

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.

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Moral competence, dilemma discussion, and sports: unraveling the significance of framework, competitive level, and sporting experience

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Abstract

Background and Study Aim Stimulation of moral development is one of the most important tasks of modern education. Findings of recent studies indicate its importance for sound development of a young person. Research Objective: Examine the impact of moral dilemma discussions, the level of competitiveness, and years of sports training (experience) on athletes' morality.

Material and Methods The research study was conducted by the diagnostic survey method and was based on a quasi-experimental design with experimental and control (CG) groups. A sample of 352 university students in sport and physical education-related faculties participated in the study. They were assessed using Lind's Moral Judgement Test (MJT) and the Moral Judgement Test in Physical Education (MJT-PE).

Results There were no interaction effects between years of sport practice and levels of general moral competence in an overall group. However, in terms of the sport-specific domain of moral competence, there was a tendency towards statistical significance of an interaction effect ($p=0.07$) on the levels of moral competence. This was in addition to the main effect ($p=0.001$) that differentiated the experimental and control groups. The findings indicated that the experimental group scored significantly higher ($p=0.0008$) on MJT-PE C-index than their control group peers. This disparity can be attributed to the amateur sports students in the experimental group, who exhibited significantly higher levels of moral competence compared to their amateur counterparts in the control group ($p=0.0022$).

Conclusions This study underscores the positive impact of dilemma discussions on athletes' moral competence within the realm of physical education and sports. The findings strongly suggest that implementing structured dilemma discussions can significantly benefit amateur athletes. This emphasizes the critical importance of incorporating ethical deliberations into athletic training programs, especially for Physical Education and Sports educators.

Keywords: moral competence, dilemma discussion, athletes' morality, mode, training, sports practice.

Introduction

Education of socially, morally and democratically conscious youth is a necessary condition for the healthy functioning and development of modern society. This necessity suggests the need to find effective and empirically proven mechanisms of influence that contribute to moral and personal growth.

Moral competence and intelligence are a psychologist's long-sought bridge between moral attitudes or moral values on one hand and moral behavior on the other. According to Lajčiaková [1], moral competence is the ability of an individual to arrive at moral judgments on the basis of his/her internal principles and subsequently act in accordance with these opinions. In this context, moral education appears not as a proposal of a

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ready-made scheme of duties or a catalogue of norms that must be implemented [2]. Instead, it serves as an incentive to strive to act morally. This involves thinking independently through the prism of personally chosen categories of values that form the basis of the motivation of the choice and the decision made [2]. But moral competence is not only the skill of moral reasoning. It is also moral behavior that is consistent with the relevant cognitive and affective components. Additionally, it aligns with the context of democratic principles of social coexistence that determine human behavior in the social world [3].

One of the focal issues in moral functioning's research is whether sport promotes moral competence or quite contrary – attitudes of selfishness. According to Shields and Bredemeier [4, 5], the rules of some competitions often allow for greater egocentrism and moral flexibility than life outside of sports. That is, the environmental context influences ethical attitudes and behavior.

Based on the well-established theoretical background of Lawrence Kohlberg [6, 7] one's moral development occurs as a result of the interaction between the person and the environment and is a part of their cognitive development. This fact could be easily interpreted. The prerequisites for an individual to behave morally are cognition and conception of concrete or abstract terms, moral judgments, and thoughts. It seems that although the individual's moral behavior is defined by both affect and cognitive aspects, Kohlberg laid emphasis on the person's cognitive capacity to make moral judgments, which is defined as "the capacity to make decisions and judgments which are moral (i.e., based on internal principles) and to act in accordance with such judgments" [8, p. 425].

Earlier, Piaget in his original theory of cognitive development [9] stressed the importance of peer interaction in child's intellectual and moral growth. It was later expanded by Kohlberg [6] in his concept of sequential stages of moral development model. This expansion was facilitated by broader social interaction and related even more to parallel cognitive development. Nonetheless, there have been many critical revisions of that theory up to date. For example, Gilligan [10] pointed out some shortages and limitations of Kohlberg's theory of cognitive (moral) development, indicating its masculine perspective. Meanwhile, Snarey [11] questioned the universality of the theory in terms of cultural application. Nevertheless, new attempts to frame a more relevant model of moral development, based on the latest research findings, have been undertaken since. The newest approach, the Social Information Processing-Moral Decision-Making (SIP-MDM) framework, was provided by Garrigan et al. [12]. It incorporates the social information processing theory based on the social neuroscience perspective. This model is worth mentioning here as it connected the former understanding of one's moral developmental processes with more advanced, neuroscience-based methods. In that model, the authors [12] indicated a few circumstances that may help in understanding the complexity of the moral development process. These circumstances include: how real-time decisions are made and mediated by social and contextual factors; what cognitive processes are required to enable moral maturing; how these processes develop over time in relation to factual behaviors. Recent research in moral psychology combines the decision-making process on moral dilemmas with human moral cognition and emotions. Studies by Greene [13] and Moll and Schulkin [14] provide evidence, using neuroimaging techniques, about the abovementioned associations. According to Rest [15], moral development typically increases until early adulthood. At that stage, it may reach a plateau. This was lately confirmed in a study by Martins, Santos, and Duarte [16] who found

such trend in a longitudinal study among nursing students in Portugal.

Previous empirical findings [17, 18] indicate the following:

a) Discussing moral dilemmas is not only an appropriate method for supporting one's morality, but it is also the most effective, particularly when discussing socio-moral dilemmas among peers [19].

b) Principled moral reasoning in undergraduate elementary and secondary education students can be enhanced through deliberate educational interventions. These interventions should include teaching moral theories and engaging in dilemma discussions [20].

Evidence [21] points out to the conclusion that group discussions on moral dilemmas (a situation in which a difficult choice has to be made between two or more equally undesirable options or conflicting moral principles) can be an effective pedagogical strategy. Although, as so far, it has been limited to general analyses of its impact on moral judgement, without going into details whether it was due more to the intrapersonal contemplation or the interpersonal discussion. This kind of instructional technique has been considered as one of the most effective in professional ethics education [21], and also in health education [22]. It focuses on the peer-interaction process that allows a participant to be faced with potentially dilemmatic situations, incompatible, but supported by competing moral reasons presenting broader picture of a situation [23]. It is worth mentioning that Thorne and Hartwick [24] found in their study on a group of auditors that contentious discussion with peers may provide vital feedback and signals on what is important and acceptable for others. This process facilitates the transformation of one's own moral reasoning.

In the context of China, Zhang [25] conducted an intervention study focusing on students majoring in economics to investigate the impact of a dilemma story-based approach on the enhancement of moral competence levels. The results revealed a statistically significant positive effect, indicating a subtle, yet discernible increase in moral competence within the group exposed to the dilemma story intervention. However, certain factors were recognized as potential contributors to the modest effect size. These factors include the relatively brief duration of each session (60 minutes) over the course of seven sessions and the limited opportunity for all group participants to express their views. For the assessment of participants' moral competence, this study employed the widely recognized Moral Judgment Test (MJT) developed by Lind [26]. Notably, the average score of moral competence, represented by the C-index, among Chinese economic students was found to hover around 19 points, providing a quantitative measure of their moral decision-

making abilities. This study's findings shed light on the efficacy of the dilemma story-based intervention as a method to enhance moral competence in the specific context of economics students in China. However, the influence of session duration and participant involvement warrants further exploration to optimize the intervention's efficacy and long-term impact.

The methodology of introducing the method of moral dilemma discussion is well-founded in the philosophy of education and in psychological and educational research. Its effects have been thoroughly analyzed in well-designed studies [17, 27, 28]. From the beginning, the dilemma discussion has shown to have a substantial effect size ($r = 0.40$); hardly ever were negative effects reported. It has shown to be highly effective in various age-groups, from ten-year-olds to adults. Method was tested and proven its effectiveness in various scientific fields [17]. But there have been no studies regarding how the method of the moral dilemma discussion affects the moral competence of the athletes.

Furthermore, in previous studies, it was found that both the years of sport experience as well as the level of competition in which the athletes are involved affect their moral judgement and behavior [29, 30, 31]. More specifically, it was found that:

a) as the years of involvement in sports increase, aggressive behavior becomes more legitimate and acceptable, especially when the participants are males [29];

b) the length of participation in sport is negatively correlated with sportspersonship behavior and moral competence [30, 31, 32];

c) professional players, in relation to amateurs, tend to display fewer positive character traits and place less emphasis on playing fairly. Additionally, athletes who participate at higher levels of sport competition (leagues) also tend to have lower ratios of moral competence [31, 32, 33].

The purpose of the present study was: a) to explore the effectiveness of a daily intervention with dilemma discussion in supporting athlete's moral competence, and b) to examine whether the level of sport competition (e.g., professional vs amateur), and the overall years of sport experience are significant factors for athletes' moral competence levels.

Materials and Methods

Participants

The research sample consisted of 199 amateur athletes, with 39.7% of them being female, and 153 professional athletes, with 41.8% of them being female. Additionally, 26 respondents who declared no participation in sports for a duration qualifying them as either amateur or professional athletes were initially part of the study. However,

they were subsequently excluded from the research. This examination took place in the academic year 2022/2023. All the respondents were students at Poznan University School of Physical Education (faculties of Physical Education and Sport major). The mean age of male and female respondents were respectively 20.4 ± 1.54 and 20.5 ± 1.78 years. The average training experience for amateurs was 6.1 ± 3.31 years, while for professional athletes it was 9.1 ± 3.57 years.

Research Design

The research study was conducted by the diagnostic survey method and was based on a quasi-experimental design with two groups – experimental (EG) and control (CG). The experiment was divided into two phases, and for testing a validated structured survey questionnaire was used. In the study Lind's Moral Judgement Test (MJT) was employed [34] to measure the level of general moral competence. One group, CG, had been asked to fill up the Lind's MJT – in 30 minutes session without any additional information or explanations to the test. This was followed directly by the second phase, the Moral Judgement Test in Physical Education (MJT-PE) [35] administered immediately afterwards (and took 15 minutes). Both phases were carried out in a one single 45 minutes session. The other group (EG), had to fill up the Lind's MJT with any additional information in 30 minutes (likewise the CG). The difference was how the second phase – the MJT-PE – was administered among students from EG. The respondents were given extended time (extra 60 minutes) which was spend on discussion with the whole-group scenario on each of the items of the second test (e.g., obeying coach/referee's decision, winning at all costs, fouling vs fair play, respect to the opponents and their health, aggressive behaviors in sport, sportsmanship vs unsportsmanship-like behaviors, rule violation, winners should not be judged). There were around 3 minutes devoted to discussion of each of the aforementioned MJT-PE test items through a group discussion, but without any final concluding statements (which took approximately 45 minutes). Discussion was moderated by a professionally prepared teacher, who conducted the session, but without making any right/wrong judgement suggestions. Finally, each responder of EG had about 15 minutes to fill up the MJT-PE.

Measures

Three self-report questionnaires were used to assess (a) demographic characteristics, (b) moral competence (in everyday life situations), and (c) moral judgment in physical education.

Demographic questionnaire

The demographic questionnaire regarded age, gender, level of sport participation, and years of

sport experience was additionally employed in this study. To recognize the modes of involvement in sports respondents were asked to indicate either no involvement, amateur, or professional practice. By professional involvement in sport it was meant engagement in regular, federated system of competitions organized by sport federations, while amateur practice meant taking part in sports as a hobby, for pleasure [36]. This was followed by a question concerning number of years of involvement and the type of specific sport they practiced.

Moral judgment (MJT)

In the study, Lind's Moral Judgement Test [26] in its validated Polish form [36] was utilized to assess the participants' level of moral competence. Respondents were presented with two moral dilemmas and asked to indicate their agreement or disagreement with the provided statements. The first dilemma depicted a scenario of unethical behavior at the workplace, wherein factory workers, suspecting that managers were illicitly using confidential information against them, resorted to breaking into the administrative office. The second dilemma revolved around a medical scenario, where a woman suffering from cancer and experiencing severe pain pleaded with her doctor to administer an overdose of morphine.

According to the research protocol with MJT [34] students responded on a 9-point Likert scale, where the points ranged from -4 (totally disagree) to +4 (totally agree). Each of the two moral dilemmas had 12 statements (6 in favour and 6 against the behavior described), with all statements corresponding to the stages of moral development (the 6 stages of Kohlbergian theoretical model [6]). Final score, called the C-index, was summarized by an algorithm as described by Lind [34] with scores ranging from 1 to 100 points, and it reflects individual's ability to evaluate a given argument basing on their personal moral quality. It measures the degree to which a responder allows their own judgements to be affected by other moral concerns and potentially influential and mediating factors, rather than personal principles, opinions, and moral constructions. The smaller the C-index score the lower the level of moral competency in a person is. Scores below 19 are considered to be low and very low, scores above 19 to 29 are considered medium, and scores above 29 are acclaimed for high and very high levels of moral competence.

Moral judgment in Physical Education (MJT-PE)

To assess students' moral competence in physical education/sport settings the Moral Judgement in Physical Education Test (MJT-PE) [35] has been implemented. This tool has been conceived as a supplement to the original Lind's test [34] based on Kohlberg's structural-developmental theory [6] for morality and on the dual aspect theory of

moral behavior. In the MJT-PE, the responders meet one moral dilemma concerning story based on the certain situation from the sports field. In short, the story-dilemma concerns athletes who participate in sport competition during a school championship tournament and act inappropriately during the last minutes of a final game, driven solely by their desire to win. This particular situation was chosen due to its relatively common occurrence in sports events.

Likewise, akin to the aforementioned Lind's test scenario it is expected from everyone to choose on a 9-point Likert-type scale (from -4 – totally disagree to +4 totally agree) how much they agree with a 12 items sequence in favour of or against the described behavior in depicted school championship situation. Each item corresponds to one of the 6 Kohlbergian stages of moral development [6]. In the context of the students' behavior, the items were divided, with 6 arguments in favor and 6 against. One illustrative item aligned with Kohlberg's developmental stage 1 in favor of the players' behavior reads as follows: The players are justified in their actions, "because if they would lose the game probably they would be reprimanded by their coach". Conversely, an example of an item corresponding to stage 4, opposing the students' behavior, it is stated as: "The students' actions are deemed inappropriate, because committing intentional fouls is against the rules of the game".

The moral dimensions addressed in the items encompass issues of trust, adherence to rules and regulations, fair play, and the spirit of healthy competition. Through a thoughtful inclusion of these diverse moral perspectives, our study endeavors to capture a comprehensive view of the ethical dilemmas surrounding the students' behavior in the context of sports competition.

Validation process reinforced the robustness and reliability of the proposed model, thus lending credibility to its utility as a valuable tool for assessing moral development in the context of sport/physical education.

The index of moral competence in physical education (C-PE-index) is calculated in the same manner as the Competence Index (C-index) from the original test, all to multivariate analysis of variance. The test contains only one dilemma, but the way the C-PE-index is computed has no side effect on the interpretation of the final scores.

Statistical Analysis

First, we checked with a two-way ANOVA for some interaction effects between variables, then due to the normal distribution of data the comparison analyses between C-index scores were carried out with the use of Student's t-test. First the groups (EG and CG) have been compared on the mean C-index and C-PE-index scores, and this was followed by more detailed analyses for potential differences

within the group of amateurs (EG vs CG) and within the professionals sample (EG and CG). This was also done with the use of Student's t-test with p value set at < 0.05. All statistical analyses were completed using the STATISTICA software package.

Ethics

The study was conducted in strict accordance with the guidelines set forth in the Declaration of Helsinki (2013). The research protocol received ethical approval from the Local Bioethics Committee of the University of Medical Sciences, Poznań (decision no. 893/18). Prior to participating in the study, all respondents were provided with detailed information regarding the study's objectives, and they were assured of the voluntary nature of their involvement. Given that all participants were above the age of 16, consent was obtained directly from each individual.

Additionally, participants were provided with explicit information regarding the confidential and anonymous handling of data collection and storage. They were reassured that their individual contributions would be kept unidentifiable during all stages of data processing, encompassing publications and reports.

Results

A two-way ANOVA analyses showed no interaction effects (nor main effects) in the whole overall group between years of sports practice and modes of training (amateur vs professional) neither in case of MJT C-index with $F(3,344)=1.4967$, $p=.2152$, nor in MJT-PE C-PE-index with $F(3,343)=.2620$, $p=.8527$. Also analyses for potential interactions between years of training group differences (EG vs CG) showed no effects with $F(5,340)=1.8553$, $p=.1016$ for MJT C- index. While in regard of MJT-PE C-PE-index it was approaching statistical significance for the interaction effect with $F(5,339)=2.0471$, $p=.0716$ with main effect statistically significant at $p=0.001$ for the differences between EG and CG.

Then, the results were analysed for the potential differences in the mean C-index scores between "discussion" and "non-discussion" groups (EG vs. CG) (Table 1) to assess the extent of disparity in the declared answers, reflecting the level of moral competence.

It can be stated that the level of moral competency between the groups (EG – "discussion" vs CG – "non-discussion" one) was comparable since there was not statistically significance difference in terms of C-index scores, and the scores fell within the range of "low level of general moral competency", as they have been below the 19 points at C-index scores (Table 1). However, MJT-PE test scores comparison indicated there was a significant statistical difference in sport-specific moral competency levels in favour of "discussion group".

Further analysis concerned checking for potential differences between modes of involvement in sport practice (Table 2) and "discussion" (EG) and "non-discussion" (CG) groups. In terms of the levels of general moral competency (MJT C-index) there were no statistically significant differences neither within the groups of amateurs (EG vs CG) nor within the groups of professionals (EG vs CG). The only statistically valid difference was found in case of comparison of groups of amateurs in MJT-PE C-index scores. It was the amateurs from "discussion" group (EG) who scored higher than their peers from CG. Among professionals there was no indication of statistical significance despite the difference also in favour of athletes from discussion EG.

Discussion

The need to support the social, moral and democratic development of young people necessitates the search for effective and proven methods of influence through which education authorities could create stimulating educational experiences of moral and personal development and self-awareness. The best-known way to foster moral and democratic competencies is to provide proper

Table 1. Comparison of C-index scores between the groups.

Index	Discussion group (EG) N =178	Non-discussion group (CG) N =174	p-Value
C-index	15.2±10.6	14.7±8.6	0.6793
C-PE index	35.5±22.6	27.3±20.7	0.0008

Table 2. Comparison of C-index scores between the amateurs and between the professionals from experimental and control groups.

Index	Amateur (EG) N =97	Amateur (CG) N =102	p-Value	Professional (EG) N =81	Professional (CG) N =72	p-Value
C-index	16.1±11.0	14.9±9.4	0.4259	14.2±10.1	14.6±7.2	0.7653
C-PE index	37.3±22.3	27.4±22.5	0.0022	33.4±23.2	28.1±18.3	0.1239

learning opportunities in which s/he feels safe to freely express his/her moral ideals and arguments and in which s/he also respects others and their right of opinion, like in the method of the moral dilemma discussion [38].

The present study aimed to explore whether dilemma discussion but also the level of competition and the years of sport training (experience) could affect players' morality. The findings of this study not only corroborate, but also expand upon existing knowledge regarding moral development in the context of sports.

In our study there were no major interaction effects found between years of sport practice and levels of general moral competence (measured by MJT) in an overall group of examined students. However, in terms of the sport-specific domain of moral competence (measured by MTJ-PE), the ANOVA analysis showed a tendency for statistical significance in the interaction effect on the levels of moral competence. This interaction effect was observed in the C-index scores for sport-related dilemmas, with the main effect differentiating the experimental and control groups.

More specifically, concerning the effect of the intervention program with dilemma and discussion method, the findings indicated that experimental (discussion) group scored significantly higher on MJT-PE C-index than their control (non-discussion) group peers. And the difference could be accounted to the amateur sports students from the experimental group, who presented significantly higher levels of moral competency than their amateur counterparts from control group. A comparison of the MJT-PE scores within the professional groups of sports students did not indicate statistically valid differences, despite the higher on average score gained by the students from experimental group than for the professional sports students from control (non-discussion) group. This would imply, according to Kohlberg's theory, a higher level in terms of moral competence for both examined groups.

A study by Patil et al. [39] suggests that in hypothetical moral dilemmas moral decision-making process might be susceptible to contextual saliency of the presentation of these dilemmas. This was investigated on participants being exposed to dilemmas in virtual reality, which they perceived more emotionally arousing than the ones provided in a form of a description in text. In an earlier meta-analysis review by Schlaefli, Rest and Thoma [18] concerning various age and intervention method groups (including group discussion of moral dilemmas, psychological development programs, humanities courses) it was found that the dilemma discussion and psychological development programs produce modest overall effect size (with optimal treatments from 3 to 12 weeks, more

effective on 24 years and older adults than younger respondents). On the other hand, Thorne, Massey, and Jones [40] indicated that group consensus might be achieved through conformity. This occurs when the minority does not accept the dominant view but accedes to the majority as a result of group discussion. Additionally, consensus can be achieved through innovation (when the majority accedes to the minority's view) or normalization (when there is reciprocal influence). The findings suggest that prescriptive discussion on a moral dilemma encourages the group to be looking for the best response (solution) to that dilemma, if it is represented by the dominating majority.

It was also found [40] that deliberative discussion may encourage the elimination of multiple viewpoints. It clearly shows how the social influence process may affect individuals' moral reasoning, but understanding what mediate the effects requires more studies. Lezley et al. [41] proved group debates to be the effective in terms of ethical issues among pharmacy students, helping them develop skills such as teamwork, peer assessment, communication, and critical evaluation. On the other hand, Friedrich et al. [42] report on the studies indicating a decrease of moral competence levels throughout medical school study time. The intervention implemented by Friedrich et al. [42] employed two different teaching methods: principle-based (maintaining balance between normative perspectives) and theory-based (providing normative perspective) case discussions. The study did not find statistically significant superiority in either of the two methods. However, the effect size suggested that principle-based case discussions may be more effective in improving moral competency. There is general consensus about the importance of ethics education for medical students, given that they encounter moral dilemmas daily in their professional work. However, there is a lack of agreement among medical universities on how to improve the skills that will enable future medical doctors to analyze and solve potential moral conflicts they may encounter. Additionally, there is uncertainty about how to incorporate these goals into their curriculum during their studies [43]. So far, research in medical moral problems indicate that some forms of educational methods (e.g., small groups and case discussions in a course lasting at least 20 hours, guided discussion and learner/problem solving methods) are more effective than others [43, 44, 45]. It is then imperative to underscore the critical significance of validating and promoting ethics education in the realm of sports.

Sport, as one of the most important and popular elements of contemporary culture, can be very helpful in character development and value learning [46]. However, the competitive nature of sport rivalry

often brings unwanted, unethical behaviors into practice due to the pressure on athletes to win [47, 48]. Professionalization and commercialization of sports emphasize winning over participation. This combination of sportsmanship and competitiveness has created a conflict between values and functionality [49]. Thus, a moral dilemma arises related to the desire and need to win against the importance of participation and following the rules of the game, a contest between fairness and merit [50].

Incidents of violence on a sport field, hate, cheating, doping, and examples of bribery in sport-related context are often broadly broadcast and reach children and youth via numerous social media platforms [51]. Ring and Kavussanu [52] found that cheating in sport was associated with motivation with goals and suggested that interventions promoting fair play could focus on influencing the goals of the young sport contenders. Yet, Šukys [53] in his research revealed that there was a strong justification pattern for cheating among male athletes who tend more often to manipulate the rules of the games than females. However the sport students with less years of sport practice tended to justify deceptive actions linked to the manipulation of the results in sports more, but less justify other cheating forms in context of sports.

Youth attracted to sports is especially vulnerable group, not yet fully developed in terms of moral competency and susceptible to various influential factors. Unfortunately, youth sport programs are not structured to foster the development of skills in dealing with moral dilemmas in sport. Additionally, they provide even less support for helping young people transfer the positive values of sport into other real and daily life domains. In earlier research on sport adolescents aged 16-18 years [54] it was found that the level of general moral competency was low concerning 71.6% female, 76.8% male. At the same time the level of competency was not correlated with years of training nor with the mode of involvement (amateur/professional) in this age group. The results of correlation analysis with type of sports (individual vs team) did not provide consistent results as well. Earlier Proios, Doganis and Athanailidis [55] in their study on the same age group of participants also showed no significant differences in development of moral reasoning across types of sports, forms of participation and years of experience in sport. Apparently, Cummings et al. [20] showed in this age-group of youth that 5 weeks of direct instruction methods and participation in moral dilemma discussions, even via online participation, can bring positive change in principled moral reasoning. At the same time, it was found that college students do not grow in their moral development and reasoning from freshman to senior year. Studies conducted

on students pursuing physical education and sport major studies, aged between 19 and 23 years, reveal concerning findings regarding the preparedness of future physical education teachers and sport coaches in handling sport-related moral dilemmas. Specifically, 70% of the examined respondents exhibited a low level of moral competency [56]. Consequently, there is a pressing need for research endeavours that investigate the efficacy of diverse methods aimed at fostering moral development within the sports context, especially among further physical education and sport specialists.

Although the research concerned testing a novel method of group discussion influence on young sportspersons some limitations of the study need to be acknowledged. The sample size is reasonable and similar in two examined groups (with random allocation of the participants), but in the future studies this could be expanded to a bigger size. Also, the quasi-experimental nature of the study design does not allow for more generic conclusions. Perhaps longer time duration of the influence (more weeks and more discussion sessions) could be more effective, and would allow for comparison of pre-test/post-test levels, which was not possible, nor sensible with the study design presented in the paper.

Conclusions

In our study we have investigated the effectiveness of dilemma discussion method in supporting athletes' moral competence, as well as examined whether the level of sport competition (e.g., professional vs amateur) and overall years of sport experience are significant factors for athletes' moral competence levels.

It was proved that the dilemma discussion method has a significant positive effect on the level of athletes' moral competence. The findings showed that there was a significant statistical difference in the levels of moral competence specific to sports dilemmas in favor of the experimental "discussion group". At the same time, it should be noted that the effectiveness of the method was higher for amateur athletes than for professional ones. This means that in our study professional athletes were less sensitive to the effects of this method. Such a result suggests that professional sports may lead to the formation of stronger attitudes in terms of immoral behavior, and to achieve a positive effect on the formation of moral competences of professional athletes, the influence of the method should be more long-term and thorough.

The results of our study should become a strong argument for conducting an analysis of the system of training athletes by coaches and education governing bodies, including councils of the sports education system. The dilemma discussion method has proven its effectiveness in its use among young

athletes and deserves careful attention from the side of physical education and sports specialists. After all, the goal of the training process should be not only to prepare the athlete to achieve the highest results in sports, but above all to educate a conscious, highly moral citizen of society.

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Conflict of interest

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

References

- Lajčiaková P. *Psychológia morálky* [Psychology of morality]. Brno: CERM; 2008. (in Slovak).
- Steć M. Konstancka Metoda Dyskusji nad Dylematem (KMDD®) Georga Linda jako metoda stymulacji rozwoju kompetencji moralnej [Konstanz Method of Dilemma-Discussion (KMDD®) by Georg Lind as a method of fostering development of moral competence]. *Psychologia rozwojowa*, 2016; 2(3): 35–46. (in Polish).
- McKay R, Whitehouse H. Religion and morality. *Psychological Bulletin*, 2015;141(2): 447–473. <https://doi.org/10.1037/a0038455>
- Shields DLL, Bredemeier BJL. *Character development and physical activity*. Champaign, IL: Human Kinetics; 1994.
- Shields DL, Bredemeier BL. Advances in Sport Morality Research. In: Tenenbaum G, Eklund RC (eds.) *Handbook of Sport Psychology*, 1st ed. Wiley; 2007. P. 662–684. <https://doi.org/10.1002/9781118270011.ch30>
- Kohlberg L. Stage and sequences: The cognitive developmental approach to socialization. In: Goslin DA, editor. *Handbook of socialization theory and research*. Chicago: Rand McNally; 1969.
- Kohlberg L. 1. Stages of moral development as a basis for moral education. In: Beck CM, Crittenden BS, Sullivan E (eds.) *Moral Education*, University of Toronto Press; 1971. P. 23–92. <https://doi.org/10.3138/9781442656758-004>
- Kohlberg L. Development of moral character and moral ideology. In: Hoffman ML, Hofmann LW, editors. *Review of child development research*. New York: Sage; 1964. P. 381–431.
- Piaget J. Cognitive development in children. In: Ripple RE, Rockcastle VN, editors. *Piaget Rediscovered: A report of cognitive studies in curriculum development*. Ithaca, NY: Cornell University School of Education; 1964. P. 7–20.
- Gilligan C. Moral Orientation and Moral Development [1987]. In: Held V (ed.) *Justice and Care*, 1st ed. Routledge; 1995. P. 31–46. <https://doi.org/10.4324/9780429499463-4>
- Snarey JR. Cross-cultural universality of social-moral development: A critical review of Kohlbergian research. *Psychological Bulletin*, 1985; 97(2): 202–232. <https://doi.org/10.1037/0033-2909.97.2.202>
- Garrigan B, Adlam A, Langdon PE. Moral decision-making, and moral development: Toward an integrative framework. *Developmental Review*, 2018; 49: 80–100. <https://doi.org/10.1016/j.dr.2018.06.001>
- Greene JD, Morelli SA, Lowenberg K, Nystrom LE, Cohen JD. Cognitive load selectively interferes with utilitarian moral judgment. *Cognition*, 2008;107(3): 1144–1154. <https://doi.org/10.1016/j.cognition.2007.11.004>
- Moll J, Schulkin J. Social attachment, and aversion in human moral cognition. *Neuroscience & Biobehavioral Reviews*, 2009; 33(3): 456–465. <https://doi.org/10.1016/j.neubiorev.2008.12.001>
- Rest JR. *Development in judging moral issues*. Minneapolis, MN: Minnesota Press; 1979.
- Martins V, Santos C, Duarte I. Bioethics education and the development of nursing students' moral competence. *Nurse Education Today*, 2020;95: 104601. <https://doi.org/10.1016/j.nedt.2020.104601>
- Lind G. *Ist Moral lehrbar? Ergebnisse der modernen moral psychologischen Forschung* [Can Morality be Taught? Results of modern moral psychological research]. Berlin: Logos-Verlag; 2002. (in German).
- Schläfli A, Rest JR, Thoma SJ. Does moral education improve moral judgment? A meta-analysis of intervention studies using the Defining Issues Test. *Review of Educational Research*, 1985; 55(3): 319–352. <https://doi.org/10.3102/00346543055003319>
- Kruger AC. The Effect of Peer and Adult-Child Transactive Discussions on Moral Reasoning. *Merrill-Palmer Quarterly*, 1992; 38(2): 191–211.
- Cummings R, Maddux R, Richmond A, Cladianos A. Moral Reasoning of Education Students: The Effects of Direct Instruction in Moral Development Theory and Participation in Moral Dilemma Discussion. *Teachers College Record*, 2010; 112(3): 621–644. <https://doi.org/10.1177/016146811011200305>
- Salvador RO. Re-examining the “Discussion” in the Moral Dilemma Discussion. *J Bus Ethics*, 2019; 156: 241–256. <https://doi.org/10.1007/s10551-017-3626-z>
- Hewko SJ, Cooper SL, Cummings GG. Strengthening Moral Reasoning Through Dedicated Ethics Training in Dietetic Preparatory Programs. *Journal of Nutrition Education and Behavior*, 2015; 47(2):156–161. <https://doi.org/10.1016/j.jneb.2014.10.001>
- Christensen JF, Gomila A. Moral dilemmas in cognitive neuroscience of moral decision-making: A principled review. *Neuroscience & Biobehavioral Reviews*, 2012; 36(4): 1249–1264. <https://doi.org/10.1016/j.neubiorev.2012.02.008>
- Thorne L, Hartwick J. The Directional Effects of Discussion on Auditors' Moral Reasoning. *Contemporary Accounting Research*, 2001; 18(2):

- 337–361. <https://doi.org/10.1506/Y917-MPRY-PANF-PRVE>
25. Zhang J. Cultivating Moral Competence of Chinese Undergraduates with KMDD-Sessions. *Ethics in Progres*, 2013; 4(1): 48–56. <https://doi.org/10.14746/eip.2013.1.4>
 26. Lind G. Wie mißt man moralisches Urteil? Probleme und alternative Möglichkeiten der Messung eines komplexen Konstrukts [How to measure moral judgement? Problems and alternative ways of measuring a complex construct] In: Portele G, editor. *Sozialisation und Moral*. Weinheim, Germany: Beltz; 1978. P. 171–201. (in German).
 27. Shim J. Investigating the effectiveness of introducing virtual reality to elementary school students' moral education. *Computers & Education: X Reality*, 2023;2: 100010. <https://doi.org/10.1016/j.cexr.2023.100010>
 28. García-Moriyón F, González-Lamas J, Botella J, González Vela J, Miranda-Alonso T, Palacios A, et al. Research in Moral Education: The Contribution of P4C to the Moral Growth of Students. *Education Sciences*, 2020;10(4): 119. <https://doi.org/10.3390/educsci10040119>
 29. Gardner RE, Janelle CM. Legitimacy judgments of perceived aggression and assertion by contact and non-contact sport participants. *International Journal of Sport Psychology*, 2002; 33: 290–306.
 30. Holowchak MA. Aggression, gender, and sport: reflections on sport as a means of moral education. *Journal of Social Philosophy*, 2003; 34(3): 387–399. <https://doi.org/10.1111/1467-9833.00189>
 31. Mouratidou K, Chatzopoulos D, Karamavrou S. Moral development in sport context: Utopia or reality? *Hellenic Journal of Psychology*, 2007; 4: 163–184.
 32. Rudd A, Stoll S. What type of character do athletes possess? An empirical examination of college athletes versus college non athletes with the RSBH value judgment inventory. *The Sport Journal*, 2004; 7(2):10–15.
 33. Stephens DE. Predictors of aggressive tendencies in girls' basketball: An examination of beginning and advanced participants in a summer skills camp. *Research Quarterly for Exercise and Sport*, 2001; 3: 257–266. <https://doi.org/10.1080/02701367.2001.10608958>
 34. Lind G. *Moral Competence Test (MCT)* [Internet]. 2016 [cited 2018 Jun 3]. Available from: <https://www.uni-konstanz.de/ag-moral/mut/mjt-engl.htm>
 35. Mouratidou K, Chatzopoulos D, Karamavrou S. Validity Study of the Moral Judgment Test in Physical Education: Development and Preliminary Validation. *Perceptual and Motor Skills*, 2008; 106(1): 51–62. <https://doi.org/10.2466/PMS.106.1.51-62>
 36. Collins English Dictionary. *Definition of "Amateurism"* [Internet]. 2023 [cited 2023 Mar 28]. Available from: <https://www.collinsdictionary.com/dictionary/english/amateurism>
 37. Nowak E. *Validation of the Polish Version of the Moral Judgment Test (MJT)* [Internet]. 2008 [cited 2018 Apr 3]. Available from: <https://www.uni-konstanz.de/ag-moral/mut/validation/MJT-polish-2008-validation-study.pdf>
 38. Lind G. *Moral ist lehrbar. Handbuch zur Theorie und Praxis der moralischen und demokratischen Bildung* [Morality can be Taught. Handbook on the Theory and Practice of Moral and Democratic Education]. München: Oldenbourg; 2003. (In German).
 39. Patil I, Cogoni C, Zangrando N, Chittaro L, Silani G. Affective basis of judgment-behavior discrepancy in virtual experiences of moral dilemmas. *Social Neuroscience*, 2014; 9(1): 94–107. <https://doi.org/10.1080/17470919.2013.870091>
 40. Thorne L, Massey D, Jones J. An investigation of Social Influence: Explaining the Effect of Group Discussion on Consensus in Auditors' Ethical Reasoning. *Business Ethics Quarterly*, 2004; 14(3): 525–551. <https://doi.org/10.5840/beq200414321>
 41. Hanna LA, Barry J, Donnelly R, Hughes F, Jones D, Lavery G, et al. Using Debate to Teach Pharmacy Students About Ethical Issues. *American Journal of Pharmaceutical Education*, 2014; 78(3): 57. <https://doi.org/10.5688/ajpe78357>
 42. Friedrich O, Hemmerling K, Kuehlmeier K. et al. Principle-based structured case discussions: do they foster moral competence in medical students? - A pilot study. *BMC Med Ethics*, 2017; 18(21). <https://doi.org/10.1186/s12910-017-0181-1>
 43. Eckles RE, Meslin EM, Gaffney M, Helft PR. Medical ethics education: Where are we? Where should we be going? A review. *Acad Med*, 2005; 80(12): 1143–52. <https://doi.org/10.1097/00001888-200512000-00020>
 44. Self DJ, Olivarez M, Baldwin DC. The amount of small-group case-study discussion needed to improve moral reasoning skills of medical students. *Acad Med*, 1998; 73(5): 521–3. <https://doi.org/10.1097/00001888-199805000-00019>
 45. Rzymaska I, Rzymiski P, Wilczak M, Włoszczak-Szubzda A, Jarosz MJ, Musielak M. The influence of passive and active moral training on medical university on changes of students' moral competence index-Results from randomized single blinded trial. *Ann Agric Environ Med*, 2014; 21(1): 161–166. <https://doi.org/10.5604/12321966.1120604>
 46. Holt NL, Neely KC, Slater LG, Camiré M, Côté J, Fraser-Thomas J, et al. A grounded theory of positive youth development through sport based on results from a qualitative meta-study. *International Review of Sport and Exercise Psychology*, 2017;10(1): 1–49. <https://doi.org/10.1080/1750984X.2016.1180704>
 47. Gerald Arthur-Banning S. Determining If Competition Level Matters in Developing Positive and Negative Youth Sportsmanship. *American Journal of Sports Science*, 2018;6(2): 38. <https://doi.org/10.11648/j.ajss.20180602.12>
 48. Stephens DG. *A Correlational Study on Parental Attachment and Moral Judgment Competence of Millennial Generation College Students*. [Dissertations]. [Internet]. 2009 [cited 2023 Aug 25]. Available from: <http://digitalcommons.unl.edu/cehdsdiss/32/>
 49. Levental O. Built heritage or lost nostalgia: Israeli

- fans and the conservation of sports venues. *Israel Stu*, 2020; 26: 1–16. <https://doi.org/10.1080/13537121.2020.1775938>
50. Jones C, Howe PD. The conceptual boundaries of sport for the disabled: classification and athletic performance. *Journal of the Philosophy of Sport*, 2005; 32: 133–146. <https://doi.org/10.1080/00948705.2005.9714678>
51. Kearns C, Sinclair G, Black J, Doidge M, Fletcher T, Kilvington D, et al. A Scoping Review of Research on Online Hate and Sport. *Communication & Sport*, 2023; 11(2): 402–430. <https://doi.org/10.1177/21674795221132728>
52. Ring C, Kavussanu M. The impact of achievement goals on cheating in sport. *Psychology of Sport and Exercise*, 2018; 35: 98–103. <https://doi.org/10.1016/j.psychsport.2017.11.016>
53. Śukys S. Athletes' Justification of Cheating In Sport: Relationship with Moral Disengagement In Sport and Personal Factors. *Baltic Journal of Sport and Health Sciences*, 2013; 3 (90): 70–77. <https://doi.org/10.33607/bjshs.v3i90.171>
54. 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; 17(15):5324. <https://doi.org/10.3390/ijerph17155324>
55. Proios M, Doganis G, Athanailidis I. Moral development and form of participation, type of sport, and sport experience. *Perceptual and Motor Skill*, 2004; 99: 633–642.
56. Bronikowska M, Korcz A, Krzysztozek J, Bronikowski M. How Years of Sport Training Influence the Level of Moral Competences of Physical Education and Sport Students. *BioMed Research International*, 2019;2019: 1–10. <https://doi.org/10.1155/2019/4313451>

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Psychological resilience for students of faculty of physical education and sports science

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Abstract

Background and Study Aim Understanding the psychological resilience of the student population is becoming increasingly significant in contemporary times. The research aims to identify the level of psychological resilience among students at the Faculty of Physical Education and Sports Sciences, and also the differences in average scores in the level of psychological resilience among them.

Material and Methods The research used a descriptive approach, employing the survey method to collect data. The research sample deliberately included 68 male and female students from the teaching, training, and rehabilitation division in the Faculty of Physical Education and Sports Sciences. The Connor-Davidson Resilience Scale (CD-RISC) was used after excluding some items to make it suitable for the Libyan environment.

Results The results show a high level of psychological resilience among the students in both the teaching and training divisions, while it was average for the students in the rehabilitation division. Additionally, there are statistically significant differences between the three divisions, with the teaching division having higher scores. There are no statistically significant differences between the training and rehabilitation divisions in terms of the scale of psychological resilience, due to the similarity of means.

Conclusions Increasing the level of students' psychological resilience may result from assigning greater responsibility to them during the field training period, which simulates their future work environment. Additionally, it is advisable to develop preventive programs aimed at reducing the low level of psychological resilience among students and to prepare guidance programs aimed at enhancing psychological resilience among students.

Keywords: psychological resilience, university, self-efficacy, life satisfaction, students

Introduction

The university stage is considered one of the important stages in an individual's life, as he seeks to achieve his goals and ambitions and determines the shape of his future life. In order for the student to pass this stage successfully, he must work hard, persevere, and fulfill many academic and social requirements. The university is also an institution that represents the top of the educational pyramid, as it is the primary contributor to building society through the specialized cadres it produces, which in turn initiate the development process in society. University youth represent an important segment of society. They are the backbone of development in various areas of life, and there is no development without an effective force that is balanced psychologically and emotionally [1, 2].

Like any age stage, the university stage has its own problems and is not devoid of various pressures and frustrations to which students may be exposed. It is due to the nature of the age and school stage,

as well as successive cognitive and technological developments, and the resulting requirements and needs for high skills and competencies. This has negatively affected them and made them vulnerable to many psychological disorders. These disorders, in turn, have affected their ability to carry out tasks. What is required of them and their accomplishment, and accepting their life and feeling satisfied with it in general.

Benard [3] states that resilient students have a high level of ambition that appears in their high expectations, the presence of goals and motivation for life, as well as the clarity of personal strength and possession of problem-solving skills. He also confirmed that these characteristics contribute to developing a sense of belonging and participation, and reducing feelings of alienation and lack of belonging.

The psychological resilience in psychology refers to the idea of an individual's tendency to remain steadfast and maintain his calm and self-balance when exposed to pressure or nervous situations, as well as his ability to effectively adapt and confront

these pressures and traumatic situations positively. Hence, in order for an individual to be able to confront various pressures, he must have a set of traits and characteristics, including psychological resilience, which helps the individual adapt to traumatic events, adversity, and continuous stressful situations. It is a continuous process through which the individual shows positive adaptive behavior in confronting adversity, trauma, and sources of psychological stress. Thus, he can achieve himself and give his life a meaning and a goal that he seeks to achieve heading into life. This is what positive psychology means, which aims to protect individuals from psychological disorders and enable them to face life's challenges [4, 5, 6]. The ultimate goal that it seeks to spread is improving the quality of life and getting the individual out of the limits of self-change to bring about positive changes in the surrounding community [7, 8, 9, 10].

The importance of the research lies in the fact that it sheds light on a topic that did not receive attention from researchers in the local community or civil society institutions in the country. This is especially relevant after the events that the country has gone through since 2011, including wars, political conflicts, and the Covid pandemic. These events have placed a burden on all institutions, particularly within the education sector, whether at the basic or higher education levels. The importance also lies in identifying the level of psychological resilience of the student population at the Faculty of Physical Education and Sports Sciences and the difference between them.

Research Problem. University youth are among the groups that face many obstacles, difficulties, psychological traumas, and pressures. This is especially true as they pass through the university study stage, which is considered one of the most challenging phases of life. In addition, they have many aspirations. A large percentage of university students deviate in their behavior due to the internal and external conflicts and frustrations they suffer due to which they feel anxious about success or lack thereof [11, 12, 13].

Through their work in the field of education, the authors noticed the pressures of life and study that university students are exposed to. They observed these pressures in light of cognitive and technological developments and the inability of some students to cope with life's changes, which can lead to additional stress. Therefore, the authors saw the need to study the psychological resilience of students at the university stage. Hence, the current study will attempt to reveal the positive aspects of the students of the Faculty of Physical Education and Sports Sciences, by identifying the level of psychological resilience and the differences between them among the research sample under study.

Research Questions:

A) What is the level of psychological resilience among students of the Faculty of Physical Education and Sports Sciences?

B) Are there differences in the average scores in the level of psychological resilience among students at the Faculty of Physical Education and Sports Sciences?

Purpose of the Study:

1. Identifying the level of psychological resilience among students at the Faculty of Physical Education and Sports Sciences.

2. Identifying the differences in average scores in the level of psychological resilience among students at the Faculty of Physical Education and Sports Sciences.

Materials and Methods

Participants

The research community consists of students from the Faculty of Physical Education and Sports Sciences that are enrolled to general, teaching, training or rehabilitation division, who number 140 male and female students.

Research Design

Research Approach. The researchers used the descriptive approach using the survey method to collect data for the research.

Research Sample. The research sample was selected deliberately from students of the Faculty of Physical Education and Sports Sciences, with a number of 68 students and a percentage of 48% distributed as listed in Table 1.

Table 1. Distribution of the community members.

Community	No.	Percentage
Teaching division	15	22%
Training division	26	38%
Rehabilitation division	27	40%
Total	68	100%

Research Domains:

A) Temporal domain: The basic study was conducted from March 01, 2023 until May 18, 2023.

B) Spatial domain: Faculty of Physical Education and Sports Sciences.

C) Human domain: Students from the Faculty of Physical Education and Sports Sciences which includes students from teaching, training, and rehabilitation division.

Data Collection Tool. In order to collect data, the researchers used The Connor-Davidson Resilience Scale (CD- RISC) [14], which was prepared by Al-Kolaly [15] before to be suitable for Egyptian environment. After presenting it to a group of experts and specialists, the following items No.

3,9,19,21,22 were excluded so that it would be suitable for the Libyan environment.

Exploratory Study. The exploratory study was conducted in the period from March 01–12, 2021 on a sample of students from the Faculty of Physical Education and Sports Sciences from within the community, and from outside the basic sample in order to extract stability coefficient and self-honesty coefficient of the scale as listed in Table 2.

Table 2. Self-honesty and stability coefficient of the scale.

Scale	Statistical Coefficients	
	Stability	Self-honesty
Psychological resilience	0.84	0.92

Statistical Analysis

Statistical Package for Social Sciences (SPSS) software, version 21, was relied upon to perform the statistical treatments, where the following calculations and statistical operation were performed:

Arithmetic mean; Assumed mean; Standard deviation; Coefficient of torsion; T-test value; Least and greatest values; One-way Analysis of Variance (ANOVA); Scheffe's test for the least significant difference.

Table 3. Descriptive statistics of psychological resilience regarding to community (n = 68).

Community	Psychological Resilience Scale							Significance Value
	Minimum Value	Maximum Value	Arithmetic Mean	Standard Deviation	Torsion coefficient	Assumed Mean	T-test Value	
Teaching division	60	93	79.60	10.56	-0.248	60	7.18	0.00
Training division	38	84	62.73	14.00	-0.230	60	0.99	0.33
Rehabilitation division	30	80	58.78	12.04	-0.422	60	-0.53	0.60

Significance level at 0.05

Table 4. One-way ANOVA for the three divisions regarding to psychological resilience scale (n = 68).

Source of Variation	Psychological Resilience Scale				
	Sum of Squares	Degree of Freedom	Mean Square	F-test Value	Significance Value
Between groups	04375.68	02	2187.84	13.89	0.00
Within groups	10235.40	65	0157.47		

Significance level at 0.05

Table 5. Significance of differences between the means of the psychological resilience scale (n = 68).

Community	Arithmetic Mean	Mean Differences		
		Teaching Division	Training division	Rehabilitation division
Teaching division	79.60		16.87*	20.82*
Training division	62.73			3.95
Rehabilitation division	58.78			

Significance level at 0.05

Results

Results of the First Research Question

It is clear from Table 3 that the value of the arithmetic mean for the sample may be included among the divisions. Students of teaching division have reached an arithmetic mean of 79.60 which is higher than the assumed mean, which indicates that the students possess a high level of psychological resilience. As for the students of training division, they achieved an arithmetic mean of 62.73 which is higher than the assumed mean, which indicates that they have a high level of psychological resilience. As for the students of rehabilitation division, the arithmetic mean reached 58.78 which is a value close to the assumed mean, which indicates that they possessed a level of average psychological resilience.

Results of the Second Research Question

It is clear from Table 4 using one-way Analysis of Variance (ANOVA) that there are statistically significant differences in the scale of psychological resilience for the students of Faculty of Physical Education and Sports Sciences for the three divisions. Accordingly, the researchers calculated significance of differences of the arithmetic means using the Scheffe's test for the least significant difference as listed in Table 5 where it is clear that

the significance of differences between the means of the psychological resilience scale for the three divisions using the Scheffe's test that:

1. There are statistically significant differences between the three divisions, in favor of teaching one.
2. There are no statistically significant differences between training and rehabilitation division in the scale of psychological resilience due to the convergence of means.

Discussion

In the following discussion, we delve into the results of our study, considering two key research questions. These findings shed light on the vital role of practical education in students' academic and professional development, while also emphasizing the significance of their interactions in real-world settings. Furthermore, our conclusions align with prior research [16, 17, 18, 19], underscoring the consistent importance of such practical experiences in education.

In the context of the first research question, the positive results can be attributed to the comprehensive practical education that students in all three divisions receive at training and therapeutic centers. This hands-on experience extends over a two-year period during their studies at the faculty. These students actively apply their knowledge by mentoring their junior peers. The initial training prepares them for practical work in schools, sports clubs, and therapeutic centers, equipping them with valuable cognitive and practical experience in environments that closely resemble their future careers. These findings are encouraging, suggesting a positive outlook for the psychological well-being of students within the Faculty of Physical Education and Sports Sciences and society as a whole. It's worth noting that our results align with previous studies by Abdelrahman and Alazab [16] and Bachene and Hasiba [17], emphasizing the importance of such practical experiences.

In light of the second research question, the observed distinctions among the scientific divisions within the faculty can be attributed to several factors. These differences notably favored the teaching division, offering diverse career prospects for its students. As future educators, they are well-prepared to work with younger age groups, showcasing exceptional skills in effective interaction. This success can also be attributed to the practical education provided during the final

years of university studies (third and fourth year). Students spent significant time in schools, actively participating in various educational activities while assuming various responsibilities. Although they received comprehensive training in fieldwork, academies, sports clubs, and practical applications at therapeutic centers and hospitals, it's worth noting that full responsibility was not consistently placed on them during these experiences. These findings align with prior research, particularly the studies conducted by Abdelrahman and Alazab [16], Alshamri [18], and Al-Sheikh [19], underscoring the significance of practical experiences in students' development.

In conclusion, the observed differences among scientific divisions, with a notable advantage for the teaching division, highlight the importance of practical education in students' preparation for future careers. The positive outcomes associated with their interaction and responsibilities in real-world settings, despite the lack of full responsibility, underscore the value of such experiences. These findings affirm the significance of practical training in shaping students' capabilities and potential for various career directions. Additionally, the alignment of our results with previous studies underscores the consistency and importance of these practical experiences in education, emphasizing their role in preparing students for their professional roles in the future.

Conclusions

In light of the research results, the following conclusions can be drawn:

1. The high level of psychological resilience among the research sample from both teaching and training divisions.
2. The level of psychological resilience for the students of rehabilitation division was average.
3. There are statistically significant differences between teaching, training and rehabilitation division, and in favor of teaching one.
4. There are no statistically significant differences between both training and rehabilitation division in the scale of psychological resilience, due to the convergence of means.

Conflict of interest

The authors declare that there is no conflict of interests.

References

1. Marabas L. *Depression of Youth*. 1st ed. Beirut: Dar Al Nahda Al Arabia; 2010. (In Arabic).
2. San Román-Mata S, Puertas-Molero P, Ubago-Jiménez JL, González-Valero G. Benefits of Physical Activity and Its Associations with Resilience, Emotional Intelligence, and Psychological Distress in University Students from Southern Spain. *International Journal of Environmental Research and Public Health*. 2020;17(12):4474. <https://doi.org/10.3390/ijerph17124474>
3. Benard B. *Fostering resilience in kids. Turning the corner: from risk to resilience*. National Resilience Resource Center, University of Minnesota; 2012.
4. Sharma B. A study of resilience and social problem solving in urban Indian adolescents. *International Journal of Indian Psychology*, 2015;2(3):70–85. <https://doi.org/10.25215/0203.010>
5. Abu Halawa MAA. *Psychological resilience: Its nature, definition, and preventive value*. Arab Psychological Network e-book. 29; 2013. (In Arabic).
6. BouSaid S. *Psychological resilience and its relationship to future anxiety among women with thyroid disorders: a field study at a specialized clinic for endocrine diseases and diabetes in the city of Ouargla* [PhD Thesis]. Faculty of Humanities and Social Sciences, Ouargla: Kasdi Merbah University; 2014. (In Arabic).
7. Ozkara, AB, Kalkavan A, Alemdag S, Alemdag C. The role of physical activity in psychological resilience. *Baltic Journal of Sport and Health Sciences*. 2016;3(102):24–29. <https://doi.org/10.33607/bjshs.v3i102.62>
8. Xu S, Liu Z, Tian S, Ma Z, Jia C, Sun G. Physical Activity and Resilience among College Students: The Mediating Effects of Basic Psychological Needs. *International Journal of Environmental Research and Public Health*. 2021;18(7):3722. <https://doi.org/10.3390/ijerph18073722>
9. Seçer E, Yildizhan YÇ. The relationship between physical activity levels and psychological resilience of university students. *Revista Turismo Estudos e Práticas-RTEP/UERN*. 2020;4:1–12.
10. Chacón-Cuberos R, Castro-Sánchez M, Pérez-Turpin JA, Olmedo-Moreno EM, Zurita Ortega F. Levels of Physical Activity Are Associated With the Motivational Climate and Resilience in University Students of Physical Education From Andalucía: An Explanatory Model. *Frontiers in Psychology*, 2019;10:1821. <https://doi.org/10.3389/fpsyg.2019.01821>
11. Osman MSH. Psychometric properties of the positive resilience scale among university youth. *Journal of the Faculty of Education - Ain Shams University*, 2010;34(2):539–573. (In Arabic).
12. Koçak, M, Özbaş AA, Gürhan N. Identification of psychological resilience and self-efficacy levels of physical education-sport students. *Beden Eğitimi ve Spor Bilimleri Dergisi*, 2017;11(2):129–135.
13. Onturk Y, Efek E, Yildiz M. Investigating the psychological resilience of students in sports sciences faculty. *International Journal of Educational Methodology*, 2020;6(2):393–403. <https://doi.org/10.12973/ijem.6.2.393>
14. Connor KM, Davidson JRT. Development of a new resilience scale: The Connor–Davidson Resilience Scale (CD- RISC). *Depression and Anxiety*, 2003;18:76–82. <https://doi.org/10.1002/da.10113>
15. Al-Kolaly MMA. The factorial structure of the american version of the resiliency scale in the egyptian environment: a study on a sample of university students. *International Journal of Educational and Psychological Science*, 2016;3:242–283. <https://doi.org/10.12816/0041347>
16. Abdelrahman R, Alazab A. Predicting psychological resilience of university students in light of some variables: Study on a sample of Ajman University students - United Arab Emirates. *Sohag Journal of Education*. 2021;84(1):257–300. (In Arabic). <https://doi.org/10.21608/edusohag.2021.148040>
17. Bachene H, Haciba B. The level of psychological resilience and its relation to the character strengths and human virtues among a sample of psychologists in autism associations. *Journal of Human and Society Sciences*, 2021;1(10):345–372. (In Arabic).
18. Alshamri MA. Psychological flexibility and its relationship to social competence among high school students in Hail. *The Arab Journal of Educational and Psychological Sciences - JASEP*. 2021;20(5):31–54. (In Arabic). <https://doi.org/10.21608/jasep.2021.162450>
19. Al-Sheikh KI. Psychological resilience and its relation with self satisfaction Afield : study on a sample of Damascus University students. *Tishreen University Journal for Research and Scientific Studies - Arts and Humanities*, 2017;2(39):371–392. (In Arabic).

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Unified bench press through the elimination of leg-drive to promote sports inclusion

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Abstract

Background and Study Aim Among the weightlifting disciplines we find the bench press in Powerlifting and Para Powerlifting, which are very similar. They have never been combined for several reasons, the most important of which is the use of two different barbell lifting techniques. Unlike Para Powerlifting, Powerlifting in the bench press involves the use of leg-drive, i.e. leg thrust, which is considered one of the possible determining factors for the success of this exercise. The aim of the study was to test whether the elimination of the leg-drive technique in Powerlifting, followed by a protocol of adapting to the Para Powerlifting technique, without leg-drive, made a difference in terms of lifting the maximum load (1RM).

Material and Methods The subjects were 10 male amateur athletes (22,3 ± 2,4 years old). The training protocol, administered for 2 weeks, consisted of finding the best possible position on the bench in the absence of leg-drive. The 1RM test with leg-drive and 1RM without leg-drive were administered. A dependent-samples t-test was used to compare the differences in 1RM test using the two techniques.

Results The result was not statistically significant ($p > .05$), as the maxima with the two techniques remained unchanged. Discussions. Para Powerlifting technique, without leg-drive, in bench press, allows athletes without disabilities to lift the same weights as the leg-drive technique, or slightly less.

Conclusions The results obtained are promising and the study, if extended and focused on high-level athletes with positive results, could open a new page in sport, representing a new step in sport towards inclusion.

Keywords: powerlifting, inclusion, strength, strategies, performance gap.

Introduction

The bench press is one of the disciplines of weightlifting, which belongs to the Italian Weightlifting Federation (FIPE). It consists of assessing the maximum abduction force of the extensor chain of the upper limbs performed with an opposite movement [1]. The bench press competitions take place in compliance with the specific Technical Regulations, according to the Federal Programme of Competitive Activities approved annually by the FIPE Federal Council. Over the years, given the ease with which the materials for practicing this discipline can be found and the simplicity with which the athletic gesture can be performed, it has also become widespread among people with disabilities [2]. The World Para Powerlifting is the international Paralympic weightlifting federation based in the German city of Bonn. We have different examples where the records of Paralympic athletes are close to those of athletes without disabilities, yet they compete separately for several reasons. The distinction in

Para Powerlifting is very similar to the traditional bench press. In general, bench press is one of the main exercises to assess upper body strength [3, 4]. The muscles involved in bench press are pectoralis major, deltoid, coracobrachialis and biceps brachii, triceps brachii and anconeus, pectoralis minor, dentate major, subclavian. The adductor muscles of the scapulae, including the gran dorsalis, play a key role during set-up and positioning.

In Powerlifting, the arch bench technique is the predominant method, the benefit of which is said to be due to the shortening of the bench's range of motion and increased leg thrust [5]. This leg thrust is called leg-drive. The use of the leg-drive has always been considered one of the possible determining factors for the success of this exercise. The alleged advantages of this technique are the improved chest set-up, which allows for an optimal thrust angle and a forceful thrust with the whole body, and not only with the trunk [6]. Due to their physical limitations, athletes with disabilities must place their legs on the bench. In fact, in Para Powerlifting there are adaptations that also allow athletes with disabilities to perform the exercise [7].

The main adaptation consisted of placing the legs stretched parallel on the bench or tied to the bench, via supports, in regulated positions. Consequently, on a technical and practical level, there was only one substantial difference: the use of the leg drive, i.e., the push of the feet into the flat bench, which is absent in Para Powerlifting and present in Powerlifting. Not everyone agreed that leg-drive had an important influence on the load lifted. A study by Gardner et al. [8] showed that the use of the leg-drive had little influence on the activation of the muscles responsible for the technical gesture of the bench press distension. The study analyzed the electromyographic activity of the muscles in three different bench press positions (standard bench press condition, with feet and legs not in thrust, leg-drive condition and feet in the air), the results of which showed no statistically significant differences between genders or conditions for any of the three muscles analyzed. Gardner later investigated the differences in subjects without disabilities in the lifting of the 1RM in the flat bench press in a standard position and with the use of the leg-drive and did not notice any significant differences, except for a slight improvement with the use of the leg-drive, probably due to the protocol focused on adaptation to this technique [9].

Aim and hypothesis. Comparative research between athletes with and without disabilities in weightlifting is sorely lacking [10]. Consequently, the aim of the present study was to verify whether the elimination of the leg-drive technique in Powerlifting, followed by a protocol of adaptation to the Para Powerlifting technique, without leg-drive, makes a difference in terms of lifting the maximum load (1RM). This study aims to test whether the absence of the leg-drive can be a strategy to reduce the gap between the two sports, promoting sports inclusion. Our hypothesis is that an appropriate training protocol is able to help athletes with disabilities adapt to the flat bench exercise without leg drive.

Materials and Methods

Participants

10 male amateur athletes (Mean \pm Standard deviation = age, 22,3 \pm 2,4 years old; weight, 71 \pm 11,9 kg; height, 175,1 \pm 8,9 cm; weightlifting background, 1,6 \pm 0,8 years) with a basic experience in weightlifting, participated in this study on a voluntary basis. The study adhered to ethical code of the Declaration of Helsinki and written informed consent was obtained from all participants, after informing them about the aim and the procedures. Data were stored and processed anonymously.

Research Design and Protocol

A one-group pretest-posttest quasi-experimental design, with a convenience sampling, was used.

The training study consisted of 2 weeks + 1 day of pre-testing and 1 day of post-testing. For 2 weeks 6 training sessions were performed to try to adapt the athletes to the new weightlifting technique without the use of leg-drive. The training sessions were conducted in a private gym during COVID-19 pandemic by a qualified instructor. Each session was divided into 3 phases. The objective was to stimulate the athlete to find the best possible position on the bench with the new technique, trying to reproduce the best possible arch. The training methodology was inspired by the work of Wilcox [11], comprised a warm up, central phase and cool down, as follow in Table 1.

Data collection. The materials used were:

- A multifunctional flat bench (VIDAXL) including a knee support at the bottom to stretch the legs and feet. This compensated for the absence of a Paralympic flat bench and therefore for a flat bench with a longer length to allow the supine position;
- cast-iron discs of various weights, mats, elastic bands;
- Decathlon non-Olympic bodybuilding barbell (weight 7.75 kg; length 1.55 m; diameter 28 mm).
- iPhone XR with metronome +.

Two maximal tests were used:

- 1RM with leg-drive, to assess the maximal load lifted, administered only on entry.
- 1RM test using Paralympic bench press technique, without leg-drive, administered on entry and exit.

Statistical Analysis

After verifying the normality of the data ($p > .05$) with the Shapiro Wilk test, the dependent-samples t-test was used to test for differences between 1RM with and without leg-drive on entry, and between 1RM with leg-drive on entry and 1RM without leg-drive after 2 weeks. Data analyzes were performed using Statistical Package for Social Science software (IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY).

Results

Participants' characteristics are shown in Table 1.

The result showed a statistical significance between 1RM test performed with and without the use of leg-drive on entry, $t(9) = 2.71$, $p < .024$. A detailed description is shown in Table 2.

After 2 weeks, the result was non-statistically significant between 1RM performed on entry using leg-drive and 1RM performed without leg-drive on exit, $t(9) = 1.50$, $p > .168$. A detailed description is shown in Table 3.

A graph on the comparison between the maximum raised with the two techniques is depicted in Figure 1.

Table 1. Participants' characteristics

Athlete	Date of birth	Age	Weight (kg)	Height (cm)	Years of gym
Athlete 1	06\02\1999	22	70	167	1
Athlete 2	23\10\1994	26	78	185	2
Athlete 3	02\03\2000	21	66	176	2
Athlete 4	12\01\1998	23	66	163	2
Athlete 5	27\11\2000	20	46	163	0
Athlete 6	18\08\2003	18	76	170	3
Athlete 7	06\04\1997	24	80	183	2
Athlete 8	23\10\1997	23	83	180	1
Athlete 9	15\02\1996	25	85	187	2
Athlete 10	30\10\1999	21	60	177	1

Table 2. T Test for paired samples on entry

Phase	Mean ± Standard deviation	Information	T-value	df	sig
Entry	1.200 ±	Maximal With Leg Drive	2.714	9	0.024
	1.398	Maximal With Ppl Technique			

Table 3. T Test for paired samples on exit

Phase	Mean ± Standard deviation	Information	T-value	df	sig
Exit	0.400 ±	Maximal With Leg Drive (entry)	1.500	9	0.168
	0.843	Maximal With Ppl Technique (exit)			

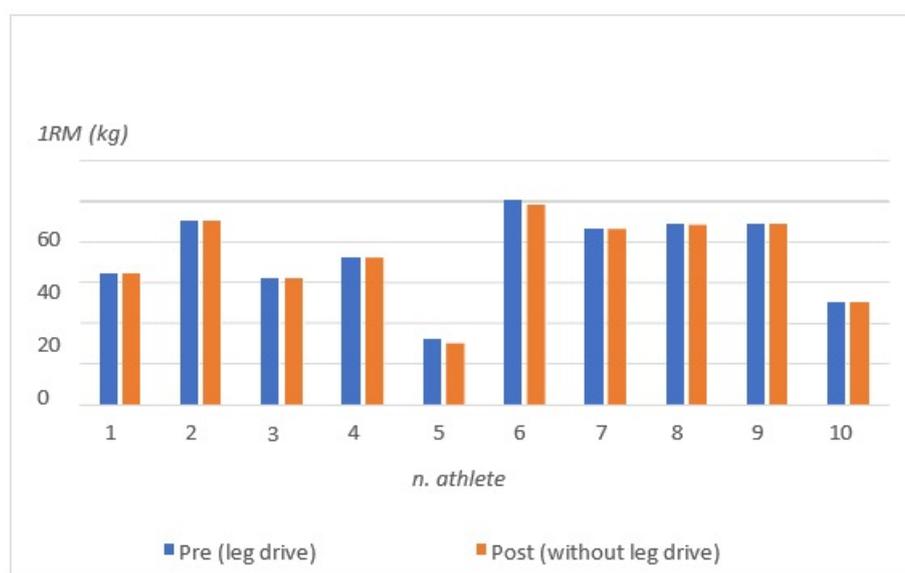


Figure 1. 1RM of 10 athletes with leg-drive (pre 2 weeks) and without leg-drive (post 2 weeks of training)

Discussion

The results showed the effectiveness of the training protocol in trying to adapt the athletes to the new flat bench technique, without the use of the leg-drive. The difference in the 1RM when using the two techniques was initially because the athletes were not used to the technique of lifting without the leg-drive. Consequently, by removing

the leg-drive to lift the load, the maximal was lower. With the right preparation, it is possible to always maintain a high ceiling, but without leg drives. This promotes sports inclusion. Sporting activity plays a very important role in training and education [12, 13], in terms of physical well-being and in keeping the body and mind fit. This was recently recognised with the introduction of

the specialist teacher in the last classes of primary school, as having the appropriate training [14, 15]. In general, competitions for Paralympic athletes are adapted according to the athletes' disability [16]. Efforts are made to promote inclusion in different ways: by analysing the performance model [17, 18], by reducing the performance of people without disabilities, by modifying motor or functional gestures [19], game rules and technological tools [20]. In our case, we simply replaced the bench press technique with leg drives with the Para Powerlifting technique, without leg drives. The aim was to test the adaptability of the Para Powerlifting technique to the bench press, demonstrating that its use would not compromise the amount of load lifted by athletes without disabilities. The use of the new technique, to the detriment of the leg-drive technique, does not massively affect the maximum lifted by athletes. This allows us to state that it is possible to use the technique used so far only in Para Powerlifting, even in Powerlifting, without any reduction in performance. In this way, we can annul all the theoretical speculations made about the impossibility of unifying the two disciplines. Starting with the main one, namely that the difference in techniques would create a large gap between the maximums lifted in the two competitions. It would therefore be desirable to create a single integrated discipline, but to do so would require addressing one problem, which is to eliminate the regulatory differences in terms of time. Currently, in fact, Paralympic athletes during competition have 1 minute more than athletes without disabilities to perform the test in the group system.

It is necessary to breakdown all barriers of prejudice and sport can be in effect a tool for integration and social inclusion. Inclusive activities are important to achieve a better perception of disability [21], change current stereotypes and promote social, cultural and educational development [22]. These results can be useful for coaches and technicians to promote sports inclusion in Powerlifting. With the right strategies, in this case the elimination of the leg-drive technique and adaptation to the leg-

drive-free technique of Para Powerlifting through specific protocols, it is possible to make athletes with and without disabilities compete together; all without reducing the performance of athletes without disabilities. University education can play a significant role in helping sports science and exercise students [23, 24], to identify, based on their own experience and knowledge, the most suitable strategies for promoting sports inclusion. The sports kinesiologist, a master's graduate student in exercise and sports science, is the ideal professional figure as it is involved in competitive athletic training activities [25, 26]. With the new sports reform and the introduction of the kinesiologist, universities should work on curricula so that they are more consistent with the respective professional profiles [27, 28].

The limitations of the study are the sample size and the reference to amateur athletes with little experience in the field. Future studies could enlarge the sample and see if our hypothesis could also be valid for high-level athletes. However, as similar studies have not been found in the literature, this could be a first step in the evolution of two very similar disciplines with enormous potential. Future studies could also investigate the athlete's attentional aspect of muscle contraction during exercise, as internal focus has been found to be effective in increasing electromyographic activity [29, 30].

Conclusions

In this section, provide a concise summary of the main findings and their implications. Reiterate the key contributions of your study and how they align with the research objectives or hypothesis. Emphasize the practical significance of your results and their potential impact on the field. Avoid introducing new information or ideas in this section; instead, focus on summarizing what has been discussed in the previous sections. Consider addressing any limitations and suggesting directions for future research. End with a strong concluding statement that leaves a lasting impression on the reader, reinforcing the importance of your work.

References

1. FIPE. *Italian Weightlifting Federation*. [Internet]. 2016 [updated 2023; cited 2023 Sept 02]. Available from: <https://www.federpesistica.it/>
2. World Para Powerlifting. *Sport week: history of Para powerlifting*. [Internet]. 2016 [updated 2023; cited 2023 Sept 02]. Available from: <https://www.paralympic.org/news/sport-week-history-para-powerlifting>
3. Di Domenico F, Raiola G. Effects of training fatigue on performance. *Journal of Human Sport and Exercise*. 2021, 16(2proc): S769-S780. <https://doi.org/10.14198/jhse.2021.16.Proc2.63>
4. Di Domenico F, Raiola G. Muscle strength and the complexity of human movement. *Journal of Human Sport and Exercise*. 2021, 16(3proc): S1481-S1490. <https://doi.org/10.14198/jhse.2021.16.Proc3.64>
5. Tungate P. The bench press: a comparison between flat-back and arched-back techniques. *Strength & Conditioning Journal*. 2019; 41(5): 86-89. <https://doi.org/10.1519/SSC.0000000000000494>
6. Lauver JD, Cayot TE, Scheuermann BW. Influence of

- bench angle on upper extremity muscular activation during bench press exercise. *European Journal of Sport Science*. 2016; 16(3): 309-316. <https://doi.org/10.1080/17461391.2015.1022605>
7. Martino L, Fonzo E, Cassese FP, D'Isanto T. Principles of adaptation of the rules for disabled athletes for an inclusion sport. *Journal of Human Sport and Exercise*. 2019, 14(Proc2): S215-S220. <https://doi.org/10.14198/jhse.2019.14.Proc2.08>
 8. Gardner JG, Chia JT, Miller KL. Leg-drive does not affect upper extremity muscle activation during a bench press exercise. *Internat J Hum Move Sports Sci*. 2019; 7(1): 12-7. <https://doi.org/10.13189/saj.2019.070103>
 9. Gardner JK, Chia JT, Peterson BM, Miller KL. The effects of 5 weeks of leg-drive training on bench press performance in recreationally-trained, college-age men. *Journal of Science in Sport and Exercise*. 2022; 4(3): 231-236. <https://doi.org/10.1007/s42978-021-00118-0>
 10. Van den Hoek D, Garrett J, Howells R, Latella C. Paralympians are stronger than you know: a comparison of Para and nondisabled Powerlifting bench press world records. *The Journal of Strength & Conditioning Research*. 2022; 37(2):452-456. <https://doi.org/10.1519/JSC.0000000000004251>
 11. Wilcox DR. *The Training of a Para Powerlifter: A Case Study of Adaptive Monitoring, Training and Overcoming* [Doctoral dissertation]. East Tennessee State University; 2019.
 12. D'Elia F. The training of physical education teacher in primary school. *Journal of Human Sport and Exercise*. 2019; 14(1): 100-104. <https://doi.org/10.14198/jhse.2019.14.Proc1.12>
 13. D'Isanto T. Pedagogical value of the body and physical activity in childhood. *Sport Science*. 2016; 9(Supplement 2): 13-18.
 14. D'Elia F. Physical education in primary school and impact on primary teacher education students from two different university sites. *Acta Kinesiologica*. 2021; 17(1). <https://doi.org/10.51371/issn.1840-2976.2023.17.1.5>
 15. D'Isanto T. Physical education in primary school and impact on educational leadership. *Acta Kinesiologica*. 2023; 17(1). <https://doi.org/10.51371/issn.1840-2976.2023.17.1.4>
 16. Blumenstein B, Orbach I. Psychological preparation for Paralympic athletes: A preliminary study. *Adapted Physical Activity Quarterly*. 2015; 32(3): 241-255. <https://doi.org/10.1123/APAQ.2014-0235>
 17. Imparato P, Sannicandro I, Izzo R, Aliberti S, D'Isanto T. Disability and inclusion: Swimming to overcome social barriers. *Journal of Human Sport and Exercise*. 2021; 16(2proc): S688-S696. <https://doi.org/10.14198/jhse.2021.16.Proc2.54>
 18. Taleb M, Aliberti S, D'Isanto T. Core training to reduce the performance gap between abled and disabled athletes in the canoe discipline. *Journal of Human Sport and Exercise*. 2021; 16(3proc): S1039-S1044. <https://doi.org/10.14198/jhse.2021.16.Proc3.21>
 19. Ceruso R, D'Isanto T, Altavilla G, Esposito G, Di Domenico F, D'Elia F. Functional classification and performance in wheelchair basketball. *Studia Sportiva*. 2022; 16: 23-32. <https://doi.org/10.5817/StS2022-1-3>
 20. Latorella V, Di Domenico F, Altavilla G. Neuromuscular adaptations to a motor skills training program for adults with intellectual disabilities. *Journal of Human Sport and Exercise*. 2020; 15(Proc3): S676-S687. doi:10.14198/jhse.2020.15.Proc3.20
 21. Aliberti S, Rago V, D'Elia F, Raiola G. Questionnaire of inclusion in Paralympic dance: validation and pilot study. *Sport Sciences for Health*. 2022: 1-9. <https://doi.org/10.1007/s11332-022-00905-4>
 22. Raiola G, Esposito G, Sgrò F. The formative value of soccer rules. *Journal of Human Sport and Exercise*. 2020; 15(Proc3): S656-S663. doi:10.14198/jhse.2020.15.Proc3.18
 23. D'Elia F. Inclusion in physical and sport education for special movement needs. *Journal of Human Sport and Exercise*. 2021; 16(2proc): S781-S787. <https://doi.org/10.14198/jhse.2021.16.Proc2.64>
 24. D'Isanto T, D'Elia F, Altavilla G, Aliberti S, Esposito G, Di Domenico F, Raiola G. In Italy compatibility between qualifying training objectives of degree courses in sport sciences and exercise and the kinesiologist profile. *Trends in Sport Sciences*. 2022; 29: 99-105. <https://doi.org/10.23829/TSS.2022.29.3-3>
 25. Raiola G, D'Isanto T, D'Elia F, Altavilla G. An exploratory study in non-professional football on the perception of stakeholders about the new working professional profile of sports kinesiologist. *International Journal of Environmental Research and Public Health*. 2022; 19(23): 15839. <https://doi.org/10.3390/ijerph192315839>
 26. Raiola G. University training for physical education teachers, sports and preventive and adapted physical activities kinesiologists and sports manager. *Acta Kinesiologica*. 2023; 17(1). <https://doi.org/10.51371/issn.1840-2976.2023.17.1.8>
 27. Aliberti S. University training of the basic kinesiologist. *Acta Kinesiologica*. 2023; 17(1). <https://doi.org/10.51371/issn.1840-2976.2023.17.1.3>
 28. Altavilla G. Impact of new professional profiles of the sports kinesiologist, preventive and adapted physical activities kinesiologist and of sports manager in the current university education. *Acta Kinesiologica*. 2023; 17(1). <https://doi.org/10.51371/issn.1840-2976.2023.17.1.10>
 29. Marchant DC, Greig M, Scott C. Attentional focusing instructions influence force production and muscular activity during isokinetic elbow flexions. *The Journal of Strength & Conditioning Research*. 2009; 23(8): 2358-2366. <https://doi.org/10.1519/JSC.0b013e3181b8d1e5>
 30. Vance J, Wulf G, Töllner T, McNevin N, Mercer J. EMG activity as a function of the performer's focus of attention. *Journal of Motor Behavior*. 2004; 36(4): 450-459. <https://doi.org/10.3200/JMBR.36.4.450-459>

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Acute effects of repeated isoinertial lunges on jump and sprint parameters

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

Abstract

Background and Study Aim Understanding the relationship between repeated isoinertial lunges and jump and sprint parameters is an important factor in achieving success in sports requiring explosive strength and speed. The aim of this study was to examine the acute effects of repeated isoinertial lunges on jump and sprint parameters.

Material and Methods Volunteered 42 students from Sports Sciences Faculty were participated to the study. They were randomly divided into experimental group (EG) (n=22, age=22.8±1.1year, height=180.6±7.1cm, body weight=77.5±8.8kg) and control group (CG) (n=20, age=23.0±2.1year, height=173.1±5.6 cm, body weight=71.3±8.4 kg). As pre- and post-tests, each participant performed squat jump (SJ), countermovement jump (CMJ), and 30m sprint on a non-motorized treadmill. Isoinertial lunges were included in 8 reps with dominant leg (DL), 1 min rest, and 8 reps with non-dominant leg (NDL). As a statistical analysis, pre- and post-test differences were analyzed with independent t test between groups and paired t test within groups. The level of significance was taken as $p \leq 0.05$.

Results There were pre-test and also post-test differences between groups in SJ ($p < 0.05$) but there were no differences within groups. Both groups had significant pre- and post-test time, velocity, and power differences [for EG: $p < 0.01$, $p < 0.001$, $p < 0.01$; for CG: $p < 0.001$, $p < 0.001$, $p < 0.01$, respectively]. EG had significant pre- and post-test differences in stride frequency (SF) ($p < 0.01$). There was a post-test SF difference between two groups ($p < 0.05$). There were no statistically significant pre-test differences between the groups in 30m sprint parameters of NDL and DL. There were only significant post-test differences between the groups in SF_{DL} ($p < 0.005$) and NDL horizontal force (HF_{NDL}) ($p < 0.01$). EG had only significant pre- and post-test differences in SF_{DL} and P_{NDL} ($p < 0.005$ and $p < 0.05$).

Conclusions Detailed studies in SF and SF_{DL} increases result by repeated isoinertial lunges should be beneficial focus on DL neuromuscular activation. Furthermore, incorporating repeated isoinertial lunges into training regimens could be a valuable strategy for enhancing specific aspects of athletic performance in sports that demand high levels of speed and explosive power.

Keywords: stride frequency, dominant leg, isoinertial lunge, horizontal force

Introduction

Strength training produces muscle adaptations at both structural and functional levels [1]. Strength training with an isoinertial resistance has become one of the popular training methods. It is a technology that improves proprioception, neuromuscular efficiency and motor coordination based on postural control by improving neuromuscular activity. It elicits an equal amount of eccentric force against the isoinertial force (concentric force) applied by athletes [2]. The supramaximal weight generated during isoinertial eccentric strength exercises leads to a muscle-lengthening contraction, greater muscle strength gains, muscle hypertrophy. It provides greater improvements in muscle coordination compared to concentric strength training [3]. Compared to other traditional strength training methods, isoinertial

resistance training method has positive effects on muscle architecture and cross-sectional area. The reason is that it achieves the same goals in less time [4]. Movements performed with isoinertial systems resulted in the same or greater strength development than the traditional weight training [5]. Isoinertial eccentric strength provides greater muscle activation on eccentric muscle contraction compared to traditional strength training [6]. Therefore, isoinertial eccentric training increases muscle strength by providing the opportunity to work on strength and speed in the muscle [7]. As a post-activity performance enhancement (PAPE), isoinertial squat and deadlift increased hamstring' eccentric strength but didn't affect the concentric strength [8]. Isoinertial system has a preventive effect against muscle tissue lesion by developing eccentric strength. It also allows gaining extensor strength [9]. It compares power/strength and balance in eccentric/concentric phases during exercise in real-time. This supports

that isoinertial training is effective in improving vertical and horizontal strength during sprinting, squat jump (SJ) and countermovement jump (CMJ). In optimal strength training, half-squat and squat jump movements are used in preventing strength and speed reductions [10]. In addition, CMJ is a commonly used movement for the assessment of isoinertial leg strength due to its simplicity and explosiveness [11]. Relationships among isoinertial strength, speed and power help to identify the mechanism responsible for maximal power and training adaptations [12]. However, Beato et al. [13] noted very few studies have investigated the acute neuromuscular mechanisms induced by isoinertial training. These studies were associated acute musculoskeletal adaptations and acute effects on PAPE. Isoinertial systems have become widespread and started to be used in different fields and purposes because of their beneficial effects.

In an isoinertial system, a resistance is exhibited in proportion to the concentric contraction exhibited during the eccentric contraction [14]. Previous studies have used isoinertial interventions for physical fitness [15] and rehabilitation [16]. Some of them found positive effects on different populations such as the elderly [17], athletes [18], athletes undergoing rehabilitation [19]. It is known that the acute and chronic increase in various performance parameters with isoinertial training varies. They depend on the type of movement in training method, volume, intensity and protocol as well as characteristics of participants. However, there are no studies on acute effects of repetitive isoinertial lunges on sprint and jump performances. The aim of this study was to investigate the acute effects of repetitive isoinertial lunges on jump and sprint parameters.

Materials and Methods

Participants

The study included 50 male volunteers who were studying at Eskisehir Technical University, Faculty of Sport Sciences aged between 18-22 years. They had not participated in an application with the isoinertial training system before, and had no health problems. The study was completed with 42 participants due to the problems in the data. The targeted number of participants was determined by G*Power 3.1.9.7 analysis. It was based on the data entered with a power size (1- β) of 0.80, $\alpha=0.05$, and an effect size (d) of 0.80. They were randomly divided into experimental group (EG) (n=22, age=22.8 \pm 1.1year, height=180.6 \pm 7.1cm, body weight=77.5 \pm 8.8kg) and control group (CG) (n=20, age=23.0 \pm 2.1year, height=173.1 \pm 5.6 cm, body weight=71.3 \pm 8.4 kg). They avoided high intensity exercise for 48 hours before the study. They were asked not to change their normal diet, smoke, drink

alcohol or consume caffeine for 24 hours before tests. Participants were informed in detail about the purpose, content, importance, application, and possible risks. They could freely discontinue the study at any time before starting the measurements and tests according to the procedures of the Declaration of Helsinki, trial measurements and tests. Each participant signed an informed consent. Istanbul Nisantasi University Ethics Committee approval (2022/24) was obtained for the study. Participants were assigned to the test protocols by simple randomization.

Research Design

After the device calibration, trial measurements and tests were performed for participants to adapt to laboratory conditions, measurements, and tests. They had a 10 min warm-up consisting of light-paced jogging, stretching and exercise movements. Participants performed 2x30m sprint tests with 3 min intervals. They had a 90 sec passive rest as stated by Kacoglu and Kale [20]. Then, they were taken to the vertical jump tests consisting of 2xSJ and 2xCMJ and the pre-tests were completed. SJ and CMJ tests were performed with 30 sec of passive rest between reps and 60 sec of passive rest between tests. The best of the 2 attempts in the jump tests was included in the statistical analysis. Before the post-tests, EG performed 16reps maximum (RM) lunges (8RM with DL in front, 1min rest, 8RM with NDL in front). CG performed repetitive lunges in the same way without isoinertial force.

Isoinertial Lunge Procedure

Each participant first performed a 10-minute warm-up consisting of light jogging, flexibility and calisthenic movements individually. Afterwards, the participant was shoeless, hands on the waist and torso upright, front foot on the phalanges on the isoinertial training system (Desmotec D11 Version Sport Pro, Italy). An adjustable rope was attached to the waist with a special belt from the bottom to the flywheel. Knees were in the flexion position between approximately 110-130°. When the participant felt ready, he performed extension until the knees reached 180° and returned to the starting position. He performed 16RM isoinertial lunges with 8RM of DL in front, 1 min rest, 8RM of NDL in front.

Height and Body Weight Measurements

Height was measured with a wall-mounted stadiometer (Holtain, UK) with an accuracy of 0.1mm. The accuracy was checked by measuring the height between the ground and the head table of the stadiometer. A 60cm standard aluminum flat bar was provided for this height. Body weight was measured using an electronic laboratory scale (Seca, Vogel & Halke, Hamburg) with an accuracy of 0.1kg. The measurements were done as recommended by Lohman et al. [21].

Sprint Test

Each participant had a 10-min warm-up consisting of light jogging, flexibility and calisthenic movements. He participated in 2x30m sprint tests with a 3-min interval on a non-motorized computer-assisted treadmill (Woodway Force 3.0, Woodway Inc., Waukesha, USA). Before the test, the horizontal force strain gauge attached to the waist was adjusted to be parallel to the treadmill. The best performance in 30m sprint tests was included in the statistical analyses. The best 30m sprint speed was calculated in m/sec from the formula $(V) = \text{distance (d)} / \text{time (t)}$. Horizontal force (HF) and vertical force (VF) data during 30m sprint were recorded on a computer at 200Hz. Means of SL and SF were determined in the best 30m sprint. The best 30m sprint HF = 30m sprint total HF (Σ HF) / 30m sprint total stride number (Σ SN) was calculated in Newton (N). The best 30m sprint VF = 30m sprint total vertical force (Σ VF) / 30m sprint total stride number (Σ SN) was calculated in N.

Jump Tests

Two different jump tests (SJ and CMJ) were applied on a jump mat that acts as an electronic on-off switch. As explained by Kale et al. [22], SJ and CMJ time was transferred to the computer. ESC 2XXX Series Data Acquisition computer software at 1000Hz [23] was used for each data transfer. Participants rested for 60sec after each jump test. Two trials were performed with 30 sec rest. Jumps were calculated with the formula $h = g \cdot t_f^2 \cdot 8^{-1} \cdot 100$; h = jump height (cm), g = gravitational acceleration ($9.81 \text{ m} \cdot \text{sec}^{-2}$), t_f = time in the air (sec) [24]. The highest jump height was taken into statistical analysis. SJ was performed on the mat with feet shoulder-width apart and hands on the waist. Eyes focused across and standing in a $\sim 90^\circ$ fixed squat position for 2-3 sec were followed by a vertical jump. CMJ was performed on the same mat with feet shoulder-width apart and hands on the waist. Eyes focused across and standing position, knees $\sim 90^\circ$ squat position as soon as possible were followed by a vertical jump.

Statistical Analysis

Data obtained from the study were analyzed using Jamovi statistical program (2.3.28.0, Stats Open Now). Skewness-Kurtosis test showed that all pre-test parameters of both groups were normally distributed. Independent sample t-test was used for between-group pre- and post-test comparisons. Paired sample t-test was used for within-group pre- and post-test comparisons. The significance level was based on $p < 0.05$. Effect sizes (ES) were analyzed through means and standard deviations as stated by Wassertheil and Cohen [25]. < 0.2 was considered as trivial, 0.2-0.5 as small, 0.5-0.8 as moderate and > 0.8 as large inference.

Results

Each parameter in the pre-tests was normally distributed ($p > 0.05$). Participants were divided into EG and CG. All results are presented in Table 1-4.

Table 1. demonstrated that there were no significant SJ differences in pre- and post-test comparisons within two groups. A statistically significant SJ difference was found between groups in pre-test [ES: 0.72 (moderate), 95% CI: [0.07, 1.36], $p < 0.05$]. A statistically significant SJ difference also was found between groups in post-test [ES: 0.78 (moderate), 95% CI: [0.13, 1.42], $p < 0.05$]. There were no statistically significant CMJ differences between-group and within-group comparisons in both pre-tests and post-tests.

Table 2. showed that no statistically significant differences in 30m sprint pre- and post-test peak parameters were found between EG and CG. There was a statistically significant difference in EG between the pre- and post-test V_{peak} [ES: -0.61 (moderate), 95% CI: [-1.06, -0.15], $p < 0.01$]. CG had also a significant difference between the pre- and post-test V_{peak} [ES: -0.63 (moderate), 95% CI: [-1.11, -0.14], $p < 0.01$]. In addition, CG had a significant pre- and post-test P_{peak} difference [ES: -0.87 (large), 95% CI: [-1.38, -0.35], $p < 0.001$]. There were no significant differences between pre- and post-test results of the other 30m sprint peak parameters within the group.

Table 1. Mean \pm SD values and comparisons of jump parameters of pre- and post-tests for EG and CG

Parameter	Group	Pre	Post	ES [95% CI]	Inference
SJ (cm)	EG	35.0 \pm 5.12	35.9 \pm 5.57	0.39 [-0.82, 0.05]	Small
	CG	30.9 \pm 6.00 [¥]	31.6 \pm 5.57 [¥]	0.21 [-0.65, 0.24]	Small
	ES [95% CI]	0.72 [0.07, 1.36]	0.78 [0.13, 1.42]		
	Inference	Moderate	Moderate		
CMJ (cm)	EG	36.3 \pm 4.77	37.4 \pm 6.49	0.30 [-0.73, 0.13]	Small
	CG	33.9 \pm 6.39	34.3 \pm 6.03	0.22 [-0.66, 0.23]	Small
	ES [95% CI]	0.43 [-0.19, 1.05]	0.49 [-0.14, 1.11]		
	Inference	Small	Small		

Data are Mean \pm SD. EG: Experimental group; CG: Control group; ES: Effect size; 95% CI: 95% Confidence interval; SJ: Squat jump; CMJ: Counter movement jump; [¥]: $p < 0.05$, between groups; [¥].

Table 2. Mean \pm SD values and comparisons of peak parameters of 30m sprint pre- and post-tests for EG and CG

Parameter	Group	Pre	Post	ES [95% CI]	Inference
V_{peak} (m.sec ⁻¹)	EG	4.98 \pm 0.73	5.26 \pm 0.57**	-0.61 [-1.06, -0.15]	Moderate
	CG	4.89 \pm 0.50	5.13 \pm 0.39**	-0.63 [-1.11, -0.14]	Moderate
	ES [95% CI]	0.14 [-0.47, 0.74]	0.28 [-0.34, 0.89]		
	Inference	Trivial	Small		
HF_{peak} (N)	EG	400 \pm 198	381 \pm 143	0.20 [-0.22, 0.62]	Small
	CG	368 \pm 151	369 \pm 140	-0.01 [-0.45, 0.43]	Trivial
	ES [95% CI]	0.18 [-0.43, 0.79]	0.08 [-0.53, 0.69]		
	Inference	Trivial	Trivial		
VF_{peak} (N)	EG	1626 \pm 484	1687 \pm 455	-0.23 [-0.66, 0.19]	Small
	CG	1611 \pm 434	1594 \pm 412	0.10 [-0.34, 0.54]	Trivial
	ES [95% CI]	0.03 [-0.57, 0.64]	0.21 [-0.40, 0.82]		
	Inference	Trivial	Small		
P_{peak} (W)	EG	1625 \pm 873	1634 \pm 636	-0.02 [-0.44, 0.40]	Trivial
	CG	1349 \pm 491	1489 \pm 525***	-0.87 [-1.38, -0.35]	Large
	ES [95% CI]	0.39 [-0.24, 0.10]	0.25 [-0.37, 0.86]		
	Inference	Small	Small		

Data are Mean \pm SD. EG: Experimental group; CG: Control group; ES: Effect size; 95% CI: 95% Confidence interval; V_{peak} : Peak velocity; HF_{peak} : Peak horizontal force; VF_{peak} : Peak vertical force; P_{peak} : Peak power; **: $p < 0.01$, within groups; ***: $p < 0.001$, within groups.

As can be seen in Table 3., there was no statistically significant difference between groups in all 30m sprint pre-test parameters. A statistically significant difference was found only in SF [ES: 0.74 (moderate), 95% CI: (-0.09, 1.38), $p < 0.05$]. EG had statistically significant t, V, SF and P differences ($p < 0.01$, $p < 0.005$, $p < 0.01$ and $p < 0.01$, respectively) between pre- and post-tests. The inferences were moderates (ES: 0.70, -0.79, -0.59 and -0.63, respectively). CG had significant differences in t and V [$p < 0.001$, ES: 0.83 (large) and $p < 0.001$, ES: -0.86 (large)], HF and P [$p < 0.05$, ES: -0.51 (moderate) and $p < 0.01$, ES: -0.81 (large)].

In Table 4., there were no statistically significant differences between groups in 30m sprint pre-test parameters based on DL and NDL. In the post-test comparisons between groups, no statistically significant differences were found in all other parameters except for SF_{DL} [EB: 0.91 (large), 95% CI: [0.24, 1.57], $p < 0.005$] and HF_{NDL} [EB: 0.78 (medium), 95% CI: [0.12, 1.42], $p < 0.01$]. DG had a significant pre- and post-test difference in SF_{DL} [ES: -0.74 (moderate), 95% CI: [-1.21, -0.26], $p < 0.005$]. DG also had a significant pre- and post-test difference in P_{NDL} [ES: -0.56 (moderate), 95% CI: [-1.00, -0.10], $p < 0.05$]. There were statistically significant pre- and post-test differences in CG for HF_{BB} [ES: -0.48 small, 95% CI: [-0.94, -0.01], $p < 0.05$]. It was observed that CG had a significant pre- and post-test VF_{DL} difference [Es: 0.48 (small), 95% CI: [0.01, 0.94], $p < 0.05$]. CG had

also a significant pre- and post-test P_{DL} difference [ES: -0.84 (large), 95% CI: [-1.35, -0.32], $p < 0.05$].

Discussion

The aim of this study was to investigate acute effects of isoinertial lunges on SJ, CMJ and 30 m sprint. In literature, there were no studies demonstrating acute effects of isoinertial lunges performed with DL and NDL on sprint and jump parameters. SJ had a statistically significant pre- and post-test difference ($p < 0.05$) between groups while no differences were found within groups. Both groups had statistically significant pre- and post-test differences in t, V, P ($p < 0.01$, $p < 0.001$, and $p < 0.01$, respectively for EG; $p < 0.001$, $p < 0.001$, and $p < 0.01$, respectively for CG). EG had a statistically significant SF difference between pre- and post-tests ($p < 0.01$). There is a statistically significant difference between groups in SF post-tests ($p < 0.05$). There were no differences between groups in pre-test DL and NDL 30m sprint parameters. There were statistically significant SF_{DL} and SF_{NDL} differences between groups in post-tests ($p < 0.005$ and $p < 0.01$). Statistically significant differences ($p < 0.005$ and $p < 0.05$) was found between pre- and post-tests in SF_{DL} and P_{NDL} in EG.

Eccentric strength training activated large motor units in hamstring muscle group and increased eccentric strength-related performance such as vertical jump [26]. Timon et al. [27] compared the

Table 3. Mean \pm SD values and comparisons of parameters of 30m sprint pre- and post-tests for EG and CG

Parameter	Group	Pre	Post	ES [95% CI]	Inference
t (sec)	EG	7.38 \pm 1.51	6.95 \pm 1.12**	0.70 [0.23, 1.17]	Moderate
	CG	7.71 \pm 1.47	7.22 \pm 1.08***	0.83 [0.31, 1.33]	Large
	ES [95% CI]	-0.22 [-0.83, 0.39]	-0.25 [-0.86, 0.36]		
	Inference	Small	Small		
V (m.sec ⁻¹)	EG	4.23 \pm 0.82	4.42 \pm 0.70***	-0.79 [-1.26, -0.30]	Moderate
	CG	4.02 \pm 0.70	4.24 \pm 0.60***	-0.86 [-1.36, -0.33]	Large
	ES [95% CI]	0.27 [-0.34, 0.88]	0.28 [-0.33, 0.89]		
	Inference	Small	Small		
SF (Hz)	EG	5.97 \pm 1.07	6.43 \pm 1.21**	-0.59 [-1.04, -0.13]	Moderate
	CG	5.60 \pm 0.82	5.71 \pm 0.77 [†]	-0.24 [-0.68, 0.21]	Small
	ES [95% CI]	0.38 [-0.24, 0.10]	0.74 [-0.09, 1.38]		
	Inference	Small	Moderate		
SL (m)	EG	0.82 \pm 0.11	0.81 \pm 0.12	0.11 [-0.31, 0.53]	Trivial
	CG	0.83 \pm 0.10	0.85 \pm 0.10	-0.26 [-0.70, 0.19]	Small
	ES [95% CI]	-0.01 [-0.62, 0.59]	-0.32 [-0.93, 0.29]		
	Inference	Trivial	Small		
HF (N)	EG	152 \pm 12	191 \pm 161	-0.24 [-0.67, 0.18]	Small
	CG	146 \pm 111	151 \pm 147*	-0.51 [-0.97, -0.03]	Moderate
	ES [95% CI]	0.53 [-0.10, 1.15]	0.34 [-0.28, 0.95]		
	Inference	Moderate	Small		
VF (N)	EG	779 \pm 148	767 \pm 171	0.09 [-0.33, 0.51]	Trivial
	CG	776 \pm 128	772 \pm 132	0.31 [-0.14, 0.76]	Small
	ES [95% CI]	0.02 [-0.58, 0.63]	0.03 [-0.64, 0.58]		
	Inference	Trivial	Trivial		
P (W)	EG	691 \pm 151	732 \pm 161**	-0.63 [-1.08, -0.16]	Moderate
	CG	612 \pm 120	681 \pm 112**	-0.81 [-1.31, -0.30]	Large
	ES [95% CI]	0.57 [-0.06, 1.20]	0.37 [-0.64, 0.58]		
	Inference	Moderate	Small		

Data are Mean \pm SD. EG: Experimental group; CG: Control group; ES: Effect size; 95% CI: 95% Confidence interval; t: time; V: Velocity; SF: Stride frequency; SL: Stride length; HF: Horizontal force; VF: Vertical force; P: Power; *: p<0.05, within groups; **: p<0.01, within groups; ***: p<0.001, within groups; [†]: p<0.05.

post-activation performance enhancement effect of traditional strength and isoinertial resistance different preload protocols. They found that vertical jump performance increased after the isoinertial preload protocol. Pre- and post-test results of this study between and within groups were compared. Isoinertial lunges performed 8RM of DL, 1min rest, 8RM of NDL didn't have acute effects on SJ and CMJ after 90sec. Therefore, SJ and CMJ results of current study were not considered to support Timon et al. [27]' study results. This may be due to the fact that in the study of Timon et al. [27]. Their jump tests were performed after 4min and 8min, while in the present study, jump tests were performed after 90sec.

Beato et al. [28] tested jumping and change of direction running after 4sets of 6reps isoinertial eccentric strength protocols. The results showed

that soccer players had no statistical differences among 3 different leg movements (cross-cutting step, leg extension and squat). It was determined that 5m change of direction performed 4min after 3 exercises showed statistically positive acute increases. Beato et al. [13] compared eccentric overloading with isoinertial strength and traditional strength with Olympic bar. Both of them increased vertical jump acutely in a statistically significant manner, but did not affect 5m sprint. In their another study, Beato et al. [29] determined that moderate isoinertial loads on athletes statistically significantly increased vertical jump. They also stated significant differences in chance of direction running performances at 30s, 3min and 6min after this loading.

Sabido et al. [30] studied chronic effects of

Table 4. Mean \pm SD values and comparisons of NDL and DL parameters of 30m sprint pre- and post-tests for EG and CG

Parameter	Group	Pre	Post	ES [95% CI]	Inference
SF _{DL} (Hz)	EG	5.96 \pm 1.05	6.58 \pm 1.14 ^{***}	-0.74 [-1.21, -0.26]	Moderate
	CG	5.57 \pm 0.92	5.69 \pm 0.75 ^{***}	-0.23 [-0.67, 0.22]	Small
	ES [95% CI]	0.40 [-0.22, 1.01]	0.91 [0.24, 1.57]		
	Inference	Small	Large		
SF _{NDL} (Hz)	EG	5.98 \pm 1.16	6.29 \pm 1.18	-0.33 [-0.75, 0.11]	Small
	CG	5.64 \pm 0.82	5.73 \pm 0.86	-0.14 [-0.58, 0.31]	Trivial
	ES [95% CI]	0.34 [-0.28, 0.95]	0.54 [-0.10, 1.16]		
	Inference	Small	Moderate		
SL _{DL} (N)	EG	0.80 \pm 0.10	0.78 \pm 0.12	0.23 [-0.20, 0.65]	Small
	CG	0.80 \pm 0.09	0.83 \pm 0.09	-0.32 [-0.76, 0.14]	Small
	ES [95% CI]	-0.02 [-0.63, 0.58]	-0.50 [-1.12, 1.13]		
	Inference	Trivial	Moderate		
SL _{NDL} (N)	EG	0.82 \pm 0.12	0.81 \pm 0.13	0.10 [-0.32, 0.52]	Trivial
	CG	0.82 \pm 0.11	0.85 \pm 0.12	-0.37 [-0.81, -0.09]	Small
	ES [95% CI]	0.05 [-0.56, 0.65]	-0.35 [-0.96, 0.27]		
	Inference	Trivial	Small		
HF _{DL} (N)	EG	156 \pm 22	156 \pm 17	0.004 [-0.41, 0.42]	Trivial
	CG	147 \pm 16	153 \pm 12 [*]	-0.48 [-0.94, -0.01]	Small
	ES [95% CI]	0.48 [-0.15, 1.09]	0.18 [-0.44, 0.78]		
	Inference	Small	Trivial		
HF _{NDL} (N)	EG	147 \pm 13	157 \pm 16	-0.40 [-0.83, 0.04]	Small
	CG	145 \pm 11	146 \pm 13 ^{yy}	0.14 [-0.30, 0.58]	Trivial
	ES [95% CI]	0.15 [-0.46, 0.76]	0.78 [0.12, 1.42]		
	Inference	Trivial	Moderate		
VF _{DL} (N)	EG	755 \pm 200	805 \pm 174	-0.23 [-0.65, 0.20]	Small
	CG	801 \pm 119	768 \pm 157 [*]	0.48 [0.01, 0.94]	Small
	ES [95% CI]	-0.28 [-0.88, 0.34]	0.22 [-0.39, 0.83]		
	Inference	Small	Small		
VF _{NDL} (N)	EG	805 \pm 180	734 \pm 227	0.34 [-0.09, 0.77]	Small
	CG	753 \pm 155	779 \pm 142	-0.40 [-0.85, 0.06]	Small
	ES [95% CI]	0.31 [-0.31, 0.92]	-0.24 [-0.84, 0.38]		
	Inference	Small	Small		
P _{DL} (W)	EG	713 \pm 187	720 \pm 169	-0.06 [0.47, 0.36]	Trivial
	CG	615 \pm 121	678 \pm 97 ^{***}	-0.84 [-1.35, -0.32]	Large
	ES [95% CI]	0.62 [-0.03, 1.24]	0.30 [-0.32, 0.91]		
	Inference	Moderate	Small		
P _{NDL} (W)	EG	678 \pm 127	745 \pm 173 [*]	-0.56 [-1.00, -0.10]	Moderate
	CG	629 \pm 110	679 \pm 131	-0.44 [-0.89, 0.03]	Small
	ES [95% CI]	0.41 [-0.21, 1.02]	0.42 [-0.20, 1.04]		
	Inference	Small	Small		

Data are Mean \pm SD. EG: Experimental group; CG: Control group; ES: Effect size; 95% CI: 95% Confidence interval; SF_{NDL}: Non-dominant leg stride frequency; SF_{DL}: Dominant leg stride frequency; SL_{NDL}: Non-dominant leg stride length; SL_{DL}: Dominant leg stride length; HF_{NDL}: Non-dominant leg horizontal force; HF_{DL}: Dominant leg horizontal force; VF_{NDL}: Non-dominant leg vertical force; VF_{DL}: Dominant leg vertical force; P_{NDL}: Non-dominant leg power; P_{DL}: Dominant leg power; *: p<0.05, within groups; ^{yy}: p<0.05, between groups; ^{***}: p<0.01, between groups.

isoinertial bilateral squat or unilateral lunges applied to athletes. Training protocols were 7 weeks, ones a week, 4 sets of 8 reps of isoinertial bilateral squat and unilateral lunges Both protocols significantly increased in CMJ and 20m sprint. Nunez et al. [31] studied isoinertial squat and lunges for 6 weeks, 2 times a-week, 4 sets of 7 reps. They provided statistically significant improvement in lower body muscle volume, strength, CMJ, 90° change of direction. They also stated that isoinertial lunges improved 90° change of direction time and deceleration percentage of both DL and NDL. Isoinertial squats improved only the 90° change of direction time and deceleration percentage of DL. In addition, Kale et al. [32] explained that isoinertial half squats performed 4RM can support sprints by tolerating SL imbalance between DL and NDL.

Conclusions

The limited training time for coaches and athletes provides research opportunities on efficient training programs and methods. The study results showed acute effects of isoinertial lunges on SF and SF_{DL} parameters. In future studies, it would be beneficial to focus on DL neuromuscular activation for optimal training in repetitive isoinertial lunges.

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Conflict of interest

The authors declare no conflicts of interest.

References

1. Aagaard P, Andersen JL, Dyhre-Poulsen P, Leffers A, Wagner A, Magnusson SP, et al. A mechanism for increased contractile strength of human pennate muscle in response to strength training: changes in muscle architecture. *The Journal of Physiology*, 2001;534(2): 613–623. <https://doi.org/10.1111/j.1469-7793.2001.t01-1-00613.x>
2. Aboodarda SJ, Page PA, Behm DG. Muscle activation comparisons between elastic and isoinertial resistance: A meta-analysis. *Clin Biomech*, 2016;39:52–61. <https://doi.org/10.1016/j.clinbiomech.2016.09.008>
3. Hollander DB, Kraemer RR, Kilpatrick MW, Ramadan ZG, Reeves GV, Francois M, et al. Maximal eccentric and concentric strength discrepancies between young men and women for dynamic resistance exercise. *J. Strength Cond. Res.* 2007;21:34–40. <https://doi.org/10.1519/R-18725.1>
4. Jidovtseff B, Croisier JL, Scimar N, Demoulin C, Maquet D, Crielaard JM. The Ability of Isoinertial Assessment to Monitor Specific Training Effects. *J Sports Med Phys Fitness*, 2008;48(1):55–64.
5. Vazquez-Guerreo J, Moras G. Changes in muscular architecture and execution velocity during squats performed using the versapulle under stable and unstable conditions in junior elite basketball players. *Cuader- nos de Psicología del Deporte*, 2015;15(3):243–252. <https://doi.org/10.4321/S1578-84232015000300029>
6. Norrbrand L, Pozzo M, Tesch PA. Flywheel resistance training calls for greater eccentric muscle activation than weight training. *Eur J Appl Physiol*, 2010;110(5):997–1005. <https://doi.org/10.1007/s00421-010-1575-7>
7. Kellett M, Patroni P, Calvetti M, Susta D. Enhanced power after a 4-week submaximal isoinertial training: a pilot study. Proceedings of the 2014 NSCA National Strength and Conditioning Association International Conference; Murcia, Spain: CCD, 2014;10(9):S188.
8. Beato M, De Keijzer KL, Fleming A, Coates A, La Spina O, Coratella G, et al. Post flywheel squat vs. flywheel deadlift potentiation of lower limb isokinetic peak torques in male athletes. *Sports Biomechanics*, 2023;22(11): 1514–1527. <https://doi.org/10.1080/14763141.2020.1810750>
9. Askling C, Karlsson J, Thorstensson A. Hamstring injury occurrence in elite soccer players after preseason strength training with eccentric overload. *Scand J Med Sci Sports*, 2003;13(4):244–250. <https://doi.org/10.1034/j.1600-0838.2003.00312.x>
10. Loturco I, Pereira, LA, Kobal R, Maldonado T, Piazzini AF, Bottino A, et al. Improving Sprint Performance in Soccer: Effectiveness of jump squat and Olympic push press exercises. *PLoS ONE*, 2016;11(4):1–12. <https://doi.org/10.1371/journal.pone.0153958>
11. Cormie P, McGuigan MR, Newton RU. Developing maximal neuromuscular power. Part 2. Training considerations for improving maximal power production. *Sports Med*, 2011;41:125–146. <https://doi.org/10.2165/11538500-000000000-00000>
12. Samozino P, Rejc E, Di Prampero PE, Belli A, Morin JB. Optimal force–velocity profile in ballistic movements—*Altius*. *Med Sci Sports Exerc*, 2012;44(2):313–322. <https://doi.org/10.1249/MSS.0b013e31822d757a>
13. Beato M, Bigby AE, De Keijzer KL, Nakamura FY, Coratella G, McErlain-Naylor SA. Post-activation potentiation effect of eccentric overload and traditional weightlifting exercise on jumping and sprinting performance in male athletes. *PLoS One*, 2019b;14(9):e0222466. <https://doi.org/10.1371/journal.pone.0222466>
14. Fiorilli G, Mariano I, Iuliano E, Giombini A, Ciccarelli A, Buonsenso A, et al. Isoinertial eccentric-overload training in young soccer players: Effects on strength, sprint, change of direction, agility and soccer shooting precision. *J Sports Sci Med*, 2020;19(1):213.
15. Norrbrand L, Fluckey JD, Pozzo M, Tesch PA.

- Resistance training using eccentric overload induces early adaptations in skeletal muscle size. *European Journal of Applied Physiology*, 2007;102(3): 271–281. <https://doi.org/10.1007/s00421-007-0583-8>
16. Romero-Rodriguez D, Gual G, Tesch PA. Efficacy of an inertial resistance training paradigm in the treatment of patellar tendinopathy in athletes: a case-series study. *Phys Ther Sport*, 2011;12(1):43–48. <https://doi.org/10.1016/j.ptsp.2010.10.003>
 17. Sanudo B, González-Navarrete Á, Álvarez-Barbosa F, De Hoyo M, Del Pozo J, Rogers ME. Effect of flywheel resistance training on balance performance in older adults. A randomized controlled trial. *J Sports Sci Med*, 2019;18(2):344.
 18. De Hoyo M, Pozzo M, Sanudo B, Carrasco L, Gonzalo-Skok O, Dominguez-Cobo S, et al. Effects of a 10-week in-season eccentric-overload training program on muscle-injury prevention and performance in junior elite soccer players. *Int J Sports Physiol Perform*, 2015;10(1):46–52. <https://doi.org/10.1123/ijsp.2013-0547>
 19. Greenwood J, Morrissey MC, Rutherford OM, Narici MV. Comparison of conventional resistance training and the fly-wheel ergometer for training the quadriceps muscle group in patients with unilateral knee injury. *Eur J Appl Physiol*, 2007;101(6):697–703. <https://doi.org/10.1007/s00421-007-0548-y>
 20. Kacoglu C, Kale M. Acute effects of lower body electromyostimulation application with two different frequencies on isokinetic strength and jumping performance. *JPES*, 2016;16(1):38–45. <https://doi.org/10.7752/jpes.2016.01007>
 21. Lohman TG, Roche AF, Martorel R. *Anthropometric Standardization Manuel*, Champaign, IL: Human Kinetics; 1988.
 22. Kale M, Asci A, Bayrak C, Acikada C. Relationships among jumping performances and sprint parameters during maximum speed phase in sprinters. *J Strength Cond Res*, 2009;23(8):2272–2279. <https://doi.org/10.1519/JSC.0b013e3181b3e182>
 23. Tümer Elektronik Ltd. *ESC 2XXX Series Data Acquisition* [Computer software]. Turkey: Ankara; 2004.
 24. Bosco C, Luhtanen P, Komi PV. A simple method for measurement of mechanical power in jumping. *Eur J Appl Physiol*, 1983;50:273–282. <https://doi.org/10.1007/BF00422166>
 25. Wassertheil S, Cohen J. Statistical Power Analysis for the Behavioral Sciences. *Biometrics*, 1970;26(3): 588. <https://doi.org/10.2307/2529115>
 26. Jakobsen MD, Sundstrup E, Andersen CH, Persson R, Zebis MK, Andersen LL. Effectiveness of hamstring knee rehabilitation exercise performed in training machine vs. elastic resistance: electromyography evaluation study. *Am J Phys Med Rehabil*, 2014;93(4):320–327. <https://doi.org/10.1097/PHM.0000000000000043>
 27. Timon R, Allemanno S, Camacho-Cardenosa M, Camacho-Cardenosa A, Martinez-Guardado I, Olcina G. Post-activation potentiation on squat jump following two different protocols: traditional vs. inertial flywheel. *J Hum Kinet*, 2019;69:271–281.
 28. Beato M, Madruga-Parera M, Piqueras-Sanchiz F, Moreno-Pérez V, Romero Rodriguez D. Acute effect of eccentric overload exercises on change of direction performance and lower-limb muscle contractile function. *J Strength Cond Res*, 2019;35(12):3327–3333. <https://doi.org/10.1519/JSC.0000000000003359>
 29. Beato M, De Keijzer KL, Leskuskas Z, Allen WJ, Iacono AD, McErlain-Naylor SA. Effect of postactivation potentiation after medium vs. high inertia eccentric overload exercise on standing long jump, countermovement jump, and change of direction performance. *J Strength Cond Res*, 2021;35(9):2616–2621. <https://doi.org/10.1519/JSC.0000000000003214>
 30. Sabido R, Hernández-Davó JL, Botella J, Navarro A, Tous-Fajardo J. Effects of adding a weekly eccentric-overload training session on strength and athletic performance in team-handball players. *Eur J Sport Sci*, 2017;17(5):530–538. <https://doi.org/10.1080/17461391.2017.1282046>
 31. Nunez FJ, Santalla A, Carrasquilla I, Asian JA, Reina JI, Suarez-Arrones LJ. The effects of unilateral and bilateral eccentric overload training on hypertrophy, muscle power and COD performance, and its determinants in team sport players. *PLoS One*, 2018;18:e0193841. <https://doi.org/10.1371/journal.pone.0193841>
 32. Kale M, Özmusul A, Heper E. Acute effects of isoinertial resistance application on sprint, vertical and horizontal jump performance. *Pedagogics, Psychology, Medical-Biological Problems of Physical Training and Sports*. 2019;23(2):76–82. <https://doi.org/https://doi.org/10.15561/18189172.2019.0204>

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Remote versus onsite proctored exams: comparing students' results in physical fitness testing

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Abstract

Background and Study Aim Since the outbreak of COVID-19, distance learning has become a widespread practice in educational institutions worldwide, leading to the adoption of remote electronic examinations (e-exams) as a primary method of assessment. This study aimed to compare the outcomes of admission tests for the sport sciences department, contrasting traditional face-to-face onsite testing with online-based remote testing.

Material and Methods A total of 500 students applied (n =177 distance learning students, n =323 onsite students). From the tests, differences in levels of physical fitness (long jump, sit-ups, burpees, and pull-ups/push-ups) were compared between the remote and the onsite participants.

Results According to univariate analysis of variance (ANOVA), there was a significant difference in the level of physical fitness (long jump, sit-up, burpees, and pull-up/push-up tests) between the remote participants (154.01 ± 83.1 cm; 13.85 ± 8.21 reps/60 sec; 6.76 ± 6.52 reps/30 sec; 11.36 ± 8.0 pull-ups/push-ups, respectively) and the onsite participants (172.34 ± 27.0; 15.28 ± 4.01 reps/60 sec; 27.29 ± 6.61 reps/30 sec; 14.76 ± 9.47 pull-ups/push-ups, respectively).

Conclusions The results of the present study indicate that the outcomes of physical fitness tests were significantly higher among onsite participants compared to remote participants. Despite the successful implementation of admission test procedures in the distance sport sciences department, the findings suggest a preference for physical fitness tests among onsite participants due to various factors, including 1) increased motivation, 2) model friction, and 3) competitive atmosphere.

Keywords: coronavirus, physical education admission tests, physical fitness tests, remote electronic examinations, traditional onsite face-to-face tests.

Introduction

Since COVID-19 struck the world in 2019, all aspects of life have changed significantly [1]. To prevent the spread of the disease, people were forced to adopt social distancing policies, since human-to-human contact was the fastest way to spread the virus [2]. Most countries had to go into full lockdown to prevent further outbreaks, which led to the idea of virtual workplaces and online schooling. In Saudi Arabia, the level of readiness to implement and use distance learning platforms was exceptional. For some majors, however, the transition to distance learning was a struggle, since they relied heavily on practice, especially at the higher educational level [3]. Physical education is just one example of those subjects that were struggling to adapt to the new schooling environment [2,3].

In physical education, many classes involve participation in indoor and outdoor physical activities and laboratory activities as well as interaction in individual and group sports [4]. Although one study reported that the level of readiness of physical education and sports students for online learning was high, it also showed there

to be low levels of motivation among such students [5,6,7]. In addition, e-learning contributed to massively reducing the physical activity and fitness levels of physical education and sport science students [5] (i.e., college students already enrolled in sport sciences). This means that students from other majors were probably at lower levels of fitness, making it harder for them to be accepted into study physical education and sport science courses during the pandemic era.

The challenges of getting accepted to study sport sciences at a Saudi university can be overwhelming due to the low number of seats available in these departments and the intensity of the admission tests. Thus, most students find themselves forced to gain admission to other majors before they subsequently try to make the transition to the sport sciences department; nevertheless; they have to go through the same admission testing system. Following the transition to fully online learning during the pandemic, the entire admission examination process had to be conducted virtually, arguably making it easier for participants to attempt. Therefore, this study aims to compare the results of tests for admission to the sport sciences department at university between traditional onsite testing and remote testing.

Materials and Methods

Participants

The data of 500 applicants (all males) were used in this study to compare traditional onsite admission tests ($n = 323$) with new remote tests ($n = 177$). These applicants had applied to transfer in Fall 2019 and Winter 2020 for the onsite tests and Winter 2021 for the online tests. The admission process for Fall 2020 was omitted because there was no onsite testing during that semester. All applicants were students who had already enrolled and been studying for at least one semester at the university in a different major.

Research Design

The traditional attendance admission test. The sport sciences admission test at UQU consists of several stages. Before the test, applicants receive general information via email about the test procedure and what they should do before arriving to conduct it. They have to undergo a standard medical examination at their local medical center, which is necessary to gain medical clearance and to rule out any students with cardiorespiratory abnormalities as well as those with vision or hearing difficulties.

For this study, on the day of the test, applicants had to arrive early so they could be divided into groups of ten, with each one given a test scoring sheet with a serial number on it. In groups, they had to move from one test station to another (Figure 1). Each group was assigned an instructor, and a senior student on the sport sciences course, and all stations were supervised by a sport sciences faculty member.

For each applicant, wearing minimal clothing, the process began at the physical testing station. There, the applicant's height and weight measurements were taken, after which their body was evaluated by a committee for any musculoskeletal abnormalities. The applicant then moved on to the interview station, where they answered committee members' questions to evaluate their hearing and speaking as well as to gain information about their athletic

background. After that, the applicant moved to each of the four fitness testing stations.

These fitness stations were designed to test the applicants' lower extremity power, core muscle strength, agility and coordination, and upper-body strength and endurance. First, the standing long jump station had been prepared with a starting line and a scale on the ground. Applicants were told to stand behind the starting line and swing their arms back and forth to generate momentum to get the best results. Two attempts were conducted, with the best result recorded. Second, the sit-up exercise was done in groups. Lying down on the ground with their knees half bent and their hands behind their heads, applicants were asked to perform as many sit-ups as possible in one minute, with a complete sit-up recorded when the body was vertical with the ground. The sport sciences students helped by holding the applicants' feet and counting for them. The completed number of sit-ups was recorded on the scoresheet.

Third, the burpee exercise was conducted in groups, with the sport sciences students counting for the applicants. A successful burpee would start with the applicant standing in an upright position. They would lower their hands to a supported squat position, kick the legs backward to a push-up position, and perform a push-up, then pull the legs back to a supported squat position, stand, and jump quickly, landing at the starting position [8]. The applicants had to complete as many burpees as they could in one minute, and the number of successful burpees was recorded. Finally, the pull-up exercise was carried out under the supervision of an expert faculty member to ensure each applicant's safety. The applicants had to perform as many pull-ups as they could with no time limit. Before starting, each applicant was helped by the instructor onto the horizontal bar, if needed. A successful pull-up was when the chin was raised above the bar, and the number of successful pull-ups was recorded. All scoring and medical sheets were collected.

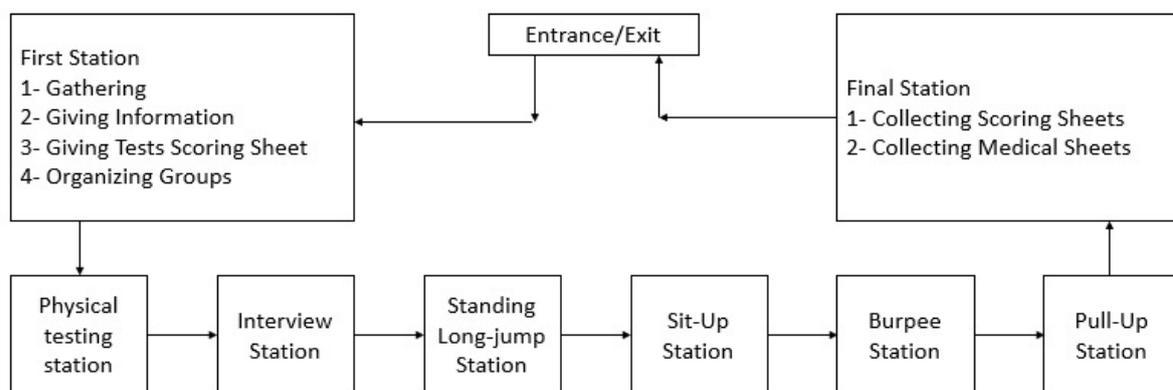


Figure 1. The explanation of attendance admission test stations.

The online remote admission test. The process of online testing also consisted of several phases. It was initiated when the applicants received an email containing very specific instructions about the test process and how to perform and record all the fitness tests. The instructions included pictures and video clips for each test. To be accepted into the sport sciences department, the applicants had to read the conditions for the actual test, which stated that they must have medical clearance, be 165 cm high or taller, and pass the fitness and physical tests. Applicants with cardiorespiratory, hearing, or vision difficulties were ruled out immediately.

The next stage was to record the fitness tests. First, each applicant had to show their ID to the camera while introducing themselves. They then had to stand in front of the camera wearing only shorts and turn around slowly to allow the committee to examine their body. Apart from the pull-up test, the overall fitness testing process was the same as that which the physical applicants performed. The standing long jump was carried out next to a measuring tape, and the results were recorded; sit-ups were performed for 1 minute, as was the burpee test. The pull-up test was replaced by a timeless push-up test to measure upper-body strength and endurance. All videos and medical examination sheets were uploaded to the sport sciences department website and reviewed by the admission committee.

Although the pull-up and the push-up tests measured upper body muscles, they were incomparable, since they measured different muscle groups.

Statistical analysis

All statistical analyses were performed using SPSS Statistics for Windows, Version 26.0 statistical software (IBM SPSS Inc., Chicago, IL), and statistical significance was set at $p < 0.05$. Descriptive statistics are expressed as means and standard deviations (95% confidence intervals). T-tests for independent

samples were used to investigate any significant difference between the remote and the onsite participants for all demographic characteristics. Differences in physical fitness testing levels between the participant groups were determined using one-way univariate analysis of variance (ANOVA). The effect sizes for mean differences were expressed as Cohen's d (difference in means divided by the standard deviation of the difference) and interpreted as small, moderate, or large, based on values of 0.2, 0.5, and 0.8, respectively [9].

Results

The participant characteristics are shown in Table 1. Of the 500 applicants, 177 were remote and 323 were onsite. Their ages ranged from 20 to 23 years (mean 21.83 years). Their BMI ranged from 14.5 to 41.10 kg/m² (mean BMI \pm SD, 21.83 \pm 4.1 kg/m²), and based on their BMI categorization, 99 applicants (19.8%) were found to be underweight, 306 (61.2%) to be normal weight, 75 (15.0%) to be overweight, and 20 (4.0%) to be obese.

Table 2 shows the differences in physical fitness testing levels between the remote and the onsite participants. ANOVA was used to determine whether there were significant differences in physical fitness levels between the two groups. The results indicate that there was a significant difference in the standing long jump test between the remote (154.01 \pm 83.1 cm) and the onsite (172.34 \pm 27.0) participants (F [1498] = 13.26; $p < 0.001$). For the sit-up test, a significant difference was found between the remote (13.85 \pm 8.21 reps/60 sec) and the onsite (15.28 \pm 4.01 reps/60 sec) participants (F [1498] = 6.82; $p < 0.001$). For the burpee test, there was found to be a significant difference between the remote (6.76 \pm 6.52 reps/30 sec) and the onsite (27.29 \pm 6.61 reps/30 sec) participants (F [1498] = 112.3; $p < 0.001$). Likewise, there were found to be significant differences in the pull-up and push-up

Table 1. Participants' demographic characteristics (n = 500)

Variables	Remote (n = 177)	Face to face (n = 323)	Overall (n = 500)	F	p-value
Age (years)	21.47 \pm 1.1	22.02 \pm 1.3	21.83 \pm 1.3	13.76	$p < 0.05$
Height (cm)	172.38 \pm 6.0	171.27 \pm 6.1	171.66 \pm 6.2	.103	$p < .743$
Weight (kg)	65.40 \pm 13.3	63.88 \pm 12.8	64.43 \pm 13.0	.827	$p < .364$
BMI (kg·m ⁻²)	22.01 \pm 4.3	21.75 \pm 4.0	21.83 \pm 4.1	.861	$p < .354$
Body mass index category n (%)					
Underweight	39 (22.0%)	60 (18.6%)	99 (19.8%)		
Normal weight	102 (57.6%)	204 (63.2%)	306 (61.2%)		
Overweight	29 (16.4%)	46 (14.2%)	75 (15.0%)		
Obese	7 (4.0%)	13 (4.0%)	20 (4.0%)		

*Mean \pm SD. World Health Organization's (WHO) classification system is; underweight (≤ 18.5 kg/m²), normal (≥ 18.5 –24.9 kg/m²), overweight (≥ 25 –29.9 kg/m²), and obese (≥ 30 kg/m²) [10]

Table 2. Differences in physical fitness testing levels between remote and face-to-face participants (n = 500).

Men	Remote (n = 177)	Face to face (n = 323)	F	p-value	Cohen's d
Standing long jump (cm)	154.01 ± 83.1	172.34 ± 27.0	13.26	p < 0.001	d = 2.60
Sit-up (reps/60 sec)	13.85 ± 8.21	15.28 ± 4.01	6.82	p < 0.001	d = 0.19
Burpee (reps/30 sec)	6.76 ± 6.52	27.29 ± 6.61	112.3	p < 0.001	d = 2.41
Pull-up and Push-up (number)	11.36 ± 8.0	14.76 ± 9.47	16.39	p < 0.001	d = 0.65

A Cohen's d value of 0.8 or greater indicates a large effect size

tests between the remote (11.36 ± 8.0 numbers) and onsite (14.76 ± 9.47 numbers) participants (F [1498] = 16.39; p < 0.001).

Large effect sizes were observed for differences in the standing long jump and burpee tests (d = 2.60 and d = 2.41, respectively). A moderate effect size was observed (d = 0.65) for differences between the remote and the onsite participants in the pull-up and push-up tests. However, small effect sizes were observed for differences in the sit-up test between the two groups (d = 0.19) (Table 2).

Discussion

E-exams have profoundly changed educational history and continue to be used in universities around the globe [11]. Before the COVID-19 pandemic, many educational institutions in Saudi Arabia had been using electronic tests as a kind of assessment-based on-campus e-exams. As a result, since the pandemic, it has become extremely difficult for educational institutions and faculties to organize exams and ensure that students can advance in their studies [12]. This study aimed to compare the results of tests for admission to the sport sciences department at UQU between traditional onsite face-to-face testing and online-based remote testing.

The results of the current study revealed that applicants with normal weight made up 61.2% of the sample (n = 306) and that the number of underweight applicants (n = 99, 19.8%) was higher than that of overweight (n = 75, 15.0%) and obese applicants (n = 20, 4.0%). This is consistent with the types of students who apply to a sport sciences department and meet the requirements disclosed to them.

This finding provides support for the hypothesis that motivation greatly influences an individual's performance in situations where one is physically capable of performing a task but is uncertain about one's capabilities and needs more personal motivation to achieve the best performance [13]. According to our results, there were significant differences in the participants' physical fitness levels (long jump, sit-up, burpee, and pull-up/push-up) between the remote and the onsite participants (p < 0.001). Unexpectedly, although the remote

participants had the opportunity to attempt a test more than once and then submit their best attempt, the onsite students had better results. This is consistent with earlier research that showed the impact of extrinsic incentives on physical fitness tests. Researchers have used a variety of motivational techniques by manipulating the environment (e.g., competition among individuals and groups, the presence of an audience, punishment, and reward systems, group affiliation, and social responsibility). For instance, Dea Karaba et al. [14] evaluated 30 young male medical students using the Wingate anaerobic test. Verbal encouragement was offered to all individuals throughout the test as a motivational component. Anaerobic power, relative anaerobic power, the slope of the power, and relative anaerobic capacity were tested in all individuals, and changes in the parameters when the test was conducted with and without verbal encouragement were recorded. When the Wingate test was administered with verbal encouragement, the findings demonstrated a statistically significant rise in the test parameter showing that conventional encouragement and feedback during the test could affect its outcome.

The COVID-19 pandemic had a significant impact on evaluations in many educational programs [15]. Proctoring in an online assessment environment can be difficult and time-consuming. The need to ensure safe, academically important online exams is more significant than ever [16]. Although they are widely used in online courses and formative assessments, they have yet to be utilized in physical fitness evaluations. Most research has focused on the potential benefits of using remote exams to protect academic integrity and test-taker behavior as well as how to combat inappropriate behavior [17]. In contrast, some studies have investigated usability and user reactions to remote exams, focusing on potential implementation issues and possible technical difficulties [18]. The literature compares proctored to traditional onsite face-to-face test outcomes in terms of evaluation research and investigating the impact of remote exams on students' results [19]. According to some studies, cheating is more likely to take place online than

face-to-face exams, and the outcomes are better [20]. Surprisingly, this study found that physical fitness levels (long jump, sit-up, burpee, pull-up/push-up) in onsite exams were significantly higher than those in remote exams. Despite the success of the admission test steps in the distance sport sciences department, the findings of this study confirm that physical fitness tests are preferred by face-to-face participants for various reasons, which include 1) motivation, 2) model friction, and 3) the general atmosphere of competition.

Lastly, it is a limitation of this study that anxiety was not measured in the students who participated remotely. Anxiety can influence physical outcomes. In addition, technical issues, such as using a mobile phone to film the physical fitness tests and then sending the link to the sport sciences department, were not addressed in this study. It is possible that

the students sent more than one test attempt and that a technical error was attempted with a minor result received by the admission committee.

Conclusions

Due to the COVID-19 pandemic, physical fitness tests (long jump, sit-ups, burpees, pull-ups/push-ups) had to be conducted remotely. Comparing the test results for remote and onsite participants, there were significant differences in participants' fitness levels (long jumps, sit-ups, burpees, pull-ups/push-ups).

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References

- Fehr AR, Perlman S. Coronaviruses: an overview of their replication and pathogenesis *Coronaviruses* 2015; 1–23. https://doi.org/10.1007/978-1-4939-2438-7_1
- Yu J, Jee Y. Analysis of online classes in physical education during the COVID-19 pandemic. *Educ Sci.* 2020; 11(1):3. <https://doi.org/10.3390/educsci11010003>
- Domokos C, Domokos M, Mirică SN, Negrea C, Bota E, Nagel A. Being a student at the faculty of sports and physical education in COVID-19 pandemic times – A moment in life. *Timisoara Physical Education & Rehabilitation Journal.* 2020; 13(24): 45-50. <https://doi.org/10.2478/tperj-2020-0007>
- Erdugan F. Investigating readiness levels of sports science faculty students towards e-learning. *Afr Educ Res J.* 2020; 8(2):272–279. <https://doi.org/10.30918/AERJ.82.20.070>
- Öncen S, Tanyeri L. Evaluation of the physical activity levels of the students in a physical education and sports science department before and during the coronavirus pandemic. *Int Educ Stud.* 2020; 13(10):148–156. <https://doi.org/10.5539/ies.v13n10p148>
- Barwais FA. Physical activity at home during the COVID-19 pandemic in the two Most-affected cities in Saudi Arabia. *Open Public Health J.* 2020;13(1):470–476. <https://doi.org/10.2174/1874944502013010470>
- Barwais FA. Assessing physical activity and sedentary time during the COVID-19 pandemic using self-reported measurement. *Natl. J. Physiol. Pharm. Pharmacol.* 2020;10(11):1019–1024. <https://doi.org/10.5455/njppp.2020.10.09241202001102020>
- Podstawski R, Kasietczuk B, Boraczyński T, Boraczyński M, Choszcz D. Relationship between BMI and endurance-strength abilities assessed by the 3 minute burpee test. *Int J Sports Sci.* 2013; 3(1):28–35. <https://doi.org/10.5923/j.sports.20130301.06>
- Cohen J. *Statistical power analysis for the behavioral sciences.* 2nd ed. Hillsdale, NJ: Lawrence Erlbaum; 1988.
- WHO. *Obesity: preventing and managing the global epidemic.* World Health Organization technical report series. 2000 (894). <https://doi.org/10.1017/S0021932003245508>
- Fluck AE. An international review of eExam technologies and impact. *Comput Educ.* 2019; 132:1–15. <https://doi.org/10.1016/j.compedu.2018.12.008>
- Birch E, De Wolf M. A novel approach to medical school examinations during the COVID-19 pandemic. *Med Educ Online.* 2020; 25(1):1785680. <https://doi.org/10.1080/10872981.2020.1785680>
- Kondric M, Sindik J, Furjan-Mandic G, Schiefler B. Participation motivation and student's physical activity among sport students in three countries. *J Sports Sci Med.* 2013; 12(1):10.
- Karaba-Jakovljević D, Popadić-Gaćeša J, Grujić N, Barak O, Drapšin M. Motivation and motoric tests in sports. *Med Pregl.* 2007; 60(5–6):231–236. <https://doi.org/10.2298/MPNS0706231K>
- Sahu P. Closure of universities due to coronavirus disease 2019 (COVID-19): Impact on education and mental health of students and academic staff. *Cureus.* 2020; 12(4). <https://doi.org/10.7759/cureus.7541>
- Andreou V, Peters S, Eggermont J, Wens J, Schoenmakers B. Remote versus on-site proctored exam: Comparing student results in a cross-sectional study. *BMC Med Educ.* 2021; 21(1):1–9. <https://doi.org/10.1186/s12909-021-03068-x>
- Dunn T, Meine M, McCarley J. The remote proctor: An innovative technological solution for online. *International Journal of Technology, Knowledge and Society.* 2010; 6(1):1832–3669. <https://doi.org/10.18848/1832-3669/CGP/v06i01/56033>
- Chen V, Sandford A, LaGrone M, Charbonneau K, Kong J, Ragavaloo S. An exploration of instructors' and students' perspectives on remote delivery of courses during the COVID-19 pandemic. *Br J Educ Technol.* 2022; 53(3):512–533. <https://doi.org/10.1111/bjet.13205>

19. Gudiño Paredes S, Jasso Peña FdJ, De La Fuente Alcazar JM. Remote proctored exams: Integrity assurance in online education? *Distance Educ.* 2021; 42(2):200–218. <https://doi.org/10.1080/01587919.2021.1910495>
20. Jaap A, Dewar A, Duncan C, Fairhurst K, Hope D, Kluth D. Effect of remote online exam delivery on student experience and performance in applied knowledge tests. *BMC Med Educ.* 2021; 21(1):1–7. <https://doi.org/10.1186/s12909-021-02521-1>

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3D kinematic analysis of salto backward in acrobatic rock and roll: a case study

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

Abstract

Background and Study Aim The aim of the study was to determine and compare basic kinematic characteristics in the key phases of the acrobatic element Salto backward tucked.

Material and Methods The research sample was created from two couples of the acrobatic rock and roll category Main class free style. The time, spatial, and time-spatial characteristics for both couples were determined based on a three-dimensional kinematic analysis. Measurements were carried out with Simi Motion 3D. The acrobatic element Salto backward tucked was chosen based on the fact that it is usually learned as the first overturn acrobatic element with the airborne phase.

Results In the time duration of the acrobatic element, a very similar duration was observed for both couples (CZ couple: 3.59 s and SK couple 3.55 s). The maximal height of the center of gravity the partner from the Czech Republic reach 3.54 m and partner from the Slovak Republic 3.35 m. The biggest difference noticed was between the male partners 14.59° in knee angle in the staff phase. Among the female partners, a difference was noted in the angle between the torso and the vertical plane at the moment of the end of the vertical displacement, when SK female partner has twice as much deviation of the torso, by exactly 19.49°. In the staff phase, differences in acceleration were also observed, when the male partner (16.56 m.s⁻²) and female partner (25.08 m.s⁻²) from the Slovak Republic achieved higher maximum acceleration. In the airborne phase was the biggest difference between female partners in the culmination point, namely in the angle in the knee joint (35.98°) and the angle between the torso in the vertical plane at the moment of opening the somersault (25.52°).

Conclusions The findings showed similarities and differences in various aspects of the performance, providing valuable insights into the kinematic structure of this acrobatic element in acrobatic rock and roll. Our study should contribute to the extension of knowledge of the kinematic structure of acrobatic element in acrobatic rock and roll.

Keywords: acrobatic rock and roll, kinematic characteristics, Salto backward tucked, Main class free style.

Introduction

Acrobatic rock'n'roll is acyclic, fast sport, which needs a high degree of coordination, strength, psychological resilience, and above all, synchronization of athletes [1, 2, 3]. Demonstration of technically demanding acrobatic elements and combinations requires a high level of coordination and an optimal difference in somatic indicators between the partners [4, 5, 6]. The optimal difference in body height is 16.7 ± 7.1 cm and in body weight 22.6 ± 1.9 kg [7]. Several researches [8, 9, 10] point to a trend in the development of acrobatic rock and roll, which is associated with increasing difficulty of the competition program and thus with increasing performance requirements for athletes. Unfortunately, it is still worthwhile for couples to choose more difficult acrobatic elements, even if they have a bad execution, because the number of points after a collision is still higher than when they

choose less demanding acrobatics.

The acrobatic competition program is limited by correct timing. Synchronization between partners is trained by "Staff" take off, when the average number of repetitions ranges from 1178 to 1645 attempts per year. Technically less demanding acrobatic exercise forms such as somersaults backward tucked make a good starting point for their more demanding variants, e.g.: somersaults with multiple turns around the horizontal and vertical axes. The number of attempted Salto backwards ranges from 265 to 369 attempts per year [11, 12].

Take off from staff position is more often in especially for the backwards elements. Despite the fact that all couples perform the same element technique, almost every couple has small individual differences in the performance. The individual differences in the performance can be affected by biomechanical parameters [13]. The results of the calculations of mathematical models show that to achieve the best results it is necessary to increase the initial speed of rush out, the height of the center

of gravity at the rush out, reduce the moment of inertia, which simplifies increasing the rotation speed of individual segments [14].

For performing any movement of an athlete, it is necessary to develop a dynamic effort determining the kinematics of the body [15]. In assessing the complexity of exercise elements, must be taken into account the degree of dynamic effort in performing movements, which is determined by the energy consumption to achieve the desired position [16, 17]. It is also necessary to take into account the static muscle tension in the process of performing exercise elements and the degree of dynamic effort to return to the final position [18]. There are three phases in performing all acrobatics elements from staff position: preparation phase, take-off phase and airborne phase, which is determined by previous two phases [11].

Materials and Methods

Participants

The acrobatic element was presented by the best Slovak (SK) couple (age: F 19 years, M 24 years; body height: F 159 cm, M 177 cm; body weight: F 47 kg, M 72 kg) and the best Czech (CZ) couple (age: F 26 years, M 29 years; body height: F 166 cm, M 190 cm;

body weight: F 51 kg, M 89 kg) of the category Main class free style in that year. Measurements were done at the end of preparatory period of the season when couples trained 6 times a week.

Research Design

In our study we used ex post facto research. We compared two couples of Main class free style category. Acrobatic element salto backward tucked belong to obligatory group 2 (acrobatic element backward) with difficulty A and value 4 points [19, 20]. We processed the kinematic records using SIMI Motion 3D software (the German company Simi Reality motion Systems GmbH) and performed a 3D analysis of the acrobatic element somersault backwards (Figure 1). 12 important anthropometric points has been identified on the bodies of the dancers where markers were placed (Figure 2). 8-camera motion analysis system records the element with sampling frequency 100 Hz. The acrobatic element starts from two kicks and kick ball change and also ended with two kicks which is usually same as in competition program. Both couples performed the acrobatic element twice and then we chose a better performance. The measurement took place at the Faculty of Sports Studies of Masaryk University in Brno (Czech Republic).

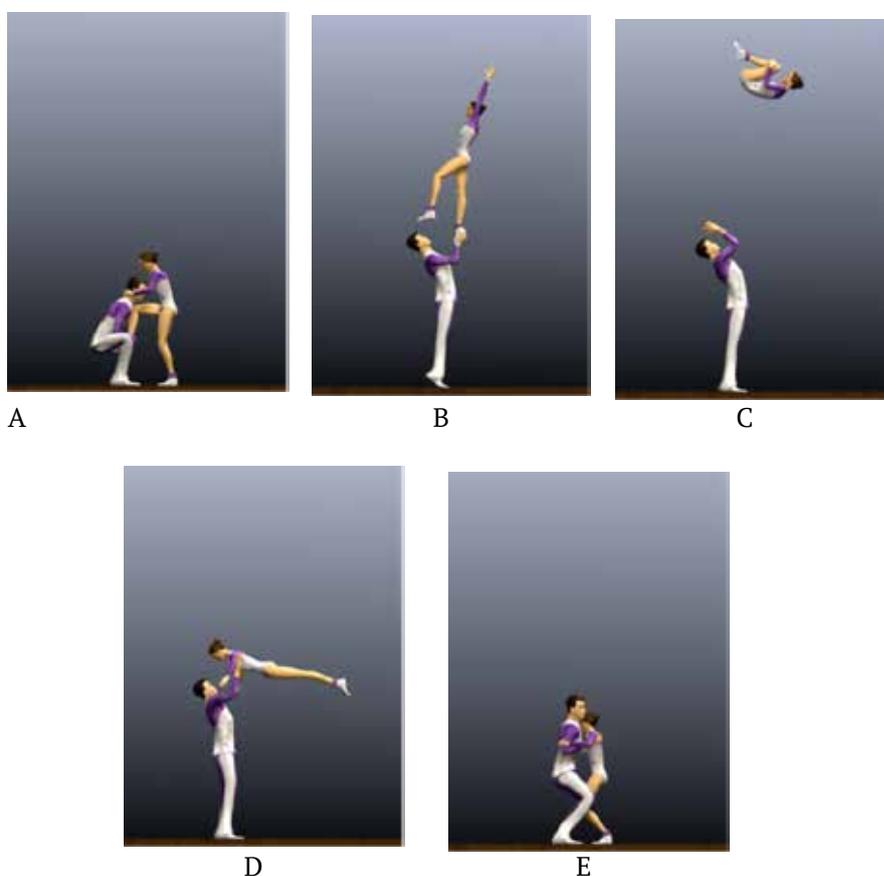


Figure 1. Salto backward tucked – preparation microphase (A), vertical displacement (B), ascending microphase and reaching the culmination point (C), descending microphase (D), contact and landing (E) [16]

Data for Analysis

Anthropometric data of the participants were used: body height, body mass. Twelve important anthropometric points on the participants' bodies were identified. A motion analysis system with 8 cameras (sampling rate of 100 Hz) was used. The acrobatic element was divided into 3 phases and 7 microphases. The duration of the element's execution was 3.59 seconds and 3.55 seconds.

Results

Acrobatic element Salto backward tucked belongs to obligatory group 2 (acrobatic element backward) with difficulty A and value of 4 points [19, 20]. Both couples started the acrobatic element from a Staff position, which is the most often used in the backwards acrobatics. The Salto backward is one of the basic acrobatic element of Main class free style category and it is usually learned as the first acrobatic element with an airborne phase. It can be shown in the basic form in all rounds of the competition. The rules tell us that the difficulty of acrobatic element should increase during the competition with a peak in the final. To understand

the kinematic characteristics of the chosen acrobatic element, we divided salto backward into 3 phases and 7 microphases (Figure 3).

Comparison of time characteristics

The time duration of the acrobatic element salto backwards was almost identical for both couples. The time duration of the element was 3.59 s for the CZ couple and 3.55 s for SK couple. The time was measured from the first movement after last kick to the landing female partner after the bounce, before start of dancing. The time duration of individual microphases is shown in Table 1.

The time characteristics of both rock and roll couples were very similar. We noticed the biggest differences in the staff phase, especially in the preparation phase. The second biggest difference was in the airborne phase, directly in the descending (0.06 s) and ascending microphase (0.02 s). This difference was caused by a longer path of movement, as the center of gravity of the Czech partner reached a greater height in the ascending microphase. The last difference was in the final phase, when in the microphase of contact with the landing was difference 0.05 s and in the bounce and dance

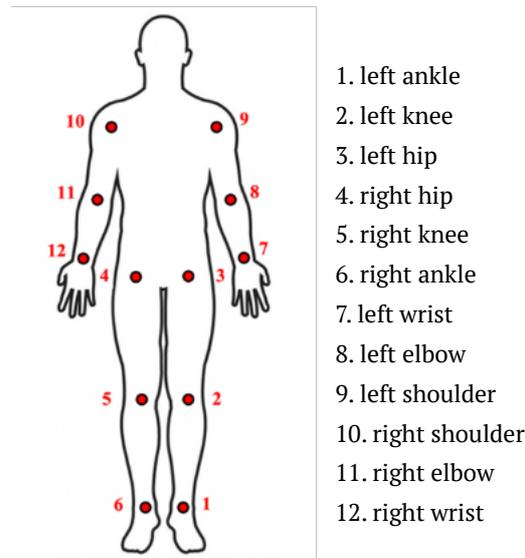


Figure 2. Anthropometric points

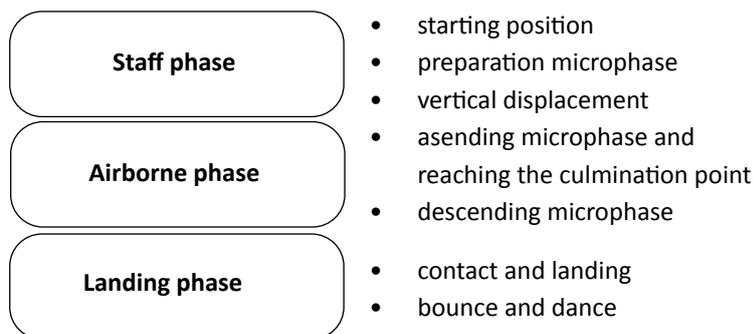


Figure 3. Phases and microphases of the acrobatic element [18]

microphase was only a small difference (0.02 s).

Comparison of spatial characteristics

In spacial characteristics we focused on the trajectory and height of center of gravity in the individual phases of the acrobatic element and also on the various angles. Trajectory of center of gravity of the Czech and the Slovak couples were very similar. The ascending and descending paths are almost parallel for both couples (Figure 4). For better view at the differences between couples we

focused also on heights of the female partner's center of gravity in the individual microphases of the acrobatic element (Table 2).

The biggest difference we found at the culmination point, which was 0.19 m. The second biggest difference was in the microphase of vertical displacement (0.17 m), when the partner from Slovakia prematurely deflected the trunk into rotation. The rest of the differences were caused by the somatic indicators of couples.

Table 1. Comparison of time duration in microphases [s]

Time duration of:	CZ	D	SK
staff phase	1.50	0.07	1.57
preparation microphase	0.88	0.07	0.95
vertical displacement	0.62	0.00	0.62
airborne phase	0.84	0.04	0.80
ascending microphase and reaching the culmination point	0.26	0.02	0.28
descending microphase	0.58	0.06	0.52
landing phase	1.25	0.07	1.18
contact with landing	0.37	0.05	0.32
bounce and dance	0.88	0.02	0.86

CZ- Czech couple, D- difference between couples SK- Slovak couple

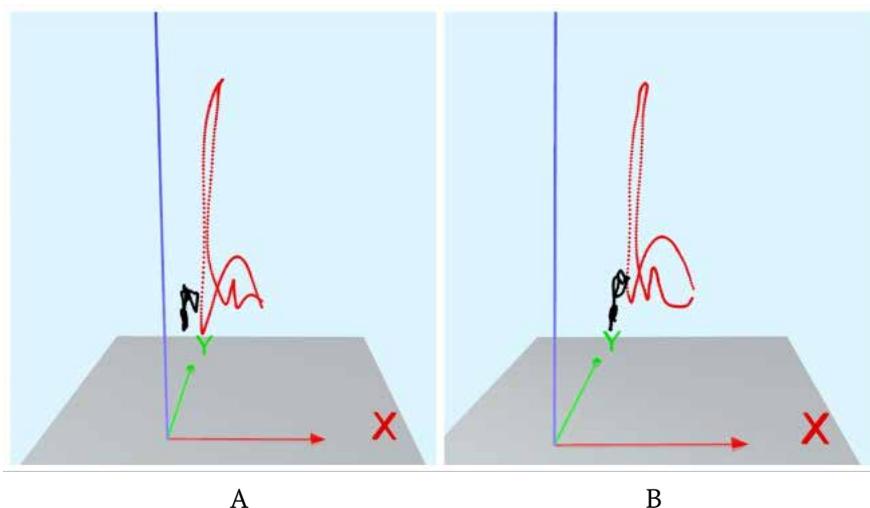


Figure 4. Trajectory of the center of gravity: Czech couple (A) and Slovak couple (B)

Table 2. Comparison of height of the center of gravity in microphases of female partner's [m]

Height of the center of gravity at the end of:	CZ	D	SK
starting position	1.09	0.13	0.96
preparation microphase	1.06	0.11	0.95
vertical displacement	3.13	0.17	2.96
ascending microphase and reaching the culmination point	3.54	0.19	3.35
descending microphase	2.23	0.07	2.16
contact with landing	0.76	0.10	0.86
bounce and dance	1.05	0.03	1.02

CZ- Czech couple, D- difference between couples SK- Slovak couple

Table 3. Comparison of other spatial characteristics

Staff phase		CZ	D	SK
F	angle in the partner's knee joint at the end of the preparation microphase	109.63° in 0.88 s	0.04°	109.56° in 0.95 s
M	angle in the partner's knee joint at the end of the preparation microphase	89.02° in 0.88 s	14.60°	74.42° in 0.95 s
F	angle between the partner's torso and the vertical plane at the time of termination	19.14° in 1.50 s	19.49°	38.63° in 1.57 s
M	maximal arch backward of the partner's torso during the vertical displacement	24.93° in 1.48s	2.17°	22.76° in 1.51 s
F	height of the swing ankle at the end of the staff phase	2.26 m in 1.50 s	0.14 m	2.40 m in 1.57 s
F	angle in the partner's knee joint at the end of the staff phase	147.05° in 1.50 s	19.03°	128.02° in 1.57 s
Airborne phase		CZ	D	SK
F	angle in the partner's knee joint at the culmination point	84.44° in 1.76 s	35.97°	120.41° in 1.85 s
F	angle between the partner's torso and the vertical plane at the moment of the salto opening	45.64° in 1.99 s	25.52°	20.12° in 1.92
F	angle between the partner's torso and the vertical plane at the end of airborne phase	48.67° in 2.34 s	2.62°	51.29° in 2.37 s
M	angle between the partner's torso and the vertical plane at the end of airborne phase	9.26° in 2.34 s	4.79°	14.05° in 2.37 s
F	angle in the partner's knee joint in the end of airborne phase	177.04° in 2.34 s	2.02°	175.02° in 3.37 s
Landing phase		CZ	D	SK
F	angle in the partner's knee joint at the end of landing microphase	80.54° in 2.71 s	30.26°	110.80° in 2.69 s

CZ- Czech couple, D- difference between couples SK- Slovak couple, F – female partner, M – male partner

In this section, we aimed on every important characteristic which did not fit into the previous subsections. The comparison of the spatial characteristics is in Table 3.

In the starting phase, we noted the largest differences in the angle in the partner's knee joint from the compared values, when the difference was 14.60° and was caused by a different style of technique, since the partner from the Slovak Republic started the vertical displacement from a deeper squat than the partner from the Czech Republic. The biggest differences between the female partners, was in the angle between the torso and the vertical plane at the end of the vertical displacement (19.49°), when the female partner from Slovakia was twice as far away from the vertical axis. In the flight phase was the biggest difference between the partners was during the culmination

point in the angle in the knee joint (35.97°) and in the angle between the trunk and the vertical plane at the moment of opening the somersault (25.52°). This difference was caused by the earlier opening of the somersault of the partner from SR, who did not complete the rotation. In the final phase, at the moment of finishing the landing, the difference in the angles in the knee joint of the partners was 30.26°.

Comparison of time-spatial characteristics

In the time-spatial characteristics, we focused on the acceleration and speed of the center of gravity of the dancers during the acrobatic element. The speed of the centers of gravity is shown in Figure 5.

In Table 4 are all the differences between the couples in time-spatial characteristics. The biggest difference was in the maximum acceleration in the starting phase for the male partner 1,74 m.s⁻² and for

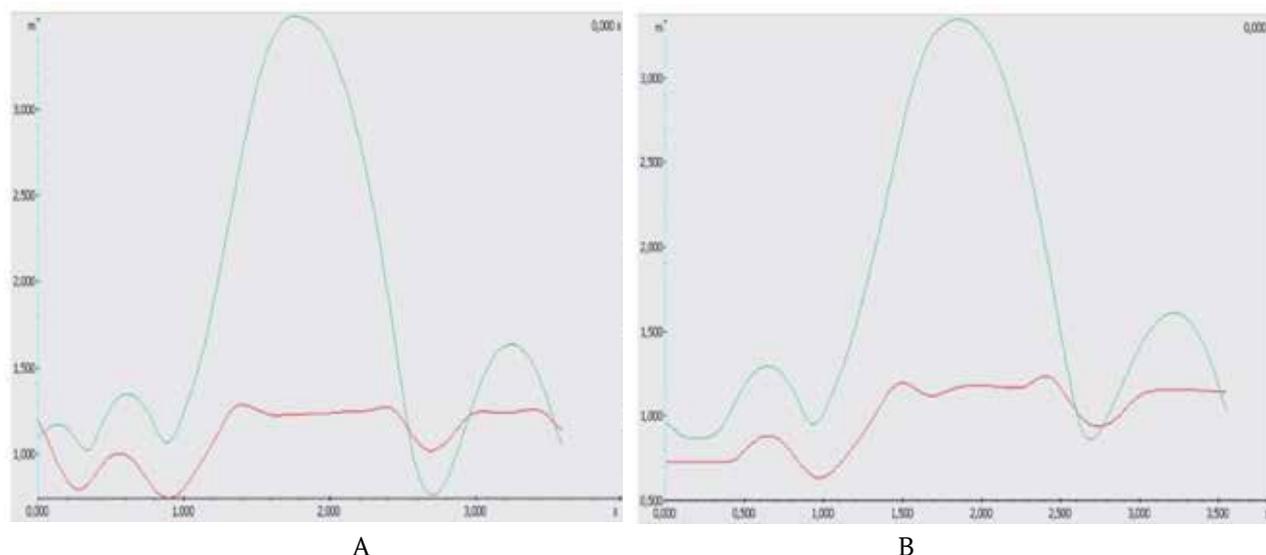


Figure 5. Speed of center of gravity of Czech (A) and Slovak (B) couple (green line- female partner, red line- male partner)

Table 4. Comparison of time- spatial characteristics

Partner's Center of Gravity Dynamics		CZ	D	SK
M	max. acceleration of the partner's center of gravity in the staff phase	14.81 m.s ⁻² in 0.31 s	1.74 m.s ⁻²	16.55 m.s ⁻² in 0.63 s
F	max. acceleration of the partner's center of gravity in the staff phase	23.68 m.s ⁻² in 0.37 s	1.39 m.s ⁻²	25.07 m.s ⁻² in 0.97 s
F	max. speed of the partner's center of gravity in the staff phase	4.54 m.s ⁻¹ in 1.32 s	0.22 m.s ⁻¹	4.32 m.s ⁻¹ in 1.43 s
F	the speed of the partner's center of gravity at the end of the staff phase	3.35 m.s ⁻¹ in 1.50 s	0.23 m.s ⁻¹	3.12 m.s ⁻¹ in 1.57 s
F	the speed of the partner's center of gravity at the end of the descending microphase	5.02 m.s ⁻¹ in 2.34 s	0.30 m.s ⁻¹	4.72 m.s ⁻¹ in 2.37 s
F	max. speed of the partner's center of gravity in the landing phase	5,77 m.s ⁻¹ in 2,47 s	0,43 m.s ⁻¹	5.34 m.s ⁻¹ in 2.45 s

CZ- Czech couple, D- difference between couples SK- Slovak couple, F – female partner, M – male partner

the female partner 1,39 m.s⁻². We noticed another difference in the final phase when the maximum speed of the center of gravity of the partner from the Czech Republic was greater by 0.43 m.s⁻¹. In other parameters, the differences were only minimal.

Discussion

This study aimed to investigate the kinematic parameters of acrobatic element salto backward tucked and compare characteristics of two rock and roll couples. Despite the absence of studies, we will compare the results also with acrobatic elements with a similar structure in acrobatic rock and roll.

Study which aimed on the same element as we, shown a few differences when we compare the highest values. In in height at the end vertical

displacement (1. 2.70 m, 2. 2.62 m, 3. 2.94 m) was difference 19.20 cm and at the culmination point (1 3.05 m, 2. 3.10 m, 3. 3.32 m) 21.70 cm. Study shows that the airborne phase was 0.29 s longer than in our research (1. 1.14 s, 2. 0.96 s, 3. 1.01 s) [12].

In comparison of kinematic characteristics of 20 couples in MCFS category. They monitored 3 acrobatic elements from the staff and one of them was also salto backward with the maximum height of the partner's center of gravity 3.06 m [13]. Taking into account of our results, we observe that a CZ couple achieved a larger maximal height of the partner's center of gravity by 47.30 cm and the SK couple by 28.30 cm compared to the average maximal height of the center of gravity in their research. The length of the airborne phase in their

study was 1.01 s and in our study for the CZ couple 0.84 s and SK couple 0.80 s so the difference is 17 s for CZ couple and 21 s for the SK couple.

The acrobatic element salto backward straight was observed on the same probands as in our study. Thanks to this, we can directly compare selected characteristics of a couple from the Czech Republic with a couple from the Slovak Republic. In terms of time characteristics, we noted a difference in the duration of the entire acrobatic element, when the difference of the CZ couple was 0.07 s and of the SK couple 0.02 s. Couples have similar durations of both somersaults, where the minimal difference indicates a longer duration of the straight salto. From the spatial characteristics, we can compare the height of the partner's center of gravity at the culmination point in the airborne phase. Here was the height almost same for the CZ couple (difference: 0.01 m), and for the SK couple (difference: 0.05 m), when SK couple, had the center of gravity higher during a straight somersault. We assume that this difference is caused by the error of the SK couple in the tucked somersault, when she stops the ascending phase with banding her knee. Since in the straight somersault partner must keep whole body extended for the entire time of the acrobatic element, she had no space for the same mistake. In the preparatory phase, we observed difference in the angle between the partner's torso and the vertical plane at the end of the vertical displacement. The Slovak partner is more deviated from the vertical plane in both acrobatic elements, in our work it was up to 38.63° and in a straight somersault 30°, so the difference was 8.63°. The Czech partner had a smaller angle, 19.14° in our work and 14° in the straight somersault, so the difference was 5.14°. From the time-spatial characteristics, we decided to compare the speed of the partner's center of gravity in the end of the preparation phase. The CZ couple reached a higher speed in the tucked salto (difference: 0.42 m.s⁻¹) and the SR couple reached a higher speed in a straight salto (difference: 0.33 m.s⁻¹) [22, 23].

From other elements with similar structure of motion is also double somersault backward. In this research was used 2D analysis to observe 15 couples (age: 17 – 25 years of female partners, 20 – 35 years of male partner). Maximal height of center of gravity shown minimal value 2.84 m a maximal value 3.66 m (median 3.30 m) which is close to our results (3.54 m and 3.35 m). In the angle between the partner's torso and the vertical plane at the end of the preparation phase was found minimal angle 14° and maximal 39° (median 30°) which is also similar to our values (24,93° a 22,76°). In the speed of center of gravity in ascending phase was the minimal speed 2.90 m.s⁻¹ and maximal 6.50 m.s⁻¹ (median 4.36 m.s⁻¹) our values was close to the median (4,54 m.s⁻¹ and 4,32 m.s⁻¹) [24].

Conclusions

Based on the results of the kinematic analysis, we can determine the errors of both couples. Within the rules, deductions are precisely defined for individual errors in the presentation of the acrobatic element. However, we have discovered errors that are not defined by collisions, but after their removal, the acrobatic element will be of higher quality. In this phase, we recognized the incorrect position of the rebounding lower limb of SK partner, which reduces the efficiency of the rebound. At the end of the preparatory phase, we also observe an incorrect position of the head in hyper extension Inadequate movements of the trunk, the upper limbs and swing of lower limbs during the vertical displacement have been performed as well by the same SK dancer. The large deviation of the partner's torso (38.63°) from the vertical plane together with the bending of the starting lower limb (128.02°) resulted in the disruption of the partner's forces and premature rotation. In the airborne phase, the biggest detected error was the bad position of the body of SK partner in somersault, where during the culmination point the partner had an angle in the knee joint of 35.97°. Such a value means a 25% deduction from the starting value of the acrobatic element. Additionally, in the culmination the SK partner made a mistake in timing - the opening of somersault has been performed very early, even before reaching the culmination. While watching CZ couple, in the landing phase, we found deficiencies in the partner's landing, namely in the height of the center of gravity (0.76 m) and in the angle in the knee joint (80.54°). This is since her partner does not help her enough when landing. For this reason, the entire landing and rebound of the CZ couple seems lengthy and lacks movement dynamics.

Recommendations

Based on the given analysis, we allow ourselves to make recommendations to eliminate the SK partner's mistake. In all these exercises, the partner tries to make a correct rebound. In addition, the perception of the position as well as the correction from the coach are important the most.

1. Individual exercises suggestions:
 - imitation of the staff phase using a bench or a box (different heights): starting from a standing position, starting from a step, staff from a standing position, staff from a step, repeated jumps with lower limbs exchange.
 - imitation of the staff phase using a bench or a box (the partner stands with her back to the wall): starting from a standing position, starting from a step, staff from a standing position, staff from a step, repeated jumps with lower limbs exchange.
2. Couple exercises suggestions:

- imitation of the staff phase - the partner sits on a bench or a box with his hands fixed in the stirrup: starting from a standing position, starting from a step, starting from a standing position with hold in extension, starting from a step with hold in extension.
- imitation of the staff phase - the partner sits on a bench or a box with his hands in the

stirrup ready for a hint of the partner's lift: starting from a place, starting from a step, starting from kick.

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References

1. Artemieva GP. *Criteria for selection and forecasting of sport improvement in acrobatic rock and roll*. [PhD thesis]. Kharkov; 2008. (In Ukrainian).
2. Zaletel P, Kajtna T. Motivational structure of female and male dancers of different dance disciplines. *Acta Gymnica*, 2020;50(2): 68–76. <https://doi.org/10.5507/ag.2020.010>
3. Halasz D, Szilagyi B, Hock M, Jaromi M, Acs P, Boncz I, et al. Examination of a sport-specific dynamic core stability programme among female acrobatic rock and roll dancers. *Value in Health*, 2019;22: S694–S694.
4. Olej P. *Objectification of performance in acrobatic rock and roll*. [PhD thesis]. Bratislava. Comenius University in Bratislava, Faculty of Physical Education and Sports, Department of Gymnastics; 1997. (In Slovak).
5. Vyčítal M. *Technique of basic acrobatic elements in acrobatic rock and roll*. [PhD Thesis]. Bratislava. Comenius University in Bratislava, Faculty of Physical Education and Sports, Department of Gymnastics; 1997. (In Slovak).
6. Prus D, Zaletel P. Body Asymmetries in Dancers of Different Dance Disciplines. *International Journal of Morphology*, 2022;40(1): 270–276.
7. Batiieva NP. Optimization of the training process with skilled athletes acrobatic rock and roll in the annual preperation of macrocykles based on model characteristics. *Pedagogics, Psychology, Medical-Biological Problems of Physical training and Sport*, 2014; 18(8), 3-8. <https://doi.org/10.5281/zenodo.9753>
8. Kozakov MV. Features of the construction of competitive programs in acrobatic rock 'n' roll in the category of young men. *Slobozans'kij naukovosportivnij visnik*. 2013; 5(38), 141-146. (In Russian).
9. Kryshapovych AH, Humeniuk SV. Building Competitive Programs of Qualified Athletes in Acrobatic Rock and Roll. *Intehratsiini pytannia suchasnykh tekhnolohii, spriamovanykh na zdorov'ia liudyny*. 2017; 261-265. (In Ukrainian).
10. Lutsenko LS, Lutsenko YM. Algorithm of competitive program's correction in acrobatic rock and roll. *TRENDS in Sport Sciences*, 2020; 27(2), 101-107. <https://doi.org/10.23829/TSS.2020.27.2-7>
11. Olej P. *Objectification of motor learning of acrobatic elements in acrobatic rock and roll*. [PhD thesis]. Bratislava. Comenius University in Bratislava, Faculty of Physical Education and Sports, Department of Gymnastics; 2005. (In Slovak).
12. Grambličková A. *Kinematic characteristics of acrobatic element in acrobatic rock and roll*. [PhD thesis]. Bratislava. Comenius University in Bratislava, Faculty of Physical Education and Sports, Department of Gymnastics; 2007. (In Slovak).
13. Krističević T, Maković KŽ, Mudronja L. Comparative kinematic analysis of airborne phase in acrobatic elements from „stuff position“. In: *7th International Scientific Conference on Kinesiology*. Faculty of Kinesiology, University of Zagreb, Croatia; 2014. P. 159-164.
14. Adashevskiy VM, Iermakov SS, Firsova II. Physical mathematical modeling of difficult elements of acrobatic rock and roll. *Physical Education of Students*. 2013; 3(17), 3-10. <https://doi.org/10.2139/ssrn.2444321>
15. Somkin AA. *Classification of exercises and the main components of the training of high class gymnasts in sports aerobics*. [PhD thesis]. Sankt-Peterburg; 2002. (in Russian).
16. Medvedeva EN. *Objectification of the technical value of elements of structural groups of rhythmic gymnastics*. [PhD thesis]. Sankt-Peterburg; 2002. (In Russian).
17. Petrenko A, Kamaiev O. Features of the classification of acrobatic exercises of group B – “balancing” and their varieties in artistic swimming. *Slobozans'kij naukovosportivnij visnik*. 2019; 5(73), 57-60. <https://doi.org/10.5281/zenodo.3596616>
18. Artemieva GP. Modern approaches to the improvement of the difficulty evaluation system of exercises in acrobatic rock-n-roll. *Scientific journal National Pedagogical Dragomanov University sport*, 2020; 6(126), 13-16.
19. WRRRC. *Scoring the acrobatics in RR Main chlass free style* [Internet]. 2023 [updated 2023 Jun; cited 2023 Sep 28]. Available from: https://www.wrrc.org/documents/rr/TR_0002_12_Scoring_the_acrobatics_in_RR_Main_Class_Free_Style.pdf
20. WRRRC. *Acrobatic Rock'n'roll Elements Code of Points*. [Internet]. 2023 [updated 2023 Jun; cited 2023 Sep 28]. Available from: https://www.wrrc.org/documents/rr/TR_0009_10_Acrobatic_Rock-n-Roll_Elements_code_of_points.pdf
21. Chlapcová A. *Kinematic characteristics of acrobatic element salto backward tucked in acrobatic rock and roll*. [PhD thesis]. Bratislava. Comenius University in Bratislava, Faculty of Physical Education and Sports, Department of Gymnastics; 2021. (In Slovak).
22. Vasilčák T. *Kinematic characteristics of acrobatic*

- element salto backward straight in acrobatic rock and roll.* [PhD thesis]. Bratislava. Comenius University in Bratislava, Faculty of Physical Education and Sports, Department of Gymnastics; 2016. (In Slovak).
23. Olej P, Vasilčák T, Zvonař M, Lednický A. Kinematic analysis of the acrobatic element Back Layout Somersault in acrobatic rock and roll. In: *Biomechanical Analysis of Movement Performance in Dance and Gymnastic Sport*. Bratislava: Slovak scientific society for Physical Education and sport; 2018 P. 66-82. (In Slovak).
24. Vadovičová B. *Variability of the double back somersault kinematic substructure in acrobatic rock and roll.* [PhD thesis]. Bratislava. Comenius University in Bratislava, Faculty of Physical Education and Sports, Department of Gymnastics; 2000. (In Slovak).
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University students' physical features- reasons, consequences, solutions

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

Abstract

Background and Study Aim Despite the growing concern about sedentary behaviors among the youth, there has been limited focus on understanding their impact. These behaviors significantly affect students' physical potential, productivity, and overall health. The aim of this study is to investigate the effects of sedentary lifestyles on students and to assess their awareness and attitudes towards these behaviors.

Material and Methods A mixed method of investigation was applied, combining preliminary quantitative research with a qualitative analysis of results. A total of 247 students were measured and tested: 122 males and 125 females, with an average age of 19.3±0.7. The anthropometric parameter focused on was body mass index. The physical test applied was the standing long jump. Students' responses from narrative essays were the basis of the qualitative analysis. The quantitative data collected through measurements and physical tests were directly compared to standards.

Results It was found that 24.5% of young men are overweight or obese. The performance of women in physical tests was lower than average, bordering on poor. Students provided their insights on these findings. Their narrative essays were qualitatively analyzed and synthesized, focusing on the reasons, consequences, and potential solutions related to this issue.

Conclusions This study adds evidence to the limited literature investigating university students' attitudes, opinions, and contexts that contribute to a decrease in their physical potential. The current generation of university students is unmotivated to consistently devote time and energy to physical activities. The comments and insights from students have provided potentially beneficial information for decision-makers in the domains of health education, overweight prevention, and physical activity promotion.

Keywords: physical potential, opinions, attitudes, wellbeing, workforce

Introduction

Weight gain and physical inactivity are global health problems responsible for the risk increment of non-communicable diseases. Overweight and especially obese individuals usually are unable to perform the recommended level of physical activity because of their low physical fitness and comorbidities. Once entered into the diet-related diseases and lack of physical activity vicious circle the health care costs increase, creating a significant and rising economic burden. When children and adolescents are not included in activities they withdraw from their peers, causing social marginalization [1]. The physical limitations and the inability to keep up with normal activities, and peers may lead to a vicious cycle of additional weight gain.

Insufficient physical activity is a risk factor for the occurrence of overweight and obesity, both in adults and children. Physical activity is considered

insufficient if is practiced less than 5 times 30 minutes of moderate activity per week or less than 3 times 20 minutes of intense physical activity weekly, or equivalent [2].

Excessive technology use, such as mobile devices led to less physical activity and contributed to weight gain. In most of the emergent economies (Brazil, India, China, Mexico), poor environmental conditions and lack of access to public parks discourage leisure time exercise [4]. World Food Program in a report from 2020 informed that 2.01 billion adults are overweight and obese [5] healthy diets being unaffordable to most people because of the costs. The costs of quality diets are estimated to be on average five times higher than diets that meet only dietary energy needs [6]. These figures also require further increased health costs either for treatment or prevention of metabolic and associated conditions.

The cumulative effect of multiple sedentary behaviors reduces total daily energy expenditure, explaining the context in which the prevalence of childhood and youth overweight and obesity has increased worldwide in recent decades and

continues to rise. According to a study conducted among Czech university students, only 9% attained the criterion of 10,000 steps each day [7]. Physical inactivity is the fourth leading risk factor for death in the world [8], killing more than 7 million people every year.

The young generation is a true digital native [9], the use of media and Internet access is essential because typing is preferred to handwriting, multitasking is a way of life, and the internet is a quicker source of information than libraries [10]. It means that if youngsters are not asleep, they are necessarily connected to a diversity of devices. On the other hand, physical activity has an indubitable beneficial effect on many aspects of quality of life [11, 12] but requires time, energy expenditure and consistency.

Through extensive pedagogical observation spanning multiple years, the research premises proposes that there are alterations in students' BMI and physical fitness. One of the main objectives of this study is to gauge the level of these parameters among the new generation of students. Moreover, we assess the students' perception and ideas about the state of BMI and fitness characteristics in relation to causes, effects and possible solutions.

Materials and Methods

We have chosen a mixed method of investigation combining preliminary quantitative research with a qualitative analysis of the results. The quantitative research implies two sets of data resulting from anthropometric measurements and physical tests in a sample of college students.

Participants

We measured and tested 122 males and 125 females with an average age of 19.3 (range 18-21). The sampling was randomly undertaken in the second university semester 2022 and the inclusion criteria were to be students in the first year, healthy, and attending regularly physical education classes. Students' participation was voluntary and anonymous.

Research Design

The anthropometric parameter we focus on is the body mass index (BMI) calculated by dividing the weight in kilograms by the square of the height in meters. The procedure was to measure and weigh every individual in light sport equipment and bare feet. BMI is an estimation of the extent to which a person is underweight, overweight, or has a healthy body weight.

The physical test we apply was the standing long jump. It is a simple test, already known from school, which tests the muscular strength and power of the lower part of the body. The physical ability assessed is explosive leg power, but good motor coordination of all body is also required. The procedure is to

measure the best jump from two or three attempts with a metric band from the takeoff line to the last body part that touches the ground.

The qualitative approach provides the student's perspective of their BMI and fitness levels. The analyzed results were presented to the participants, and they were asked to comment on what the reasons; consequences and possible solutions are related to the anthropometrical and fitness features of the present student population. We received opinions from 56 respondents: 22 men and 34 women.

Statistical analysis

A statistical summary data was computed and further, we compare the results with standard reference data for youngsters over 16. The assessed variables were the overweight and obesity prevalence and the level of fitness in university student population. Statistical analysis consisting in descriptive statistic and the one sample t-test, where computed using SPSS and Excel data analysis tool. The main research findings were presented in tables and charts.

Results

Following the research purpose, we collected data in a sample consisted of 247 students, studying at Bucharest University of Economic Studies. The sampling was randomly undertaken from freshmen college students attending physical education classes.

The group was divided according to BMI range:

- Underweight – below 18.5 kg/m²;
- Normal weight – between 18.5 and 24.9 kg/m²;
- Overweight – 25 – 29.9 kg/m²;
- Obese – more than 30 kg/m².

Observing the results in our sample a different distribution between men and women could be noticed (Fig. 1, 2; Tabl. 1). The majority of women, 87 % fall into the underweight and normal weight categories, while men have a half percentage of underweight cases as women and relatively equal values in the normal weight category. Men in change, compensate with a higher percentage of persons caring excessive weight (Tabl. 2).

At 19 years of age, almost a quarter (24,5%) of young men in our research sample are overweight and obese. Having in mind that less than 1 percent (1 of 210 men and 1 of 124 women) of obese adults get back to healthy body weight [13], there are plenty of chances for this generation to surpass the statistics. It already indicates that overweight adults in Romania are more numerous than slim ones, the proportion being roughly 55% to 45% in favor of the heavy ones [14].

At first glance, young women seem to be more concerned about physical appearance than men (13% with excessive weight), maybe because of the social pressure and the beauty standard promoted in media.

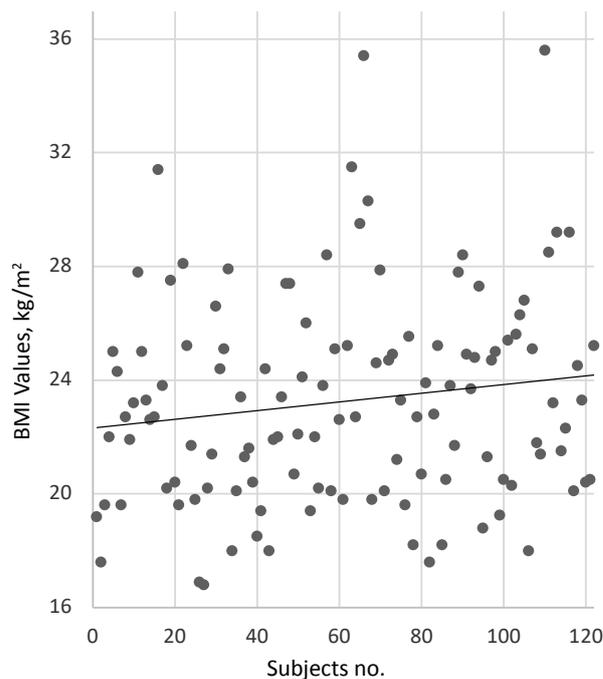
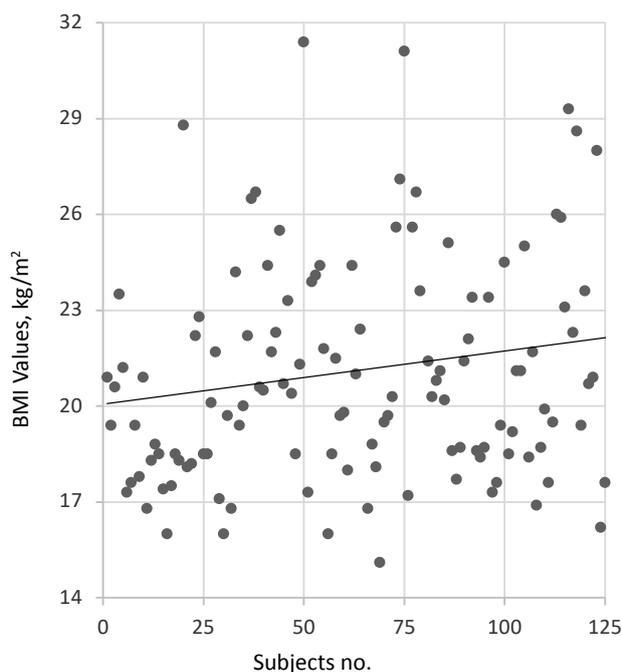


Figure 1. Female BMI distribution (Mean 21.05 ± 2.7) **Figure 2.** Male BMI distribution (Mean 23.25 ± 3.6)

Table 1. Descriptive statistic BMI

Gender	Mean	Std. Deviation	N
Male	23.25 kg/m ²	3.6	122
Female	21.05 kg/m ²	2.7	125

Table 2. Overweight and obese persons percentage

Gender	Under-weight	Normal-Weight	Overweight	Obese
Female	22%	65%	11.5%	1.5%
Male	11%	64.5%	19%	5.5%
Total	16.5%	64.75%	15.25%	3.5%

Fitness level (Tabl. 3). Standing long jump is a simple physical test with which students are already accustomed from primary school. Its purpose is to measure the explosive power of the lower limbs. Standing long jump is testing a combination of two physical abilities: strength and speed resulting in the capability to produce both in a short time over a relatively short distance. It is routinely used by specialists for talent selection and prediction of potential in several sports [15].

Table 3. Descriptive statistic standing long jump

Gender	Mean	Std. Deviation	N
Male	2.13 m	0.23	122
Female	1.50 m	0.18	125

Putting these results in context could lighten the significance and the depth of the motor abilities level. Therefore, a comparison between the obtained data and a reference raking brought information regarding fitness performance. The reference data are estimated for men over 19 years [16].

The SLJ average result of men was of 2,13 m, meaning it has fallen just 3 centimeters below average. The lowering of power for girls is more obvious than for boys (Tabl. 4). Their average SLJ performance of 1,50 m is on the border between “Below average” and “Poor”.

Table 4. Comparative table of long jump results by category for men and women (m)

Category	Men's		Women's	
	Results	Mean	Results	Mean
Excellent	>2.44		>1.91	x
Good	2.29-2.43		1.78-1.90	x
Average	2.16-2.28		1.77-1.63	x
Below Average	1.98-2.15	2.13	1.50-1.62	1.50
Poor	<1.98		<1.50	x

Testing the hypothesis that there is a significant difference between the average of our sample and the average reference values, we applied the one sample t test 2 tail: $t = (x - \mu) / (s/\sqrt{n})$.

The results for men $t_{(120)} = 40.9$ ($p < .00,1$) confirms that the difference between the two means is statistically significant. Also for women sample the t-test result $t_{(125)} = 12,5$ ($p < .00,1$) demonstrates a significant statistical difference between the two data sets. Both calculated t-values ($40.9 > 3.373$ and $12.5 > 3.373$) are greater than the critical tabular t-value, and consequently, we can conclude that the difference between the sample and reference values is 99.9% statistically significant.

Qualitative research. In the present research, we explore the students' understanding and opinion about the stage of the university population in terms of physical and fitness features. Following this purpose, we delivered e-mails with the quantitative study results to those students we measured and tested before. We received narrative essays from 56 students randomly selected from those previously measured and tested and they commented on those data in terms of reasons, consequences, and solutions. The content, supported by quotes, was analyzed and sorted into themes, categories, and subcategories grounded in literature models [17, 18]. After coding the main themes, categories, and subcategories deducted in the process of transcribing and analyzing the narrative material, we were able to synthesize the participant's opinions and their insights and perspectives, as can be seen in Table 5.

Discussion

Many people spend most of their time in a seated position, so their gluteal muscles are stretched out for a long time. Inactivity affects most of those muscles and those which run parallel to the spine. Remaining inactive for long periods results in muscle atrophy, lowering physical abilities, and even causing pain. Physical insufficient activity explains the decrease in fitness levels and has an influential role in weight gain in the young population.

According to a National Statistics Institute report, just half of the Romanian children in primary school (6-14 years) play, practice a sport or are physically active in their leisure time. Moreover, less than 20% of teenagers and youngsters between 15-24 years spend time being actively involved in hobbies or independent activities which require physical effort at least once a week [19]. As they grew older Romanian adults tend to ignore physical activities.

- Reasons. One of the reasons for the impact of both physical appearance and a decrease in fitness level is an inadequate focus on formal physical education lessons. Once physical education has been excluded from the baccalaureate exam the interest of secondary school students has steadily

decreased. It seems to be not just a personal or singular experience, but a widespread phenomenon.

"First reason may be connected to the fact that physical education is no longer taken seriously in general schools and high schools. Being a high school student not long ago, I, myself can confirm the fact that PE lessons are being conducted superficially, mostly in every high school. However, this was not always the case. For example, before the year 2008, a physical education evaluation was included in the Baccalaureate exam. That means students were used to be more involved in physical activities and considered it part of their Baccalaureate preparation. Since the evaluation was ruled out from the exam, shortly after 2008, I believe there is a strong connection between this aspect and the decreasing results of the study we are analyzing."

The main physical education objectives, regardless of context, grade, or gender are harmonious physical development, a reasonable level of physical abilities, and strengthening the state of health. Physical development is a long term approach planned to help students of all ages and all abilities optimize their body functions and reach their potential. Several conditions should be met to achieve these goals; among them, continuity and active involvement are critical in the educational process.

Continuity is a principle derived from a law of biology: "if you don't use it, you lose it". It means that if there is no regularity in physical effort and a progressive load that stimulates the body, the fitness level returns slowly to the original level. Widely spaced loading will produce little or no fitness improvement [20]. The lack of sufficient physical activity will lead to muscle atrophy and causes changes in the ratio of muscle mass and body fat percentage even in young adults. The muscle mass decreases even more with age [21] and is replaced by adipose tissue followed by changes in body shape and volume.

Active involvement in exercise means that for a physical education program to be fully effective the student needs drive and consistency or the will of active participation. It should not be forgotten that success in the educational process is a combination of student efforts and teacher skills. Teachers could motivate students by involving them in a wider variety of activities because the preferences and "trends" changed as the following comment reveals:

"Another fact that led to an increase in the body mass index is the change in the exercising trends over the years; if 20 years ago people would prefer aerobics, running, different sports and light exercises aiming to keep in shape, nowadays people prefer heavy training, using machines and heavyweights. These different types of exercises can change the appearance of the body and the body mass index because they stimulate the body in a different way."

Table 5. Students' opinions and perspectives – synthesis

Theme	Categories	Subcategories
Reasons	<i>Inadequate focus on formal P.E.</i>	Superficial classes
		Exclusion from baccalaureate exam
	<i>Increased access to technology</i>	Changes in preferences
		Virtual versus real activity
		Eating, snacking more
	<i>Parent neglect</i>	Time consuming sedentary activities
Lack of interest for outdoor activities		
<i>Unhealthy diet</i>	Lack of time for cooking, house chores, family physical activities	
	Poor quality food	
<i>Transportation</i>	Excess of sugar	
	Processed versus natural products	
<i>Bad habits</i>	Excessive use of car versus “green transportation”	
	Smoking, alcohol abuse, use of psychoactive substances	
Consequences	<i>Deteriorated health</i>	Low energy
		Low concentration
		Heart related disease, diabetes
		Depression
		Low birth rate
		Increase mortality rate
<i>Economic effects</i>	Immunodeficiency	
	Physical limitations in carrying out tasks	
	Low productivity	
	Pressure on social security budget	
Solutions	<i>Education</i>	Constrains on labor market
		Diminished lifetime expectancy
		Decrease in future workforce quality
		PE and sport promotion
		Programs for parenting
<i>Awareness raising</i>	<i>Personal</i>	Making P E content appealing
		PE friendly approach & climate
		Nutrition classes in elementary school
	<i>Public</i>	Enough sleep
		Weight management
		Exercise regularly
<i>Awareness raising</i>	<i>Public</i>	Responsibility for own choices
		Awareness of consequences
		Interesting and appealing projects
<i>Awareness raising</i>	<i>Public</i>	Campaigns for children and parents
		National action plan against obesity

Indeed, aerobic gymnastics, jogging, and team sports are addressing the cardio system aiming for functional improvements, while bodybuilding aims for an improved physical appearance. The focus has shifted from efficient functioning to an appealing appearance, from content to shape, and from substance to form.

Increased access to technology is an issue addressed in most of the essays. Students explain that being connected to a device almost all the time becomes an addictive activity from childhood.

“Almost every child uses a mobile phone; instead of playing in parks with their friends or going for a walk they prefer to spend time surfing the internet.”

Spending a significant amount of time on screen activities reduces the time allocated to other tasks, including any kind of dynamic activities. Adolescents spent 57% of the after school period in sedentary behaviors including watching TV, video games, doing homework, motorized transport, social media [22].

“...they are replacing physical activities with social media and computer / mobile games. Willing to have more and more time to spend on social media and [games, surfing internet] they neglect any other activity.”

A form of retreat from real life is signaled in the previous paragraph; virtual reality is preferred maybe because is more dynamic and more prompt in responding to immediate needs. The same tendency can be included in the withdrawal from the natural environment into the anthropic one.

“Throughout the past years, teenagers have been spending more and more time in front of computers and phones, replacing many physical, real life activities with virtual ones.”

They communicate and coexist online almost every hour of the day, which leads to a lack of interest in outdoor activities and, therefore, less physical activities.

A connection between the excessive use of technology and the decrease in physical abilities has been made:

“... considering the increased amount of time spent using such technologies by teenagers, we surely can see a connection between the excessive use of technology and the decrease of physical abilities.”

Technology does not just keep us seated in front of our desks or on sofas but has increased the propensity to consume snack foods [23]. Changes in eating habits add more weight than the lack of physical activity alone and our respondents noticed this consequence:

“...spending a lot of time at the computer is associated with eating more, usually low quality food – such as fast food, snacks, and sweets.”

There is a real interest in studying the link between the use of technology and being overweight. A comprehensive study in 27 OECD countries

revealed that for every 10% increase in information communications technology investment as a share of gross capital formation, the obesity rate climbs 1.4 % on average. At the same time, a 1 % increase in the number of physically active people can prevent a 0.2 percentage point rise in obesity [24].

It seems easier to increase investments in technology by 10 percent than make 10 percent more physically active people. Technology development increases productivity while physical inactivity is the 4th leading risk factor for death worldwide. It is estimated that more than 5.3 million people die annually due to being sedentary [3].

An unhealthy diet and parental neglect are other reasons signaled by some students.

“Unhealthy food is more accessible than ever, especially to the younger population. Fast foods are strategically placed close to universities and high schools”.

Nevertheless, food habits and customs do change during the second half of the Twentieth Century, and they are influenced by urbanization, globalization, and the contemporary “fast forward” way of living. Communities do not depend on local food resources anymore and working people are not accustomed to cook in a traditional, slow manner. Therefore, fast food, and processed products are always within reach and an apparently time saving solution, but with repercussions on nurturing habits and consequently on health.

“The products found on the market are more and more processed that are a lot easier to cook, a fact that is attracting the younger population, leading to young people eating a lot of unhealthy food, like fast food, which has a very small positive nutritional value but contains a lot of unhealthy calories and fats that, if ate regularly can lead to obesity and a number of health problems.”

The family has a decisive role in promoting a healthy lifestyle because excessive weight tends to run in families. Parental style influences children’s self-regulation in calorie intake until a certain age, eating, and daily life habits are passed down from one generation to another. Parents have an important responsibility in giving a good example for their children. Childhood health condition has a lasting impact on health and socioeconomic status in middle adulthood, [25]. There is a 50% chance for a child of being overweight if one parent is overweight or obese, and if both parents have weight management problems the chances will increase to 80%. A child who has overweight parents, who eat high-calorie foods and are physically inactive, will likely become overweight too.

However, if the family adopts healthy eating and involves children in outdoor activities, house chores, or green transportation their chance of being overweight or obese is reduced proportionally. Parent’s neglect is explained by a lack of time and

stress or pressure to fulfill multiple and different tasks:

“I think a good part of the fault belongs to their parents, which, because of the continuing pressure on them from all directions in our world, have less and less time to dedicate to their children, to involve them in time consuming and old-fashioned activities such as food preparation, outdoor games and so on.”

A study undertaken by WZB Berlin Social Science Center found that preschoolers aged between three and four years old are more at risk of obesity if their mothers work for more than 35 hours a week. If mothers are working less than 24 hours per week the risk of a child becoming overweight is lower [26]. Up to a certain working program mothers could balance the family and job efficiency, having time and dedication to implement a healthier diet and a more rigorous program for their children. As more hours are spent on the job, less time and energy for children care and “old fashioned activities” remains.

- Consequences. Two categories emerged related to the consequences of BMI increase and physical skills decay: deteriorated health and economic effects. Among the health issues mentioned were predictably heart-related diseases, diabetes, immunodeficiency, and depression. More interesting seems to be the discussion about increasing the mortality rate in “an unhealthy society” and a low birth rate:

“...they might die younger. Dying younger also means that these people are less likely to have children as some of them might not have the time. Even if they do have children, they are likely to promote unhealthy lifestyles, like the ones they had which only perpetuates the existing problems”.

The result might be negative population growth or a positive trend in the number of overweight and obese adults. Unfortunately, Romania faces both sides of this problem and does not seem to have realistic solutions. A related question to the previous statement could be how many years of healthy life are losing individuals by failing to tackle obesity and comorbidities?

An interesting idea emerged from our respondents' comments; it corresponds to the ancient quote of a sound mind in a sound body or “Mens sana in corpore sano”. The link between body health and the ability to focus the mind was brought into the discussion. A poor diet, through its consequences, may affect general well-being, making youngsters unable to perform physically and intellectually as well as their age would normally allow if they led a healthy lifestyle. This holistic approach suggests that keeping the body in a good state of functioning and stimulating the regeneration of energy resources will result in a better mood, better concentration, and improved focus. The meaning of “a sound mind in a sound body” is for the contemporary man the emotional,

physical, and mental well-being.

Economic effects. Diet related non-communicable diseases including high blood pressure, stroke, diabetes, and coronary heart disease, with a concomitant increase in health care costs, create a significant and rising economic burden. The pressure on health and social security budgets was correctly underpinned by our group, students in the business and economics faculties.

“A precarious state of health of the student’s bodies could determinate a decrease in their academic performances as well. Therefore, the quality of our society’s future workforce will also decrease”.

There are also concerns linking workforce low quality with low productivity due to physical limitations in carrying out tasks. The implications of these three elements are constraining on the workforce sustainability and local labor market.

- Solutions. The solutions identified follow two main directions: education and rising public and individual awareness regarding weight gain and physical skills decay. All respondents highlighted the educational aspect of preventing obesity spread and suggested measures for formal physical education and sports. Among those a friendly approach in lessons and extracurricular activities sounds more feasible, depending more on teachers, specific contexts, materials, curricula content, and not so much on public policies.

Motivation is a pivotal element in involving actively students in physical activities [27] and convincing them to invest time and energy in getting tired and sweating. Variety could maintain the student’s interest and motivation. One of the new generation features is that they lose interest and get bored quicker than any other generation before. Adapting and adjusting the curricula to correspond to their needs requires time, energy, and creativity on the PE teacher’s part.

“Education should be done in a friendly manner, not by forbidding them [students] from technology or fast food, but rather by making them aware that the commodity of sitting all day long and eating tasty but unhealthy food comes with concerning consequences”.

From the above quote, another task for educators stands out: the necessity of nutrition and health classes in elementary school not only for students but for parents too.

“Food education classes could be introduced into school curricula, and the number of physical education hours could be increased. In addition, campaigns based on this topic can be created for both children and parents, as they have a great influence on young people’s lives”.

In our student’s opinion a few simple, common sense prescriptions should be followed to prevent life long lasting consequences: weight management, exercise regularly, enough sleep, and taking responsibility for own choices. The right choices

are made by being aware of side effects, long term consequences, and available alternatives. Awareness rising against overweight and insufficient physical activity needs to be a more intense presence in the media, in public campaigns, and through the health and education system.

Further research is needed to determine how the generation that experienced pandemic confinement during their studies will fit into the labor market.

Conclusions

The research novelty consists of adding evidence to the limited literature investigating future workforce attitudes, opinions and context that causes a decrease in their physical potential. Several limitations may explain the partial achievement of

physical education objectives: the limited access to sports facilities, limited time allocated to physical education in the curriculum, the gap between teachers' skills and knowledge and the changing of student's needs and interests. The present generation of university students is unmotivated to spend consistent time and energy on physical activities, and is reluctant to physical and emotional fatigue.

Solutions are required and salient in education and prevention, considering the two years of sanitary constraints and the long term consequences for individuals, communities, and society. Health care, education and quality of life are three pillars of social sustainability that can support a valuable future work force.

References

- de la Haye K, Dijkstra JK, Lubbers MJ, van Rijsewijk L, Stolk R. The dual role of friendship and antipathy relations in the marginalization of overweight children in their peer networks: The TRAILS Study. *PLoS ONE*, 2017;12(6): e0178130. <https://doi.org/10.1371/journal.pone.0178130>
- WHO. *Physical activity* [Internet]. 2023 [updated 2023 Jun; cited 2023 Sep 28]. Available from: <https://www.who.int/news-room/fact-sheets/detail/physical-activity>
- French P, Crabbe M. *Fat China. How expanding waistlines are changing a nation*. London; New York: Anthem Press; 2010
- WHO. *Global Nutrition Report*. [Internet]. 2018 [updated 2023 Jun; cited 2023 Sep 28]. Available from: https://www.who.int/nutrition/globalnutritionreport/2018Global_Nutrition_Report.pdf
- Bencsik A, Horvath-Csikos G, Juhasz T, Csanadi A. Healthy lifestyle and behavior of Z Generation. *Journal of Eastern European and Central Asian Research (JEECAR)*, 2019;6(2): 297–308. <https://doi.org/10.15549/jeecar.v6i2.269>
- The State of Food Security and Nutrition in the World* [Internet]. 2020 [updated 2023 Jun; cited 2023 Sep 28]. Available from: <http://www.fao.org/3/ca9692en/CA9692EN.pdf>
- Lee IM, Shiroma EJ, Lobelo F, Puska P, Blair SN, Katzmarzyk PT. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *The Lancet*, 2012;380(9838): 219–229. [https://doi.org/10.1016/S0140-6736\(12\)61031-9](https://doi.org/10.1016/S0140-6736(12)61031-9)
- Sigmundova D, Chmelik F, Sigmund E, Feltlova D, Frömel K. Physical activity in the lifestyle of Czech university students: Meeting health recommendations. *European Journal of Sport Science*. 2013;13(6):744–50. <https://doi.org/10.1080/17461391.2013.776638>
- Porras J, Heikkinen K, Kinnula M, Sørensen LT, Hennala L, Melkas H, et al. *User 2020: A WWRF Vision*. [Internet]. 2014 [updated 2023 Jun; cited 2023 Sep 28]. Available from: <https://www.wwrf.ch/files/content%20wwrf/publications/outlook/Outlook14.pdf>
- European Obesity Day*. [Internet]. 2019 [updated 2023 Jun; cited 2023 Sep 28]. Available from: <https://insp.gov.ro/sites/cnepss/wpcontent/uploads/2016/05/02-Analiza-de-situatie-ZEIO-2019-FINAL-APR.pdf>
- Fildes A, Charlton J, Rudisill C, Littlejohns P, Prevost AT, Gulliford MC. Probability of an Obese Person Attaining Normal Body Weight: Cohort Study Using Electronic Health Records. *Am J Public Health*. 2015; 105(9):e54–9. <https://doi.org/10.2105/AJPH.2015.302773>
- Pop CL. Overweight and obesity risk assessment – two methods, different results. *Physical Education of Students*, 2016;3:53–57. <https://doi.org/10.15561/20755279.2016.03>
- “Obesity in Romania (ORO)” - *Prevalence of obesity and risk factors for obesity in the adult population in Romania*. [Internet]. 2014 [updated 2023 Jun; cited 2023 Sep 28]. Available from: <https://www.mediafax.ro/stiinta-sanatate/studiu-obezitatea-in-romania-mai-frecventa-la-barbati>
- Keating CL, Moodie ML, Swinburn BA. The health-related quality of life of overweight and obese adolescents – a study measuring body mass index and adolescent-reported perceptions. *International Journal of Pediatric Obesity*, 2011;6(5–6): 434–441. <https://doi.org/10.3109/17477166.2011.590197>
- Burr JF, Jamnik RK, Baker J, Macpherson A, Gledhill N, McGuire EJ. Relationship of physical fitness test results and hockey playing potential in elite-level ice hockey players. *J Strength Cond Res*. 2008;22(5):1535–43. <https://doi.org/10.1519/JSC.0b013e318181ac20>
- Hede C. *PE Senior Physical Education for Queensland*. UK: Oxford University Press. 2011.
- Bardi M. Learning the practice of scholarly publication in English – A Romanian perspective. *English for Specific Purposes*, 2015;37: 98–111. <https://doi.org/10.1016/j.esp.2014.08.002>
- Swales JM. *Research Genres: Explorations and*

- Applications*. 1st ed. Cambridge University Press; 2004. <https://doi.org/10.1017/CBO9781139524827>
19. Deliens T, Deforche B, De Bourdeaudhuij I, Clarys P. Determinants of physical activity and sedentary behaviour in university students: a qualitative study using focus group discussions. *BMC Public Health*, 2015;15(1): 201. <https://doi.org/10.1186/s12889-015-1553-4>
 20. Chatterjee A, DeVol RC. *Waistlines of the world the effect of information and communications technology on obesity*. [Internet]. 2012 [updated 2023 Jun; cited 2023 Sep 28]. Available from: <http://assets1b.milkeninstitute.org/assets/Publication/ResearchReport/PDF/Waistlines-of-the-World.pdf>
 21. WHO, European Commission. *Romania. Physical activity factsheet*. [Internet]. 2018 [updated 2023 Jun; cited 2023 Sep 28]. Available from: <https://www.euro.who.int/en/health-topics/disease-prevention/physical-activity/data-and-statistics/physical-activity-fact-sheets/physical-activity-country-factsheets/romania>
 22. Thomson Peter JL. *Introducing to Coaching. The Official IAAF Guide to Coaching Athletics*. IAAF: UK; 2009.
 23. Wilkinson DJ, Piasecki M, Atherton PJ. The age-related loss of skeletal muscle mass and function: Measurement and physiology of muscle fibre atrophy and muscle fibre loss in humans. *Ageing Research Reviews*, 2018;47: 123–132. <https://doi.org/10.1016/j.arr.2018.07.005>
 24. Arundell L, Fletcher E, Salmon J, Veitch J, Hinkley T. A systematic review of the prevalence of sedentary behavior during the after-school period among children aged 5-18 years. *International Journal of Behavioral Nutrition and Physical Activity*, 2016;13(1): 93. <https://doi.org/10.1186/s12966-016-0419-1>
 25. Gortmaker SL, Must A, Perrin JM, Sobol AM, Dietz WH. Social and Economic Consequences of Overweight in Adolescence and Young Adulthood. *New England Journal of Medicine*, 1993;329(14): 1008–1012. <https://doi.org/10.1056/NEJM199309303291406>
 26. Li J, Akaliyski P, Schäfer J, Kendall G, Oddy WH, Stanley F, et al. Non-linear relationship between maternal work hours and child body weight: Evidence from the Western Australian Pregnancy Cohort (Raine) Study. *Soc Sci Med*. 2017; 186:52-60. <https://doi.org/10.1016/j.socscimed.2017.05.046>
 27. Suhrcke M, de Paz Nieves, Carmen. *The impact of health and health behaviours on educational outcomes in high-income countries: a review of the evidence*. [Internet]. 2011 [updated 2023 Jun; cited 2023 Sep 28]. Available from: <https://www.euro.who.int/en/publications/abstracts/impact-of-health-and-health-behaviours-on-educational-outcomes-in-high-income-countries-the-a-review-of-the-evidence>
 28. Sierra-Díaz MJ, González-Villora S, Pastor-Vicedo JC and López-Sánchez G.F. Can We Motivate Students to Practice Physical Activities and Sports Through Models-Based Practice? A Systematic Review and Meta-Analysis of Psychosocial Factors Related to Physical Education. *Front. Psychol*. 2019;10:2115. <https://doi.org/10.3389/fpsyg.2019.02115>

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Sensory integration research: priority scientific directions based on the analysis of Web of Science Core Collection resources

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Abstract

Background and Study Aim Monitoring the condition of athletes is one of the leading tasks in sports science. Predicting success and skill growth is an integral part of monitoring. The fulfillment of this task requires the use of modern methods and the sensory integration analysis occupies an important place. The purpose of this article is to analyze publications on sensory integration and identify priority research areas in this field.

Material and Methods The bibliometric database Web of Science Core Collection (WoS) was analyzed. 388 sources that met the search criteria for 2013-2023 were selected for primary analysis. Bibliometric methods were used for processing the obtained information. The program VOSviewer 1.6.18 was used for keyword analysis and direct citation analysis with the construction of bibliometric maps, visualization of cluster density, and weight – citations.

Results The leading publication categories in WoS were Neurosciences, Sport Sciences, Psychology, Psychology Experimental, Physiology, Rehabilitation. The distribution of publications by years was fairly evenly. Most publications were related to Germany and the USA. The most frequent institutions were German Sport University Cologne, Universidade de Sao Paulo, Shanghai University of Sport, Institute National de la Sante et de la Recherche Medicale Inserm, University of Freiburg. The most cited authors were identified. The constructed bibliometric maps allowed us to identify the leading thematic areas of research and current research directions in the field. The two most important clusters were identified. The largest cluster reflects research on balance and posture and the use of special exercises for rehabilitation in different population groups. The second cluster includes the most significant keyword in the whole map – “sensorimotor integration”. The works reflect studies of sensorimotor integration, the study of movement features, and coordination and control of movement at different levels.

Conclusions The conducted bibliometric analysis of publications confirms the relevance of sensorimotor integration. A stable interest in this problem has been determined. Research in this area has neurophysiological, sports-recreational, and medical-rehabilitation directions. Neurophysiological research is aimed at analyzing balance and equilibrium and the application of various tests and functional samples. The sport context studies sensory integration in different sports. Recreational publications have investigated sensory integration as a criterion of health. The therapeutic and rehabilitation focus explores the use of sensory integration as a criterion for treatment and rehabilitation. A characteristic feature is the intersection of these directions. There is a lack of studies devoted to sensory integration in sport dancing. There is a lack of studies aimed at studying the psychophysiological state. These types of research should be assessed as relevant.

Keywords: sensory integration, bibliometric mapping, VOSviewer.

Introduction

One of the leading tasks in modern sports science is monitoring the functional state of athletes. Prediction of success and growth of sportsmanship is an integral part of monitoring, as it combines the following main tasks: collection and analysis of

information and development of a forecast based on the results obtained [1, 2]. The fulfillment of this task requires the use of modern methods of analysis, among which techniques aimed at sensory integration occupy an important place.

Currently, sensory integration is understood as the ability to synthesize, systematize, and process sensory information received from the body and environment. This process is based on the interaction of the brain, peripheral nervous system,

and musculoskeletal system. Sensory integration largely ensures the functional state of a person and determines the peculiarities of tiredness formation, performance, and productivity of sports activity [3, 4, 5].

Timing, integration, and coordination between sensory perception and motor skills are necessary conditions for successful planning and execution of all complex movements. This integrated approach is important for success in sport [6, 7]. However, there is relatively little research in this area. The study of the nature of the influence of training on the motor qualities of athletes is recognized as an actual direction of sports science.

Ensuring effective professional selection allows to ensure a high level of athlete success. The essence of such selection is a complex assessment of physical and psychophysiological properties with the help of a system of special tests. The main task of psychophysiological selection is to determine the state and degree of development of psychophysiological, mental, and personal qualities of the athlete. These qualities contribute to the successful mastery and effective use of professional skills [2].

The importance of psychophysiological features in optimizing the functional state of athletes is beyond doubt. The impact of certain sports on cognitive sensorimotor abilities and basic brain functions was assessed in the study [8]. The authors analyzed the features of the psychophysiological state of athletes in martial arts, rock climbing, and racket. Persons who did not engage in sports were the control group. It is shown that martial arts athletes had the best indicators of reaction time. The test performance was the most stable with the lowest number of errors. These athletes show the best motor readiness. The highest activity associated with postperceptual processing of attention was also determined in martial arts athletes. It is concluded that martial arts can provide the best functional level for athletes.

The psychophysiological features of athletes' conditions are an important component of ensuring success. Testing of coordination, reaction speed, concentration, and switching of attention and memory is used to control the state in various sports. Correlation between psychophysiological indicators and other criteria allow evaluation of training and prediction of the growth of mastery [9].

The effects of various exercises on postural balance control and the underlying physiological mechanisms have been extensively investigated. However, little is known about how the demanding conditions of exercise contribute to improved body balance and to what extent these changes can be explained by sensorimotor and/or neuromuscular adaptations [10, 11]. The aim of the review [10] was to analyze the literature investigating the

adaptation and control of posture in sport-specific training conditions and assess its correlation with sports performance indicators. The analysis made it possible to identify gaps in the existing research and offer suggestions for its optimization. The correlation between static and/or dynamic balance and sports performance criteria has been determined in archery, golf, and baseball. There is a tremendous amount of evidence to support neurophysiological adaptation to control postural balance due to exercise. However, there is insufficient research that explains balance adaptation and its effects on athletic performance. The correlation between performance and improved neuromuscular function induced by sport-specific balance exercises has not been definitively resolved. There is an opinion that this may be due to the influence of general physical exercises. It is concluded that there is a need for further research in this field.

In this context, it was of interest to conduct a bibliometric analysis of scientific publications devoted to sensory integration in journals of the international database Web of Science Core Collection.

The aim of this study was to analyze the publications devoted to sensory integration and to identify the priority scientific directions in this field.

Methodology

Data sources

Web of Science Core Collection (WoS) bibliometric database was selected as the source of the research sample as at 29.09.2023.

The main criterion for selecting databases was the quality of the information sources. 388 publications were selected (WoS). The sources met the criteria «sensory integration» + «sport». The added keywords used were «multisensory integration», «posture control», «sensorimotor integration», «sensory reweighting». The search time interval was from 2013-01-01 to 2023-09-29.

The leading WoS categories were Neurosciences with 142 publications (36.5%), Sport Sciences with 105 (27.1%), Psychology with 43 (11.1%), Psychology Experimental with 36 (9.3%), Physiology with 32 (8.2%), and Rehabilitation with 28 (7.2%).

The distribution of publications by years was fairly even. For the last 5 years of analysis, the specific weight of publications was: 2023 – 33 (8.5%), 2022 – 64 (16.5%), 2021 – 46 (11.9%), 2020 – 42 (10.8%), and 2019 – 41 (10.6%).

Analysis of document types confirmed most research articles. The number of article – 325 (83.8%), review article – 35 (9.0%), meeting abstracts – 12 (3.1%), proceedings papers – 12 (3.1%), and early access – 7 (1.8%).

Most publications were related to the following countries: Germany, 92 (23.7%); USA, 83 (21.4%);

England, 74 (19.1%); China, 36 (9.2); and France, 35 (9.0%). The analysis of affiliations allowed us to identify the most frequently occurring institutions: German Sport University Cologne – 19 (4.9%), Universidade de Sao Paulo – 19 (4.9%), Shanghai University of Sport – 17 (4.4%), Institute National de la Sante et de la Recherche Medicale Inserm – 16 (4.1%), University of Freiburg – 16 (4.1%).

Data analysis

Bibliometric methods [12, 13] for processing the obtained information in the context of sensory integration were used to analyse and determine the leading directions of research on the problem under study. To create and visualize bibliometric networks, we used the special program VOSviewer 1.6.18 [14]. This tool allows the analysis of keywords [12] and direct citations [13]. The calculation of the main indicators for analysing and identifying the most significant categories was performed according to the method [15]. The most cited references were used to identify promising research directions in this category. Distance-based bibliometric maps were used, in which the distance between two elements reflects the strength of the link between the elements. A smaller distance usually indicates a stronger link.

Results

The program VOSviewer 1.6.18 created a set of bibliometric maps based on the purpose of the study. The main purpose of these maps is to identify trends in sensory integration research and highlight priority fields. The network visualization is presented in Figure 1.

The network was created based on 133 elements – keywords that had a repeatability of at least 5. They are organized into 6 clusters. The network is characterized by 2033 links, with a total strength of 3946. The size of the circles-keywords corresponds to the number of links received. The proximity of these circles on the map indicates the strength of the correlations between the elements. According to Fig. 1, the most common studies can be identified. They are centred around the keywords “sensorimotor integration”, “balance”, “performance”, “perception”, “proprioception”, “movement”.

The first cluster includes 38 keywords. This is the most significant cluster. It is marked on the map in red. The cluster is conditionally named “balance”. It is the most significant keyword. It has 122 links with other keywords in the map, and the total link strength (TLS) is 671. Next in order of decreasing number of links are: “gait” 53, (TLS 104), “reliability” 53, (TLS 106), “exercise” 51, (TLS 82), “older-adults” 50, (TLS 101), “walking” 44, (TLS 80), “adults” 41, (TLS 65), “individuals” 39, (TLS 71), “people” 39, (TLS 53), “young” 37, (TLS 59), “deficits”

35, (TLS 61), “risk” 34, (TLS 58), “recovery” 33, (TLS 45), “falls” 32, (TLS 60), “concussion” 28, (TLS 54), “physical-activity” 28, (TLS 38), “therapy” 28, (TLS 36), “injury” 27, (TLS 42), “symptoms” 24, (TLS 44), “quality-of-life” 22, (TLS 31), “risk-factors” 22, (TLS 31), “management” 22, (TLS 29), “tai chi” 22, (TLS 27), “association” 21, (TLS 27), “cognitive task” 21, (TLS 29), “error scoring system” 21, (TLS 37), “time” 21, (TLS 34), “anxiety” 20, (TLS 21), “health” 20, (TLS 22), “space” 20, (TLS 29), “synchronization” 20, (TLS 24), “prevalence” 19, (TLS 23), “epidemiology” 19, (TLS 22), “validity” 17, (TLS 29), “fatigue” 17, (TLS 20), “orientation” 16, (TLS 19), “instability” 15, (TLS 24), “traumatic brain- injury” 15, (TLS 25).

The keywords in this cluster reflect the focus of research on balance and posture and the use of special exercises for rehabilitation in different population groups. The maximum total link strength of the keywords “balance”, “gait” and “reliability” confirms this assumption. The analysis of key words allows us to assess the peculiarities of the research design, focus on studying the peculiarities of the human condition, and the prevalence of injuries and diseases that lead to balance disorders.

The second cluster includes 37 keywords. It is marked on the map in green. The cluster is tentatively named “sensorimotor integration”. It is the most significant keyword in the entire map. It has 128 links with other keywords in the map (TLS 782). Next, in order of decreasing number of links are as follows: “movement” 82, (TLS 193), “coordination” 47, (TLS 92), “motor control” 45, (TLS 78), “dynamics” 41, (TLS 80), “brain” 41, (TLS 65), “mechanisms” 41, (TLS 56), “humans” 40, (TLS 69), “model” 35, (TLS 55), “pain” 32, (TLS 38), “transcranial magnetic stimulation” 32, (TLS 51), “activation” 31, (TLS 42), “cortex” 31, (TLS 41), “visual feedback” 30, (TLS 35), “touch” 29, (TLS 50), “inhibition” 28, (TLS 39), “motor imagery” 26, (TLS 30), “stiffness” 25, (TLS 32), “healthy” 24, (TLS 30), “plasticity” 23, (TLS 32), “body” 22, (TLS 29), “discrimination” 21, (TLS 25), “hand” 21, (TLS 28), “position sense” 21, (TLS 29), “cognition” 20, (TLS 25), “knee osteoarthritis” 20, (TLS 27), “representation” 19, (TLS 26), “sensory feedback” 18, (TLS 21), “sensorimotor control” 17, (TLS 25), “motor cortex” 17, (TLS 25), “size” 15, (TLS 16), “embodiment” 15, (TLS 20), “functional magnetic resonance imaging” 13, (TLS 16), “precision grip” 13, (TLS 16), “human brain” 12, (TLS 13), “internal models” 11, (TLS 15), “rubber hand illusion” 11, (TLS 17).

This cluster illustrates the focus of research specifically on sensorimotor integration, the study of movement patterns, and coordination and control of movement at different levels. Most of the keywords in this cluster reflect neurological approaches to research in both healthy and sick people.

The third cluster includes 20 keywords. It is indicated in blue on the map. The cluster is conditionally named “performance”. This is the

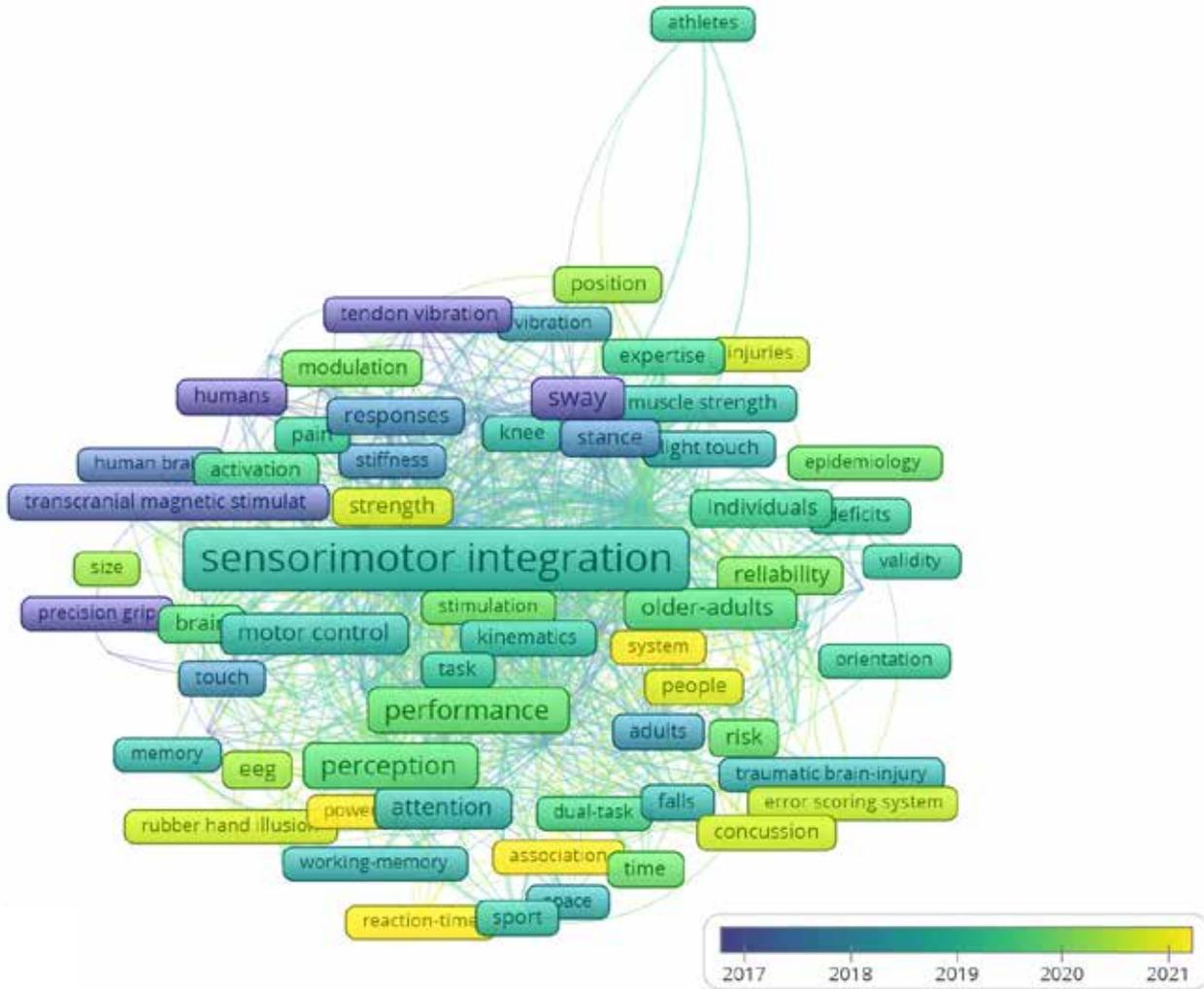


Figure 2. Distribution of keywords by years in publications on sensor integration and overlay visualization. Source: authors’ research based on data retrieved from WoS and analyzed with VOSviewer (29.09.2023).

The importance of the visual system in providing control of posture and balance is reflected in the name of the cluster. Studies in this cluster are mainly devoted to age-related aspects of sensory integration, peculiarities of adaptation to different conditions, and motor and biomechanical aspects.

The fifth cluster is marked on the map in purple. It includes 16 key words. The conditional name of the cluster is “proprioception”. This keyword has 73 links and TLS 163. Next, in order of decreasing number of links are: “age” 52, (TLS 103), “responses” 44, (TLS 94), “strength” 41, (TLS 60), “modulation” 33, (TLS 53), “knee” 31, (TLS 42), “variability” 29, (TLS 41), “ankle” 28, (TLS 34), “electromyography” 25, (TLS 27), “reflex” 24, (TLS 28), “strategies” 24, (TLS 29), “muscle vibration” 24, (TLS 41), “tendon vibration” 24, (TLS 49), “vibration” 22, (TLS 35), “h-reflex” 14, (TLS 19), “sports” 14, (TLS 18).

This cluster reflects research that examines one’s sense of body and posture predominantly in older adults. The key words illustrate the importance of musculoskeletal and neuromuscular regulation in maintaining posture and stable balance.

The sixth cluster is indicated in blue on the map. It includes only 6 keywords. The conventional name of the cluster is “information”. This keyword has 62 links and TLS 183. Next, in order of decreasing number of links are: “sway” 57, (TLS 169), “position” 33, (TLS 58), “light touch” 22, (TLS 44), “stroke” 18, (TLS 22), “athletes” 4, (TLS 9). The research of this cluster is aimed at studying the peculiarities of posture in athletes and its changes under the influence of various factors. The overlay visualization network is shown in Fig. 2.

Figure 2 displays the frequency of the occurrence of keywords in publications from 2017 to 2021. This allows us to assess the focus of research in recent years. The most common keywords occur most frequently in the 2019-2020 publications. These include “sensorimotor integration”, “balance”, “performance”, and “perception”. The results corroborate the visualization network data given earlier. The 2020-2021 publications are characterized by the emergence of new keywords. These include “reaction-time”, “power”, “association”, “quality-of-life”, “system”, “motor learning”, “strength”,

The bibliometric program VOSviewer is widely used in sports science. Its application allowed us to analyze publications devoted to the rehabilitation of patients with Alzheimer's disease with physical culture [19]. With the help of this program, an analytical analysis of Web of Science publications devoted to sport dancing was conducted, and the main directions of research in this area were established [1].

The analysis of the constructed bibliometric maps allowed us to identify the main directions of scientific research on this problem. They are defined as neurophysiological (the study of sensorintegration to control posture and balance, the use of tests and functional samples to analyze sensorintegration), sports and recreational (the use of sensorintegration in sports and recreational physical culture), and rehabilitation and therapeutic (sensorintegration as part of rehabilitation and treatment).

Sensory integration study for posture and balance control

Learning new movement patterns is a normal part of daily life, but of critical importance in both sport and rehabilitation. A major question is how different sensory signals are integrated together to give rise to motor adaptation and learning [20].

Multisensory integration is necessary for maintaining motor and cognitive abilities. It ensures normal functioning. Balance control is compromised during aging or movement disorders, increasing the likelihood of injuries and falls [4].

Human sensorimotor control involves inter-segmental coordination to cope with the complexity of a multi-segment system. The combined activation of hip and ankle muscles during upright stance represents the hip-ankle coordination. The study [21] postulates that the coordination emerges from interactions on the sensory levels in the feedback control. Seven subjects were standing with eyes closed on an anterior-posterior tilting motion platform. Postural responses in terms of angular excursions of trunk and legs with respect to vertical were measured and characterized using spectral analysis. The presented control model consists of separate feedback modules for the hip and ankle joints, which exchange sensory information with each other. The findings show that the hip-ankle coordination can be explained by interactions between the feedback control modules of the hip and ankle joints.

Sensorimotor integration processes play an important role in everyday life. Their implementation requires the analysis of different sources of information - information related to the object under the control of the indicator agent and information about the goal of the action [22]. The use of EEG has confirmed that complex sensorimotor

integration is realized through a cascade of theta- and beta-band activity in the ventral-flow-parietal-frontal network.

Movement planning is determined by factors such as accuracy and effort. Improving the quality and efficiency of movement is associated with minimizing force and increasing accuracy. Optimal movement is characterized by feedback control, which allows for prompt correction of errors. However, the quality of sensory feedback during motion can be significantly affected by the motion generated [23]. The results show that trajectory planning is sensitive to motor input and takes sensory input into account. This is an argument in favor of optimal motion control.

Body sensing involves the integration of different sensory cues according to their contextual relevance (i.e., multisensory integration). Most studies of multisensory integration and body ownership have examined the influence of vision, touch, and proprioception. The role of the vestibular system and interoception remains poorly understood. A previous study [5] confirmed that the vestibular system influences multisensory integration. A possible pathway of influence was to reevaluate the multifaceted connections between proprioception, vision, and affective touch.

The ability to assess visual and proprioceptive information is crucial for maintaining postural stability in a dynamic environment [17]. Healthy people control the balance of their standing posture with the help of active feedback. This communication is based on a combination of motion and orientation signals from the visual, vestibular, and proprioceptive systems. The contribution of each of these sensory systems varies depending on the perturbations occurring during stance and the environmental conditions [16]. The process of adjusting the sensory contribution to balance control is called sensory reweighting. In a study involving healthy young adults, the responses to changes in a swinging platform combined with different visual stimuli were examined. The different contribution of extrinsic and intrinsic factors to posture control and balance maintenance was confirmed.

In the study [24], how the nervous system manages muscle forces and controls upright posture and locomotion in varying gravity is reviewed. The main aspects of posture and gait control for short- and long-term adaptation are presented. These include sensory feedback integration and biomechanical outcomes that determine the quality of motor skills.

Removing or adding sensory cues from one sensory system during standing balance changes the contribution of the remaining sensory systems, a process referred to as sensory reweighting [16]. Changes in sensory conditions were achieved by adding or removing visual (light on/off) or

proprioceptive cues (surface sway). A dependence of steady-state responses on upcoming transitions was observed, suggesting that knowledge of impending changes can influence sensory weighting.

The vestibular system contributes to multisensory integration by balancing conflictual sensory information [25]. It was shown that vestibular signals modulate the weight of each sensory modality according to the context in which they are perceived and that such modulation extends to different aspects of tactile stimulation: felt and seen touch are differentially balanced in multisensory integration according to their epistemic relevance.

The use of virtual reality (VR) is another way to explore balance control, a tool for gait rehabilitation. VR offers the possibility of decoupling the visual from the somatosensory and vestibular systems. This means that it enables training under conflicting sensorimotor stimulation that creates additional demands on sensory reweighting and balance control. The results of the study [26] allow us to recommend the use of VR to assess adaptation to balance changes.

A promising method for studying sensory integration is the use of fractal analysis. Multifractal analysis is used to study balance. This allows us to understand the patterns of movement of the centre of pressure at different spatial scales [27]. In this paper [27], this method was used to compare balance in obese and normal weight children. It was confirmed that balance disorders in obese children may be the result of reduced proprioceptive abilities.

A similar aim was found in another work [28]. The effect of physical activity level on postural control in obese and overweight Spanish adult males was studied. The anthropometric parameters, body composition, and physical activity variables were evaluated. Postural control was assessed using the sensory organization test. It was concluded that altered integration of somatosensory signals affects balance in sedentary men with a high percentage of total fat masses.

The purpose of another study [29] was to compare the postural control of young and elderly people. Older people had worse sensory and motor characteristics and greater amplitude of body sway while standing. A stronger correlation between body sway and movement in a moving room was observed in the elderly. It was confirmed that increasing the complexity of motor task impairs posture control in elderly individuals.

In another study [30], the effects of distance and optical flow structure on visual information and body jiggle interaction in children and young adults were studied. The effect of distance and visual flow structure on the transmission of visual information and body sway is dependent on age. The effect is more pronounced in children. The authors

attribute this to the immaturity of the coordination mechanisms.

Another study [31] evaluated the dynamics of pose parameters when subjects switched from a habitual passive pose to an actively corrected pose. We confirmed that changes in sagittal postural parameters can be used for diagnostic purposes in postural disorders and regulation.

Tests and functional tests used to analyse sensory integration

At present, a large number of functional tests and trials are used to study the peculiarities of sensory integration. The purpose of this study [32] was to determine the sensitivity of the instrumental-modified clinical sensory integration test for balance assessment. The test consisted of opening and closing the eyes while on a hard and frothy surface. A special sensor was used to detect deviation. The time of the stable position was also determined. The effectiveness of the test used to assess central sensory integration deficits was confirmed.

The use of computer programs for testing has several advantages in monitoring the functional state. This variant of testing is characterized by promptness, mobility, accessibility, and informativeness. Approbation of the complex confirmed the possibility of assessing the peculiarities of athletes' condition, confirming the specificity of the influence of sports, and allowing the identification of predictors of success in various martial arts [2, 33, 34].

A set of psychophysiological tests was used in study [33] to assess the sensory systems of the body of taekwondo athletes. A special computer program for devices with iOS operating system was used. The device used was an Apple tablet computer (iPad, 4th generation) with a screen diagonal of 9.7 inches. Reaction choice or complex visual-motor reaction evaluated the reaction time to a stimulus with certain qualitative characteristics. The reaction to a moving object consisted of stopping the object at a given location at a given speed of the moving object. The size test consisted of fixing the moment when the size of a gradually increasing circle coincided with the size of the template.

Another methodological technique used to investigate sensory integration is the use of Achilles tendon stimulation. This approach was used in the study [35]. Bilateral Achilles tendon vibration was used to disrupt the accuracy of proprioceptive information. Participants were in a standing position and performed two tasks: maintaining a standing posture and waiting for virtual objects. It was concluded that there is an age dependence of the ability to maintain posture. It was suggested that the results could be used to prevent fall-related injuries in the elderly.

A study [36] used muscle electromyography

under different conditions to compare the postural control of young and elderly people. Participants were placed on a fixed platform (baseline: 2 minutes), followed by 3 min on a platform with sway control (adaptation) and a final 3 min again on a fixed platform (reintegration). Older adults exhibited greater joint contraction of lower limb muscles under conditions of increased postural instability. This response reflects a compensatory postural strategy.

In another study [37], a comparative evaluation of tests that are used to assess sensory dependence was conducted. The sensory organization test (SOT) is a standard for quantifying sensory dependence via sway-referenced conditions (sway-referenced support and sway-referenced vision (SRV)). However, the SOT is limited to expensive equipment. Thus, a practical version of the SOT is more commonly employed—the clinical test for sensory integration in balance; however, it fails to induce postural instability to the level of SRV. It was indicating that stroboscopic vision could be a portable and relatively inexpensive alternative for the assessment of sensory dependence and reweighting.

The design of the study [38] involved assessing postural balance while standing blindfolded on a fixed platform, then on a fixed platform, and then again on a fixed platform. The sway-oriented platform was more malleable for young adults and elicited similar levels of sway in both age groups. Participants were asked to press a button whenever they felt the platform stopped moving. It was confirmed that older people took longer than younger people to feel the platform stabilize. It was concluded that sensory integration is less effective in the elderly.

In another study [39], participants performed a temporal rhythm reproduction task. The experiment included auditory (beeps), visual (flashing dots), and audiovisual conditions (beeps and dots simultaneously). The results showed higher accuracy and less variability in the auditory condition than in the visual condition. It is concluded that the auditory modality dominated the multimodal perception in the task. The visual modality was ignored and did not enhance the playback performance.

A mediated reality device called MIRAGE was used in the study [40]. The purpose of this study was to examine how the brain evaluates visual and proprioceptive information during a hand place task. Children aged 4–11 years estimated the position of their index finger after viewing visual and proprioceptive information about hand position. It was confirmed that the way visual and proprioceptive information is integrated is optimized throughout development. It was found that the propensity for visual information increases with age.

An integrated approach in the evaluation of

sensor integration contributes to the effectiveness of the study. In this study [7], a set of specific tests was used for comparative assessment of sensory integration. These include T-test agility, stork static balance test, and Y-balance test. Significant differences in the performance of these functional tests in athletes with different postures were confirmed.

A rather large battery of tests was used in the study[41]. It was including the modified Balance Error Scoring System (mBESS), concussion balance test (COBALT), and sensory organization test (SOT) in healthy young adults. The mBESS conditions included double limb stance, single limb stance, and tandem stance. The COBALT was comprised of yaw plane head shake (HS) and vestibular ocular reflex cancellation conditions performed on firm and foam surfaces. The representativeness and informativeness of the tests used and the presence of correlation between the results were confirmed.

The analysis of correlations between neurocognitive data, performance, and balance was performed in the study [9]. The sensory organization test (SOT) was used in college athletes. The test's scoring criterion is composite and includes three measures of sensory relations: vestibular (VEST), visual (VIS), and somatosensory (SOM). Their use describes the overall sensory organization of athletes and their ability to use signals from each sensory system to maintain balance.

Functional ankle instability in soccer players is an important risk factor for athletic performance [42]. The aim of this study was to evaluate the effectiveness of tai-chi exercises together with joint taping for the rehabilitation of soccer athletes. A set of sensor integration tests was used as an assessment tool. These include the Star Excursion Balance Test (SEBT), UniPedal Stance Test (UST), and toe touch test (TTT).

Agility and the ability to maintain balance are important qualities for success in sport and physical education. Determining informative and adequate tests for their evaluation is an important task in sports science [43]. In this study, we studied the correlation between agility and dynamic balance in elementary school children. The modified Star Excursion Balance Test (SEBT) and shuttle run (4 10 m) were used to assess dynamic balance and agility. The presence of correlations between the test results was confirmed.

SEBT was used to assess the motor skills of golfers [44]. Differences in postural control were observed in golfers with chronic low back pain. This group had more pronounced balance deficits than those without pain. The informative and accessible nature of the SEBT allows it to be recommended for skill assessment of elite golfers.

The Y-Balance-Test is a functional test that assesses balance features. It was proposed to use this

test to assess the preservation of balance in soccer players with different game roles and different skill levels [45]. The determined differences show how these factors influence the development of asymmetry. They should be considered in the development of preventive and health improvement programs.

Analysing balance and equilibrium requires developed benchmarks and normative indicators. This was the purpose of this study [46]. The battery of tests used included the Counter Movement Jump (bipodal jump), 5-m Shuttle Run Sprint Test (speed/agility), Barrow Test (agility), Y Balance Test (posture control), Single Hop Test, and Triple Hop Test (unipodal jump). Approbation was carried out with the participation of 42 professional soccer players who were functionally assessed during two seasons (2012/13 and 2013/14) at three different times: pre-season, midpoint of the season, and end of the season. The paper contributes reference values that can be used to determine the sports performance or quantify the degree of functional recovery of a professional injured soccer player during his recovery.

Another study [47] examined gender differences in postural balance, physical activity, BMI, and body composition in athletes with visual impairment. The Clinical Sensory Integration and Balance Test was used to assess postural balance. The test was performed in four standing positions: with eyes open on a hard surface, with eyes closed on a hard surface, with eyes open on a pliable surface, and with eyes closed on a pliable surface. Depending on the athletes' levels of fitness, differences in postural maintenance have been found.

The aim of this study [48] was to study the possibility of improving functional status in patients with Down syndrome who practiced taekwondo. The evaluation of exercise performance included a balance study. A battery of tests included the modified clinical sensory integration and balance test (mCTSIB) with eyes open and closed. Dynamic balance was measured using the limits of stability (LOS) test.

The aim of this study [6] was to investigate the effect of synchronized training using a metronome on sensorimotor synchronization in elite and semi-elite female soccer players. Timing accuracy was assessed by synchronizing hand and foot movements with a rhythmic sound. The results show that the training variant used can positively affect attention and working memory functioning. This leads to better movement planning and improved performance and accuracy of movements. It was confirmed that an increase in speed is positively correlated with accuracy and duration of movement execution.

Another study [49] examined the effects of karate-do classes on improving the motor skills

of adolescents with developmental coordination disorder. A short form of the Bruininks-Oseretsky test was used as the instrument. This test assesses the accuracy and integration of fine motor skills, upper extremity dexterity and coordination, bilateral coordination, balance, strength, speed, agility, and overall motor skill level of the participants.

Another study investigated the effect of calf muscle taping on postural stability [50]. A battery of tests was used, namely a balance test, a surface sensory function test, and a combined cortical sensation test. The adequacy of the tests used for solving the task was confirmed.

A computer complex of 10 psychophysiological tests was used for comparative analysis of the psychophysiological features of athletes in different types of wrestling [2]. The applied battery of tests allows us to estimate the speed of the reaction to various signals, coordination, concentration, and sense of space. A different magnitude of the contribution of the studied indicators to the formation of the functional system of wrestlers was established. In judoka and sambo wrestlers, these are the tapping test, the number of touches in simple motor skills, and the form matching test. The applied tests are informative for the assessment of athletes' functional states.

Use of sensory integration in sports and recreational physical culture

Visual skills in sport are considered relevant variables of athletic performance. However, data on the specific contribution of stereopsis - as the ability to perceive depth - in sport performance are still scarce and scattered in the literature. The aim of review [51] is therefore to take stock of the effects of stereopsis on the athletic performance, also looking at the training tools to improve visual abilities and potential differences in the visuomotor integration processes of professional and non-professional athletes. Dynamic stereopsis is mainly involved in catching or interceptive actions of ball sports, whereas strategic sports use different visual skills (peripheral and spatial vision) due to the sport-specific requirements. As expected, professional athletes show better visual skills as compared to non-professionals. However, both non-professional and professional athletes should train their visual skills by using sensory stations and light boards systems. Non-professional athletes use the visual inputs as the main method for programming motor gestures. In contrast, professional athletes integrate visual information with sport expertise, thus, they encode the match (or the athletic performance) through a more complex visuomotor integration system.

Sensorimotor stimulation during the sensitive period is crucial for proper brain development. Sports training stimulates these sensorimotor

functions. The aim of this study [52] was to investigate the effect of such stimulation on specific sensorimotor characteristics of adolescents. A comparative analysis of stability limits in the athletes and control group was carried out. It was found that training in martial arts improves balance control and proprioceptive integration.

Improving balance control is one of the most important tasks in sports and physical education. Improved balance is positively associated with improved athletic performance and negatively associated with lower extremity sports injuries. Proprioception is critical to balance control, and ankle proprioception is perhaps the most important. An article [18] reviewed ankle proprioception and investigated its interaction with balance control, which is particularly important in a sporting context.

A previous study [53] investigated the integration of visual and auditory cues to control interceptive movements. A baseball launch was evaluated as a model. Human observers estimated its trajectory. It was shown that auditory and visual cues integrate. This integration process should occur as early as possible.

Vision is the dominant sensory system in sports, but many sports require multisensory integration to perform tasks effectively. Accelerating the processing of auditory information contributes to improved reaction speed, considering the audiovisual characteristics of the signals. In the study [54], the response speed of elite badminton athletes to sport-specific monosensory (visual and auditory) and multisensory (audiovisual) stimulation was studied. The results emphasize the importance of auditory information in accelerating reaction times in sport-specific multisensory situations. The results can be used to optimize training in racket sports.

Stimulus identification and understanding of action results are crucial for fast and accurate reaction selection in racket sports. The article [55] investigated the neurodynamics of visual anticipation in tennis by manipulating the postural and kinematic information associated with the body of opponents with a spatial occlusion protocol. Experienced athletes were characterized by better resource allocation, reaction speed, and sensorimotor representation.

A previously cited study [9] examined the correlation between neurocognitive data, performance, and balance in college athletes. Reaction time and executive function were significantly correlated with balance characteristics. These processes may affect athletes' ability to organize and process information and generate appropriate responses to changes in the environment.

The study of the dynamics of psychophysiological indicators of 15-16 years old ice hockey players was the aim of this study [56]. The battery of tests

included the speed and accuracy of visual-motor reactions, the level of sensorimotor and arbitrary coordination of movements, and the functional state of the central nervous system. The mental state was determined using the Lusher test. Interference resistance of hockey players increases at the end of the competitive period because of the improvement in arousal concentration. Sensorimotor and arbitrary coordination of movements changes only in the static form of muscle contractions. The mental status of hockey players varies from conditional norm to stressful, which requires individualized corrective measures.

The relative contribution of sensory signals to balance control in the standing position is dynamically regulated. These processes are influenced by age and athletic ability. This is especially characteristic of sports in which balance and balance maintenance are important, for example, in artistic gymnastics. The aim of study [57] was to investigate sensory reweighting processes to adjust standing posture in children and adults with different gymnastic expertise (gymnasts, G, and non-gymnasts, NG). Sensory integration was assessed by standing on a balancing platform with the eyes open and closed. Gymnast children required less time to regain balance and performed fewer movements than non-gymnast children. Maintaining balance was more effective with the eyes open. It is concluded that age may have a positive effect on balance recovery processes and that gymnastic experience may contribute to better postural control.

Exercise, particularly gymnastics, contributes to balance improvement. The aim of this study [11] was to evaluate balance control and adjustment in children and adults with different gymnastic experiences. The characteristics of sensorimotor control in children with no gymnastic experience differed significantly from those of gymnast children. Gymnast children were characterized by better coordination and posture control than adults.

Another study [58] investigated the effect of sports experience on the sensory control of posture. The participants were experienced soccer players, ballet dancers, and non-sports individuals. Soccer athletes were more field dependent than were non athletes. They are performed (a) a Rod and Frame test and (b) a 100-s bipedal stance task during which vision and proprioception were successively or concurrently disrupted in 20-s blocks. During standing, dancers were more destabilized by vibration and required more time to reweigh sensory information compared with the other 2 groups. These findings reveal a sport skill-specific bias in the reweighing of sensory inputs for spatial orientation and postural control.

Balance control in sports is essential for success. In the study [59], a comparative analysis of such

control in kung fu athletes and swimmers was conducted. The aim of this study was to determine which activities are more effective in developing the ability to maintain balance. The deviation of the center of gravity while standing on two and one leg on a stabilometric force platform under open-eye and closed-eye conditions was used as the main evaluation criterion. Unicyclists were characterized by better control in the one-legged stand. Swimmers were confirmed to have better control in the two-legged stand. It is concluded that both types of exercise positively affect the ability to maintain balance.

A comparative analysis of the psychophysiological features of taekwondo athletes of different ages was carried out in the study [33]. The change in reaction speed to different stimuli was confirmed. An increase in age and years of training leads to an improvement in reaction speed indicators. The established correlations between the tests used also reflect the improvement in the psychophysiological state of athletes as age increases.

The effect of Tai Chi exercise on cognitive processes was investigated in the study [60]. The authors compared elderly people with a long history of tai chi with those with a long history of walking. The results showed that the accuracy of the Tai Chi group was higher than that of the control group because of increased perceptual sensitivity. It is concluded that prolonged Tai Chi exercise improves multisensory integration in the elderly.

The review [61] evaluated the effectiveness of Tai Chi exercise in improving walking and posture control in older adults. This meta-analysis confirmed that Tai Chi can be an excellent exercise strategy for improving walking function and posture control in older adults with knee osteoarthritis. Tai Chi exercises are quite effective and safe. It is recommended that they be used as a supportive and reliable physical training strategy to improve walking function and balance control.

Another study [62] presented a developed neuromuscular model that describes jumping movements. The model evaluates the effects of the proprioceptive length (LFB), velocity (VFB), and force feedback (FFB) pathways of the leg extensor muscle on the stability, performance, and efficiency of jumping. The model predicted that different reflex pathway compositions selectively optimize specific hopping characteristics (e.g., performance and efficiency). Both FFB and LFB were pathways that enable hopping. FFB resulted in the largest hopping heights, LFB enhanced hopping efficiency and VFB had the ability to disable hopping. Results indicate that different feedback pathway compositions may serve different functional roles.

Sensory integration is very important in sports such as badminton [63]. The "rubber hand illusion" was used to assess the athlete's hand representation.

A negative correlation was found between the playing experience and the magnitude of the illusion. This finding suggests that tool embodiment obtained by the prolonged use of the badminton racket is less likely to be disturbed when holding the racket.

The dependence of sensory integration on age was studied in a previous study [64]. The ability of young and old people to maintain their posture under normal conditions and under the influence of destabilizing factors was studied. It was confirmed that elderly people have less ability to reduce the destabilizing effects of multisensory perturbations on posture.

In other article [65] investigated the effects of bimodal integration in a sport-specific task. Beach volleyball players were required to make a tactical decision, responding either verbally or via a motor response, after being presented with visual, auditory, or both kinds of stimuli in a beach volleyball scenario. In Experiment 1, players made the correct decision in a game situation more often when visual and auditory information were congruent than in trials in which they experienced only one of the modalities or incongruent information. Decision-making accuracy was greater when motor, rather than verbal, responses were given. It is concluded that the integration of visual and auditory information leads to more accurate decision making in sports than unimodal information.

The study [66] confirmed that auditory cues influence motor behavior and emotional valence. It is shown that sounds that do not match the movement being performed are processed at a lower rate of information processing. The results obtained are important for the use of auditory cues in sport competitions, given their influence on motor behavior.

The review [67] discusses the possible difference between effort and tension and the implications of such differences for understanding the role of representations in pace control during exercise. Estimates of perceived exertion and effort are considered extremely important for intensity regulation during physical activity at an individualized pace.

Qualitative sensory perception is related to success factors in sports. In the study [68], stereognosis, self-body perception, and kinesthesia were compared in karate athletes and individuals who did not practice sports. The athletes had significantly better perception and accuracy in performing fast dynamic movements compared with the controls.

The review [69] evaluated the possibility of using dance to improve the health of healthy individuals and Parkinson's disease patients. Dance as a sensorimotor activity stimulates the nervous system. It improves structures involved

in movement planning and execution, sensory integration, and cognitive processing. Dance interventions in healthy older adults were associated with increased activation of the prefrontal cortex and improved functional connectivity between the basal ganglia, cerebellum, and prefrontal cortex. Overall, the data suggest that dance interventions can induce neuroplastic changes in healthy elderly participants. This leads to improvements in both motor and cognitive functions.

A comparative analysis of balance control in athletes of different sports was conducted in the study [70]. The study involved judo athletes, equestrian sport athletes, and non-athletes. The influence of sports experience on postural control was confirmed. The severity of the influence depends on the sport. Equestrian athletes had a greater dependence on vision than non-athletes. This confirms the different contributions of sensory components to balance control in different sports.

The analysis of sensory integration in athletes requires the use of standardized tools and the development of specific norms. This was the aim of this study [71]. The modified clinical test of sensory interaction and balance (m-CTSIB) was used as the instrument. Analyzing the results of the athletes confirmed the differences by gender. Norms for the test results were developed for the entire sample and by gender. It has been suggested that norms can be used to assess the effects of sports injuries.

In another study [72], posture control and vestibularocular apparatus of pistol shooters were evaluated. The posture of athletes is characterized by a significant shift of the center of gravity in the anteroposterior and medial-lateral directions. This causes significant changes in posture control.

Habitual posture is important for ensuring sensory integration in sports. In the study [7], a comparative analysis of sensorimotor integration of athletes with different head postures was performed. Athletes with a forward head tilt were characterized by impaired sensorimotor processing and decreased fitness compared with those with a normal sagittal head posture.

Golf is a sport in which the result mostly depends on correct body position and control. Blind trainings are practiced in this sport to improve sensation [73]. Beginning golfers performed strokes with and without visual control. The results suggest that the body position task provides adequate sensory cues for successful execution.

The possibility of using visual information for prediction in tennis was analyzed in the study [74]. Video recordings of matches in the Australian Open Tennis Championship were used as material. Experienced tennis players predicted where the ball would land on the opponent's half of the field. It is shown that the louder the sound of racket contact with the ball, the longer the participants predicted

the trajectory of the ball. It is concluded that action-related auditory cues can significantly influence the prediction of stroke outcomes in tennis.

The effect of multi-ball table tennis training on balance performance in males and females was investigated in another study [75]. Compared with male table tennis athletes, females showed worse dynamic posture control. The results obtained should be considered in the training of athletes.

Anticipation of ground reaction force (GRF) in depth jumping requires multisensory integration of exteroceptive, vestibular, and proprioceptive inputs. Vision contributes to the anticipation of GRF in drop landings and may influence depth jump performance when disrupted. The purpose of this investigation [76] was to evaluate the effects of stroboscopic vision on depth jump performance. Stroboscopic vision could be used to modify the intensity of depth jumping and should be considered for inclusion into plyometric training.

Physical inactivity and sensory integration dysfunction are public health problems in preschool children in China [77]. To optimize the situation, a functional training program was developed for healthy children aged 5 to 6 years. The purpose of this study [77] was to evaluate the effectiveness of this program. It was concluded that a 12-week functional training program improved large motor skills, physical fitness, and sensory integration in healthy Chinese children aged 5-6 years.

The importance of sensory integration in cyber sports is discussed in the study [78]. It should be noted that there are still insufficient criteria to differentiate elite athletes in this sport. Using the example of first person shooter games, a comparative analysis of the state of cyber athletes of different levels and the control group was carried out. The position and speed of cursor movements for target acquisition were evaluated. Higher-level gamers demonstrate superior motor planning and sensorimotor integration. These qualities can be improved with training.

Success in soccer depends on proposing and implementing unpredictable, sudden, and yet creative ideas in situations with large time constraints. Accordingly, the performance of creative tasks in soccer should be primarily driven using fast and automatic cognitive processes. In the study [79], we investigated whether functional patterns of brain activation during the observation of real soccer game situations can predict the performance of creative soccer tasks. Machine learning, which is based on multidimensional pattern recognition, was used as a tool. The study was conducted with experienced soccer players. The results showed that brain activation while watching soccer scenes significantly predicted the performance of creative tasks.

Proper posture is a predictor of success in

archery. Posture control can improve performance, prevent injury, and maintain optimal performance. The main parameters of posture and movements of experienced archers were analyzed in the study [80]. The angles of the main joints are important for quality shooting. An algorithm for automating the evaluation of the biomechanical features of archery was proposed.

Sports equipment is one of the factors affecting postural balance. Possible differences in stability between standing conditions in ski boots and barefoot were analyzed in the study [81]. The authors evaluated the influence of surface type on stability and determined the differences in stability levels between different planes. Restriction of ankle joint mobility due to wearing ski boots resulted in decreased stability of participants, especially in the sagittal plane. The differences found were due to difficulties reorganizing muscle coordination at the hip joints. The use of mechanical ski boot support was effective in reducing lower limb muscle tone. The use of a soft surface improved the subjects' stability in the frontal plane but did not change the stability in the sagittal plane. The soft surface may have helped to reduce excessive corrective movements, thereby improving the participants' postural stability.

Another study [82] analyzed the peculiarities of postural maintenance in volleyball players compared with non-athletes. Athletes showed a different pattern of sensory integration of postural stability than the control group. Large deviations of the center of gravity reflect these differences. Increasing levels of athletic skill contribute to better postural control. It is proposed to use this protocol to evaluate the effectiveness of training programs, select elite players, and determine playing roles.

A similar design was used in the study [83]. The aim of this study was to compare the postural control of players of the Polish women's national volleyball team with a control group of women. Participants stood on a force plate with their eyes open. The center of gravity signals were recorded in the medial-lateral and anteroposterior planes. It was confirmed that the high demands of volleyball movements resulted in the formation of unique postural control abilities in female volleyball players. On the court, athletes optimally distribute their sensory resources between balance control and game actions. There are no well-defined criteria for an optimal postural strategy for elite athletes. These criteria may be sport-specific.

The effects of core training using slings and Togus on the improvement of posture control in Taekwondo club students, that is, balance ability, were investigated [84]. The result suggests that active core exercise using Slings and Togus can be applied as a very effective exercise program for enhancing balance, which is an important physical factor for

Taekwondo club students.

Another study [85] determined the effect of proprioceptive training on balance, strength, agility, and ball handling in adolescent soccer players. Specific exercises were used to improve balance, stability, and strength with and without a ball. Pre- and post-tests included the static balance (Balance Error Scoring System (BESS)), vertical, horizontal, and lateral jumping, and the completion of agility ("arrowhead") and dribbling ("short dribbling") tests. The results of the study revealed that sports training on the foam surfaces determined a superior progress of the development of proprioception compared to the increased training on the firm surfaces.

Interest in the study of short-term memory of athletes is due to the integral nature of this criterion and its correlation with indicators important for assessing the state. The design of the study [86] was to simultaneously record psychophysiological (short-term memory) and physiological (HR) parameters. The importance of short-term memory for success in martial arts has been confirmed. Athletes need not only fast reaction but also accuracy of work, which is evaluated by this parameter. Comparative analysis of the results confirmed the dependence on the level of athletic skill.

Sensory integration as a part of rehabilitation and treatment

Multisensory integration is currently defined as the ability to effectively combine information received from different senses. This process is quite variable and depends on the aging process. The main factors that impair processing is age, balance disorders, and cognitive impairment. The aim of the review [87] was to evaluate the evidence for the feasibility of multisensory perception training. It was confirmed that training with feedback during task performance using standardized protocols resulted in improved task performance. The training results indicate that physical activity protocols require further investigation as a means of improving multisensory integration.

Balance disorders are a frequent complication of brain injury and can be quite long lasting. The sensorimotor responses of healthy individuals and individuals with balance disorders due to brain injury were compared in the study [88]. The consequences of the injuries led to longer time delays in performing special tests and significantly reduced motor activation compared with controls. The results indicate that the effectiveness of rehabilitation is enhanced when interventions aimed at correcting balance disorders are implemented.

Another study [69] evaluated the possibility of using dance to improve the condition of patients with Parkinson's disease. The results showed an improvement in the quality of life and mobility of

patients. It has been confirmed that dance therapy is a popular additional method of treatment of this pathology in addition to pharmacological therapies.

The significant prevalence of knee joint injuries in athletes indicates the use of sensory integration indicators as a criterion for the effectiveness of treatment and rehabilitation. These include indicators of sensory integration that ensure the maintenance of balance [89]. The use of stabilometric analysis confirmed the restoration of balance. It is proposed to use sensorimotor integration as a screening test for the primary and secondary prevention of anterior cruciate ligament injuries.

It has been proposed that balance indices should be used as criteria for the effectiveness of rehabilitation of soccer players after concussion [90]. Static balance in the anteroposterior and medial-lateral directions was assessed in a quiet stance with eyes open and closed. Participants with concussion were characterized by deficits in balance control, particularly pronounced in the anteroposterior direction.

A similar design was used in the study [91]. The effects of concussions in former rugby players were assessed. Susceptibility to sound illusion was selected as a criterion for assessing the effects of injury. Diagnostic value of a multisensory integration study in athletes with outcomes of a concussion was confirmed.

The state of sensory integration is used in sports as a criterion for the effectiveness of recovery and rehabilitation after injuries. The dynamics of auditory perception in young athletes after concussion was used in the study [92] for this purpose. The usefulness of the test for assessing auditory perception and motor skills was confirmed.

A consequence of concussion in athletes is deficit in neuromuscular control. The long-term persistence of this deficit significantly affects athletic performance. Therefore, studying the correlations between brain activity and motor control is important for evaluating the effectiveness of rehabilitation. In the study [93], brain activity and leg press performance by female athletes who had a concussion were compared with those who did not have such injuries. The experimental group had less neural activity in certain brain regions than the control group. We conclude that changes in neural activity in brain regions important for sensorimotor integration and motor attention reflect compensatory neural mechanisms. These mechanisms may underlie the persistent deficits in neuromuscular control associated with concussion.

Chronic ankle instability in athletes is responsible for pain, decreased postural control, and decreased balance stability that affect athletic performance. The use of special aids to improve stability is an effective means of rehabilitation. In the study [94], a

medial wedge at an angle of 4 degrees was used for this purpose. The wedge was applied to the insole of the hind foot. The use of a medial wedge improved static and dynamic balance in athletes with ankle instability. The use of foot insoles to correct balance deficits in athletes has been suggested.

The high prevalence of head injuries in ice hockey players significantly affects their performance in this sport. The study [95] used resting-state functional magnetic resonance imaging to evaluate changes in the functional connectivity of the frontoparietal brain network responsible for executive functions. This study was conducted with the participation of university doubleheader hockey players in the dynamics of one season. An increase in functional connectivity between the areas involved in sensory integration was observed. More pronounced changes in connectivity were observed in those who had more head hits. It has been hypothesized that these results reflect the effects of head injuries.

In the study already cited [49], karate-do classes were used as an alternative to rehabilitation programs for developing motor skills. A special training program was conducted in adolescents with different socioeconomic statuses for 8 consecutive weeks (3 sessions per week, each session lasted 75 minutes). The state of motor skills after completion of the program confirmed its effectiveness.

Intensive loads in gymnastics lead to injuries and pain in the lower back. This necessitates the search for effective and informative rehabilitation criteria. A comparative analysis of the musculoskeletal apparatus in rhythmic gymnastics athletes with and without low back pain was performed in the study [96]. It was suggested that anthropometric parameters be used to monitor the musculoskeletal system in this group. The spinal curvature in the sagittal plane was recorded using a pantograph. Torso flexor and extensor muscle tone was monitored using a myotonometer. The difference in body height in the supine and standing positions was calculated to illustrate the elasticity of the spine. The presence of imbalance in the tone of the trunk flexor and extensor muscles, unsatisfactory posture control, predominance of lumbar lordosis, and decreased spine elasticity in gymnasts with low back pain was confirmed.

Conclusions

The conducted bibliometric analysis of publications confirms the relevance of sensory integration. Stable interest in this problem has been determined. The studies in this area have neurophysiological, sports-recreational, and medical-rehabilitation directions. Neurophysiological studies are aimed at analyzing balance and equilibrium and the application of various tests and functional samples. The sport

context studies sensory integration in different sports. Recreational publications have investigated sensory integration as a criterion of health. The therapeutic and rehabilitation focus explores the use of sensory integration as a criterion for treatment and rehabilitation. A characteristic

feature is the intersection of these directions. There is a lack of studies devoted to sensory integration in sport dancing and aimed at studying the psychophysiological state. These types of studies should be assessed as relevant.

References

- Podrihalo O, Xiaohong G, Mulyk V, Podrigalo L, Galashko M, Sokol K, Jagiello W. Priority scientific areas in sports dances research: the analysis of the scientific resources of Web of Science Core Collection. *Physical Education of Students*. 2022;26(5):207-223. <https://doi.org/10.15561/20755279.2022.0501>
- Podrigalo L, Iermakov S, Romanenko V, Rovnaya O, Tropin Y, Goloha V. Psychophysiological features of athletes practicing different styles of martial arts - the comparative analysis. *International Journal of Applied Exercise Physiology*. 2019;8(1):84-91. <https://doi.org/10.30472/ijaep.v8i1.299>
- Venhorst A, Micklewright DP, Noakes TD. The Psychophysiological Determinants of Pacing Behaviour and Performance During Prolonged Endurance Exercise: A Performance Level and Competition Outcome Comparison. *Sports Medicine*. 2018;48(10):2387-2400. <https://doi.org/10.1007/s40279-018-0893-5>
- White O, Babic J, Trenado CI, Johannsen L, Goswami N. The Promise of Stochastic Resonance in Falls Prevention. *Frontiers in Physiology*. 2019; 9: 1865. <https://doi.org/10.3389/fphys.2018.01865>
- Ponzo S, Kirsch LP, Fotopoulou A, Jenkinson PM. Balancing body ownership: Visual capture of proprioception and affectivity during vestibular stimulation. *Neuropsychologia*. 2018;117:311-321. <https://doi.org/10.1016/j.neuropsychologia.2018.06.020>
- Ronnqvist L, McDonald R, Sommer M. Influences of Synchronized Metronome Training on Soccer Players' Timing Ability, Performance Accuracy, and Lower-Limb Kinematics. *Frontiers in Psychology*. 2018;9:2469. <https://doi.org/10.3389/fpsyg.2018.02469>
- Moustafa I, Kim M, Harrison DE. Comparison of Sensorimotor Integration and Skill-Related Physical Fitness Components Between College Athletes With and Without Forward Head Posture. *Journal of Sport Rehabilitation*. 2023;32(1):53-62. <https://doi.org/10.1123/jsr.2022-0094>
- Quinzi F, Modica M, Berchicci M, Bianco V, Perri RL, Di Russo F. Does sport type matter? The effect of sport discipline on cognitive control strategies in preadolescents. *International Journal of Psychophysiology*. 2022;177:230-239. <https://doi.org/10.1016/j.ijpsycho.2022.05.016>
- Vander Vegt CB, Register-Mihalik JK, Ford CB, Rodrigo CJ, Guskiewicz KM, Mihalik JP. Baseline Concussion Clinical Measures Are Related to Sensory Organization and Balance. *Medicine & Science in Sports & Exercise*. 2019;51(2):264-270. <https://doi.org/10.1249/MSS.0000000000001789>
- Zemkova E, Kovacikova Z. Sport-specific training induced adaptations in postural control and their relationship with athletic performance. *Frontiers in Human Neuroscience*. 2023;16: 1007804. <https://doi.org/10.3389/fnhum.2022.1007804>
- Busquets A, Ferrer-Uris B, Angulo-Barroso RM, Federolf P. Gymnastics Experience Enhances the Development of Bipedal-Stance Multi-Segmental Coordination and Control During Proprioceptive Reweighting. *Frontiers in Psychology*. 2021; 12: 661312. <https://doi.org/10.3389/fpsyg.2021.661312>
- He Q. Knowledge discovery through co-word analysis. *Libr Trends*. 1999;48:133-59.
- Smith LC. Citation analysis. *Libr Trends*. 1981;30:83-106.
- VOSviewer version 1.6.17. [Internet]. VOSviewer, 2021. [updated 2021 July 22; cited 2021 Sep 11]. Available from: <https://www.vosviewer.com/>
- Van Eck NJ, Waltman L. Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*. 2010;84(2):523-538.
- Asslander L, Peterka RJ. Sensory reweighting dynamics following removal and addition of visual and proprioceptive cues. *Journal of Neurophysiology*. 2016;116(2):272-285. <https://doi.org/10.1152/jn.01145.2015>
- Asslander L, Peterka RJ. Sensory reweighting dynamics in human postural control. *Journal of Neurophysiology*. 2014;111(9):1852-1864. <https://doi.org/10.1152/jn.00669.2013>
- Han J, Anson J, Waddington G, Adams R, Liu Y. The Role of Ankle Proprioception for Balance Control in relation to Sports Performance and Injury. *BioMed Research International*. 2015; 2015:842804. <https://doi.org/10.1155/2015/842804>
- Iermakov S, Podrigalo L, Podrigalo O et al. Means and methods of physical activity in the context of prevention and treatment of Alzheimer's disease (analysis of Russian-language scientific resources) and the perspective of implementing the unique achievements of the "Polish School of Safe Falling". *Arch Budo* 2022; 18: 121-143
- Izadi M, Franklin S, Bellafiore M, Franklin DW. Motor Learning in Response to Different Experimental Pain Models Among Healthy Individuals: A Systematic Review. *Frontiers in Human Neuroscience*. 2022; 16: 863741. <https://doi.org/10.3389/fnhum.2022.863741>
- Hettich G, Asslander L, Gollhofer A, Mergner T. Human hip-ankle coordination emerging from

- multisensory feedback control. *Human Movement Science*. 2014;37:123-146. <https://doi.org/10.1016/j.humov.2014.07.004>
22. Bottcher A, Wilken S, Adelhöfer N, Raab M, Hoffmann S, Beste C. A dissociable functional relevance of theta- and beta-band activities during complex sensorimotor integration. *Cerebral Cortex*. 2023; 33(14): 9154–9164. <https://doi.org/10.1093/cercor/bhad191>
 23. Yeo SH, Franklin DW, Wolpert DM. When Optimal Feedback Control Is Not Enough: Feedforward Strategies Are Required for Optimal Control with Active Sensing. *Plos Computational Biology*. 2016;12(12): e1005190. <https://doi.org/10.1371/journal.pcbi.1005190>
 24. Ritzmann R, Gollhofer A, Freyler K. Posture and Locomotion. *Sensory Motor and Behavioral Research in Space*. 2017: 1-35. https://doi.org/10.1007/978-3-319-68201-3_1
 25. Ponzo S, Kirsch LP, Jenkinson PM et al. Vestibular modulation of multisensory integration during actual and vicarious tactile stimulation. *Psychophysiology*. 2019;56(10). <https://doi.org/10.1111/psyp.13430>
 26. Ketterer J, Ringhof S, Gollhofer A et al. Sinusoidal Optic Flow Perturbations Reduce Transient but Not Continuous Postural Stability: A Virtual Reality-Based Study. *Frontiers in Physiology*. 2022;13:803185. <https://doi.org/10.3389/fphys.2022.803185>
 27. Fink PW, Shultz SP, D'Hondt E, Lenoir M, Hills AP. Multifractal Analysis Differentiates Postural Sway in Obese and Nonobese Children. *Motor Control*. 2019;23(2):262-271. <https://doi.org/10.1123/mc.2016-0085>
 28. Delfa-de la Morena JM, Castro EA, Rojo-Tirado MÁ, Bores-Garcia D. Relation of Physical Activity Level to Postural Balance in Obese and Overweight Spanish Adult Males: A Cross-Sectional Study. *Int. J. Environ. Res. Public Health*. 2021;18(16):8282. <https://doi.org/10.3390/ijerph18168282>
 29. Toledo DR, Barela JA. Age-related differences in postural control: effects of the complexity of visual manipulation and sensorimotor contribution to postural performance. *Experimental Brain Research*. 2014;232(2):493-502. <https://doi.org/10.1007/s00221-013-3756-1>
 30. Godoi D, Barela JA. Optical Flow Structure Effects in Children's Postural Control. *PLOS ONE*. 2016;11(6). <https://doi.org/10.1371/journal.pone.0158416>
 31. Ludwig O, Mazet C, Mazet D, Hammes A, Schmitt E. Changes in Habitual and Active Sagittal Posture in Children and Adolescents with and without Visual Input - Implications for Diagnostic Analysis of Posture. *Journal of Clinical and Diagnostic Research*. 2016;10(2):SC14-SC17. <https://doi.org/10.7860/JCDR/2016/16647.7283>
 32. Martini DN, Gera G, Brumbach BH, Campbell KR, Parrington L, Chesnutt J, et al. Symptoms and Central Sensory Integration in People With Chronic mTBI: Clinical Implications. *Military Medicine*, 2023;188(11–12): 3553–3560. <https://doi.org/10.1093/milmed/usac157>
 33. 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>
 34. Podrihalo O, Iermakov S, Podrigalo L, Perevoznyk V, Paievskiy V, Deineko A, Oleinichuk V. Methods of predictive selection in wrestling compared with martial arts. *Arch Budo Sci Martial Art Extreme Sport*. 2022;18:117-124.
 35. Eikema DJA, Hatzitaki V, Konstadakos S, Papaxanthis C. Elderly adults delay proprioceptive reweighting during the anticipation of collision avoidance when standing. *Neuroscience*. 2013; 234:22-30. <https://doi.org/10.1016/j.neuroscience.2012.12.053>
 36. Craig CE, Calvert GHM, Doumas M. Effects of the availability of accurate proprioceptive information on older adults' postural sway and muscle co-contraction. *European Journal of Neuroscience*. 2017;46(10):2548-2556. <https://doi.org/10.1111/ejn.13703>
 37. Kim KM, Kim JS, Oh J, Grooms DR. Stroboscopic Vision as a Dynamic Sensory Reweighting Alternative to the Sensory Organization Test. *Journal of Sport Rehabilitation*. 2021;30(1):166-172. <https://doi.org/10.1123/jsr.2019-0466>
 38. Craig CE, Doumas M. Slowed sensory reweighting and postural illusions in older adults: the moving platform illusion. *Journal of Neurophysiology*. 2019;121(2):690-700. <https://doi.org/10.1152/jn.00389.2018>
 39. Hildebrandt A, Griefsbach E, Cañal-Bruland R. Auditory perception dominates in motor rhythm reproduction. *Perception*. 2022;51(6):403-416. <https://doi.org/10.1177/03010066221093604>
 40. Ratcliffe N, Greenfield K, Ropar D, Howard E, Newport R. The Relative Contributions of Visual and Proprioceptive Inputs on Hand Localization in Early Childhood. *Frontiers in Human Neuroscience*. 2021;15:702519. <https://doi.org/10.3389/fnhum.2021.702519>
 41. DeFeo C, Heebner N, Baker C, Hoch M, Morelli N. The Relationship Between Measures of Postural Control in Concussion Assessment. *Journal of Sport Rehabilitation*. 2022;31(4):452-456. <https://doi.org/10.1123/jsr.2021-0291>
 42. Li YH, Liu XY, Luo X, Guo CJ. Effect of Tai Chi combined with Kinesio taping on posture control of football players with FAI: protocol for a randomized controlled trial. *Trials*. 2022;23 (1): 162. <https://doi.org/10.1186/s13063-022-06083-5>
 43. Calatayud J, Martin F, Flandez J. Relationship between the modified star excursion balance test and the 4x10 m shuttle run test in children. *Cultura Ciencia y Deporte*. 2017;12(35):111-116.
 44. Peng YC, Hsu CY, Tang WT. Deficits in the Star Excursion Balance Test and Golf Performance

- in Elite Golfers with Chronic Low Back Pain. *Journal of Sports Science and Medicine*. 2021;20(2):229-236. <https://doi.org/10.52082/jssm.2021.229>
45. Prieto MF, Morales SB, Fernandez FTG. Y-balance-test in soccer players according to the competition level. *Retos-Nuevas Tendencias en Educacion Fisica Deporte y Recreacion*. 2020;37:333-338.
 46. Piqueras PG, Gonzalez-Villora S, de Baranda PS. The functional assessment as a key element in the recovery of football players after an injury. *SPORT TK-Revista Euroamericana de Ciencias del Deporte*. 2020;9(1):15-25.
 47. Esatbeyoglu F, Kin-Isler A. Gender differences in postural balance, physical activity level, BMI, and body composition in athletes with visual impairment. *British Journal of Visual Impairment*. 2022;40(3):530-544. <https://doi.org/10.1177/026461962111009921>
 48. Carter K, Horvat M. Effect of Taekwondo Training on Lower Body Strength and Balance in Young Adults with Down Syndrome. *Journal of Policy and Practice in Intellectual Disabilities*. 2016;13(2):65-172. <https://doi.org/10.1111/jppi.12164>
 49. Ghadiri F, O'Brien W, Soltani S, Faraji M, Bahmani M. The effect of karate interventions on the motor proficiency of female adolescents with developmental coordination disorder (DCD) from high and low socio-economic status. *BMC Sports Science, Medicine and Rehabilitation*. 2022; 14(1):121. <https://doi.org/10.1186/s13102-022-00501-6>
 50. Hung MH, Chen HY, Chang YC, Chiu CW, Chang HY. Effects of the direction of Kinesio taping on sensation and postural control before and after muscle fatigue in healthy athletes. *Scientific Reports*. 2023;13(1):1282. <https://doi.org/10.1038/s41598-023-27801-2>
 51. Presta V, Vitale C, Ambrosini L, Gobbi G. Stereopsis in Sports: Visual Skills and Visuomotor Integration Models in Professional and Non-Professional Athletes. *Int. J. Environ. Res. Public Health*. 2021;18(21):11281. <https://doi.org/10.3390/ijerph182111281>
 52. Blanchet M, Prince F. Mediolateral Postural Control Mechanisms and Proprioception Improve With Kicking Sports Training During Adolescence. *Pediatric Exercise Science*. 2023;35(3):118-126. <https://doi.org/10.1123/pes.2020-0204>
 53. Kreyenmeier P, Schroeger A, Cañal-Bruland R, Raab M, Spering M. Rapid Audiovisual Integration Guides Predictive Actions. *ENEURO*. 2023;10(8). <https://doi.org/10.1523/ENEURO.0134-23.2023>
 54. Huelsduenker T, Riedel D, Kaesbauer H, Ruhnnow D, Mierau A. Auditory Information Accelerates the Visuomotor Reaction Speed of Elite Badminton Players in Multisensory Environments. *Frontiers in Human Neuroscience*. 2021;15:779343. <https://doi.org/10.3389/fnhum.2021.779343>
 55. Costa S, Berchicci M, Bianco V, Croce P, Di Russo F, Quinzi F et al. Brain dynamics of visual anticipation during spatial occlusion tasks in expert tennis players. *Psychology of Sport and Exercise*. 2023;65:102335. <https://doi.org/10.1016/j.psychsport.2022.102335>
 56. Fedorovna SME, Viktorovich EV, Andreevna MK. Psychophysiological features of hockey players aged 15-16 years in the annual training macrocycle. *4th International Conference on Innovations in Sports, Tourism and Instructional Science (ICISTIS)*. 2019;17:262-265.
 57. Busquets A, Aranda-Garcia S, Ferrer-Uris B, Marina M, Angulo-Barroso R. Age and gymnastic experience effects on sensory reweighting processes during quiet stand. *Gait & Posture*. 2018;63: 177-183. <https://doi.org/10.1016/j.gaitpost.2018.05.009>
 58. Thalassinos M, Fotiadis G, Arabatzi F, Isableu B, Hatzitaki V. Sport Skill-Specific Expertise Biases Sensory Integration for Spatial Referencing and Postural Control. *Journal of Motor Behavior*. 2018;50(4):426-435. <https://doi.org/10.1080/00222895.2017.1363704>
 59. Baccouch R, Rebai H, Sahli S. Kung-fu versus swimming training and the effects on balance abilities in young adolescents. *Physical Therapy in Sport*. 2015;16(4):349-354. <https://doi.org/10.1016/j.ptsp.2015.01.004>
 60. Wang AJ, Wang TT, Yue C, Zhang M. Long-term Tai Chi training reduces the fusion illusion in older adults. *Experimental Brain Research*. 2023;241(2):517-526. <https://doi.org/10.1007/s00221-023-06544-6>
 61. You YW, Liu JX, Tang MMA, Wang D, Ma XD. Effects of Tai Chi exercise on improving walking function and posture control in elderly patients with knee osteoarthritis A systematic review and meta-analysis. *Medicine*. 2021;100(16): e25655. <https://doi.org/10.1097/MD.00000000000025655>
 62. Schumacher C, Seyfarth A. Sensor-Motor Maps for Describing Linear Reflex Composition in Hopping. *Frontiers in Computational Neuroscience*. 2017; 11. <https://doi.org/10.3389/fncom.2017.00108>
 63. Sakamoto M, Ifuku, H. Experience-Dependent Modulation of Rubber Hand Illusion in Badminton Players. *Journal of Sport & Exercise Psychology*. 2022;44(1):14-22. <https://doi.org/10.1123/jsep.2020-0178>
 64. Eikema DJA, Hatzitaki V, Konstadakos S, Papaxanthis C. Application of intermittent galvanic vestibular stimulation reveals age-related constraints in the multisensory reweighting of posture. *Neuroscience Letters*. 2014; 561:112-117. <https://doi.org/10.1016/j.neulet.2013.12.048>
 65. Klatt S, Smeeton NJ. Visual and Auditory Information During Decision Making in Sport. *Journal of Sport & Exercise Psychology*. 2020;42(1):15-25. <https://doi.org/10.1123/jsep.2019-0107>
 66. Stanton TR, Spence C. The Influence of Auditory Cues on Bodily and Movement Perception. *Frontiers in Psychology*. 2020;10:3001. <https://doi.org/10.3389/fpsyg.2019.03001>
 67. Abbiss CR, Peiffer JJ, Meeusen R, Skorski S. Role of Ratings of Perceived Exertion during Self-Paced Exercise: What are We Actually Measuring? *Sports Medicine*. 2015;45(9):1235-1243. <https://doi.org/10.1007/s40279-015-0344-5>

68. Tapajcikova T, Liska D, Batalik L, Tucker CP, Kobesova A. Levels of Gnostic Functions in Top Karate Athletes-A Pilot Study. *Motor Control*. 2022;26(2):258-277. <https://doi.org/10.1123/mc.2021-0127>
69. Meulenberg CJW, Rehfeld K, Jovanović S, Marusic U. Unleashing the potential of dance: a neuroplasticity-based approach bridging from older adults to Parkinson's disease patients. *Frontiers in Aging Neuroscience*. 2023; 15: 1188855. <https://doi.org/10.3389/fnagi.2023.1188855>
70. Viseu JP, Yiou E, Morin P-O, Olivier A. Sport dependent effects on the sensory control of balance during upright posture: a comparison between professional horseback riders, judokas and non-athletes. *Frontiers in Human Neuroscience*. 2023; 17: 1213385. <https://doi.org/10.3389/fnhum.2023.1213385>
71. Moran RN, Meek J, Allen J, Robinson J. Sex differences and normative data for the m-CTSIB and sensory integration on baseline concussion assessment in collegiate athletes. *Brain Injury*. 2020;34(1):20-25. <https://doi.org/10.1080/02699052.2019.1669824>
72. Lourenco CP, Silva ALD. Posture control and vestibular oculomotor system in pistol sport shooters. *Revista Brasileira de Medicina do Esporte*. 2013;19(5):313-316. <https://doi.org/10.1590/S1517-86922013000500002>
73. Fisher KM, Fairbrother JT. Seeing is Believing: Blind Putting Drills Confer No Advantage to the Novice Golfer. *Research Quarterly for Exercise and Sport*. 2020;91(2):335-345. <https://doi.org/10.1080/02701367.2019.1674443>
74. Canal-Bruland R, Muller F, Lach B, Spence C. Auditory contributions to visual anticipation in tennis. *Psychology of Sport and Exercise*. 2018;36:100-103. <https://doi.org/10.1016/j.psychsport.2018.02.001>
75. Gu YD, Yu CX, Shao S, Baker JS. Effects of table tennis multi-ball training on dynamic posture control. *PEERJ*. 2019;6:e6262. <https://doi.org/10.7717/peerj.6262>
76. Kroll M, Preuss J, Ness BM, Dolny M, Louder T. Effect of stroboscopic vision on depth jump performance in female NCAA Division I volleyball athletes. *Sports Biomechanics*. 2023;22(8):1016-1026. <https://doi.org/10.1080/14763141.2020.1773917>
77. Fu T, Zhang DR, Wang W, Geng H, Lv Y, Shen R, Bu T. Functional Training Focused on Motor Development Enhances Gross Motor, Physical Fitness, and Sensory Integration in 5-6-Year-Old Healthy Chinese Children. *Frontiers in Pediatrics*. 2022; 10: 936799. <https://doi.org/10.3389/fped.2022.936799>
78. Toth AJ, Hojaji F, Campbell MJ. Exploring the mechanisms of target acquisition performance in esports: The role of component kinematic phases on a first person shooter motor skill. *Computers in Human Behavior*. 2023;139:107554. <https://doi.org/10.1016/j.chb.2022.107554>
79. Rominger C, Koschutnig K, Memmert D, Papousek I, Perchtold-Stefan CM, Benedek M et al. Brain activation during the observation of real soccer game situations predicts creative goal scoring. *Social Cognitive and Affective Neuroscience*. 2021;16(7):707-715. <https://doi.org/10.1093/scan/nsab035>
80. Phang JTS, Lim KH, Chiam DH. Deep Learning Pose Estimation for Kinematics Measurement in Archery. *International Conference on Green Energy, Computing and Sustainable Technology (GECOST)*. 2022: 298-302.
81. Tchoorzewski D, Bujas P, Jankowicz-Szymanska A. Body Posture Stability in Ski Boots Under Conditions of Unstable Supporting Surface. *Journal of Human Kinetics*. 2013;38:33-44. <https://doi.org/10.2478/hukin-2013-0043>
82. Agostini V, Chiaramello E, Canavese L, Bredariol C, Knaflitz M. Postural sway in volleyball players. *Human Movement Science*. 2013;32(3):445-456. <https://doi.org/10.1016/j.humov.2013.01.002>
83. Borzucka D, Krecisz K, Rektor Z, Kuczynski M. Postural control in top-level female volleyball players. *BMC Sports Science Medicine and Rehabilitation*. 2020;12(1):65. <https://doi.org/10.1186/s13102-020-00213-9>
84. Yoon SD, Sung DH, Park GD. The effect of active core exercise on fitness and foot pressure in Taekwondo club students. *Journal of Physical Therapy Science*. 2015;27(2):509-511. <https://doi.org/10.1589/jpts.27.509>
85. Gidu DV, Badau D, Stoica M, Aron A, Focan G, Monea D et al. The Effects of Proprioceptive Training on Balance, Strength, Agility and Dribbling in Adolescent Male Soccer Players. *International Journal of Environmental Research and Public Health*. 2022;19(4):2028. <https://doi.org/10.3390/ijerph19042028>
86. Romanenko V, Podrigalo L, Cynarski WJ, Rovnaya O, Korobeynikova L, Goloha V, Robak I. A comparative analysis of the short-term memory of martial arts' athletes of different level of sportsmanship. *Ido Movement For Culture. Journal of Martial Arts Anthropology*. 2020;20(3):18-24. <https://doi.org/10.14589/ido.20.3.3>
87. O'Brien J, Mason A, Chan J, Setti A. Can We Train Multisensory Integration in Adults? A Systematic Review. *Multisensory Research*. 2023;36(2):111-180. <https://doi.org/10.1163/22134808-bja10090>
88. Campbell KR, King LA, Parrington L, Fino PC, Antonellis P, Peterka RJ. Central sensorimotor integration assessment reveals deficits in standing balance control in people with chronic mild traumatic brain injury. *Frontiers in Neurology*. 2022; 13: 897454. <https://doi.org/10.3389/fneur.2022.897454>
89. Gandolfi M, Ricci M, Sambugaro E, Valè N, Dimitrova E, Meschieri A et al. Changes in the sensorimotor system and semitendinosus muscle morphometry after arthroscopic anterior cruciate ligament reconstruction: a prospective cohort study with 1-year follow-up. *Knee Surgery, Sports Traumatology, Arthroscopy*. 2018;26(12):3770-3779.

- <https://doi.org/10.1007/s00167-018-5020-5>
90. Powers KC, Kalmar JM, Cinelli ME. Recovery of static stability following a concussion. *Gait & Posture*. 2014;39(1):611-614. <https://doi.org/10.1016/j.gaitpost.2013.05.026>
91. Cunningham J, O'Dowd A, Broglio SP, Newell FN, Kelly Á, Joyce O et al. Multisensory perception is not influenced by previous concussion history in retired rugby union players. *Brain Injury*. 2022;36(9):1123-1132. <https://doi.org/10.1080/02699052.2022.2109732>
92. Bialunska A, Salvatore AP. The auditory comprehension changes over time after sport-related concussion can indicate multisensory processing dysfunctions. *Brain and Behavior*. 2017;7(12):e00874. <https://doi.org/10.1002/brb3.874>
93. Zuleger TM, Slutsky-Ganesh AB, Anand M, Kim HW, Warren SM, Grooms DR et al. The effects of sports-related concussion history on female adolescent brain activity and connectivity for bilateral lower extremity knee motor control. *Kpsychophysiology*. 2023;60(9):e14314. <https://doi.org/10.1111/psyp.14314>
94. Chang HY, Chang YC, Cheng SC, Wang CH. The effectiveness of rearfoot medial wedge intervention on balance for athletes with chronic ankle instability. *Medicine*. 2019;98(26):e16217. <https://doi.org/10.1097/MD.00000000000016217>
95. DiFabio MS, Smith DR, Breedlove KM, Pohlig RT, Buckley TA, Johnson CL. Altered brain functional connectivity in the frontoparietal network following an ice hockey season. *European Journal of Sport Science*. 2023;23(5):684-692. <https://doi.org/10.1080/017461391.2022.2069512>
96. Kums T, Erelina J, Veldre G, Gapeyeva H, Pääsuke M, Vain A. Markers for monitoring adaptive peculiarity of the musculoskeletal system in rhythmic gymnasts with non-specific low back pain. *Gazzetta Medica Italiana Archivio per le Scienze Mediche*. 2017;176(5):237-246. <https://doi.org/10.23736/S0393-3660.16.03358-1>

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The relationship between physical activity and efficacy levels of university students

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Abstract

Background and Study Aim Physical activity encompasses a range of behaviors across different domains. A critical aspect is the correlation between the frequency of physical activity and perceived competence in these activities. This study aims to explore the relationship between the levels of physical activity and the self-assessed proficiency in physical activities among university students who opt for health-related elective courses.

Material and Methods This study involved 88 university students enrolled in health-related elective courses, including Spinal Health (SH), Posture Disorder (PD), and Physical Activity in Health Promotion (PAHP). Data collection was conducted using the International Physical Activity Questionnaire-Short Form (IPAQ-SF) and the Physical Activity Efficacy Scale (PAES) surveys. For data analysis, one-way analysis of variance (ANOVA) and the Tukey test, a Post-hoc multiple comparison method, were employed.

Results The study revealed a weak negative correlation between IPAQ-SF and PAES scores. This indicates that as self-confidence and sense of competence increased, the level of physical activity decreased ($p < 0.05$). Participants in the PAHP course exhibited higher levels of physical activity, as reflected in their PAES scores, compared to those enrolled in the SH course ($p < 0.05$). Despite having a lower average income, students in the PAHP course demonstrated higher physical activity levels than those in other courses.

Conclusions The study demonstrated that as levels of physical activity efficacy increase, actual physical activity levels decrease, and vice versa. Furthermore, students enrolled in PAHP courses exhibited improved physical activity scores compared to those in other courses. It was also concluded that the income level of students does not significantly impact their level of physical activity.

Keywords: physical activity level, elective courses, university students, physical efficacy, healthy lifestyle

Introduction

A healthy lifestyle must include physical activity, especially for university students [1]. There is substantial data supporting the numerous physical, psychological, aesthetic, and social advantages of frequent engagement in physical activities [2]. A number of illnesses and ailments, such as coronary artery disease, heart disease, stroke, diabetes, high blood pressure, colon cancer, breast cancer, and overweight and obesity are all made less likely by regular physical activity [3]. Numerous research in the area have documented a tendency toward less physical activity among adults, adolescents, and children in various civilizations [4]. The level of physical activity among university students was found to be relatively low during the pandemic, and this process also had a detrimental impact on the students' quality of life [5]. Walking, moderate, vigorous, and overall physical activity levels have decreased among university students from many nations who have been quarantined due to the

COVID-19 epidemic [6]. In this context, the study of Kljajević [7] and colleagues showed that physical activity has a positive effect on the development and maintenance of physical fitness and activity after COVID-19. Additionally, Bevans et al. [8] study also noted that identifying the structure and process determinants of activity levels will support the allocation of resources and promote instructional practices that best support increasing student activity levels at the most cost-effective manner possible.

One of the most popular teaching methods in health sciences related school is the lecture course, which has the benefit of allowing for the dissemination of knowledge to a large number of students and has the potential to be effective in conveying factual information [9]. Whether or not it is successful, lecturing is still the most popular teaching style since it is affordable and useful, especially when there are many students and few resources. Physical education provides cognitive content and instruction designed to develop motor skills, knowledge, and behaviors for physical activity and physical fitness [10]. Supporting schools to establish

physical education can provide students with the ability and confidence to be physically active for a lifetime [11]. Health-related elective courses have been added to the university curriculum to increase students' health-related knowledge and awareness levels. However, the fact that studies investigating the physical activity levels of university students do not take physical activity adequacy into account leads to an inability to understand how physically competent the participants consider themselves. Physical activity competence is questioned about how confident a person is in participating in various physical activities. The phrase "Self-Confidence" expresses your belief that you can complete something successfully [12]. The purpose of this study is to examine the relationship between physical activity levels and physical activity efficacy of university students who choose health-related elective courses. For this purpose, we hypothesized that students who choose health-related elective courses are different in terms of their physical competence.

Materials and Methods

Participants

A total of 88 university students who chose courses from different 2-year departments (Banking Services, Business Administration, Office Management, Coaching, Orthopedic Prosthesis Orthosis) at Ahi Evran University were included voluntarily in the study.

Research Design

Relational screening model was used in this study, which examined the relationship between physical activity level and efficacy of university students.

Data Collection Tools

The data of the research were obtained face to face with the "Personal Information Form", "International Physical Activity Questionnaire-Short Form" and "Physical Activity Adequacy Scale".

Personal Information Form: A form prepared by the researchers was used to determine the demographic characteristics of the students participating in the research. The personal information form includes questions such as age, gender, students' departments and income status.

International Physical Activity Questionnaire (IPAQ): This study was based on the short form of the International Physical Activity Questionnaire (IPAQ), which was developed by Craig et al. [13] and adapted into Turkish by Öztürk et al. [14] and used to determine the physical activity levels of the participants. The scale consists of 7 questions and covers inquiries about activities performed in the past seven days. The scale, which can be self-administered by the participants, provides

information about the time spent on walking, moderate-intensity, and vigorous activities, as well as the time spent sitting. The calculation of scores in the scale utilized the sum of the Metabolic Equivalent of Task (MET) values assigned to the activities. The MET values assigned for the activities were determined as follows: 1.5 for sitting, 3.3 for walking, 4.0 for moderate-intensity physical activity, and 8.0 for vigorous physical activity. The participants' physical activity levels were classified as physically inactive (sedentary) (<600 MET-min/week), physically active at a low level (minimally active) (600-3000 MET-min/week), and physically active at a sufficient level (highly active) (>3000 MET-min/week) [14].

The Physical Activity Efficacy Scale (PAES) was created by Campbell et al. [15] in 2016 and later validated by Saygın et al. [12]. This scale comprises five dimensions and 26 items, categorized as follows: at school (6 items), in transportation (3 items), at home (5 items), leisure and recreation (6 items), and in school excursions and transportation (6 items). The first part of the scale gathers demographic information, while the second part assesses the respondents' confidence in participating in physical activities across these five areas. A 10-point Likert-type scale is used for the items, ranging from 0 ('I do not trust at all') to 100 ('I completely trust'). The total average score, indicating the level of physical activity proficiency, is calculated from the item responses within each domain, with possible scores ranging from 0 to 100. Higher scores indicate greater physical activity proficiency.

Ethical Approval

Voluntary consent form was signed by the students to be included in the study and to use their data. The study was approved by the Ethics Committee of the Non-invasive Clinical Trials of Haliç University (Decision number: 2023-03/60). Additionally, study number (NCT05711251) were obtained from clinicaltrials.gov.

Statistical Analysis

The data obtained from the study were analyzed using SPSS 26.0 program. Percentage and frequency descriptive statistics methods were used to determine the distribution of participants' socio-demographic information such as age and gender. Skewness and kurtosis values were examined by applying the Kolmogorov Smirnov test to determine whether the data showed normal distribution. It was observed that the distribution of the data was in accordance with the normal distribution. Paired Sample t test was applied for intra-group comparisons of variables. Homogeneity of variances was evaluated with the Levene test. The relationship between more than two groups was determined by one-way analysis of variance (ANOVA). Tukey test, one of the multiple comparison (Post-hoc) tests,

was used to determine between which groups the significant difference determined as a result of the Anova test occurred. The significance level was determined as $p < 0.05$.

Results

In the analyzes conducted before the elective courses, it was found that there was no difference between the physical activity levels of the students. In addition, because the groups that chose the course had similar characteristics, their physical activity scores showed a normal distribution. Demographics of participants appear in Table 1.

While 84.4% of the students in the PAHP course stated that they did not have any chronic disease, this rate was 92.9% in the SH course and 100% in the PD course. When looking at the IPAQ-SF scores, 50% of the students who chose the PAHP and PD courses were inactive (< 600 MET- min/week), while this rate was found to be 75% in the SH course. The rates of students who stated that they were very active (> 3000 MET- min/week) were 31.3% in the PAHP course, 17.9% in the PD course, and 28.6% in the SH course. PAES test results were 71.02 ± 15.72 in PHAP, 48.05 ± 14.55 in SH and 57.86 ± 16.29 in PD. According to the Anova test results of physical activity scores in the groups receiving PAHP, SH and

PD, a statistically significant difference was found in the IPAQ-SF and PAES ($p < 0.05$) (Table 2).

According to the Post-hoc test results of the participants' scores from the PAES, a significant difference was found between those who received SH and PAHP. According to this difference, participants from PAHP showed a higher level of physical activity as a result of the PAES compared to participants who from SH (Table 3).

When the correlation analysis between IPAQ-SF and PAES scores is made, it is seen that there is a weak negative correlation between the two scores, and as the feeling of self-confidence and competence increases, the level of physical activity decreases ($p = -0.016$) (Table 4).

Discussion

Findings show that elective courses affect university students at various rates. It will be easier to understand this situation if we consider that SH and PD courses provide students with various health-related information, independent of physical activity. The results also show improvement in physical activity scores of students who choose the health-related elective courses. As expected, training in physical activity and exercise prescription is crucial to promoting the adoption of this strategy

Table 1. Participant characteristics

Spinal Health (n:28, 60.7% female)		
Demographics	Min-Max	X±Std.
Age (years)	19-26	20.96±1.89
BMI (kg/m ²)	18-26.8	21.7±2.6
Income Status (TL)	800-15.000	2.455±2.797
Posture Disorder (n:28, 64.3% female)		
Age (years)	19-30	21.21±2.09
BMI (kg/m ²)	16-28	22.3±2.6
Income Status (TL)	200-5.000	1.542±1.147
Physical Activity in Health Promotion (n:32, 62.5% female)		
Age (years)	19-23	20.53±1.01
BMI (kg/m ²)	17.1-31.2	22±2.9
Income Status (TL)	500-6.600	1.378±1.106

Table 2. Anova test results according to the scores of participants taking different courses from different physical activity scales

Variables		df	F	p
IPAQ-SF	Intergroup	2	0.051	.950
	In-group	85		
	Total	87		
PAES	Intergroup	2	16.535	.000
	In-group	85		
	Total	87		

Table 3. Post hoc test results according to the scores of participants taking different courses from different physical activity scales

Assessment Variables	Elective Courses		Mean Change (I-II)	p
IPAQ-SF	PAHP	SH	.018	.994
		PD	.054	.946
	SH	PAHP	-.018	.994
		PD	.036	.977
	PD	PAHP	-.054	.946
		SH	-.036	.977
PAES	PAHP	SH	22.975	.000
		PD	13.161	.004
	SH	PAHP	-22.975	.000
		PD	-9.814	.053
	PD	PAHP	-13.161	.004
		SH	9.814	.053

Table 4. Correlation analysis

Assessment Variables	Analysis	PAES	IPAQ-SF
PAES	Pearson Correlation	1	-.016
	Sig. (2-tailed)		.880
	n	88	88
IPAQ-SF	Pearson Correlation	-.016	1
	Sig. (2-tailed)	.880	
	n	88	88

for preventing and treating noncommunicable chronic illnesses, which account for 36 million deaths worldwide annually. [16]

The universities closure and cancellation of face-to-face physical activity classes due to the COVID-19 pandemic decreased overall PA, sport/fitness PA level and academic performance in PE in all participants. [17] Offering courses in health, wellness, and health-related physical activity as required or elective courses for graduation colleges is a means through which to develop health and physical literacy in students resulting in a positive influence on public health. [18] From this perspective, the importance of added elective courses in terms of increasing the physical activity levels and efficacy of university students and raising their awareness is obvious. Organizing the content of one of these courses within the scope of physical activity is very important in raising students' awareness compared to other courses. However, a recent study points to the need for a review of education policies to allow the adoption of more flexible curricula and promote the inclusion of physical activity in the classroom. [19] In addition to a more flexible curriculum, adding these elective courses to the curriculum with similar content and in accordance with the standards will also raise awareness in the society.

Another important issue is that the contents of physical activity courses vary from university to university and the students taking the course have different levels of physical activity. The study conducted by Verma et al. [4] showed that physical education and other aspects of health are inadequately and heterogeneously represented in university curricula. Despite this heterogeneity, the addition of health-related elective courses to the curriculum, especially the course added to improve physical activity, raised students' awareness and efficacy. According to our study, the fact that the inactivity rate reaches up to 75% indicates the need not only for adding courses to the curriculum, but also for the university administration to actively create environments where physical activity can be increased. In a meta-analysis study conducted by Keating et al. [20] in 2005, they stated that almost 50% of university students were inactive. Garcia et al. [21] examined the physical activity level of 900 college students studying at Columbian University and found that 68.90% of the students were low-active or inactive. As stated by İlaslan et al. [22], increasing the students' knowledge level regarding the acquisition of habits in physical activity, structuring the physical spaces and encouraging students to engage in activity provides positive gains.

Also, Ryan et al. [23] suggests that strengthening young persons' belief in their ability to find and create environments that support physical activity might promote increases in their physical activity. Contrary to the study, in our study, it was observed that the physical activity levels of students with high levels of physical competence were lower. It is thought that this is related to the person's belief that he can do something more than he actually can do it.

The limitations of this study are that due to the cold weather in the fall semester, students' physical activities decreased as they preferred public transportation instead of walking, and the accuracy of the answers given to the surveys was

not monitored with a concrete method such as pedometer application.

Conclusions

According to the results of the research, it was determined that the physical activity levels of university students were insufficient. In order to raise young people's awareness on this issue, access to physical activity opportunities should be increased, especially on university campuses located in small residential areas, as well as courses on the negative effects of physical inactivity in education curricula. More comprehensive studies on physical activity training are needed to reduce the negative effects of inactivity and determine effective strategies.

References

1. Kostecka M, Bojanowska M, Stoma M. The role of physical activity in instilling healthy lifestyle habits in children. *Balt J Heal Phys Act.* 2017;9(3):133–40. <https://doi.org/10.29359/BJHPA.09.3.13>
2. Sáez I, Solabarrieta J, Rubio I. Motivation for physical activity in university students and its relation with gender, amount of activities, and sport satisfaction. *Sustain.* 2021;13(6). <https://doi.org/10.3390/su13063183>
3. Kim C, Song Y, Jeon YJ. The effect of college students' physical activity level on depression and personal relationships. *Healthc.* 2021;9(5):1–11. <https://doi.org/10.3390/healthcare9050526>
4. Verma AK, Singh G, Patwardhan K. Patterns of Physical Activity Among University Students and Their Perceptions About the Curricular Content Concerned With Health: Cross-sectional Study. *JMIRx Med.* 2022;3(2):e31521. <https://doi.org/10.2196/31521>
5. Bulguroğlu Hİ, Bulguroğlu M, Özasan A, Üniversitesi AM, Ankara T. Fiziksel Tıp ve Ve Rehabilitasyon, Examination of Physical Activity, Quality of Life and Depression Levels of University Students During the Covid-19 Pandemic. *Fiz Tıp ve Rehabil.* 2021;12(2):306–11. <https://doi.org/10.31067/acusaglik.852175>
6. López-Valenciano A, Suárez-Iglesias D, Sanchez-Lastra MA, Ayán C. Impact of COVID-19 Pandemic on University Students' Physical Activity Levels: An Early Systematic Review. *Front Psychol.* 2021;11:1–10. <https://doi.org/10.3389/fpsyg.2020.624567>
7. Kljajević V, Stanković M, Đorđević D, Trkulja-Petković D, Jovanović R, Plazibat K, et al. Physical activity and physical fitness among university students—A systematic review. *Int J Environ Res Public Health.* 2022;19(1):158. <https://doi.org/10.3390/ijerph19010158>
8. Bevans KB, Fitzpatrick LA, Sanchez BM, Riley AW, Forrest C. Physical Education Resources, Class Management, and Student Physical Activity Levels: A Structure-Process-Outcome Approach to Evaluating Physical Education Effectiveness. *J Sch Health.* 2010;80(12):573–80. <https://doi.org/10.1111/j.1746-1561.2010.00544.x>
9. Alaagib NA, Musa OA, Saeed AM. Comparison of the effectiveness of lectures based on problems and traditional lectures in physiology teaching in Sudan. *BMC Med Educ.* 2019;19(1):1–8. <https://doi.org/10.1186/s12909-019-1799-0>
10. *Educating the Student Body: Taking Physical Activity and Physical Education to School.* Washington, D.C.: National Academies Press; 2013. P. 18314. <https://doi.org/10.17226/18314>
11. Centers for Disease Control and Prevention (CDC). School health guidelines to promote healthy eating and physical activity. *MMWR. Recommendations and reports: Morbidity and mortality weekly report. Recommendations and reports,* 2011;60(RR-5): 1–76.
12. Saygin Ö, Göral K, BiNgöl E, Ceylan Hİ. Turkish adaptation of the physical activity efficacy scale: the study of validity and reliability. *International Journal of Sports, Exercise & Training Science,* 2017;3(2): 44–44. <https://doi.org/10.18826/useabd.308845>
13. Craig CL, Marshall AL, Sjöström M, Bauman AE, Booth ML, Ainsworth BE, et al. International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc.* 2003;35(8):1381–95. <https://doi.org/10.1249/01.MSS.0000078924.61453.FB>
14. Sağlam M, Arikan H, Savci S, Inal-Ince D, Bosnak-Guclu M, Karabulut E, Tokgozoglu L. International physical activity questionnaire: reliability and validity of the Turkish version. *Percept Mot Skills.* 2010;111(1):278–84. <https://doi.org/10.2466/06.08>
15. Campbell N, Gray C, Foley L, Maddison R, Prapavessis H. A domain-specific approach for assessing physical activity efficacy in adolescents: From scale conception to predictive validity. *Psychol Sport Exerc.* 2016;22:20–6. <https://doi.org/10.1016/j.psychsport.2015.05.002>
16. Corbin CB. Conceptual physical education: A course for the future. *J Sport Heal Sci.* 2021;10(3):308–22. <https://doi.org/10.1016/j.jshs.2020.10.004>
17. Osipov AY, Ratmanskaya TI, Zemba EA, Potop V, Kudryavtsev MD, Nagovitsyn RS. The impact of

- the universities closure on physical activity and academic performance in physical education in university students during the COVID-19 pandemic. *Phys Educ Students*. 2021;25(1):20–7. <https://doi.org/10.15561/20755279.2021.0103>
18. Ladd GG. Public health education: the status of health and health-related physical activity courses in Texas community colleges. *Front Public Heal*. 2023;11:1–12. <https://doi.org/10.3389/fpubh.2023.1199734>
19. Shorey S, Ng ED. The lived experiences of children and adolescents with non-communicable disease: A systematic review of qualitative studies. *J Pediatr Nurs*. 2020;51:75–84. <https://doi.org/10.1016/j.pedn.2019.12.013>
20. Keating XD, Guan J, Piñero JC, Bridges DM. A meta-analysis of college students' physical activity behaviors. *J Am Coll Heal*. 2005;54(2):116–26. <https://doi.org/10.3200/JACH.54.2.116-126>
21. García Puello F, Herazo Beltrán Y, Tuesta Molina R. Levels of physical activity among colombian university students. *Rev médica Chile*. 2015;143(11):1411–8. <https://doi.org/10.4067/S0034-98872015001100006>
22. İlaslan E, Taylan S, Özkan İ, Adibelli D. Investigation of Physical Activity Levels and Associated Factors of University Students in a District. *Turkiye Klin J Intern Med*. 2020;5(1):15–21. <https://doi.org/10.5336/intermed.2019-71187>
23. Ryan GJ, Dzewaltowski DA. Comparing the Relationships between Different Types of Self-Efficacy and Physical Activity in Youth. *Heal Educ Behav*. 2002;29(4):491–504. <https://doi.org/10.1177/109019810202900408>

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