occurred in the EG of girls.

The findings suggest that the changes and differences in the BA of boys and girls in the EG and CG are caused by the combined influence of the factor of PE software and that of adaptation changes in the students' PS in the annual PE process.

Lower initial values of BA in girls compared to boys indicate an important role of genetic mechanisms in determining BA. It is safe to assume that genetic mechanisms, modulating the influence of software on BA, determine the specificity of adaptation rearrangements and changes in students' BA in the process of PE, which were most pronounced by the end of the experiment in EG girls.

Lower initial values of girls' BA and a more pronounced reliable decrease of BA by the end of the pedagogical experiment give grounds to conclude that aging processes in girls are slower in comparison with boys. Under the influence of the experimental program the BA of girls is more amenable to decrease compared to boys of EG and students of both control groups.

The novelty of the results of the present study is that for the first time interactions of BA indices of students aged 17-19 years old with different groups of their PS indices under the influence of experimental and university PE programs were studied.

The canonical analysis allowed us to study the peculiarities of mutual influence of several groups of variables of students' PS and BA:

a) the group of functional indices and those of the combined group of PD and PF;

b) the group of BA indices and the group of functional indices;

c) the group of BA indices and the combined group of PD and PF indices;

d) the group of BA indices and the combined group of all analyzed PS indices.

The results of the mutual influence of the group of functional variables and the group of PD and PF variables demonstrate that in EG boys and girls PD and PF indices exert a stronger impact on functional indices compared to that of functional indices on PD and PF indices. In the control groups, on the contrary, the influence of functional indices on PD and PF indices is stronger than that of PD and PF indices on functional indices. Explanation of the mechanisms of such mutual influence requires further more in-depth studies.

The values of canonical correlation coefficients, percentage of variability of indices, and chi-square (χ^2) values in EG and CG of girls and boys afford ground to assert that the influence of the group of functional indices on BA is stronger than the inverse impact of BA on functional indices.

It was revealed that the influence of the combined group of PD and PF indices is responsible for the variability of most of the variance of the group of BA indices in all studied groups of students. The reverse impact of BA on the variability of PD and PF indices in EG and CG of students is significantly lower. In the control groups of students, the mutual influence of BA variables and PD, and PF variables is low and statistically insignificant.

The canonical analysis of the mutual influence of the most informative parameters of PS (18 out of 55 parameters) of students and BA parameters in the combined group of students indicates that under their combined influence 79.5 % ($p<0.0000$) of the BA dispersion changes. At the same time, the impact of BA provides only 29.2% ($p<0.0000$) of the dispersion of PS parameters' changes.

The revealed dependencies reflect the presence of a certain positive cross-transfer between the groups of studied indices:

1) functional state;

2) PD and PF;

3) all studied parameters of PS;

4) students' BA.

The degree of mutual influence of these groups of indices in students' BA decrease is most pronounced in the experimental groups of girls and boys. This can also be considered as one of the criteria and confirmations of the developed program's positive impact on the PS and BA of the experimental groups' students.

The conducted studies have shown an insignificant influence of the university (standard) program on the BA, functional and physical fitness of students in the control groups.

The insufficient efficiency of the university program impact on PS and BA of students, revealed by our research, is confirmed by the findings of other authors [19, 27, 30].

The results obtained are consistent with the findings of Prysiazhniuk et al. [1], Kolokoltsev et. al. [27], Pavanello et al. [31] on the positive effect of increased motor activity on BA and youth health.

The results substantiate the necessity of introducing additional PE programs into the system of pedagogical process in higher education institutions.

The obtained results are also an addition to our previous studies [2, 4, 23] and to the studies of a number of authors who dealt with the problem of interrelations of motor activity, health and BA and youth [10, 27, 31].

The experimental motor activity program caused a decrease in BA, an increase in functional

capabilities and physical fitness of students of the experimental groups, which were most pronounced in girls.

The novelty of the obtained results consists in the following:

a) the quantitative characterization of the influence of the following factors on students' BA is given: PE software, gender, adaptation changes of students' PS in the dynamics of PE, the group of PS functional parameters, the group of parameters of PD and PF, the combined group of all studied parameters of PS. Of the PS parameters, the combined group of functional and physical fitness parameters has the greatest influence on BA;

b) the effectiveness of the experimental motor program of predominantly aerobic orientation impact on the physical state and BA of students was confirmed. The efficiency of the developed PE software is characterized by a decrease in BA and slowing down the processes of aging of students' bodies, an increase in functional capabilities and physical fitness of boys and girls of the experimental groups in the annual cycle of training;

c) the degree of mutual influence of integral parameters of PS and BA of boys and girls aged 17-19 years old was determined for the first time. The degree of mutual impact of BA and the group of the most informative parameters of PS (18 indices) is most pronounced when BA decreases in the experimental groups of girls and boys.

Conclusions

1. The use of dispersion and canonical analysis methods allowed to confirm the effectiveness of physical education experimental program, to determine the degree of mutual influence of PS and BA integral parameters of boys and girls aged 17-19 years old.
2. BA and physical state changes of students of CG and EG in the dynamics of annual process of physical education reflect the specificity of the influence of standard and experimental programs, as well as adaptation changes in the PS of boys and girls. More pronounced positive changes in PS parameters with a greater decrease in BA in the experimental groups confirm the efficiency of the developed program.
3. Adaptation changes of PS in the process of software implementation are accompanied by a decrease in BA in the experimental groups. The gender factor has the highest influence on students' BA - lower values of BA and its more pronounced decrease has been observed in girls by the end of the experiment in comparison with boys.
4. The canonical analysis showed that 79.5% ($p<0.0000$) of students' BA dispersion changed under the influence of the key PS parameters (functional, physical development, and physical fitness), while only 29.2% ($p<0.0000$) of students' PS parameters dispersion changed under the influence of BA. The degree of mutual impact of BA and all the studied PS parameters is most pronounced in the experimental groups of girls and boys.
5. The greatest impact on students' BA is exerted by the group of PD and PF indices: 65.6% ($p<0.000...$) of the BA dispersion changes under their influence. At the same time, under the influence of BA, 40% ($p<0.000...$) of the dispersion of PD and PF indices changes.
6. One of the criteria and confirmations of the developed physical education program efficiency is the degree of mutual influence of PS integral parameters, which is most pronounced during BA decrease in the experimental groups of girls and boys.

Conflict of interests

The authors declare that there is no conflict of interests.

References

1. Prysiazhniuk S, Tolubko V, Oleniev D, Parczevskyy Y, Prontenko K, Griban G, et al. The influence of physical activities on biological age parameters of the first-year female students from the special medical department. *Journal of Physical Education and Sport*, 2018;18(2):561–564. https://doi.org/10.7752/jpes.2018.02081
2. Pryimakov O, Sawczuk M, Tymoshenko O, Mazurok N. Model characteristics of the structure and interrelations of integral parameters of students' physical condition. *Physical Education of Students,* 2023;27(5):279–293. https://doi.org/10.15561/20755279.2023.0508
3. Chainikov PN, Cherkasova VG. Biological age and age changes rate in athletes of playing kinds of sport and untrained persons. *Perm Medical Journal,* 2017;34(1):95–99.
4. Razmahova SY, Timofeeva OV, Epp TI. Assessment of the biological age of full-time and part-time students. *Tomsk State University Journal*, 2023;(486): 221–227. https://doi.org/10.17223/15617793/486/24
5. Korol SA. Assessment of physical health and physical fitness of students of technical specialties of I course. *Pedagogics, Psychology, Medical-Biological Problems of Physical Training and Sports*, 2014;11:23–29. https://doi.org/10.15561/18189172.2014.1105
6. Sazanov AV, Sazanov ML, Demina NL, Popova GA. Assessment of the level of physical health and adaptive capabilities of freshmen of a humanitarian university. *Modern Problems of Science and Education,* 2015;5:100-105.
7. Apanasenko GL, Havruliuk V. *Biological degradation of HOMO SAPIENS: ways of counteraction. Basics. Concepts. Methods*. Palmarium Academic Publishing; 2014. (In Russian).
8. Guthold R, Stevens GA, Riley LM, Bull FC. Global trends in insufficient physical activity among adolescents: a pooled analysis of 298 population-based surveys with 1.6 million participants. *Lancet Child & Adolescent Health*, 2020; 4(1):23–35. https://doi.org/10.1016/s2352-4642(19)30323-2
9. Bazilevich N. Optimizing physical education of students using crossfit. *InterConf,* 2021; (55): 353–371. https://doi.org/10.51582/interconf.7-8.05.2021.038 (In Ukrainian).
10. Dao Chanh T. The influence of physical activities on biological age parameters of females from 17 to 18 years old. *Journal of Sports Medicine and Therapy*, 2018;3(3): 075–079. https://doi.org/10.29328/journal.jsmt.1001030
11. Rebelo-Marques A, De Sousa Lages A, Andrade R, Ribeiro CF, Mota-Pinto A, Carrilho F, et al. Aging Hallmarks: The Benefits of Physical Exercise. *Frontiers in Endocrinology*, 2018;9: 258. https://doi.org/10.3389/fendo.2018.00258
12. Elhakeem A, Murray ET, Cooper R, Kuh D, Whincup P, Hardy R. Leisure-time physical activity across adulthood and biomarkers of cardiovascular disease at age 60-64: A prospective cohort study. *Atherosclerosis,* 2018;269:279–287. https://doi.org/10.1016/j.atherosclerosis.2017.11.019
13. Arefiev V, Tymoshenko O, Malechko T, Domina Z, Bezkopylny O, Dutchak Y, et al. Methodology of Differentiation of Health-Improving Classes in Physical Education for Primary School Students. *International Journal of Applied Exercise Physiology*, 2020;9(7): 134–143.
14. Parsons N, Griffin XL, Achten J, Chesser TJ, Lamb SE, Costa ML. Modelling and estimation of health-related quality of life after hip fracture: A re-analysis of data from a prospective cohort study. *Bone Joint Res*. 2018;7(1):1–5. https://doi.org/10.1302/2046-3758.71.BJR-2017-0199
15. Moore SC, Patel AV, Matthews CE, Berrington De Gonzalez A, Park Y, Katki HA, et al. Leisure Time Physical Activity of Moderate to Vigorous Intensity and Mortality: A Large Pooled Cohort Analysis. Khaw KT (ed.) *PLoS Medicine*, 2012;9(11): e1001335. https://doi.org/10.1371/journal.pmed.1001335
16. Garatachea N, Pareja-Galeano H, Sanchis-Gomar F, Santos-Lozano A, Fiuza-Luces C, Morán M, et al. Exercise Attenuates the Major Hallmarks of Aging. *Rejuvenation Research*, 2015;18(1): 57–89. https://doi.org/10.1089/rej.2014.1623
17. Voitenko VP. *Health of the healthy. Introduction to Sanology*. Kyiv: Health; 1991. (In Russian).
18. Belozerova LM. The biological age determination by blood test. *Clinical Gerontology,* 2006;12(3):50–52.
19. Zhong X, Lu Y, Gao Q, Nyunt MSZ, Fulop T, Monterola CP, et al. Estimating Biological Age in the Singapore Longitudinal Aging Study. *The Journals of Gerontology*: *Series A*, 2020;75(10):1913–1920. https://doi.org/10.1093/gerona/glz146
20. Sindeeva LB, Nikolaev VG, Kochetova TF, Kovrigina OA. Component composition of the body as a criteria of biological age. *Siberian Medical Review*, 2015;5:61–65. (in Russian). https://doi.org/10.20333/25000136-2015-5-61-66
21. Belsky DW, Caspi A, Houts R, Cohen HJ, Corcoran DL, Danese A, et al. Quantification of biological aging in young adults. *Proceedings of the National Academy of Sciences*, 2015;112(30). https://doi.org/10.1073/pnas.1506264112
22. Govorukhin AA, Mushty KA. Effect of sports specialization on body composition and anthropometric data in female students of pedagogical universities. *Human Sport Medicine*, 2020;20(4): 31–39. https://doi.org/10.14529/hsm200403
23. Pryimakov O, Sawczuk M, Prysiazhniuk S, Mazurok N, Petrachkov O. Interrelations of physical state parameters and biological age of students in the process of physical education. *Physical Education of Students,* 2024;28(1):16–28. https://doi.org/10.15561/20755279.2024.0102
24. World Medical Association Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects. *JAMA*, 2013;310:2191. https://doi.org/10.1001/jama.2013.281053
25. Timoshenko OV, Ievtushok MV, Malenko LV, Nikol's'kij AV. *Regulation on the Organization of*

Physical Education and Mass Sports at National Pedagogical Dragomanov University. Kyiv; 2022. (In Ukrainian).
26. Borovikov VP. *A popular introduction to modern data analysis in STATISTICA. Methodology and technology of modern data analysis*. Moscow: Goryachaya Liniya-Telecom; 2018.
27. Kolokoltsev M, Romanova E, Vorozheikin, Bochar I, Karuzin K, Martusevich A, et al. The effect of physical activity on biological age and body composition in 18–19-year-old girls. *Journal of Physical Education and Sport*, 2022;22(4):981–987. https://doi.org/10.7752/jpes.2022.04125
28. Kang YG, Suh E, Lee J woo, Kim DW, Cho KH, Bae CY. Biological age as a health index for mortality and major age-related disease incidence in Koreans: National Health Insurance Service Health screening 11-year follow-up study. *Clinical Interventions in Aging*, 2018; 13: 429–436. https://doi.org/10.2147/CIA.S157014
29. Levine ME. Modeling the rate of senescence: can estimated biological age predict mortality more accurately than chronological age? *J Gerontol A Biol Sci Med Sci*. 2013;68(6):667–74. https://doi.org/10.1093/gerona/gls233
30. Mozolev O. Monitoring of the physical health state among 16-17-year-old female students. *Baltic Journal of Health and Physical Activity*, 2021;13(3): 47–54. https://doi.org/10.29359/BJHPA.13.3.06
31. Pavanello, Campisi, Tona, Lin, Iliceto. Exploring Epigenetic Age in Response to Intensive Relaxing Training: A Pilot Study to Slow Down Biological Age. *International Journal of Environmental Research and Public Health*, 2019;16(17): 3074. https://doi.org/10.3390/ijerph16173074

Information about the authors:

Oleksandr Pryimakov; (Corresponding author); https://orcid.org/0000-0003-0351-486X; sanaol7.alex@gmail.com; Faculty of Physical Culture and Health Promotion, Szczecin University (Szczecin, Poland); Faculty of Physical Culture and Health, Mykhailo Drahomanov Ukrainian State University (Kyiv, Ukraine).

Marek Sawczuk; https://orcid.org/0000-0002-5730-5249; Marek.Sawczuk@usz.edu.pl; Division of Molecular Biology, Department of Health and Natural Sciences, Faculty of Physical Culture, Gdansk University of Physical Education and Sport; Gdansk, Poland.

Stanislav Prysiazhniuk; https://orcid.org/0000-0002-3017-0268; stas046@ukr.net; NDUU The National Defence University of Ukraine named after Ivan Cherniakhovskyi; Kyiv, Ukraine.

Georgiy Korobeynikov; https://orcid.org/0000-0002-1097-4787; k.george.65.w@gmail.com; National University of Physical Education and Sport of Ukraine (Kiev, Ukraine); Department of Theory and Methodology of International Wrestling, Uzbek State University of Physical Education and Sports (Chirchik, Tashkent, Uzbekistan).

Nataliya Mazurok; https://orcid.org/0000-0001-7346-1156; natprim75@gmail.com; Faculty of Physical Culture and Health Promotion, Szczecin University (Szczecin, Poland); Faculty of Physical Culture and Health, Mykhailo Drahomanov Ukrainian State University (Kyiv, Ukraine).

Cite this article as:
Pryimakov O, Sawczuk M, Prysiazhniuk S, Korobeinikov G, Mazurok N. Interaction of integral parameters of physical state and biological age of students aged 17-19 years old in the process of adaptation to standard and experimental physical education programs. *Physical Education of Students,* 2024;28(2):120–133. https://doi.org/10.15561/20755279.2024.0209

Received: 02.03.2024

Accepted: 29.04.2024; **Published**: 30.04.2024

CONTACT INFORMATION
box 11135, Kharkiv-68, 61068, Ukraine
phone. +38 0986839912
http://www.sportpedu.org.ua
e-mail: sportart@gmail.com

Information:
Sponsors, Partners, Sponsorship:
Ukrainian Academy of Sciences.

SCIENTIFIC EDITION (journal)

Physical Education of Students, 2024;28(2)

Editorial to the publisher department:
certificate DK No 7472; 07.10.2021
---
designer - Sergii Iermakov
editing - Tetiana Yermakova T.
administrator of sites - Sergii Iermakov
designer cover - A. Bogoslavets
————————————————————