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CONTENT

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Evaluation of the functional state of taekwondo athletes 7-13 years old according to the indicators of the finger-tapping test

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Abstract

Background and Study Aim. The functional state of organs and systems determines the level of preparedness of athletes in modern sports. The evaluation of the state of the central nervous system is of particular importance. The purpose of the study is a comparative analysis of the results of the tapping test of taekwondo athletes of different ages.

Material and Methods. 42 taekwondo athletes were divided into groups of 14 people depending on age: group 1 - (7.50±0.14) years, group 2 - (10.07±0.22) years, group 3 - (13.36±0.27) years. Participants of groups 1 and 2 were engaged in the amateur level, and group 3 had a skill level of 2 Gup - 1 Dan. A special computer program for devices with the iOS operating system was used. An Apple tablet was used - iPad, 4th generation with a screen diagonal of 9.7 inches. The finger-tapping test was carried out for 60 s, 12 subtests of 5 s each. For analysis, we evaluated the total number of depressions during the entire test, the average number of depressions per 5 s, the number of depressions in each subtest, the duration of depressions in each subtest, and the dynamic performance index (DPI). Group results were compared using the nonparametric Rosenbaum test (Q) and sign test (z).

Results. It was found that the athletes of the 2nd group performed more depressions in the test as a whole and in 11 out of 12 subtests compared with the athletes of the 1st group. Comparison of the middle and senior groups also confirmed the best results of the athletes of the senior group in 6 subtests out of 12. The senior athletes had a longer duration of depressions in 2 subtests. The most pronounced differences were established when comparing the results of the junior and senior groups. A significant excess in the number of depressions was confirmed for senior athletes in all subtests. The duration of depressing was longer in senior athletes in 2 subtests. A significant reduction in the number of depressions from the beginning to the end of the test was determined. Changes in the duration of depressions were opposite, and the time increased from the beginning to the end of the test.

Conclusions. The presence of a direct dependence of the results of the finger-tapping test of taekwondo athletes on age is determined. An increase in the number of depressions in the test, an increase in the integral criterion - an indicator of dynamic performance was determined. The results reflect an increase in the strength of nervous processes, positive changes in the functional state under the influence of regular training loads. This condition should be evaluated as a predictor of the success of taekwondo athletes. The computer version of the test is mobile, informative and valid. It can be used in monitoring the functional state of combat sports athletes.

Keywords: combat sports, taekwondo, finger tapping test, age groups.

Анотація

Ольга Подрігало, Вячеслав Романенко, Леонід Подрігало, Сергій Єрмаков, Олег Ольховий, Анастасія Бондар, Алла Семізорова, Володимир Галімський. Оцінка функціонального стану таеквондістів 7-13 років за показниками теппінг-тесту. Мета: порівняльний аналіз результатів тепінг-тесту атлетів таеквондо різного віку. **Матеріали і методи**: 42 атлети таеквондо були поділені на групи по 14 осіб залежно від віку: 1 група – середній вік (7.50±0.14) років, 2 група – (10.07±0.22) року,

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3 група – (13.36±0.27) років. Учасники 1 та 2 груп займалися на аматорському рівні, 3 група мала рівень майстерності 2 Gup – 1 Dan. Використовували спеціальну комп'ютерну програму для пристроїв з операційною системою iOS. Було використано планшетний комп'ютер фірми Apple – iPad, 4-го покоління з діагоналлю екрану 9,7 дюймів. Тепінг-тест проводився протягом 60 секунд, 12 субтестів по 5 секунд. Для аналізу використовували загальну кількість натискань протягом усього тесту, середню кількість натискань за 5 с, кількість натискань у кожному субтесті, тривалість натискань у кожному субтесті, показник динамічної працездатності (ПДР). Результати груп порівнювали за допомогою непараметричного критерію Розенбауму (Q) та критерію знаків (z). **Результати:** аналіз результатів 1 і 2 групи показує, що старші атлети виконували більшу кількість натискань у тесті в цілому та в 11 субтестах із 12. Порівняння середньої та старшої груп також підтвердило кращі результати атлетів старшої групи за 6 субтестами з 12. Старші атлети мали більше натискань під час виконання 2 субтестів. Найбільш виражені відмінності встановлені при порівнянні результатів молодшої та старшої груп. Підтверджено значне перевищення кількості натискань у старших атлетів за усіма субтестами. Тривалість натискань була більшою у старших атлетів за двома субтестами. Аналіз динаміки виконання тесту показав значне скорочення кількості натискань від початку до кінця тесту. Зміни тривалості натискань були протилежні, час збільшувався з початку до кінця тесту. **Висновки:** показано наявність прямої залежності результатів тепінг-тесту атлетів таеквондо від віку. Встановлено збільшення кількості натискань у тесті, зростання інтегрального критерію – показника динамічної працездатності. Результати відбивають збільшення сили нервових процесів, позитивні зміни функціонального стану під впливом регулярних тренувальних навантажень. Комп'ютерний варіант тесту є мобільним, інформативним та валідним. Він може бути використаний у моніторингу функціонального стану атлетів єдиноборств.

Ключові слова: єдиоборства, таеквондо, теппінг-тест, вікові групи

Introduction

The functional state of organs and systems determines the level of preparedness of athletes in modern sports. The assessment of the state of the central nervous system is of particular importance. Many sports place high demands on the nervous system and, especially, on the ability to function in extreme conditions (Svitlana et al., 2020). Athletes of extreme sports are characterized by high indicators of the strength of nervous processes, reactions to a moving object, and an increase in the level of dynamic muscle endurance under the conditions of a finger tapping test. These psychophysiological features may have prognostic value.

Motor speed is an important indicator and predictor of cognitive and physical function. One of the most common methods for assessing the speed of movements is the finger tapping test (FTT) (Austin et al., 2011). This test belongs to the classical methods of analyzing the psychophysiological state of a person (Austin et al., 2011; Mochurad & Hladun, 2021), analyzing performance, diagnosing, and predicting fatigue (Prigatano et al., 2020), assessing the speed of motor skills and motor control (Christianson & Leathem, 2004), and measuring the motor activity of the upper limbs (Barut et al., 2013).

FTT assesses fine motor skills, the ability to control and coordinate precise movements with the muscles of the hand. Fine motor skills are associated with information processing speed functions, learning skills, and other cognitive abilities. In a study by Sahin et al. (2020) carried out a comparative analysis of the results of FTT in elite athletes and students of various specialties. The test results were used as a criterion for the effectiveness of training. Similar results were obtained in another study (Ari & Deliceoglu, 2020). The results of the finger tapping test made it possible to assess the level of maturation of primary schoolchildren. The informativeness of this test for assessing the development of motor skills has been confirmed.

Correlation between motor qualities, physical fitness, and academic performance of schoolchildren was determined using FTT (Batez et al., 2021). It is confirmed that test results are significant predictors of academic performance. Their contribution to the GPA was the largest.

An important task of sports science is the choice of adequate and informative tests to monitor the condition of athletes and amateurs (Butenko et al., 2017). The reliability and informativeness of FTT served as the basis for its use in assessing the physical fitness of students (Duc, 2021). The conclusion is made about the possibility of using this test in health monitoring.

FTT is used to analyze the state of the nervous system of athletes and assess the potential of functionality and effectiveness of training (Balgimbekov et al., 2021; Bisio et al., 2021; Ambroży et al., 2022). It allows to evaluate the ability to synchronize movements. This quality also applies to predictors of success in many sports. A comparative analysis of the results of the finger tapping test in tennis athletes and the control group was carried out in another study (Bisio et al., 2021). The best level of development of motor skills in athletes, higher quantitative and qualitative indicators of test performance are determined.

A comprehensive analysis of the anthropometric profile and fitness profiles of junior karate athletes was conducted in the study (Martinez-De-Quel et al., 2021). The finger tapping test was part of the used test battery. The results confirm the high level of preparedness of the athletes. Participants were between the 80th and 90th percentile compared with the general population.

Similar results were obtained in another study (Ambroży et al., 2022). The authors studied the effectiveness of using a fitness program in the training of kickboxing athletes. Significant changes in the indicators of general and special physical training were determined. A significant optimization of the results of the findertapping test was confirmed in the dynamics of the state of the participants.

The psychomotor characteristics of elite athletes were studied in another study (Petrenko et al., 2021). High rates of mobility of nervous functions and finger tapping test were determined in middle-distance runners. It is proposed to use psychomotor indicators for the selection and specialization of athletes in athletics at each stage of training. These indicators can be used to predict individual progress and correct general and special physical fitness.

The conditions of the test must be appropriate for the activity to be performed. This created a foot version of the test. The foot tapping test (TAP) is also widely used in sports science. Its reliability, validity, and sensitivity in football players have been confirmed (Chaabouni et al., 2022). A high correlation of TAP and FTT results was determined. The conclusion is made about the prospects of its use in sports where the main load falls on the lower limbs.

Both options (TAP and FTT) were used to analyze the state of female athletes in artistic and rhythmic gymnastics in the dynamics of training (Scotton et al., 2021). The effect of two opposite factors associated with training load has been confirmed. The development of fatigue minimizes productivity. The formation of neuromuscular activation is aimed at improving performance.

Similar results are presented in another study (Aksović et al., 2021). The authors investigated the impact of the development of motor skills on the results in the sprint. TAP and FTT results had a significant impact on performance. The correlation with speed and explosive power was confirmed.

Thus, the available results confirm the relevance of using the finger tapping test for the selection and prediction of the growth of sportsmanship, monitoring the condition of athletes. It is of interest to evaluate its features in combat sports athletes of various age groups.

Based on the foregoing, the **aim of this study** was a comparative analysis of the results of the finger tapping test of taekwondo athletes of different ages.

Material and Methods of the research

Participants.

The study involved 42 taekwondo athletes and representatives of the Vulkan sports school (Cherkasy, Ukraine). The participants were divided into groups of 14 people depending on age: group 1 - (7.50±0.14) years, group 2 - (10.07±0.22) years, group 3 - (13.36±0.27) years. Participants of groups 1 and 2 were engaged in the amateur level, and group 3 had a skill level of 2 Gup - 1 Dan.

Ethics Statements and Participants. This study was approved by the Bioethics Committee for Clinical Research and conducted according to the Declaration of Helsinki. All participants and his parents gave their written consent to research and were informed about the purpose and test procedures and about the possibility of withdrawal of consent at any time for any reason.

Study design.

The design of the study involved conducting a finger tapping test by depressing on the screen. The duration of the test was 60 s. Participants sequentially performed 12 subtests for 5 s in separate squares of the screen. A special computer program for devices with the iOS operating system was used. The device used was an Apple tablet computer - iPad, 4th generation with a screen diagonal of 9.7 inches.

For analysis, we used the total number of depressions during the entire test (abs), the average number of depressions per 5 s (abs), the number of depressions in each subtest (abs), and the duration of depressions in each subtest (ms).

The dynamic performance index (DPI) was determined as an integral criterion for the strength of nervous processes (Makarenko, 1996). This criterion was found by the formula:

$$DPI = -0.06 \times (-6 \times n_1 - 5 \times n_2 - 4 \times n_3 - 3 \times n_4 - 2 \times n_5 - n_6 + n_7 + 2 \times n_8 + 3 \times n_9 + 4 \times n_{10} + 5 \times n_1 + 6 \times n_{12}) \quad (1),$$

where n is the number of depressions in a particular subtest.

Statistical analysis of the obtained data was carried out using licensed MS Excel. The indicators of descriptive statistics were determined: arithmetic mean (X) and standard deviation (SD). Considering the size of the sample and the nature of the data distribution, the significance of differences between the groups was assessed using a nonparametric indicator - the Rosenbaum test (Q), the differences were considered significant at ($p<0.05$). The dynamics of the test results within the groups were assessed by comparing 1, 7, and 12 subtests using the sign test (z), and differences were considered significant at ($p<0.05$).

Results of the research

The results obtained are shown in table 1.

Table 1. Results of the finger tapping test for taekwondo athletes of different age groups (X±SD)

Indicator	1 group (n=14)	2 group (n=14)	3 group (n=14)
Total number of depressions, abs	300.50±19.08	345.29±22.38	374.50±70.32
Average number of depressions per 5 s, abs	25.06±1.59	28.79±1.87	31.18±5.87
Number of depressions in subtest 1, abs,	30.21±2.01	33.86±2.60	35.29±8.52
Number of depressions in subtest 2, abs	28.00±2.08	31.43±2.28	34.14±9.75
Number of depressions in subtest 3, abs	26.71±2.13	30.57±2.31	33.29±9.90
Number of depressions in subtest 4, abs	25.64±1.50	28.93±2.59	31.86±6.80
Number of depressions in subtest 5, abs	24.71±2.64	28.57±2.21	31.36±6.81
Number of depressions in subtest 6, abs	24.36±2.06	28.00±2.72	29.36±2.87
Number of depressions in subtest 7, abs	24.00±1.88	27.21±2.72	30.29±6.81
Number of depressions in subtest 8, abs	23.57±2.31	26.36±3.46	27.79±2.99
Number of depressions in subtest 9, abs	23.29±1.77	27.29±2.13	30.36±7.70
Number of depressions in subtest 10, abs	24.07±2.46	27.43±1.91	28.71±3.10
Number of depressions in subtest 11, abs	23.07±2.13	27.57±2.68	29.50±7.23
Number of depressions in subtest 12, abs	23.07±3.02	27.71±3.63	28.86±3.18
Duration of depressions in subtest 1, ms	62.75±11.79	65.53±12.18	73.44±18.98
Duration of depressions in subtest 2, ms	66.73±13.32	69.24±11.27	76.10±15.04
Duration of depressions in subtest 3, ms	69.51±20.21	72.63±16.46	75.88±16.52
Duration of depressions in subtest 4, ms	67.89±17.62	72.16±17.45	74.49±18.75
Duration of depressions in subtest 5, ms	72.86±18.17	68.67±11.69	72.36±17.68
Duration of depressions in subtest 6, ms	75.21±22.29	67.19±10.68	72.36±16.33
Duration of depressions in subtest 7, ms	70.70±20.31	70.12±13.43	75.54±17.89
Duration of depressions in subtest 8, ms	74.75±21.87	71.21±16.92	78.25±20.64
Duration of depressions in subtest 9, ms	76.46±20.13	71.00±14.41	73.08±15.62
Duration of depressions in subtest 10, ms	69.84±14.99	68.58±12.59	80.80±16.07
Duration of depressions in subtest 11, ms	75.97±14.63	70.14±13.59	80.66±15.25
Duration of depressions in subtest 12, ms	78.03±20.54	67.66±16.41	80.74±14.66
Dynamic performance index, abs	5.27±1.34	4.73±2.02	5.45±5.32

The analysis made it possible to determine many significant differences between the groups. The main trend was an increase in test results in direct proportion to age. When comparing groups 1 and 2, a significant increase in the total number of depressions (Q=21, p<0.01), the average number of depressions per 5 seconds (Q=21, p<0.01), the number of depressions in subtests 1–12 (p<0.01) were confirmed.

When comparing groups 2 and 3, a significant increase in the total number of depressions (Q=7, p<0.05), the average number of depressions per 5 seconds (Q=7, p<0.05), the number of depressions in subtests 4.5,6,7.9, 10 (p<0.05). In group 3, an increase in the duration of depressions was found in subtest 6 (Q=8, p<0.05), in subtest 10 (Q=11, p<0.01). DPI was higher in group 3 (Q=25, p<0.01).

The differences between groups 1 and 3 were the most pronounced. A significant increase in the total number of depressions (Q=23, p<0.01), the average number of depressions per 5 seconds (Q=23, p<0.01), the number of depressions in subtests 1–12 (p<0.05) were confirmed. Senior athletes had a longer duration of depressions in subtest 1 (Q=8, p<0.05), in subtest 10 (Q=7, p<0.05). DPI was higher in group 3 (Q=26, p<0.01).

In group 1, a significant decrease in the number of depressions between subtests 1 and 7 (z=0, p<0.01), subtests 1 and 12 (z=0, p<0.01), an increase in the duration of depressions between subtests 1 and 7 (z=3 , p<0.05), an increase in the duration of depressions between subtests 1 and 12 (z=1, p<0.01). In group 2, a significant decrease in the number of depressions was confirmed between subtests 1 and 7 (z=0, p<0.01), subtests 1 and 12, (z=1, p<0.01). In group 3, a significant decrease in the number of depressions between 1 and 7 subtests (z=0, p<0.01), 1 and 12 subtests (z=0, p<0.01), an increase in the duration of depressions between 1 and 12 subtests (z=3 , p<0.05).

Discussion

Combat sports are very popular sports among young people (Bayraktar et al., 2021; Lyuchkova et al., 2022). This necessitates the development of methods for selecting and predicting the effectiveness of training athletes. The most informative in this context is the study of physical development and functional state (Podrigalo et al., 2019; Romanenko et al., 2020).

The choice of the finger tapping test to assess the psychophysiological state of the participants was due to its availability, integrity and validity. This test is widely used in sports science (Duc, 2021; Balgimbekov et al., 2021; Bisio et al., 2021; Petrenko et al., 2021), including combat sports (Ambroży et al., 2022; Martinez-De-Quel et al., 2021; Korobeynikov et al., 2020).

Features of the complex visual-motor reaction of boxers with different types of functional asymmetry were assessed using the time of simple and two complex visual-motor reactions (Korobeynikov et al., 2020; Korobeynikov et al., 2019). The motor component of the motor response was studied using the finger tapping test. The results are interpreted as a reflection of the predictors of the success of athletes.

Variations of FTT are widely used in scientific research. It has been proposed to use a short version of this test to check the neuropsychological status of participants (Ashendorf et al., 2015). It was confirmed that both versions of the test have a high predictive and informative value.

The development of multimedia technologies has made it possible to develop computer and mobile versions of FTT (Mochurad & Hladun, 2021; Christianson & Leathem, 2004; Behrens et al., 2022). A special application for a cell phone has been developed that allows performing the FTT (Mochurad & Hladun, 2021). This application is characterized by information content, allows conducting research quickly directly in the process of activities.

The CoGNIT tablet application was developed for automatic, standardized and efficient assessment of cognitive functions (Behrens et al., 2022). The possibility of automatic testing using the specified application for assessing memory, psychomotor speed, executive function, attention, visual-spatial abilities was confirmed. A comparative analysis of the computer version of the test with traditional similar methods was carried out in another study (Christianson & Leathem, 2004). A high correlation between the results of the methods used was confirmed.

In our study, a program based on an Apple iPad, was used. The use of such programs allows you to quickly monitor the functional state of athletes, adjust training loads (Romanenko et al., 2020; Podrigalo et al., 2023).

A broad system of indicators was used to evaluate the test results. It included the number of total and average depressions, the number of depressions in each subtest, the duration of depressions in each subtest, as well as the integral indicator - DPI. This makes it possible to significantly improve the quality of the analysis of the results.

Similar approaches are described in the available literature. Austin D, Jimison H (2011) suggested using not only the number of depressions, but also the duration of the intervals between depressions to evaluate FTT. The presence of significant dependencies between the average speed of depressions and the average value of such intervals has been determined. A similar system of criteria was used in another study (Bisio et al., 2021). It included the frequency of movements, the duration of depressions, the duration of the interval between depressions.

The validity of the choice of indicators for evaluating the test results is confirmed by the available literature data. The average number of depressions and the temporal fluctuations of the intervals between depressions were used in another study (Barut et al., 2013). The use of these indicators significantly increases the level of results analysis.

The design variant used is the comparison of athletes of different age groups is widely used in sports science. This approach allows us to evaluate the influence of age, the increase in the length of training on the level of preparedness of athletes. In another study (Martinez-De-Quel et al., 2021), such an analysis made it possible to determine reference values for the parameters of combat sports athletes. It is recommended to use them when testing young male and female karate athletes.

Comparison of artistic swimming athletes of different skill levels was carried out in another study (Rovnaya et al., 2016). Experienced athletes were characterized by higher functional capabilities of the respiratory system. A direct relationship has been established between the experience of training and the adaptive potential of female athletes.

Comparison of the psychophysiological state of athletes of different skill levels was carried out in another study (Romanenko et al., 2020). It was confirmed that more experienced athletes completed the tests faster, with fewer errors. Parallel monitoring of physiological parameters confirmed the absence of adaptation stress. Experienced athletes have the best level of workability, the best ability to mobilize and economize the work of the body. Our results confirm the data presented in this study.

Performing an FTT is a complex task, the results of which

are influenced by many factors. These include external stimuli, mood and health status. In a sports context, it is also necessary to consider the level of skill, physical and technical training of athletes.

The ability to perform movements with maximum frequency is an integral indicator of speed (Makarenko, 1996). It is the nervous system that determines the speed qualities of athletes, due to its mobility, lability and endurance. The strength of nervous processes is an indicator of the performance of nerve cells and the nervous system as a whole. A strong nervous system withstands a load greater in magnitude and duration than a weak one (Makarenko, 1996). Therefore, the use of FTT makes it possible to predict the success of athletes in combat sports. A comparison of the results of athletes of different ages makes it possible to evaluate the effectiveness of their training, to predict the growth of sportsmanship (Podrigalo et al., 2023).

A direct dependence of test results on age has been confirmed. The senior athletes performed more presses on the test than the junior athletes. The DPI also increased with age. This relationship was confirmed when comparing all groups. Thus, the ability to maintain the maximum rate of hand movement increases with age. This is due to an increase in the strength and endurance of the nervous system.

An improvement in the psychophysiological parameters of combat sports athletes in parallel with age and training experience was researched in another study (Podrigalo et al., 2023). A positive change in the speed of reaction to various stimuli of taekwondo athletes of different ages was confirmed. The determined correlations between all tests used also reflect the improvement in the psychophysiological state of the athletes as the age increases.

The total number of depressions in the test characterizes the dynamic muscle performance. It was high enough in all groups. The increase in this indicator with age illustrates the increase in fitness, optimization of the functional state of athletes under the influence of regular physical activity. The results of FTT confirm the increase in the strength of nervous processes, overall performance due to sports training. Positive changes in the nervous system with age arise due to the high motor density of training, the use of high-intensity speed-strength and self-strength loads in training (Latyshev et al., 2022).

Analysis of the results of groups 1 and 2 shows that senior athletes performed more depressions in the test as a whole and in 11 out of 12 subtests. This allows concluding that the functional state of the nervous system of senior athletes is better.

Comparison of the middle and senior groups also confirmed the differences in the results of the finger tapping test. However, they were less pronounced than when comparing the junior and middle groups. The best results of the athletes of the senior group were determined in 6 out of 12 subtests. The senior athletes had a longer duration of depressions when performing 2 subtests.

The most pronounced differences were determined when comparing the results of the junior and senior groups. A significant excess in the number of depressions was confirmed for senior athletes in all subtests. The senior athletes had a longer duration of depressions when performing 2 subtests.

The results of FTT depending on gender, age and performance level were researched in the study by Prigatano et al. (2020). A direct correlation between age and the number of depressions has been determined. Females had more errors than males. The effects of fatigue and learning did not depend on the gender and age of the participants.

Similar results were obtained in another study (Christianson & Leathem, 2004). The higher performance of males compared to females, better results of the dominant hand and a decrease in the number of depressionsin the dynamics of the test were confirmed.

An analysis of the dynamics of the test execution made it possible to determine a significant reduction in the number of depressions from the beginning to the end of the test. Changes in the duration of depressions were opposite, the time increased from the beginning to the end of the test. However, this dependence was determined only in the junior and senior groups.

The results obtained confirm the available literature data. Higher FTT results in elite athletes have been determined in another study (Sahin et al., 2020). It is concluded that this test can be used as a predictor of success in sports.

An analysis of the motor abilities of preschool children, primary school and secondary school age involved in football was carried out in another study (Bubnjević et al., 2020). The correlation between test results has been confirmed to increase as the age of the participants' increases. Our results confirm a pronounced improvement in FTT results with increasing age and increasing experience in sports among junior taekwondo athletes.

Conclusions

Analysis of the results of the finger tapping test of taekwondo athletes of different ages showed direct dependence on age. An increase in the number of depressions in the test, an increase in the integral criterion - a dynamic performance index was determined. The results reflect an increase in the strength of nervous processes, positive changes in the functional state under the influence of regular training loads. This condition should be evaluated as a predictor of the success in taekwondo athletes. The computer version of the test is mobile, informative and valid. It can be used in monitoring the functional state of combat sports athletes.

Author Contributions

Olha Podrihalo: study design, data collection, statistical analysis, manuscript preparation.

Vyacheslav Romanenko: study design, data collection, statistical analysis, manuscript preparation.

Leonid Podrigalo: study design, data collection, statistical analysis, manuscript preparation.

Sergii Iermakov: study design, data collection, statistical analysis, manuscript preparation.

Oleh Olkhovyi: study design, statistical analysis, manuscript preparation.

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Volodymyr Galimskyi: data collection, manuscript preparation.

Conflicts of Interest

The authors declare no conflict of interest.

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Assessment of educators' physical activity in conditions of social isolation

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Abstract

Purpose: To assess the educators' physical activity in the conditions of social isolation during the Covid-19 pandemic with the use of data on daily energy costs in the dynamics of 16 years.

Material & methods. To solve the problems, the data of 925 teachers of preschool and general secondary education institutions were analyzed (436 people – in 2005, 404 people – in 2018, 85 people – in 2021). Age composition of the participants of the scientific observation: I age group (I AG) up to 31 years old – 165 people (17.84 %), II age group (II AG) 31-40 years old – 271 people (29.30 %), III age group (III AG) 41-50 years old – 253 people (27.35 %), IV age group (IV AG) older than 50 years – 236 people (25.51 %). Among the teachers, 690 people (74.59 %) were residents of the regional center, 207 (22.38 %) were residents of district centers, and 28 (3.03 %) were residents of rural areas. The following methods were used during the study: questionnaire; natural experiment; statistical processing of the received data.

Results. The study revealed a tendency towards a decrease in the average values of teachers' energy expenditure of daily physical activity from 2005 (2818.78±38.32 kcal) to 2021 (2804.03±20.77 ($F_{2005\text{-}2021}$ =14.049; p=0.000)) and a natural decrease in the average value of the indicator of energy expenditure of daily physical activity during the distance learning (2412.34±21.08 kcal) by 13.96 % compared with the similar indicator during the traditional form of learning in 2021 (2804.03±20.77 kcal), ($t_{offline - online}$ =34.913; p=0.000).

Conclusions. In the dynamics of the studied period, there is a decrease in the average values of teachers' energy expenditure of daily physical activity from 2005 (2818.78±38.32 kcal) to 2021 (2804.03±20.77 ($F_{2005\text{-}2021}$ =14.049; p=0.000)).

The average value of the indicator of daily energy expenditure for physical activity during the distance learning (2412.34±21.08 kcal) is 13.96 % lower, compared with the similar indicator of teachers' work using the traditional form of learning in 2021 (2804.03±20.77 kcal), ($t_{offline - online}$ =34,913; p=0,000).

Keywords: physical activity, professional burnout, educators, COVID-19 pandemic.

Анотація

Ірина Калиниченко, Miroslawa Cieslicka, Ганна Латіна, Михайло Антомонов, Ганна Заікіна. Оцінка фізичної активності працівників галузі освіти в умовах соціальної ізоляції. Мета: оцінити фізичну активність працівників галузі світи в умовах соціальної ізоляції під час пандемії COVID-19 із використанням даних про добові енерговитрати у динаміці 16 років. **Матеріал та методи:** для вирішення завдань було проаналізовано дані 925 вчителів закладів дошкільної та загальної середньої освіти (436 осіб – у 2005 році, 404 осіб – у 2018 році, 85 осіб – у 2021 році). Віковий склад учасників наукового спостереження: І вікова група (І ВГ) до 31 року – 165 осіб (17,84%), ІІ вікова група (ІІ ВГ) 31 – 40 років – 271 особа (29,30%), ІІІ вікова група (ІІІ ВГ) 41-50 років – 253 особи (27,35%), IV вікова група (IV ВГ) старше 50 років – 236 осіб (25,51%). Серед вчителів – 690 осіб (74,59%) були жителями обласного центру, 207 (22,38%) – районних центрів, 28 (3,03%) – жителі сільських поселень. Під час проведення дослідження застосовувались наступні методи: анкетування; натурний експеримент; статистична обробка отриманих даних. **Результати:** Виявлено тенденцію до зниження середніх значень енерговитрат добової фізичної активності вчителів з 2005 року (2818,78±38,32 ккал) до 2021 року

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(2804,03±20,77 ($F_{2005-2021}$ =14,049; p=0,000)) і закономірне зниження середнього значення показника енерговитрат добової фізичної активності під час дистанційної форми навчання (2412,34±21,08 ккал) на 13,96% порівнюючи із аналогічним показником під час традиційної форми навчання у 2021 році (2804,03±20,77 ккал), ($t_{of\text{-}line\text{-}\ on\ line}$ =34,913; p=0,000). **Висновки:** У динаміці досліджуваного періоду спостерігається зниження середніх значень енерговитрат добової фізичної активності вчителів з 2005 року (2818,78±38,32 ккал) до 2021 року (2804,03±20,77 ($F_{2005-2021}$ =14,049; p=0,000)). Середнє значення показника добових енерговитрат на фізичну активність під час дистанційної форми навчання (2412,34±21,08 ккал) на 13,96% є нижчим, порівняно із аналогічним показником під час роботи педагогів за традиційною формою навчання у 2021 році (2804,03±20,77 ккал), ($t_{of\text{-}line\text{-}\ on\ line}$ =34,913; p=0,000).

Ключові слова: фізична активність, професійне вигорання, педагогічні працівники, пандемія COVID-19.

Introduction

Problem Statement and Research Relevance

Human health is considered to be the most valuable national wealth, the preservation and strengthening of which is a matter of social importance. Unfortunately, the incidence of noncommunicable diseases is increasing among the population. Almost 84 % of all deaths in Ukraine are caused by cardiovascular diseases, diabetes, cancer, chronic obstructive pulmonary disease and mental health disorders. Most noncommunicable diseases are associated with behavioral factors, one of which is insufficient physical activity (Indeks Zdorovia. Ukraina – 2019: Rezultaty zahalnonatsionaloho doslidzhennia, 2020).

Therefore, in the system of preventive measures aimed at strengthening and preserving the population's health, physical education, maintaining an optimal movement regime in combination with a rational diet and a healthy lifestyle are significant and effective methods. Today, the low level of physical activity is associated with the use of mainly passive forms of recreation, leading a sedentary lifestyle at home and at work (WHO guidelines on physical activity and sedentary behavior. Geneva: World Health Organization, 2020).

This situation occurs in different countries. Thus, at least 40 % of Singaporeans do not meet the daily norm of physical activity (Chew et al, 2021). The effectiveness of multi-level lifestyle interventions to increase physical activity has been established. A conclusion was made regarding the need to apply elements of technology, behavioral economics, gamification, marketing, and communications. Similar results were obtained in another study (Latorre-Román et al, 2020). A decrease in the level of physical activity in the population of Spain is associated with a deterioration in the quality of life and an increase in morbidity from the cardiovascular system.

The analysis of the physical activity level in the population of rural areas of South Africa was carried out in the work of Chikafu H. et al. (2020). Weekly physical activity amounted to more than 15 hours. Gender differences were established: the activity of men was 37 % higher than that of women.

The low level of physical activity in the population of the Persian Gulf countries was stated in the work of Pearson F. et al. (2020). At the same time, there is a high prevalence of overweight, obesity and diabetes. The authors suggested to develop complex programs of improvement, in which data on the volume of motor activity, anthropometric indicators and severity of risk factors for chronic diseases should be used as necessary information.

In the context of anti-epidemic measures introduced by countries during the COVID-19 pandemic, caused by the SARS-CoV-2 coronavirus, the prevention of noncommunicable diseases is under threat. Prevention of diseases, both infectious and non-infectious at the individual level, is the fifth operational function of public health, which was adopted in 2012 by the European Regional Office of the WHO as part of the public health development and the "European Action Plan for Strengthening Public Health Capacities and Services" (Slabkyi et al., 2017).

WHO defines the European Region as having the highest rates of noncommunicable morbidity and mortality of any region in the world. The restrictive measures introduced during the COVID-19 pandemic have complicated the process of maintaining the required level of physical activity. The level of physical activity (PA) has significantly decreased due to the cessation of the usual mode of motor activity, which leads to an increase in the risk of obesity and development of diabetes and cardiovascular diseases (Kluge et al., 2020).

Therefore, it is natural that the COVID-19 pandemic caused a new wave of actualization and popularization of PA, due to the need to recover from an infection and rehabilitate patients with post-coronavirus syndrome, focusing attention on preventing the side effects of anti-epidemic measures due to the spread of the coronavirus disease (COVID-19), in particular increasing physical activity in the conditions of a pandemic (2021 Physical Activity Factsheets for the European Union Member States in the WHO European Region, 2021; Spruit, 2020).

The relevance of conducting a study of physical activity in conditions of social isolation, especially in people with a sedentary lifestyle, is confirmed by the need for the implementation of the Sustainable Development Goals, namely the achievement of the third Goal: "good health and well-being" and the implementation of the new Global Action Plan for increasing the level of physical activity for 2018-2030, which presents four strategic goals and 20 specific recommended policy measures for the implementation by member states, international partners and WHO of activities to increase physical activity worldwide (WHO guidelines on physical activity and sedentary behavior. Geneva: World Health Organization, 2020). A number of issues need to be clarified: what is the relationship between PA and professional activity, how does the amount of PA change over time with changes in the social conditions of life, what is the structure of daily PA by categories, what factors influence the educators' PA?

Today, a significant problem for most developed countries is the increase in the contribution of hypodynamism to the lifestyle of the population due to professional activity (Castillo-Retamal et al., 2011; Wang et al., 2019). According to research by Tremblay et al (2017), a sedentary lifestyle can be defined as an activity with energy expenditure ≤ 1.5 units of metabolic equivalent (MET), which corresponds to work in a sitting and lying position.

Sedentary behavior is common among the adult population in Ukraine, which takes, on average, from 218.2 minutes in rural areas to 245.5 minutes in cities every day (Doslidzhennia STEPS, 2020).

According to Prince et al (2019), working adults spend 60 % of their time per day on sedentary activities, both during professional activities and during leisure time. In addition, it has been proved that a sedentary lifestyle at work is also reflected in the choice of a form of recreation. In their free time

from work, educators choose sedentary forms of activity, in particular: watching television programs, browsing social networks (Castillo-Retamal et al., 2011). Therefore, the introduction of programs to increase physical activity must be carried out directly at the workplace, as evidenced by the research of French scientists Smith et al (2016), Genin et al. (2018).

The existence of a relationship between motor activity and cognitive abilities of elderly people was studied in the work of Krell-Roesch et al. (2021). The results of a longitudinal study confirmed that a high intensity of motor activity in old age slows down the rate of cognitive abilities deterioration. Similar conclusions were drawn in another study (Wade et al., 2020). It has been confirmed that aerobic fitness classes are positively associated with the improvement of cognitive functions in physically healthy adolescents and youth without metabolic disorders.

National strategies to contain the COVID-19 pandemic have led to restrictions on normal daily activities. Numerous scientific studies prove a decrease in the level of physical activity during the pandemic (Yang et al, 2020; Ráthonyi et al., 2021). Thus, in studies of motor activity by Taeymans et al. (2021) in the working adult population of Europe during the pandemic, a higher average duration of daily sitting (more than 8 hours during the day) was established in 36.1 % of respondents and a lower average of up to 9 units of median total MET minutes per week. In addition, scientists have proved the positive impact of dosed physical activity on mental health during the COVID-19 pandemic, in particular, at least 270 minutes of moderate-intensity exercise per week (Nie et al., 2021).

The global outbreak of the pandemic became the impetus for finding the ways to overcome critical problems in the field of education, related to the health and safety of educational process participants, economic issues and difficulties in fulfilling professional duties, technostructure and modernization of educational facilities (Li et al., 2021).

There are also research findings that demonstrate a higher risk of hospitalization during SARS-CoV-2 infection in individuals who violate WHO recommendations for physical activity (Sallis et al., 2021; Després 2021).

Analysis of teachers' professional PA indicates a predominantly sedentary lifestyle at the expense of direct professional activity (Bogaert et al., 2014; Kalynychenko, 2021). A study of teachers' PA before the COVID-19 pandemic proves its dependence on the profession. Thus, according to Pavlova's research (2012), physical education teachers had the highest level of energy expenditure, which was 22 181 MET-min/week. In contrast, basic health teachers spent only 13 565 MET-min/week, and their level of physical activity was the lowest. The level of energy expenditure among physical education teachers was high not only due to significant physical activity at the workplace (the indicator of energy expenditure at work is 10 872 MET-min/week), but also due to the fact that they spent their free time actively (running, aerobics, volleyball, swimming, etc.) and devoted more time to housework or worked longer in the yard (energy expenditure index 6 612 MET-min/week) (Pavlova, 2012). The study of pedagogical workers conducted by S.Y. Agha, S.A. Al-Dabbagh has proved the predominance of their high level of PA (56.8 %). At the same time, it was established that teachers aged 15-29 years (42.3 %) were more active compared to teachers aged 30-44 years (37%) and 45-64 years old (37.8 %). The analysis of the amount of time spent by teachers sitting proves that teachers with a low level of PA spent more than 10 hours sitting (47.2 %), up to 4.5 hours were spent by teachers with a high level of PA (49.4 %) (Agha et al, 2012).

In the conditions of COVID-19 pandemic, a transformation of the teachers' lifestyle took place (Latina 2020; Parra et al., 2021), in particular, the duration of work at the computer increased (Fleming, 2020), and the share of a sedentary lifestyle increased (McClintok, 2021). The need to work online for up to 4 hours a day has led to undue stressors and increased demands on physical health (Trinidad, 2021). One of the most serious consequences of long-term professional stress is the syndrome of "professional burnout" (PB).

Based on the analysis of approaches to the study of the "professional burnout" syndrome, this syndrome was defined as a stress reaction that occurs as a result of the long-term professional stresses of medium intensity (Latina, 2020; Kalynychenko et al., 2021).

Based on the results of the assessment of teachers' physical activity during the COVID-19 pandemic, it was established that 38.34 hours per week were spent on professional duties, 80 % of teachers exercised at home for 4.12 hours per week, 57.39 % of teachers walked for 1.69 hours (Aperribai et al., 2021).

Thus, at the stage of modern social transformations caused by the COVID-19 pandemic, a sedentary lifestyle is a threat to the development of passivity, increasing the risk of developing non-infectious diseases and can be one of the manageable factors to overcome the dangers of future pandemics (Ramirez Varela et al., 2021).

Purpose: to assess the educators' physical activity in the conditions of social isolation during the Covid-19 pandemic with the use of data on daily energy costs in the dynamics of 16 years.

Material and Methods of the research

Participants. The research summarizes the results of scientific observation of 925 teachers of preschool and general secondary education institutions (436 people – in 2005, 404 people – in 2018, 85 people – in 2021), thus using the hypothesis about the significant influence of professional activity and social factors, related to the conditions of the distance learning on the teachers' physical activity. The contingent of respondents was made up of women, who form the vast majority of the teaching staff at the education institutions.

Age composition of the participants of the scientific observation: I age group (I AG) up to 31 years old – 165 people (17.84 %), II age group (II AG) 31-40 years old – 271 people (29.30 %), III age group (III AG) 41-50 years old – 253 people (27.35 %), IV age group (IV AG) older than 50 years – 236 people (25.51 %).

Among the teachers – 690 people (74.59 %) were residents of the regional center, 207 (22.38 %) – district centers, 28 (3.03 %) – residents of rural areas.

The study was conducted in compliance with the principles of voluntariness, with a guarantee of human rights and freedoms protection, inviolability of physical and mental integrity, observance of the principles of justice and equality, with preliminary detailed information of the volunteers about the essence of the study in accordance with the "World Medical Association Declaration of Helsinki" (2008).

The study is a fragment of the research work of the Department of Public Health and Medical-Biological Foundations of Physical Culture of the Educational-Scientific Institute of Physical Culture of the Sumy State Pedagogical University named after A.S. Makarenko "Comprehensive study of the functional state, adaptive capabilities of the body and the risk of develop-

ing diseases in various population groups", state registration number 0120U100799 (01.2020 – 12.2025).

Procedure

The study lasted from 2005 to 2021, with three periods being distinguished (as of 2005, 2018 (before the start of quarantine measures) and 2021 – the period of remote work due to the coronavirus pandemic and introduced quarantine measures).

For the physiological and hygienic characteristics of the teachers' physical activity, we used: 1) analysis of the materials of the teachers' questionnaire survey according to the specially developed "Chart of formalized self-report on physical activity"; 2) determination of teachers' energy consumption by tabular-timing method.

The formalized report made it possible, with the help of self-assessment of the time spent during the day on different (by intensity) categories of PA, to determine the average daily energy expenditure and, according to the obtained data, to assess the level of PA, both for a specific person and for groups as a whole (Cale et al, 2006; Polka et al. et al., 2011).

The chart of the formalized timing self-report consisted of two blocks: the characteristics of the weekday and the description of the day off. Data from the timing self-report of each respondent were entered into a summary table by PA categories: background (basic), very low, low, medium, high, very high.

Energy consumption during performance of a certain type of activity was calculated by multiplying the energy "cost" of the type of work by its duration during the day. The amount of energy "cost" of each type of activity was used from previous scientific studies in the form of the MET indicator (metabolic equivalent of physical activity, as the amount of energy expenditure at rest, which approaches the amount of maximum oxygen consumption, which is 3.5 ml/kg/min (1.2 kcal/kg)). In the corresponding energy expenditure calculations, MET is a coefficient (Metabolic equivalent). Therefore, the use of MET allows to correctly compare energy costs between people with different body weights and to act as coefficients, which can be conditionally accepted as kcal/min.

In accordance with the energy "cost" of individual types of PA, a classification of PA categories by energy expenditure (Metabolic equivalent) was developed (Table 1).

The level of teachers' professional burnout was assessed according to V.V. Boiko's method "Diagnostics of the level of emotional burnout" (Raihorodskyi, 1998). PB was determined based on twelve symptoms. According to the sum of the points of each symptom, the high, average and low levels of PB were determined (110 points and less – low (1), 111-180 points – average (2), 183 points and more – high level (3)).

Statistical analysis

Descriptive statistics were used to determine the arithmetic mean (*M*), standard deviation (*S*), error of the mean (*m*) and estimate the probability of differences using a Student's *t*-test. Differences and associations were considered probable at a significance level of $p<0,05$. The obtained values of the Student's *t*-test were evaluated by comparison with the critical values (Antomonov, 2017). Quantitative values of the indicators were assessed for compliance with the normal distribution according to the Kolmogorov-Smirnov test. Distribution in samples of quantitative values of energy expenditure of physical activity (EE PA) in the period before the introduction of quarantine measures in 2005 (K-S $d = 0.062$; $p<0.15$), in 2018 (K-S $d = 0.045$; $p>0.20$), after the introduction of quarantine measures (K-S $d = 0.067$; $p>0.20$), point assessments of professional burnout symptoms before the introduction of quarantine measures in 2005 (K-S $d = 0.060$; $p<0.10$), in 2018 – (K-S $d = 0.056$; $p>0.20$), after the introduction of quarantine measures (K-S $d = 0.062$; $p>0.20$) testified to the compliance of the samples with the law of normal distribution. Nominal and ratio variables were described as percentages. For nominal variables (nomenclature scales), the relationship was calculated according to conjugation tables using the Pearson's χ^2 test.

The significance of the difference between the mean values of dependent quantitative variables by groups of factors was determined using one-way (ANOVA) analysis of variance. Significance testing in analysis of variance was based on a comparison of variance due to between-group variance (MSeffect) and variance due to within-group variance (called mean squared error or MSerror). The obtained within-group variances can be compared using the *F*-test, which tests whether the variance ratio is indeed significantly greater than 1.

Dependent values were energy expenditure and duration of different categories of physical activity and assessment of professional burnout. Independent values were four age groups, work experience (group 1 – less than 10 years, group 2 – 11-20 years, group 3 – 21-30 years, group 4 – more than 30 years), levels of professional burnout.

Accumulation and systematization of the received data was carried out in Microsoft Office Excel spreadsheets. Statistical analysis was performed using the STATISTICA 10.0 pro-

Table 1. Classification of physical activity categories according to energy expenditure

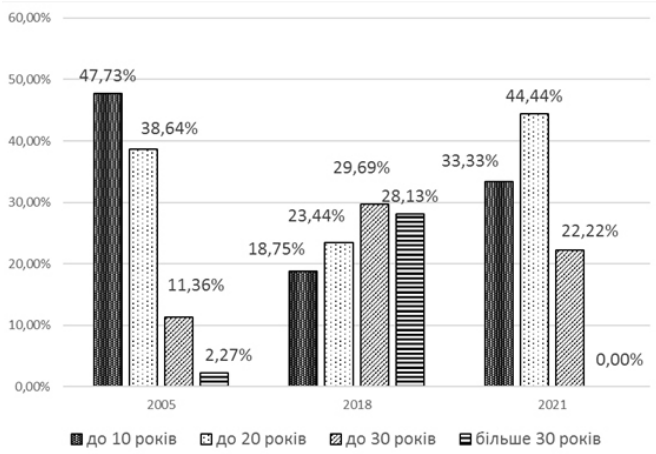
The intensity of physical activity (category PA)	Energy "cost" (MET)	Types of activity
Background (basic) (B)	0.9	Sleep
Very low (VL)	1.3	Checking notebooks, working with documents, preparation for lessons (sitting), communication with parents, transportation, eating, reading, watching TV, working with computer (including searching for Internet resources, moderating parent/student chats), advanced training courses, surfing social networks
Low (L)	2.6	Conducting lessons, preparation of visual aids, educational work with children, personal hygiene
Medium (M)	4.0	Walking at a fast pace, walking in the open air, household work
High (H)	6.0	Sports classes with intense physical activity

gram (developer – StatSoft.Inc).

Results of the research

One of the consequences of a teacher's intense work is professional burnout, which negatively affects the psychosomatic health of specialists. In general, among the respondents, 13.70±1.13 % of people have a high level of PB, 37.90±1.59 % have an average level, and 48.41±1.64 % have a low level. A high level of PB has the highest specific weight in the groups of teachers aged 30 to 40 and 40 to 50 years old (32.76±1.54 % and 26.72±1.45 %, respectively), compared to the groups of the youngest colleagues of the I AG (17.24±1.24 %) and senior colleagues of the IV AG (12.27±1.08 %).

Educators with a high level of PB are most often found in groups of people with experience up to 10 and up to 20 years (30.77±1.52 % in each group). The analysis of the distribution of PB among teachers in the temporal aspect was performed. In particular, in 2005, a high level of PB was found mainly among teachers of the II AG (47.73 %). In 13 years, the symptoms of the high-level PB prevailed among teachers of the IV AG (39.68 %), and during the period of online education, the burden of high-level PB was again registered among the teachers of the II AG (55.56 %). At the same time, the minimum specific weight of high-level PB was determined among teachers of the I AG and IV AG (11.11 % in each group).



less than 10 years, more than 30 years

Fig. 1. Distribution of teachers with a high level of professional burnout by work experience by specialty (%)

Confirmation of such a tendency can be found by analyzing the distribution of teachers with a high level of PB by work experience (Fig. 1). In 2005, a high level of PB was most often found among teachers with less than 10 and up to 20 years of work experience, and it is these groups that include individuals of the I AG and the II AG. The period of education modernization, widespread introduction of information technologies in the period until 2018 was accompanied by an increase in the number of respondents in groups of teachers with experience of up to 30 years and more than 30 years.

The results of variance analysis for the average values of the energy expenditure of daily physical activity (EE DPA) and the indicator of professional burnout of teachers as a whole allowed to establish a statistically significant effect of the age of teachers only on the indicator of EE DPA in the period before the introduction of quarantine measures (F=3.47; p=0.016).

Taking into account the different social conditions for professional activity in connection with the introduction of distance education, the age characteristics of the investigated indicators were analyzed separately in different years.

In 2005, a probable dependence on age was established only for the indicator of the general PB syndrome (F=5.65; p=0.0008). According to the variance analysis of the 2018 indicators, a probable influence of the age factor on the average values of the energy expenditure of the daily PA was recorded (F=3.25; p=0.022).

However, in 2021, under the condition of blended learning using *online* mode, no age-specific characteristics of the average values of the studied indicators were found (p=0.358 – 0.676).

In the range of sixteen years of observation, a probable connection with the place of residence existed only in 2005 according to the average value of the indicator of the general PB syndrome with a predominance among teachers of the regional center (113.95±50.01 c.u.) compared to teachers of rural areas (76.53±45.70 c.u.; F=9.668; p = p<0.001).

A tendency towards a decrease in the average values of energy expenditure of teachers' daily physical activity from 2005 (2818.78±38.32 kcal) to 2021 (2804.03±20.77 (F2005-2021 =14.049; p<0.001)) and a natural decrease of the indicator of EE DPA during the distance learning (2412.34±21.08 kcal) by 13.96 % compared with the similar indicator during the traditional form of learning in 2021 (2804.03±20.77 kcal), (t offline – online =34.913; p<0.001) were revealed.

All components of teachers' daily physical activity (except for a low level) depended on the time of observation, which is confirmed by the statistical characteristics of variance analysis (Table 2).

The dependence of DPA on the level of teachers' PB was revealed, namely: in all years of observation, a low average indicator of energy expenditure of DPA was recorded in persons with a high level of professional burnout (Table 3).

Probable differences were established for the indicators of EE DPA in 2021, when the educational process was car-

Table 2. Indicator of the duration of the components of teachers' daily physical activity in the dynamics of the observation period (min), (M±m)

Components of daily physical activity	Years				F (for off-line)	p (for on-line)
	2005 n=436	2018 n=404	2021			
			offline n=85	online n=85		
Back-ground level	436,17±3,37	421,25±3,11	402,07±5,38	402,07±5,38	12,317	p<0,001
Very low level	419,48±9,03	463,62±5,62	521,35±7,89	774,41±8,76	22,319	p<0,001
Low level	349,09±7,74	351,88±5,12	319,26±8,15	42,08±1,49	2,636	0,072
Medium level	225,39±7,77	189,98±3,95	197,14±6,47	197,14±6,47	9,902	p<0,001
High level	11,95±1,32	13,69±1,21	24,29±2,23	24,29±2,23	8,929	p<0,001

Table 3. Indicators of daily energy expenditure of teachers with different levels of professional burnout syndrome according to the tabular-timing method (kcal/min), (M±σ)

Levels of general symptom of professional burnout	Years			
	2005	2018	2021	
			offline	online
Low (1) *n*=410	2804,75±667,86	2730,467±262,58	2868,134±190,31 t_{1-2}=2,605; *p*=0,011	2483,505±175,75 t_{1-2}= 2,766; *p*=0,007
Average (2) *n*=321	2872,231±821,31	2773,754±225,06 t_{2-3}=2,006; *p*=0,046	2759,645±172,17	2367,011±1,18
High (3) *n*=116	2754,320±638,76	2705,481±224,80	2720,722±209,68 t_{1-3}= 2,051; *p*=0,046	2303,278±195,12 t_{1-3}= 2,535; *p*=0,014

ried out in a blended form and the duration of very low physical activity in the online mode (774.41±8.76 min) exceeded by 32.68 % the duration of the similar component in the offline mode (521.35±7.89; *t*=24.48; *p*<0.001).

Discussion

Increasing physical activity is an effective tool for population health management. However, there are certain problems of motor activity regulation. Siedler et al (2021) analyzed 95 guidelines published since 2000 that included recommendations for physical activity to improve general health and prevent cardiometabolic diseases. It was concluded that most of the recommendations on physical activity were not specific enough for practical implementation. The overall quality of the manuals improved over time, but the lack of specificity of the recommendations remained.

It is well known that physical activity is an integral part of a person's lifestyle and reflects a socially motivated attitude of a person to an active lifestyle. In everyday life, the usual PA often does not meet the biological needs of the body in movement, which contribute to health strengthening and preservation.

The tasks of the work included the use of the method of timing self-report on daily physical activity with subsequent calculation of energy expenditure.

These methods are widely used in population health monitoring. Thus, in the work of Chen et al (2021) physical activity was measured in metabolic equivalents using the International Physical Activity Questionnaire (IPAQ). It was concluded that meeting moderate and vigorous physical activity recommendations in adults was associated with a reduced likelihood of liver dysfunction in both urban and rural Chinese populations.

Special questionnaires for analyzing the level of motor activity were used in works (Rai et al, 2020; Jacob et al, 2020; Chen et al, 2021). The use of such assessment tools makes it possible to differentiate the levels of motor activity of the respondents, to establish the dependence with health and lifestyle features, to identify the factors with the greatest impact on health.

Distance education has fundamentally changed the teacher's work: the requirements for mastering a computer and software components have increased, the stressful nature of work has increased, and the peculiarities of communication with students and parents have arisen. Adaptive reactions of the body to online learning emerged in the form of PB in a group of young teachers with less than 10 years of experience and up to 20 years of experience. In the group of teachers with more than 30 years of experience, there were no individuals with a high level of PB. Probably, it is caused by the peculiarities of personnel provision of the educational process with a decrease in the number of teachers with considerable work experience.

In the study, it was established that energy expenditure of DPA is in a fairly wide range: from 2412.34±21.08 kcal to 2818.78±18.32 kcal and depends on many factors related to the life activities of the respondents. Nowadays, there are no common recommendations on PA regulation of the adult population. The obtained data coincide with the data of previous scientific studies by Agha et al (2012), Pavlova (2012), Parra et al (2021).

Several main areas of PA research can be identified: 1) study of functional changes in the body under the influence of PA; 2) determination of PA norms for different age and gender groups; 3) studying the energy characteristics of PA. Today, the direction of development of the methods of quantitative and qualitative assessment of PA remains relevant. The most widespread are: the method of pedometry, registration of energy expenditure, determination of the time spent during the day, week, month, year on all forms of physical activity, the ratio of dynamic and static components of muscle activity during the day, timing, pulsometry, the method of determining the sum of movements in linear indicators of locomotion, self-control (Polka et al, 2011; Kalynychenko et al, 2021).

In the European region, the term "health-enhancing physical activity" is widely used. As noted by experts of the Institute for Health Promotion Research, this definition emphasizes the connection of physical activity with health and means "any form of physical activity that promotes health and increases functional capabilities, but such that does not cause harm and not associated with undue risk" (Cavill et al, 2006).

According to the definition of WHO, physical activity is any movement of the body, which is carried out by skeletal muscles and is accompanied by energy expenditure. The term "physical activity" refers to any type of movement, in particular during rest, travel, and work. Improving health is facilitated by both moderate and intense physical activity (Hlobalni rekomendatsii shchodo fizychnoi aktivnosti dlia zdorovia, 2010).

We believe that analysis of the PA category should be conducted according to the concept of R. V. Sylla, the essence of which is that the regulation of the optimal amount of PA, which is a stimulus for the development of the body and strengthening of health, should be based on the duration of "useful" PA with an

increase in metabolism substances in 5-10 times, compared to the state of rest (with a pulse rate of 130-160 beats per minute) (Sylla et al, 1980).

The results of self-reporting on daily energy expenditure by teachers made it possible to determine that, on average, the specific weight of the time spent on physical exercises and independent sports activities in free time was 5.85 % (24.29±2.23 min per day) of the total daily time budget during quarantine measures in 2021. In previous years, the high level of DPA was lower: 11.95±1.32 min – in 2005 and 13.69±1.21 min – in 2018.

Widely known are WHO recommendation for adults to adhere to 150 minutes of moderate physical activity or 75 minutes of vigorous physical activity per week, or to combine moderate and vigorous physical activity. Therefore, it can be assumed that teachers in today's conditions are responsible for their health and increase the share of high-level PA in their daily time budget.

An interesting fact is the constancy of the indicators of the average intensity of DPA among teachers. We believe that the average intensity of motor activity consists of such types of motor activity as: household work, childcare, walking and walks in the fresh air. Their time share in the teachers' daily schedule has not changed because the conditions for performing these types of motor activity have not changed. The research was carried out during the third wave of quarantine measures and the teachers performed the types of activities inherent in the average level of intensity of motor activity, at their usual time, after returning from the education institution.

In 2005, among teachers with experience of 31 years and more, a probable predominance of a low level of PB (p<0.05) over the indicators of other groups of teachers by work experience was observed, which can be explained by the formed adaptation to the professional stressors of the working conditions of teachers with extensive experience in pedagogical work. In the following years, in our opinion, in connection with the intensification of the educational process and informatization, teachers with considerable work experience and older age groups performed professional duties with a significant strain of adaptation processes. However, the mechanisms of adaptation to new working conditions in the online mode allowed teachers of older age groups with considerable work experience to successfully provide the educational process without pronounced PB syndrome.

Analysis of the obtained data testifies to the formation of a high level of PB among younger teachers with the leading importance of the manifestation of the symptom complex of resistance in the teachers of the regional center, which is determined by a rapid emotional reaction, emotional and moral disorientation, expansion of the sphere of saving emotions, reduction of professional duties, which cannot not be marked on the level of pedagogical activity effectiveness.

Studies confirm the hypothesis of a connection between PB and DPA level. In particular, it was established that a decrease in the energy expenditure of DPA naturally accompanies the educational process in the online mode (especially in persons with a high level of PB) due to an increase in the time of a very low level of physical activity (774.41±8.76 min), a decrease in the dynamic component of the daily budget time due to low DPA level from 319.26±8.15 min to 42.08 ±1.19 min (t=33.47; p<0.001).

Conclusions

1. In the dynamics of the studied period, there is a decrease in the average values of energy expenditure of teachers' daily physical activity from 2005 (2818.78±38.32 kcal) to 2021 (2804.03±20.77) ($F_{2005\text{-}2021}$ =14,049; p<0,001)).

2. The average value of the indicator of daily energy expenditure for physical activity during the distance learning (2412.34±21.08 kcal) is lower by 13.96 %, compared to the similar indicator during the work of teachers in the traditional form in 2021 (2804.03±20.77 kcal), ($t_{offline - online}$ =34,913; p<0,001).

3. The body's adaptive reactions to online learning emerged in the form of PB in a group of young teachers with less than 10 years of experience and up to 20 years of experience. In the group of teachers with more than 30 years of experience, there were no individuals with a high level of PB.

4. In the conditions of the distance form of the educational process, a dangerous complex of the risk of psychosomatic diseases is formed, which consists of the formed syndrome of emotional professional burnout and low daily physical activity.

Author Contributions

Iryna Kalynychenko: – research design, data collection, statistical analysis, manuscript preparation.

Miroslawa Cieslicka: data collection, statistical analysis, manuscript preparation.

Hanna Latina: data collection, statistical analysis, manuscript preparation.

Mykhailo Antomonov: - research design, data collection, statistical analysis, manuscript preparation

Hanna Zaikina: statistical analysis, manuscript preparation

Conflicts of Interest

The authors declare no conflict of interest.

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Study of the psychomotor abilities of athletes in cyclic sports, martial arts and esports

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Abstract

Purpose: to conduct a comparative analysis of psychomotor abilities in athletes of cyclic sports (short track), martial arts (karate, taekwondo) and esports (CS:GO).

Materials, participants and methods: The study involved athletes of percussion martial arts (n=10, age 18,9±0,12, candidates for master of sports), elite players of semi-professional CS:GO teams (n=10, age 19,2±0,50), short track speed skaters (n=10, age 19±0,09, masters of sports). The choice reaction time, the frequency of local movements (60-second tapping test), and the reaction time to a change in the size of the object (Size-test) were determined.

Research results. Esports athletes have the best reaction time of choice and tapping test compared to other athletes. The wrestlers showed the best reaction to distinguishing the size of an object in the Size-Test. Skaters have high rates of complex reaction time and frequency of movements. The duration of the tapping test has a likely inverse relationship with the frequency of tapping.

Conclusions. It was found that esports athletes have a significantly better choice reaction time ($p<0,05$) than martial arts athletes. The results of short track skaters do not have significant differences with martial arts and esports athletes ($p>0.05$). The results of the tapping test in terms of the total number of movements and the average number for 5 s in esports athletes tend to be higher compared to short track speed skaters and martial arts athletes. The fastest response time to a change in the size of an object in the Size-test was shown by martial arts athletes, the slowest by short-track skaters. This reflects the trend towards better results of this type of reaction in martial arts athletes compared to short track speed skaters and esports athletes.

Key words: choice reaction time, tapping test, Size-test, martial arts, sports, short track

Анотація

Світлана П'ятисоцька, Вячеслав Мулик, Анатолій Губа, Наталія Долгополова, Андрій Єфременко, Яна Жерновнікова. Дослідження психомоторних здібностей атлетів циклічних видів спорту, єдиноборств та кіберспорту. Мета: провести порівняльний аналіз психомоторних здібностей у атлетів циклічних видів спорту (шорт-трек), єдиноборств (карате, таеквондо) та кіберспорту (CS:GO). **Матеріали, учасники та методи:** У дослідженні взяли участь атлети ударних видів єдиноборств (n=10, вік 18,9±0,12, кандидати в майстри спорту), елітні гравці напівпрофесійних команд з CS:GO (n=10, вік 19,2±0,50), ковзанярі шорт-треку (n=10, вік 19±0,09, майстри спорту). Визначали час реакції вибору, частоту локальних рухів (60-секундний теппінг-тест) та час реакції на зміну розміру об'єкту (Size-test). **Результати дослідження.** Кібератлети мають кращі показники часу реакції вибору та теппінг-тесту у порівнянні з іншими атлетами. Єдиноборці показали кращу реакцію на розрізнення розміру об'єкту у Size-test. Ковзанярі мають високі показники часу складних реакцій та частоти рухів. Тривалість натискань у теппінг-тесті має вірогідний зворотний зв'язок із частотою натискань. **Висновки.** Встановлено, що кібератлети мають достовірно кращий час реакції вибору ($p<0,05$), ніж атлети єдиноборств. Результати ковзанярів шорт-треку не мають достовірних відмінностей із атлетами єдиноборств та кібератлетами ($p>0,05$). Результати теппінг-тесту за загальною кількістю рухів та середньою кількістю за 5 с у кібератлетів мають тенденцію до більших величин у порівнянні з ковзанярами шорт-треку та атлетами єдиноборств. Найшвидший час реакції на зміну розміру об'єкту у Size-test показали атлети єдиноборств, найповільніший – ковзанярі шорт-треку. Це відображає

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тенденцію до кращих результатів даного виду реакції у атлетів єдиноборств у порівнянні з ковзанярами шорт-треку та кібератлетами.

Ключові слова: час реакції вибору, теппінг-тест, Size-test, єдиноборства, esport, шорт-трек

Introduction

The psychophysiological functions of a person depend on the characteristics of the nervous system. They characterize the process of formation and improvement of special motor skills in the conditions of sports activity (Korobeinikov et al., 2012). Psychomotor abilities determine the coordination of motor actions with nervous processes and determine the ability of athletes to perform high-quality motor actions (Lyzohub et al., 2021). The time of sensorimotor reactions is one of the simplest, most accessible, and at the same time quite accurate neurophysiological indicators that reflect the dynamics of nervous processes and human motor coordination (Rovnyiy & Romanenko, 2016). At the same time, motor activity in different sports determines the features of the manifestation of sensorimotor abilities. It is customary to distinguish sports with a cyclic structure of movements (running, swimming, cycling, speed skating, etc.), acyclic (situational sports, in particular, sports and martial arts), as well as such specific types of sports activities that are not related to physical activity. (chess, go, sports poker, esports).

One of the characteristic representatives of cyclic sports is short track - it is a dynamic and high-speed sport. Short track racing is a direct competition held over several series. In each series, the rank by which the athlete is qualified for the next round is important, not the time. One of the most important performance indicators for athletes in short track is neuromuscular conduction and the associated dynamics and speed of muscle response (Felser et al., 2016). Then the whole race is full of dynamic accelerations to get a higher rank or defend your position in the current race. The race ends with a dynamic acceleration to the finish line (Menting et al., 2019). The performance of motor actions of elite athletes under other almost identical conditions - the speed of movement, strength, technique, conditions on the ice, equipment are similar, and the performance may differ by milliseconds. Therefore, at the beginning of the race, it is especially important to take an advantageous position and be the first to start moving at the start. As in other cyclic sports, simple reaction time plays an important role in short track speed skating (Noorbergen et al., 2016). The researchers note that “reaction time to peripheral stimuli increases as race tension increases and situational demands increase”, which affects on-ice safety even in the face of ever-changing ice conditions, as well as distractions such as visual tracking of others skaters while drafting or watching the coach’s signals from the side (Konings & Hettinga, 2018). Therefore, when solving strategic problems during the race, the complex reactions of athletes also play an important role (Podrigalo, O. et al., 2019).

The success of competitive activity in martial arts is closely related to the speed of response in conditions of increased mobility of an athlete and dynamic variability of the situation (Podrigalo, L. et al., 2022). At the same time, the athlete’s performance is determined by the level of mastery of technical techniques and tactical readiness (Veretelnykova et al., 2022). The adequacy of reactions of psychophysiological functions to training or competitive loads can be an indicator of both the level of preparedness of an athlete and the development of fatigue and overstrain processes in him (Podrigalo, L. et al., 2019). Training and competitive activities in martial arts contribute to the formation of a whole complex of specific reactions and perception abilities in athletes (Lyzohub et al., 2021; Iermakov et al., 2016). They are based on the threshold of perception of stimuli entering different sensory systems. The main role is played by the levels of musculoskeletal, visual, vestibular and auditory sensations. The higher the level of sportsmanship of an athlete, the more important is the development of psychophysiological functions to achieve a competitive result (Podrigalo, L. et. al., 2022). The level of complex sensorimotor reactions is of great practical importance for martial arts athletes. A high level of manifestation of sensorimotor reactions allows you to quickly master the technical and tactical actions, effectively solve the tasks in a competitive duel.

Separately, it is necessary to consider sports in which competitive activity is not associated with physical activity. One of the new sports in this category is esports, in which the competition takes place in a virtual environment (Pluss et al., 2020). To achieve victory, the player must quickly and accurately control the game character in the virtual space using the keyboard, computer mouse or joystick (Campbell et al., 2018). It should be noted that, unlike intellectual games, success in e sports is associated with the development of psychomotor abilities, cognitive functions and the speed of sensorimotor reactions of players. Researchers argue that there is a connection between individual manifestations of these abilities and the ability to solve game problems with maximum speed and efficiency (Pluss et al., 2020). In esports, both specific and general components of motor activity play an important role. Experienced video game players outperform amateurs on a variety of cognitive and perceptual tasks, including visual selective attention (Leigh & Clark, 2022), visual stimulus detection, visual search efficiency, contrast sensitivity, cognitive flexibility, visual conciseness (Bediou et al., 2018), and attention switching and multisensory integration (Di Luzio et al., 2021).

Thus, the researchers note the extremely important role of psychomotor abilities for the implementation of effective competitive activity. Therefore, the study of the features of the manifestation of psychomotor abilities in athletes with different types of competitive activity is an important area of scientific research.

Purpose of the study: to conduct a comparative analysis of the psychomotor abilities of elite athletes in cyclic sports (on the example of short track), martial arts (on the example of karate and taekwondo) and eSports (on the example of the CS:GO discipline related to the first-person shooter genre).

Material and Methods of the research

This study was approved by the Bioethics Committee for Clinical Research and conducted according to the Declaration of Helsinki (protocol of the Commission on Bioethics of the Kharkov State Academy of Physical Culture No. 38).

Participants: the study involved 30 middle-aged athletes (19±0.24) years old, divided into groups according to the sport. Group 1: athletes of percussion martial arts, n=10, age (18.9±0.12) years, candidates for master of sports. Group 2: elite players of semi-professional CS:GO teams, n=10, age (19.2±0.50) years. Group 3: short track speed skaters n=10, age (19±0.09), masters of sports.

Methods. Using special programs for tablet computers running iOS, developed at the departments of martial arts, computer science and biomechanics of the KSAPC, the following manifestations of the psychomotor abilities of athletes were

studied: 1) choice reaction time; 2) frequency of local movements (60-second tapping test); 3) Size-test.

The evaluation of the *choice reaction* among static objects was carried out using the following test: the subject must respond to one given signal out of 5 proposed (12 attempts). In case of an incorrect reaction, an error is counted. If the subject scores more than 3 errors, the program offers to take the test again. The test result includes the average value of the 10 best attempts, the value of the Shapiro-Wilk criterion, the number of errors.

Assessment of the frequency of local movements (60-second tapping test). To assess the strength of nervous processes, namely the frequency of movements, the TappingPro program was used. The study used a test duration of 60 seconds. The program allows, along with determining the number of clicks (in each 5 second interval), to record the duration of the clicks, which is very important for additional characterization of the dynamics of nervous processes.

Size test. Evaluation of the speed of interaction between the visual analyzer and the neuromuscular apparatus, the ability to respond to the moment of removal or approach of an object. The subject needs to respond to a change in the size of the object (square). The test can be run in three modes:

"Increase" – object increase;

"Decrease" – object decrease;

"In/De", where the object can both increase and decrease. An early reaction is considered a mistake. If the subject scores more than 3 errors, the program offers to take the test again. The velocity of the object size configuration is 0,002 m/s. The test result includes: average of the best 10 attempts, Shapiro-Wilk test, number of errors.

Statistical processing of the research results was carried out using the Statistica 13 program, the following methods were used: descriptive statistics, checking the compliance of the distribution of the sample population with the normal law according to the Shapiro-Wilk criterion, testing statistical hypotheses using the Mann-Whitney criterion, analysis of variance using the Kruskal-Wallis criterion, correlation by Spearman criterion.

Results of the research

A study of the choice reaction time allowed us to establish that this indicator for esports athletes is 1,4% less (better) than short-track skaters ($p>0,05$), and 7,98% for martial arts athletes ($p<0,05$). The verification of compliance with the normal distribution of populations was carried out using the Shapiro-Wilk test. This criterion is highly sensitive and helps to identify deviations from the normal distribution already at $n\geq10$. It was found that the distribution in each of the three groups corresponds to the normal $\alpha=0,05$ (Table 1).

The significance of differences between the reaction times of the three groups of athletes was tested using the Kruskal-Wallis test. It was found that at least 2 study groups have significant differences ($H=6,17$, $p<0,05$). This necessitated a subsequent verification by the Mann-Whitney criterion. There was a significant difference between the reaction time indicators of esports athletes and martial arts athletes ($Z=2,38$, $p<0,05$). There were no significant differences between the results of short track speed skaters with esports athletes ($Z=0,72$, $p>0,05$) and martial arts athletes ($Z=1,62$, $p>0,05$).

Comparison of the total number of local movements and the average number of clicks in 5 s showed that esports athletes have the highest result of all three groups, however, these differences are not significant ($p>0,05$). The greatest range of variation is observed in the group of short track skaters, although the group is homogeneous in terms of skill level (Table 2).

The smallest range of variation was found in the group of martial arts athletes, which indicates a lower variability of the results within the group (Figure 1).

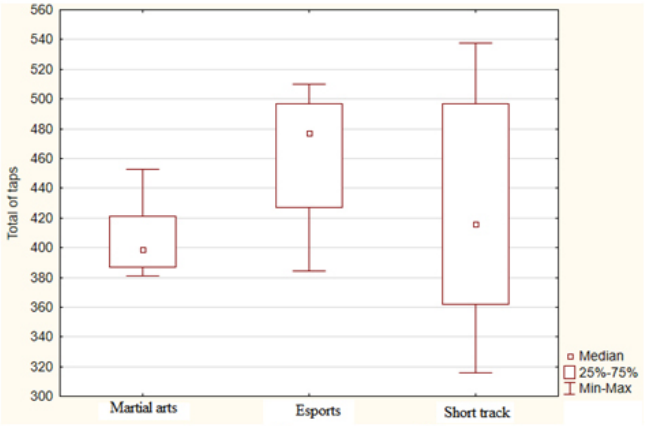
Analyzing the dynamics of the frequency of movements of athletes of cyclic types and martial arts, we can conclude that the number of local movements in each group tends to decrease from the 1st to 5-6 stages, then the graphs enter the stabilization stage. In esports athletes, the highest frequency is observed at the beginning of the test, by the 3rd stage it slightly decreases, then from 3 to 5 the stage increases, and the frequency stabilizes from stage 7 until the end of the test. In

Table 1. Choice reaction time test results

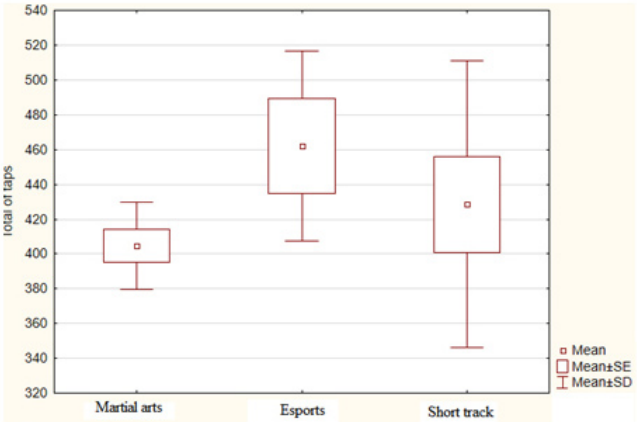
Indicator	Sports specialization	$\bar{X}\pm m$	Me	σ	v	Shapiro-Wilk
Choice reaction time, ms	martial arts	655,5±21,3	665,4	73,68	11,24	0,86
	esports	607,1±8,8	579,1	55,94	9,22	0,91
	short track	617,6±17,3	607,9	54,58	8,84	0,96

Table 2. Results of testing the frequency of local movements according to the 60-second tapping test

Indicators	Sports specialization	$\bar{X}\pm m$	σ	v
Average number of clicks per 5 s	martial arts	33,7±0,9	2,11	6,27
	esports	38,5±2,6	4,55	11,81
	short track	35,7±2,4	6,86	19,21
Total number of clicks in 60 s	martial arts	404,7±10,3	25,12	6,21
	esports	462,0±31,5	54,58	11,81
	short track	428,4±29,1	82,42	19,24



a) median, quartiles



b) average, standard deviation, standard error

Figure 1. Comparison of three groups of athletes by the range of variation

martial arts athletes, the highest frequency of movements is observed at 1-4 stages of the test, then there is a decrease in frequency and stabilization by the end of the test. Short track skaters showed the highest frequency of movements from stages 1 to 5, then the frequency decreased slightly and remained at the level of stages 3-4 (Figure 2).

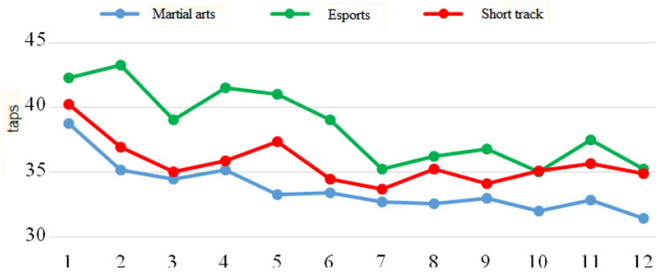


Figure 2. Dynamics of movement frequency during the test

For a qualitative analysis of the test results, the average duration of clicks is also observed at each stage of the test. The duration of clicks has a has a reverse relationship with the frequency of clicks (the correlation ratio from -0,46 to -0,83). As can be seen from the schedule (Figure 3), with an increase in the stage, the duration of clicks tends to increase due to fatigue. The smallest time of clicks is observed in a group of esports athletes, the largest short tracks.

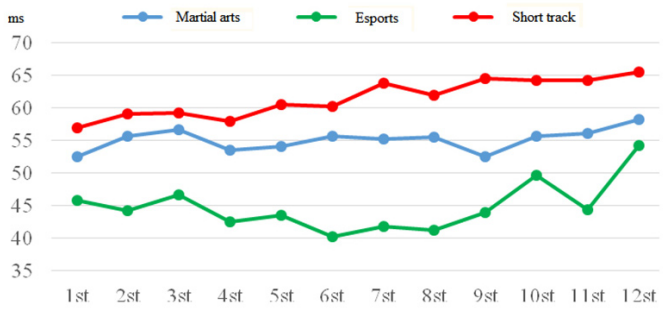


Figure 3. The average duration of clicks at the stages of the test

During the implementation of SIZE-Test, the reaction time to a change in the size of the object was recorded. The fastest reaction was shown by the athletes of martial arts, the slowest athletes of the short track. Checking the conformity of the normal distribution of electoral aggregates was made using the criterion of the Shapiro-Uylka. It was established that the distribution in each of the three groups corresponds to normal at α = 0,05 (table 3). However, in the group of martial arts and esports athletes there was a shift in the median towards an increase relative to the distribution center (Figure 4).

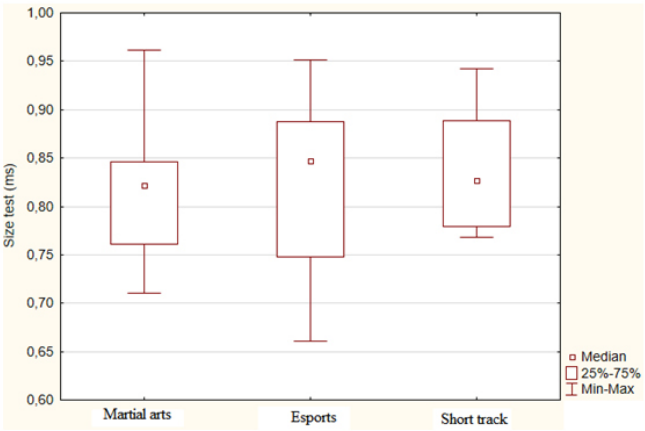


Figure 4. Comparison of the results of the Size-test performance of different specializations athletes

Testing of the statistical hypothesis about the reliability of differences between the results of athletes of different special-

Table 3. Size-test test results

Indicator	Sports specialization	$\bar{X}$±m	Me	σ	v	Shapiro-Wilk
Reaction time, s	martial arts	0,816±0,028	0,822	0,080	9,86	0,96
	esports	0,828±0,028	0,847	0,090	10,87	0,96
	short track	0,836±0,021	0,827	0,064	7,64	0,88

izations was carried out according to the Kruskal-Wallis criterion, no significant differences were found (H=0,37, p>0,05). According to the scattering characteristics, the groups also did not have significant differences, in all groups a high degree of uniformity (within 10%) was observed.

Discussion

The study of the functional capabilities of the central nervous system in terms of the speed and accuracy of performing a visual-motor test is a method with a high level of sensitivity. It allows you to identify the magnitude of functional shifts in dynamically changing sports situations. In this case, the response time to simple sensory stimuli will reflect the functional state of the central nervous system (Veretelnykova et.al., 2022). By the magnitude of the latent period, one can judge the functional state of the body and the lability of the central nervous system (Podrigalo, LV, et. al., 2019; Romanenko et. al., 2020; Korobeynikov et. al., 2021)

The design variant used - comparing the characteristics of athletes from different sports is widely used in sports science (Podrigalo, OO, et al., 2019; Grushko et al., 2021). Psychophysiological research allows to identify the factors that are important for effective selection in certain sports. The results reflect the specific impact of the sport on the body of athletes (Podrigalo, OO, et al., 2019). Grushko et al. (Grushko et al., 2021) conducted a comparative analysis of the perceptual-cognitive abilities of semi-professional esports athletes and professional football and basketball players. Esports athletes and athletes performed equally well on complex tests measuring attentional control, short-term and working spatial memory, attention distribution, reaction time, and hand-eye coordination. Esports athletes outperformed athletes in visual search speed. These data support the idea that esports and traditional team sports require the same level of perceptual-cognitive ability from professionals and can provide similar cognitive benefits and hand-eye coordination. The researchers also argue that perceptual-motor abilities may underlie professional esports prowess (Deleuze et al., 2017; Pluss et al., 2020).

The choice reaction is defined as the ability of a person to choose the most appropriate motor response to various visual signals in the shortest time (Rovnyiy & Romanenko, 2016). As a result of the study, it was found that the reaction of choice is a very important type of reaction for athletes of the chosen specializations. An analysis of the manifestation of the reaction of choice showed that martial artists are of greater importance compared to other specializations. Also, the indicators of martial arts athletes have the greatest variability. This can be explained by the fact that martial arts athletes of different manners and styles of fighting took part in the study. Another study (Tropin et.al., 2021; Romanenko et.al., 2022) proved that representatives of different manners, fighting styles and weight categories have different levels of its manifestation. Comparison of the results of martial arts athletes with the previously established model characteristics (Rovnyiy & Romanenko, 2016) showed that the results of qualification athletes, candidates for the master of sports, have an average level within the established standards.

Esports athletes showed the best indicators of choice reaction time in three sports specializations. In our opinion, this is due to the peculiarities of the esports disciplines in which the studied players specialize, namely CS:GO and DOTA 2. Competitive activity is to localize the position of the opponent as quickly as possible and eliminate him. In this case, the players use the keyboard and mouse to control the activities of the game character and all operations to achieve victory. The selectivity of their reaction consists in identifying a player of the opposing team and applying a technique that is adequate to the situation (Bediou et al., 2018). Esports players must anticipate the stimulus from the opponent and respond to it as quickly and accurately as possible by manipulating the keys or joystick. Pluss et al. note that for success in esports, developed perceptual-motor abilities are necessary, since successful control of the keyboard and mouse is one of the most important factors for victory (Pluss et al., 2020). Playing computer games requires higher perceptual, attentional, cognitive and fine motor skills (Sousa et al., 2020). For example, in games, visual information displayed on the monitor and auditory information through headphones can be stimuli. So, perceptual-motor abilities can underlie professional skills in esports (Pluss et al., 2020).

Experts note the exceptional importance of control and development of reaction time in different sports (Campbell et al., 2018; Konings et al., 2008; Podrigalo, OO, et al., 2019; Sousa et al., 2020). Biofeedback methods have been proven to be effective in improving the performance of professional athletes in many sports (Podrigalo OO, et al., 2019; Grushko et al., 2021). In short track skating in particular, the fastest starting reaction combined with the starting technique, starting power and acceleration gives a significant advantage to the athlete. Short track speed skating is influenced by several factors, including reaction time and speed during sprints, muscle strength and endurance during long distance skating, style of skating over different distances, mental focus for constant attention during competitions (Noorbergen et al., 2016). All of the above factors are related to each other and have a mutual influence. For example, factors related to reaction time and speed are combined with muscle strength and indicate plyometric strength index (Menting et al., 2019). Also, factors that take into account the length of the sliding time are combined with factors regarding the speed and direction of repulsion, and are an indicator of technical readiness (Konings et al., 2016). Konings and Hettinga (Konings & Hettinga, 2018) suggest that developing reaction time abilities in skaters will improve both speed and safety during the race.

In most sports, neuromuscular evaluation plays a very important role in achieving better performance (Chaabouni et al., 2022). Indeed, physical exercise is associated with various physiological changes and neuromuscular adaptation aimed at identifying factors that limit performance. Many tests have been used to examine neuromuscular responses in the upper and lower extremities, allowing a simple and rapid assessment. The finger tapping test is a neuropsychological test that assesses movement speed and motor control. Based on the results of this test, you can evaluate the properties of the nervous system [Hubel et al. 2013].

An analysis of the results of the frequency of local movements of the hand showed that among the athletes of the three groups of sports, esports athletes have the best result, and also show a shorter duration of touch during the test. It has been established that the characteristic features of highly qualified athletes of various sports specializations are a high level of development of sensory-motor reactions with little variability within groups (V<12%). This once again confirms the assumptions made on the adequacy of the study of psychomotor properties for the analysis of the state of athletes in these sports. High rates of frequency of local movements were also determined, with somewhat greater variability within groups (V<20%).

High results in the tapping test among esports athletes are

due to the fact that during the game they analyze a different number of stimuli and perform complex actions with their fingers. This allows for the creation of a smooth, coordinated action and minimizes the number of erroneous decisions that could harm his desired goals. Some studies have shown that people who play video games may have faster response times but lower accuracy in some measures of executive function (Campbell et al., 2018). Similarly, a study of FPS and MOBA game types found that FPS gamers had faster reaction times but lower braking control than MOBA players (Deleze et al., 2017). In a study by Sousa, A., et al. (Sousa et al., 2020) determined index finger speed on both the dominant and non-dominant hand as a proxy for motor cortical area, efferent motor pathway integrity, and motor functioning. It has been established that after the game, the speed of movement of the dominant hand significantly increases compared to the non-dominant one. Şahin et al. found that highly skilled athletes have significantly better test performance compared to lower-skilled athletes and non-athletes (Şahin et al., 2020).

The study of the reaction time to a change in the shape of an object in the Size-Test made it possible to determine that visual discrimination of a change in the size of an object is important for all athletes who took part in pedagogical testing. In practice, the manifestation of this reaction can be seen in martial arts athletes in a sports duel, short-track skaters during a competitive race, when athletes react to minor changes in the distance to their opponent. For esports athletes, this type of reaction allows you to distinguish the slightest changes in the game situation, which is closely related to the performance of the player, the duration of his stay in each game round. Comparison of the results of martial arts athletes with previously established model characteristics (Rovnyiy & Romanenko, 2016) showed that the results of qualified athletes, candidates for master of sports, correspond to the average level of established standards for highly qualified athletes (MSIG and MS).

Conclusions

In a comparative analysis of elite athletes in martial arts, short track and esports, it was found that psychophysiological features are important for achieving the highest level of skill. The current level of development of these abilities is also important, as well as the possibility of their improvement in the course of performing activities specific to different sports. Objective criteria that allow assessing the functional state of the nervous system are indicators of sensorimotor reactions.

It has been established that esports athletes have a significantly better choice reaction time ($p<0.05$) than martial arts athletes. The results of short-track skaters do not have significant differences with martial arts athletes and esports athletes ($p>0,05$).

The results of the tapping test in terms of the total number of movements and the average number for 5 seconds of esports athletes tend to be higher in comparison with short track speed skaters and martial arts athletes.

The fastest response time to a change in the size of an object in the Size-test was shown by martial arts athletes, the slowest by short-track skaters. This reflects a trend towards better results of this type of reaction in martial arts athletes compared to short track speed skaters and esports athletes.

More research is needed to confirm established trends and provide the necessary information. The approved set of tests is an adequate and informative tool and can be used in monitoring the functional state of athletes in these sports.

Author Contributions

A – research design/planning; B – data collection/entry; C – data analysis/statistics; D – data interpretation; E – manuscript preparation; F – literature analysis/search; G - fundraising.

Svitlana Piatysotska: A, B, C, D, F
Viacheslav Mulyk: A, F, G
Anatolyi Huba: D, F, G
Nataliia Dolgopolova: D, E, F, E
Andrii Yefremenko: A, D, F, G
Yana Zhernovnikova: B, E

Conflicts of Interest

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Stakeholders' Awareness, Understanding, and Acceptability of the Goals and Objectives of a Sports Science and Exercise Program: Basis for Formative Curriculum Evaluation

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Abstract

Purpose: This study aimed to assess the awareness, understanding, and acceptability of the goals and objectives of a sports science program in the Cagayan State University, Philippines among stakeholders, including students, faculty, and industry professionals.

Material and Methods: A survey was conducted using a self-administered questionnaire to collect data from 342 stakeholders. The questionnaire consisted of items related to stakeholders' demographic profile, awareness and understanding of the program's goals and objectives, and their acceptability of the program.

Results: Results showed that stakeholders had a moderate level of awareness, acceptability, and understanding of the program's goals and objectives, with internal stakeholders having higher understanding in general than external stakeholders.

Conclusion: The study concludes that there is a need to improve communication and collaboration between the program and external stakeholders to increase their understanding and acceptance of the program's goals and objectives. The findings of this study can serve as a basis for formative curriculum evaluation and curriculum improvement, enabling the program to better meet the needs of students and the industry.

Keywords: Program Alignment, Educational Evaluation, Higher Learning in Sports, Industry Perspectives

Анотація

Обізнаність зацікавлених сторін, розуміння та прийнятність цілей та завдань спортивної науки та програми вправ: основа для формуючої оцінки навчальної програми. Мета: це дослідження було спрямоване на оцінку обізнаності, розуміння та прийнятності цілей та завдань спортивної наукової програми в Кагаянському державному університеті (Філіппіни) серед зацікавлених сторін, включаючи студентів, викладачів та фахівців галузі. **Матеріали та методи:** опитування було проведене з використанням анкети для самостійного заповнення, зібрано дані від 342 зацікавлених сторін. Анкета складалася з питань, пов'язаних із демографічним профілем зацікавлених сторін, обізнаністю та розумінням цілей та завдань програми, а також їх прийнятністю. **Результати:** результати показали, що зацікавлені сторони мали помірний рівень обізнаності, прийнятності та розуміння цілей та завдань програми, при цьому внутрішні зацікавлені сторони загалом краще розуміли, ніж зовнішні зацікавлені сторони. **Висновки:** у дослідженні зроблено висновок про необхідність покращення комунікації та співробітництва між програмою та зовнішніми зацікавленими сторонами, щоб покращити розуміння та прийняття цілей та завдань програми. Результати цього дослідження можуть бути основою для формуючої оцінки та покращення навчального плану, дозволяючи програмі краще задовольняти потреби студентів та галузі.

Ключові слова: узгодження програм, освітня оцінка, вища освіта у галузі спорту, галузеві перспективи.

Introduction

Sports science programs have gained significant attention in recent years as an es-

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sential field of study that focuses on the scientific principles and techniques that enhance athletic performance and prevent injuries (Denysova et.al, 2022; Haugen et.al, 2019). As such, the demand for qualified professionals in this field has increased, leading to the development of academic programs aimed at producing experts in sports science and exercise (Onambélé-Pearson et.al, 2021; Fullagar et.al, 2019). However, the effectiveness of these programs in meeting the needs and expectations of stakeholders, including students, educators, and employers, remains unclear (Almasi, 2019). To address this issue, this study aims to evaluate stakeholders' awareness, understanding, and acceptability of the goals and objectives of a sports science and exercise program, which will serve as the basis for formative curriculum evaluation.

Despite the growing importance of sports science, the field is relatively new in the Philippines and has yet to gain widespread recognition and acceptance among stakeholders, including students, educators, and sports practitioners. This lack of awareness and understanding may hinder the program's implementation and evaluation and impede its ability to achieve its intended outcomes. Research has shown that the success of any academic program depends on many factors and one of those is the stakeholders' awareness, understanding, and acceptance of its goals and objectives (Batan et.al, 2023; Gomez & Basco, 2022; Seres, 2019).

Several studies have investigated stakeholders' awareness and understanding of sports science programs. For instance, a study by Tasleem (2018) surveyed sports science students, academics, and professionals in Pakistan and found that while students and academics had a good understanding of the field, professionals lacked awareness of the specific skills and knowledge that sports science graduates could offer. Similar results were found in the study of Mortejo et.al (2022) towards a sports clinic program in a province in the Philippines. Similarly, a study by Stevens et.al (2018) and Beaumont et.al (2026) explored the perceptions of sports science graduates and found that while they felt adequately prepared for employment, employers often did not recognize the value of their degree. These findings suggest a need for greater communication and collaboration between sports science programs and industry stakeholders to ensure that graduates are equipped with the skills and knowledge that meet the needs of the industry.

After conducting a search of relevant literature published in 2017 up to present, it appears though that there are relatively few studies that have specifically focused on stakeholders' awareness, understanding, and acceptability of sports science and exercise programs in universities. Some studies have examined related topics, such as the impact of sports science and exercise programs on student learning and the competencies required of graduates to succeed in the industry. However, there is still a lack of research on stakeholders' perceptions of these programs, which could help improve their quality and relevance.

One study that highlights this gap is by Sharma and D'Souza (2018), who conducted a survey of students enrolled in a sports science program in India. While the study examined students' perceptions of the program, it did not explore the views of other stakeholders such as educators and employers. Another study by Soosay et.al (2019) investigated the competencies required of sports science graduates to succeed in the industry. While the study identified the skills and knowledge needed, it did not examine stakeholders' perceptions of the program itself.

Overall, it is clear that there is a need for more research on stakeholders' awareness, understanding, and acceptability of sports science and exercise programs in universities (Nozaleda, 2019). By addressing these gaps, this study can provide valuable insights into the stakeholders' perspectives on the sports science program's goals and objectives in the Philippines and inform the development of strategies to enhance its effectiveness and relevance to the needs of stakeholders.

The aim of this study is to investigate the awareness, understanding, and acceptance of the vision and mission of Cagayan State University (CSU) and the goals and objectives of the Bachelor of Science in Exercise and Sports Sciences (CSU-BSESS). Ultimately, the findings of this study can contribute to the improvement of the sports science program's quality and relevance to the needs of stakeholders. It can inform the development of strategies to enhance stakeholder engagement and collaboration in the program's implementation and evaluation. Ultimately, this study can provide valuable insights into the stakeholders' perspectives on the goals and objectives of a sports science program, which can inform future curriculum development and evaluation.

Material and Methods of the research

Research Design

This study employed the descriptive method to carry out successfully the objectives of this study. A survey was conducted by the researcher to gather pertinent data and will be treated using descriptive and inferential statistics. According to Scheuren (2004), a survey is a general view, examination, or description of people's attitudes, impressions, opinions, expectations, beliefs, and behaviors on specific facts.

Instrument and Data Gathering Procedure

The research instrument was a survey questionnaire framed by the researcher herself. The instrument was subjected for validation by experts in the field of measurement and evaluation. In gathering data, the survey was administered using an online platform. Google Survey links were forwarded to the identified stakeholders with the help of the college officials, faculty members, and students through their Facebook group chats.

It is important to note that prior to administering the survey, participants were informed about the purpose of the study, the nature of the survey questions, and the potential risks and benefits of participating. Informed consent was obtained from all participants before they were allowed to proceed with answering the survey. Participants were informed that their participation in the study was voluntary, and that they could withdraw from the study at any time without penalty. The researcher ensured the anonymity and confidentiality of the participants' responses by not collecting any personally identifiable information. This process adheres to ethical standards of research involving human subjects.

Participants of the Study

The respondents of this study were individuals or groups of people who affect or are affected by an organization or institution like the Cagayan State University who referred to as the "stakeholders". In this study the stakeholders were classified as external and internal. The number of respondents in this study is shown in Table 1.

Table 1 shows the frequency distribution of the respondents. It can be seen that majority of the respondents are internal stakeholder with 256 or 74.85% of the population. Among the specific categories of stakeholders, majority are students followed by the parents/guardians. Meanwhile, Table

Table 1. Frequency Distribution of the Respondents

	Frequency	Percentage
Internal Stakeholders	256	74.85
External Stakeholders	86	25.15
Admin Officials and Personnel	35	10.23
Faculty Members	22	6.43
Parent/Guardian	91	26.61
Student	108	31.58
Alumnus/Alumna	62	18.13
Industry/Linkage/Cooperating Agency	24	7.02
Total	**342**	**100**

Table 2. Sex and Age of the Respondents

Variable	Frequency	Percentage
Sex		
Male	175	51.17
Female	131	38.30
LGBTQIA+	36	10.53
Age		
18-22 years old	102	29.82
23-27 years old	52	15.20
28-32 years old	25	7.31
33-37 years old	29	8.48
38-42 years old	36	10.53
42 above	98	28.65
Total	**342**	**100%**

2 shows the frequency distribution of the ages and gender of the respondents.

Data Analysis

The data collected was tabulated and analyzed using Statistical Package for the Social Sciences (IBM SPSS Statistics v.20, 2011.). Mean was used to determine the awareness and acceptance on the VMGO and in the analysis of the stakeholders' understanding of the Vision and Mission. To determine the differences among the level of awareness, acceptance and understanding on the VMGO between the external and internal stakeholders, Independent Samples T-test was used at 0.10 level of significance.

Results of the research

Level of Awareness of the Stakeholders

Table 3 suggests that the overall awareness of the preambular provisions of the CSU-BSESS program among the stakeholders is moderate. However, the level of awareness is slightly higher among the internal stakeholders as compared to the external stakeholders. It also indicates that stakeholders are more aware of the university's vision and mission than the specific objectives of the BSESS program.

Level of Acceptability of the Stakeholders

The findings from Table 4 suggest that the vision and mission statements of the CSU-BSESS program are less acceptable to stakeholders compared to the program's objectives. The table also indicates that internal stakeholders, such as faculty and staff, found the vision, mission, goals, and objectives to be more acceptable than external stakeholders, such as students and industry partners.

Level of Stakeholders' Understanding

Based on the Table 5, it appears that there is a moderate level of understanding among stakeholders regarding the vision, mission, goals, and objectives of the sports science program in CSU. However, the external stakeholders seem to have a higher level of understanding than the internal stakeholders. It is also noteworthy that stakeholders have a higher level of understanding of the vision and mission compared to the objectives.

Comparative Analysis of the Awareness, Understanding, and Acceptability of Stakeholders

The findings in Table 6 suggest that there is a significant difference in the understanding of the vision, mission, goals, and objectives (VMGO) of the sports science program between internal and external stakeholders of Cagayan State University. Specifically, external stakeholders have a higher level of understanding compared to internal stakeholders. This could imply that external stakeholders, such as community members, alumni, and industry professionals, have a better grasp of the program's overall goals and objectives than those who are directly involved in the program, such as faculty and staff.

Discussion

Firstly, the findings on the level of awareness of the respondents suggest that there is room for improvement in terms of awareness of the preambular provisions of the CSU-BSESS

Table 3. Awareness of both internal and external stakeholders

	Mean								
	Internal Stakeholders				External Stakeholders				Total
	Administrator	Faculty Member	Student	**Overall**	Parent/ Guardian	Alumni	Industry	**Overall**	
Vision CSU is a University with global stature in the arts, culture, agriculture and fisheries, the sciences as well as technological and professional fields	3.22	3.42	2.59	**3.08**	3.33	3.38	2.81	**3.17**	**3.13**
Mission Cagayan State University shall produce globally competent graduates through excellent instruction, innovative and creative research, responsive public service and productive industry and community engagement.	3.43	3.15	3.58	**3.39**	3.57	3.64	3.61	**3.61**	**3.50**
Goals									
To produce competent teachers through a well-rounded program of Music, Arts, Physical Education and Health Activities and;	3.56	3.63	2.69	**3.30**	2.79	2.76	3.05	**2.87**	**3.08**
To produce individuals who are experts in the field of Sports Coaching,Fitness and Sports management.	3.46	3.34	3.58	**3.46**	3.38	3.67	2.60	**3.22**	**3.34**
Overall Mean for Goals	2.55	2.60	2.71	**3.38**	3.59	3.14	2.96	**3.04**	**3.21**
Objectives									
Disciplinal Knowledge	2.81	2.52	3.34	**2.89**	3.44	2.92	2.61	**2.99**	**2.94**
Professional Competence	2.83	3.51	3.16	**3.17**	3.48	2.90	2.66	**3.01**	**3.09**
Professional Accountability and Responsibility	3.18	2.89	3.60	**3.22**	3.62	2.68	2.53	**2.94**	**3.08**
Communication	3.09	2.70	2.98	**2.93**	3.51	2.77	2.80	**3.03**	**2.98**
Overall Mean for Objectives	**2.98**	**2.90**	**3.27**	**3.05**	**3.52**	**2.82**	**2.65**	**2.99**	**3.02**
Overall Weighted Mean	**3.04**	**3.02**	**3.04**	**3.22**	**3.50**	**3.24**	**3.01**	**3.20**	**3.21**

***Legend**: 1-1.74 (Very Low), 1.75-3.24 (Moderate), 3.25-4.00 (High)*

Table 4. Level of Acceptability of the Stakeholders of the VMGO of CSU-CHK

	Mean								
	Internal Stakeholders				External Stakeholders				Total
	Administrator	Faculty Member	Student	**Overall**	Parent/ Guardian	Alumni	Industry	**Overall**	
Vision CSU is a University with global stature in the arts, culture, agriculture and fisheries, the sciences as well as technological and professional fields	2.57	2.68	3.23	**2.83**	3.52	3.51	2.90	**3.31**	**3.07**
Mission Cagayan State University shall produce globally competent graduates through excellent instruction, innovative and creative research, responsive public service and productive industry and community engagement.	2.72	3.02	2.84	**2.86**	2.82	2.68	2.65	**2.72**	**2.79**
Goals									
To produce competent teachers through a well-rounded program of Music, Arts, Physical Education and Health Activities and;	2.61	3.24	3.20	**3.02**	3.10	2.97	2.72	**2.93**	**2.98**
To produce individuals who are experts in the field of Sports Coaching,Fitness and Sports management.	3.36	2.70	3.56	**3.20**	2.54	2.51	2.99	**2.68**	**2.94**
Overall Mean for Goals	2.53	3.71	3.26	**3.11**	3.36	3.42	2.64	**2.81**	**2.96**
Objectives									
Disciplinal Knowledge	2.53	3.58	3.45	**3.19**	3.44	2.67	3.68	**3.26**	**3.23**
Professional Competence	3.69	3.36	3.44	**3.50**	3.41	2.68	3.69	**3.26**	**3.38**
Professional Accountability and Responsibility	3.51	3.12	3.47	**3.36**	2.62	2.76	2.79	**2.72**	**3.04**
Communication	3.36	2.73	3.25	**3.11**	3.17	3.70	3.64	**3.50**	**3.31**
Overall Mean for Objectives	**3.27**	**3.20**	**3.40**	**3.29**	**3.16**	**2.95**	**3.45**	**3.19**	**3.24**
Overall Weighted Mean	**2.77**	**3.15**	**3.18**	**3.02**	**3.21**	**3.14**	**2.91**	**3.01**	**3.01**

***Legend**: 1-1.74 (Very Low), 1.75-3.24 (Moderate), 3.25-4.00 (High)*

Table 5. Stakeholders' Level of Understanding of the VMGO of CSU-CHK

	Mean								
	Internal Stakeholders				External Stakeholders				Total
	Administrator	Faculty Member	Student	**Overall**	Parent/ Guardian	Alumni	Industry	**Overall**	
Vision CSU is a University with global stature in the arts, culture, agriculture and fisheries, the sciences as well as technological and professional fields	2.87	3.68	3.04	**3.20**	3.17	3.12	3.56	**3.28**	**3.24**
Mission Cagayan State University shall produce globally competent graduates through excellent instruction, innovative and creative research, responsive public service and productive industry and community engagement.	2.91	3.05	3.04	**3.00**	2.76	3.57	3.25	**3.19**	**3.10**
Goals									
To produce competent teachers through a well-rounded program of Music, Arts, Physical Education and Health Activities and;	3.09	3.13	2.91	**3.04**	2.66	3.35	3.59	**3.20**	**3.12**
To produce individuals who are experts in the field of Sports Coaching,Fitness and Sports management.	2.51	3.13	3.42	**3.02**	3.00	3.30	2.86	**3.05**	**3.04**
Overall Mean for Goals	2.87	3.70	3.34	**3.03**	3.52	3.65	3.45	**3.13**	**3.08**
Objectives									
Disciplinal Knowledge	2.91	3.60	2.99	**3.17**	2.89	2.94	3.71	**3.18**	**3.17**
Professional Competence	2.67	2.70	2.73	**2.70**	3.21	2.56	2.64	**2.81**	**2.75**
Professional Accountability and Responsibility	2.57	3.71	3.41	**3.23**	2.91	3.52	3.16	**3.20**	**3.21**
Communication	2.94	2.89	3.31	**3.04**	2.97	3.39	3.05	**3.14**	**3.09**
Overall Mean for Objectives	**2.77**	**3.23**	**3.11**	**3.04**	**2.99**	**3.10**	**3.14**	**3.08**	**3.06**
Overall Weighted Mean	**2.86**	**3.41**	**3.13**	**3.07**	**3.11**	**3.36**	**3.35**	**3.17**	**3.12**

***Legend**: 1-1.74 (Very Low), 1.75-3.24 (Moderate), 3.25-4.00 (High)*

Table 6. Test of difference between the stakeholders' awareness, understanding, and acceptability

Dimensions	Group	Mean	p-value	Std. Error difference
Awareness	Internal	3.22	**0.529**	**0.157**
	External	3.20		
Understanding	Internal	3.07	**0.092**	**0.087**
	External	3.17		
Acceptability	Internal	3.02	**0.606**	**0.160**
	External	3.01		

program among stakeholders, especially among external stakeholders. It is important to develop effective communication strategies to increase awareness and understanding of the program's preambular provisions (Villa et.al, 2017). The results also imply that more efforts should be made to raise awareness of the specific objectives of the BSESS program. This can be achieved by providing more information about the program and its objectives to the stakeholders.

Additionally, the findings highlight the importance of internal stakeholders in promoting the preambular provisions of the CSU-BSESS program. They can play a key role in disseminating information about the program to external stakeholders, which can increase overall awareness (Thapa et.al, 2021; Galvao et.al, 2021; Dholakia, 2017). In fact, the result of the study corroborates that of Raza et al. (2019) on stakeholder awareness of environmental sustainability practices in universities found that internal stakeholders were more aware of the practices than external stakeholders. Meanwhile, the implication of the study can be supported by the study Lam et al. (2020) and Cornachione et.al (2010) on stakeholder engagement in higher education institutions who found that effective communication strategies were essential for increasing stakeholder awareness and understanding of programs and initiatives.

It is interesting to note that the observation that the internal stakeholders are more aware than the external stakeholders can be explained by the fact that the internal stakeholders are inside the school premises. Consequently, the data suggests that the program has been successful in communicating its VMGO to its internal stakeholders and that these stakeholders have a good understanding of what the university and its departments aim to achieve. This could help foster a sense of belonging and commitment among these stakeholders (Villanca et.al, 2020). Secondly, the lower level of awareness among external stakeholders could suggest a need for the university to increase its efforts in disseminating information about its VMGO to these stakeholders. This could include developing better communication strategies to reach these stakeholders and involve them more in university activities (Tan & Borres, 2020; Harland et.al, 2017; Preiser et.al, 2014).

As regards the acceptability, the moderately acceptable rating of the preambular provisions of the program could have implications for the overall effectiveness and success of the program. If stakeholders do not fully support the program's vision and mission, it may be more challenging to achieve the program's goals and objectives (Marshall & Marshall, 2018). In addition, if external stakeholders have lower acceptability rat-

ings than internal stakeholders, it could indicate a disconnect between the program and its external partners, which could limit the program's impact on the industry and society (Balbachevsky, 2015).

The finding that the objectives are the most acceptable provision of the program is consistent with the literature on program evaluation, which suggests that clear and measurable objectives are critical for the success of a program (Fischer et.al, 2020; Scriven, 1991). The lower ratings for the vision and mission statements are also not uncommon, as previous studies have found that stakeholders often have difficulty understanding or connecting with these high-level statements (Torelli et.al, 2020; Grünig & Kühn, 2015).

However, it is important to note that the specific reasons for the stakeholders' ratings are not provided in the table, and further research would be needed to understand why certain provisions of the program are more or less acceptable. Additionally, it would be useful to explore ways to increase the acceptability of the vision and mission statements, particularly among external stakeholders.

Overall, the findings suggest that the CSU-BSESS program may need to focus on improving the acceptability of its vision and mission statements, particularly among external stakeholders, to increase the program's impact and effectiveness.

In terms of the level of understanding of the stakeholders, the findings suggest that there is a need for the sports science program in CSU to improve its communication and engagement with its internal stakeholders, particularly in clarifying the objectives of the program. The fact that external stakeholders have a higher level of understanding may indicate that the program is doing well in communicating its purpose to those outside the organization. However, it is also possible that external stakeholders have a different perspective and understanding of the program compared to internal stakeholders.

These findings are consistent with previous studies on stakeholder understanding and engagement in organizational contexts. For instance, a study by Langrafe et.al (2020) and by Mitchell et al. (1997) found that stakeholders may have different levels of understanding and interest in the objectives of an organization, and that it is important for organizations to communicate their goals and objectives effectively to stakeholders. Similarly, a study by Selsky and Parker (2005) highlights the importance of engaging stakeholders in the development and implementation of organizational strategies, to ensure that their perspectives are considered and that the organization is able to meet its goals.

In terms of refuting or confirming these findings, further research would be needed to determine whether the results are consistent across different contexts and organizations. It would also be valuable to explore the reasons behind the differences in understanding between internal and external stakeholders, and to identify strategies that organizations can use to improve stakeholder engagement and understanding.

Furthermore, it is important to note from the test of difference, that while external stakeholders have a higher level of understanding, the level of awareness and acceptability of the VMGO is statistically equal among both groups of stakeholders. This could suggest that both internal and external stakeholders recognize and support the program's goals and objectives despite differences in their level of understanding.

Several studies have investigated the role of stakeholders in program development and implementation. One study by Toth et.al (2014) examined stakeholder perspectives on the development of a health promotion program and found that involving both internal and external stakeholders in program planning and implementation can lead to a more successful program. Another study by Boyd et.al (2017) explored the role of stakeholders in a sustainable tourism program and found that stakeholder involvement can lead to better program outcomes and increased support for the program.

In conclusion, the finding that external stakeholders have a higher level of understanding of the VMGO of the sports science program in Cagayan State University highlights the importance of involving a diverse group of stakeholders in program development and implementation. The fact that both internal and external stakeholders show equal levels of awareness and acceptability of the VMGO suggests that despite differences in understanding, both groups recognize and support the program's goals and objectives.

Conclusions

In conclusion, the assessment of stakeholders' awareness, understanding, and acceptability of the goals and objectives of a sports science program in the Philippines provides valuable insights into the strengths and weaknesses of the program. The results of this assessment can be used as a basis for formative curriculum evaluation, helping to identify areas for improvement and ensure that the program meets the needs of students and the industry. By incorporating feedback from stakeholders, the program can be revised to better align with the expectations of students and the demands of the industry. Ultimately, this can lead to a more effective and relevant sports science program that produces graduates with the skills and knowledge required for success in the field.

From the results, it is apparent that formative curriculum evaluation is an essential process for improving educational outcomes by assessing the effectiveness of curriculum implementation and identifying areas for improvement. Based on the results of this study, the following are the policy implications for formative curriculum evaluation which the researcher believed to have a significant impact on the quality of education provided to students.

Develop more industry-specific courses: Based on stakeholders' feedback, the curriculum could be revised to include more courses that align with the needs of the industry. This could help prepare graduates with the specific skills and knowledge required by employers.

Increase practical training opportunities: Stakeholders' feedback may suggest that graduates need more practical training and hands-on experience to be job-ready. The curriculum could be revised to include more practical training opportunities, such as internships, work placements, and hands-on laboratory sessions.

Enhance communication and collaboration: Based on stakeholders' feedback, the program could be improved by increasing communication and collaboration between the university and industry stakeholders. This could involve inviting industry professionals to give guest lectures, participating in industry events, and forming partnerships with relevant organizations (Leavy et.al, 2011).

Incorporate technology: Stakeholders' feedback may suggest that the program needs to incorporate more technology and digital tools to keep up with the latest industry trends and innovations. The curriculum could be revised to include courses on emerging technologies such as data analytics, wearable technology, and virtual reality.

Review program goals and objectives: Based on stakeholders' feedback, the program's goals and objectives may need to be reviewed to ensure they are aligned with the needs of the industry and the expectations of students. This could involve conducting a program evaluation to identify areas for improvement and revising the program's mission statement to better reflect its goals and objectives.

Author's contribution

In this research article, the author was instrumental in developing the research question, designing the study, and collecting and analyzing the data. Her expertise and leadership were crucial in ensuring the success of the project.

Conflict of Interest Statement

There is no conflict of interest in this study.

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Changes in Counter Movement Jump Height, Take-off Force and Maximum Concentric Power of Collegiate Athletes After Two Sessions Per Week Plyometric Training on Different Training Surfaces

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Abstract

Purpose: This study aimed to examine the effects of two sessions per week plyometric training on different surfaces on the counter movement jump height, take-off force, and maximum concentric power of collegiate athletes.

Material and methods: Male collegiate athletes (n=24, age=18.46±1.14 years, weight=64.88±5.61 kg and height=1.72±0.07 metres)) from a physical training centre were randomly and equally assigned to three groups, each trained on different surfaces (synthetic, cinder and sand). The training intervention was implemented twice a week and lasted for 8 weeks. The athletes were tested before and after the intervention to assess changes in the performance of counter movement jump height (CMJHT), take-off force (CMJTOF) and maximum concentric power (CMJMCP).

Results: Results showed that overall measurement of CMJHT, CMJTOF and CMJMCP improved significantly (p≤0.05, Δ %=10.50; p≤0.05, Δ%=11.11; p≤0.05, Δ%=11.41). However, training surfaces have no significant effect on the improvement of the selected variables (CMJHT:$F(2,21)=2.37$, $p=0.118$, $\eta_p^2=0.184$; CMJTOF:$F(2,21)=1.28$, $p=0.299$, $\eta_p^2=0.109$; CMJMCP:$F(2,21)=0.061$, $p=0.941$, $\eta_p^2=0.006$). Further, for the synthetic track surface group CMJHT, CMJTOF and CMJMCP improved significantly (p≤0.05, Δ%=16.36; p≤0.05, Δ%=17.50; p≤0.05, Δ%=17.99); for the cinder track surface group CMJHT and CMJMCP improved significantly (p≤0.05, Δ%=9.15; p≤0.05, Δ%=10.33) and for the sand surface group only CMJHT improved significantly (p≤0.05, Δ%=5.68).

Conclusions: The findings suggest that plyometric training on different surfaces can effectively improve athletic performance, but the specific surface type does not appear to impact the outcomes significantly. The study further suggested analysing the injury risk associated with plyometric training on various training surfaces and discovering the optimal training surface for minimising injury risk while maximising performance gains.

Keywords: counter movement, jump height, take-off force, maximum concentric power, plyometric, and training surface.

Анотація

Зміни показників висоти стрибка в протирусі, сили відштовхування та максимальної концентричної сили спортсменів-студентів після двох занять на тиждень пліометрічним тренуванням на різних тренувальних поверхнях. *Мета:* це дослідження було спрямоване на вивчення впливу двох занять пліометричним тренуванням на тиждень спортсменів-студентів на різних поверхнях на показники висоти стрибка в протирусі, сили відштовхування та максимальної концентричної сили. *Матеріали та методи:* спортсмени-чоловіки (n=24, вік=18,46±1,14 рік, вага=64,88±5,61 кг, зріст=1,72±0,07 м)) з центру фізичної підготовки були випадковим чином однаково розподілені три групи, кожна з яких тренувалася. на різних поверхнях (синтетика, бігова доріжка та пісок). Тренувальне заняття проводилося двічі на тиждень і тривало 8 тижнів. Спортсменів тестували до та після тренувального заняття для оцінки змін показників висоти стрибка у протирусі (ЗПСП), сили відштовхування (СВ) та максимальної концентричної сили (МКС). *Результати:*

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результати показали, що загальний вимір показників ЗПСП, СВ і МКС значно покращився (p≤0,05, Δ%=10,50; p≤0,05, Δ%=11,11; p≤0,05, Δ%=11 ,41). Однак тренувальні поверхні не мають істотного впливу на поліпшення обраних змінних (ЗПСП:F(2,21)=2,37, p=0,118, ηp2=0,184; СВ:F(2,21)=1,28, p=0,299, ηp2 = 0,109; МКС: F (2,21) = 0,061, p = 0,941, ηp2 = 0,006). Крім того, для групи з синтетичним покриттям показники ЗПСП, СВ і МКС значно покращилися (p≤0,05, Δ%=16,36; p≤0,05, Δ%=17,50; p≤0,05, Δ% =17,99); для групи на біговій доріжці показники ЗПСП, СВ і МКС значно покращилися (p≤0,05, Δ%=9,15; p≤0,05, Δ%=10,33), а для групи з піщаним покриттям значно покращилися тільки показник ЗПСП (p≤0,05, Δ%=5,68). *Висновки:* результати показують, що пліометричні тренування на різних поверхнях можуть ефективно покращити спортивні результати, але конкретний тип поверхні істотно не впливає на результати. У дослідженні також пропонувалося проаналізувати ризик травм, пов'язаний з пліометричними тренуваннями на різних тренувальних поверхнях, і знайти оптимальну поверхню для тренування для мінімізації ризику травм при максимальному підвищенні продуктивності.

Ключові слова: протирух, висота стрибка, сила відштовхування, максимальна концентрична сила, пліометрія, поверхня тренування.

Introduction

Plyometrics training is a method to enhance explosive strength. As coaches and players have realised the potential improvements it can bring to athlete performance, they have started including plyometric exercises in their general training and made it a key element in planning athletic development programmes. Apart from improving explosive strength, it is a very effective technique for building explosive power (Davies et al., 2015). It is based on the idea that rapid muscle lengthening just before contracting would increase the muscles' elastic strain energy, improving an athlete's ability to accelerate and start faster, change direction more quickly, and increase overall speed (Davies et al., 2015). In addition, it provides a great deal of variation regarding exercises and load designing. Voluntary and involuntary muscular contractions are both included in plyometric training. As a result, many motor units are engaged during a single contraction, increasing an individual's motor coordination (Chimera et al., 2004). Concentric contraction occurs immediately following the eccentric contraction in plyometric activities (Behrens et al., 2016). Stretch-shortening is a process that combines eccentric (muscle lengthening) and concentric (muscle shortening) actions (Behrens et al., 2016). When an athlete drops his or her weight, an eccentric muscle movement occurs; when the athlete lifts his or her weight, a concentric muscle movement occurs (Aboodarda et al., 2015; Behrens et al., 2016). When an eccentric action follows a concentric action, the equivalent force output of the concentric action is enhanced (Aboodarda et al., 2015). This stretch-shortening acts similarly to an extended rubber bend and aids in the execution of the movement accordingly.

The effectiveness of plyometric exercises can vary based on the intensity, volume and selection of exercises (Davies et al., 2015). That is why the individuals performing plyometrics should understand how to work out, execute, and modify the programme to maximise its effectiveness. However, the volume, intensity, or type of exercise do not always influence plyometric exercise effects. Many researchers were concerned about the combined effect of plyometric exercises and training surfaces. Among them, Ramirez-Campillo et al. (2018) reported that using moderate plyometric exercise volume on a hard surface can significantly increase reactive strength. Whereas Ozen et al. (2020) found that plyometric exercises on wooden or sand surfaces had not caused any differences in improving jumping performance. However, another research further indicated that sand training might be more effective in developing speed and agility among young athletes, and a similar result was also reported by Hammami et al. (2020) in a different study. Another study Çimenli et al. (2016) reported the significant effect of plyometric training on the jump performance of volleyball players but rejected the idea of different training effects of plyometric exercises in two different training surfaces (wooden and synthetic). Although research had established that athletes' performance could also be affected by environmental factors like playing surfaces (Ozen et al., 2017), no study had directly investigated the effect of plyometric exercises on three different training surfaces (i.e., Synthetic Track Surface, Cinder Track Surface and Sand Surface). Since the compositions of different training surfaces differ significantly and may affect not only speed, endurance and balance but also the technique. Therefore, it is very important to understand how plyometric training can affect differently on different training surfaces.

Coaches and researchers commonly use the Counter Movement Jump (CMJ) test as an indirect method to assess the explosive power output of the lower body of an individual (Petrigna et al., 2019). In most cases, the performance of the CMJ is measured in terms of jump height or relative peak power output. However, other variables like Take off Force, Impact Force, Maximum Concentric Power, Average Speed Concentric Phase, Peak Speed, Take Off Speed etc., can also be measured using specialised equipment like Force Platform, Accelerometer, High-Speed Camera etc. Many studies have examined the direct effect of plyometric training on CMJ jumping ability, ground reaction forces, isokinetic forces, take-off force, take-off velocity, power etc. (Borah & Sajwan, 2022; Correia et al., 2020; Ismail et al., 2014; Matavulj et al., 2001; Ramirez-Campillo et al., 2021; Stojanović et al., 2017), and reported their individual results and conclusions. However, very few studies have investigated the effect of plyometric training on the performance of the CMJ test in different training surface settings.

The purpose of the study: Therefore, the current study was conducted to investigate the effect of plyometric training on selected CMJ variables of collegiate athletes on three different training surfaces (Synthetic Track Surface, Cinder Track Surface and Sand Surface). In this study, the performance of CMJ test was tested on three variables, i.e., CMJ height, CMJ take-off force and CMJ maximum concentric power.

Material and Methods of the research

Participants

The participants were selected from a physical training centre, which trains collegiate sportspersons for competitions as well as to participate in various competitive examinations which required physical fitness tests. The minimum sample size was determined using the software "G*Power Version 3.1.9.2." (Verma & Verma, 2020); according to which a minimum of eighteen (18) samples were required to obtain a large effect with predetermined power of 80% and alpha 5%. However, keeping in mind the potential participants attrition and the result of the sample size determination test, a total of twenty-four (N=24) participants (age=18.46±1.14 years, weight=64.88±5.61 kg

and height=1.72±0.07 metres) were randomly selected for the study. Furthermore, the participants were equally and randomly (8 participants in each group) assigned to three different training surface groups; i.e., Synthetic Track Surface group, Cinder Track Surface group and Sand Surface group.

Experimental design

A two-factorial design was adopted as the experimental design for the study. The first factor was "Surface Type" and the other factor was "Training Duration." The "Surface Type" factor had three levels of measurements comprising three types of training surfaces while the other factor "Training Duration" had two levels of measurement, i.e., pre-test and post-test. The participants were trained with two sessions of plyometric training per week. The training sessions were distributed as per the schedule mentioned in Table 1. Furthermore, the training sessions were maintained throughout the duration of eight (8) weeks. The training sessions were designed as per the recommendation from Bedoya et al. (2015) and Çimenli et al. (2016). The training sessions started with 10 minutes of warm-up exercises, and 35-45 minutes of plyometric exercises and ended with 10 minutes of cooling-down exercises (sample training schedule: Table 2). With the progression of duration, the volume, intensity and frequency of the exercises also increased as per the suggestions from Bedoya et al. (2015) and Çimenli et al. (2016). The pre-test was conducted two days before the start of training sessions and was completed in a single day. While the post-test was conducted two days after the completion of eight (8) weeks of training sessions separately for each training surface group. The effect of fatigue was presumed nil based on the finding of Monteiro et al. (2019). The overall flow of the study can be understood using the Figure 1.

Testing equipment

The tests for data collection were administered inside the sports biomechanics laboratory of Lakshmibai National Institute of Physical Education, Gwalior, India. To collect data, BTS G-WALK® system was used (BTS Bioengineering S.p.A., Italy). The whole system comprised of a device named 'G-Sensor' and a dedicated software named 'G-Studio'. The system is a highly reliable and valid tool for measuring gait and jump parameters (Gogoi, Borah, et al., 2021; Gogoi, Rajpoot, et al., 2021).

Testing protocol

To analyse specific movements, specific protocols were prescribed in the manual of BTS G-WALK® system. The current study was also conducted following the mentioned protocols; according to which the G-Sensor device was placed at the

Table 1. Schedule of training sessions

Day	Training group
Monday	X
Tuesday	Y
Wednesday	Z
Thursday	X
Friday	Y
Saturday	Z

X: Synthetic track surface
Y: Cinder track surface
Z: Sand surface

Figure 1. Experimental Design

Table 2. Sample training program

Exercise		Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Hurdle hopping		2×10		2×10	3×10		3×10		3×10
Single leg hopping			2×10			3×10		3×10	
Box jump			2×10			3×10		3×10	3×10
Depth jump				2×10	3×10		3×10		
Tuck jump		2×5		2×10			2×10	2×10	
Bunny hops		2×10				3×10		3×10	3×10
Single leg stair				2×10			3×10		3×10
Squat jump				2×10	3×10			3×10	
Poggo hopping			2×10			3×10			3×10
Lateral hops		2×10				3×10	3×10	3×10	
Ankle jumps			2×5		2×10		3×10		3×10
Power skipping			2×10	2×10		3×10		3×10	
Jumping lunge		2×10			3×10		3×10		3×10
Total Volume		90 FC	90 FC	120 FC	140 FC	180 FC	200 FC	200 FC	210 FC
Recovery	R	30 sec	30 sec	30 sec	30 sec	20 sec	20 sec	20 sec	20 sec
	S	120 sec	120 sec	100 sec	100 sec	100 sec	100 sec	90 sec	90 sec

FC: Foot contact
R: Repetition
S: Sets

back, in line with two dimples of Venus - lumbosacral passage, which corresponds to S1-S2 vertebrae of the human body. To perform CMJ the subjects stood in an upright position with feet apart according to shoulder width and hands on hip. Then the subject jumped on the command of start by the operator, after doing a countermovement downward action by bending their knees up to 90^0. Using the software G-Studio, the required data were generated after the completion of the CMJ action of the subject. The execution of CMJ was also demonstrated by the researcher to the subjects and a familiarisation session was conducted before the commencement of the actual test.

Variables

The dependent variables: the 'Countermovement Jump Height (CMJHT)' is defined as the highest point that the athlete can reach during the execution of a countermovement jump and was measured in the unit centimetre (cm), the 'Countermovement Jump Take-off Force (CMJTOF)' is defined as the measure of the maximal force generated by an individual's lower body during a countermovement jump test (Muraki et al., 2008) and was measured in the unit kilonewton (kN), and the 'Countermovement Jump Maximum Concentric Power (CMJMCP)' is a measure of an individual's maximal power output during a countermovement jump test (Hody et al., 2019) and the unit of measurement was kilowatt (kW).

Statistical analysis

The Normality assumption of the data was tested employing Shapiro-Wilk statistics, the Homogeneity of Variance Covariance Matrices assumption was tested using Box's M test, the equality of error variances assumption was tested by using Levene's Test, and the Sphericity assumption was tested by applying the Mauchly's W test. All the assumptions were verified independently by two of the authors and found satisfactory. In descriptive statistics, mean and standard deviation were displayed. To test the hypothesis of the study; the two-way ANOVA test was applied to test the main effect of both within and between-subject factors. Paired t-test was applied to check the difference between pre and post test measurements for every variable separately for different training surfaces. In addition, the partial eta-squared test was performed to calculate the test's effect size. All statistical tests were conducted using Statistical Package for Social Sciences (SPSS), version 25.00 (Armonk, 2017) and tested at the significance level of 0.05 ($p<0.05$).

Ethics

The study was a part of a doctoral-level study, and the institute's departmental research committee approved the proposal (No. Academic/Ph.D./379/1294). The study was conducted following the latest guideline mentioned in the Declaration of Helsinki (World Medical Association, 2013). The participants were fully informed about the purpose of the study, the detailed experimental design, and potential risks and benefits before registering for the study. All participants voluntarily agreed and gave written consent to participate in the study. The participants were also given the right to withdraw from the study at any time if they felt so.

Results of the research

The results (table 3) of the study revealed that for the measurements of all the dependant variables, the *F* value for the within-subject factor 'Training Duration' (main effect) was significant (CMJHT: $F(1, 21)=50.45$, $p=0.000$, $\eta_p^2=0.706$; CMJTOF: $F(1, 21)=10.25$, $p=0.004$, $\eta_p^2=0.328$; CMJMCP: $F(1, 21)=11.11$, $p=0.03$, $\eta_p^2=0.346$) which indicates that the main effect of 'Training Duration' is meaningful and significant at the level of 5% with large effect size ($\eta_p^2 \geq 0.14$). Hence, it can be said that there were significant differences among measurements of pre and post training for all the variables irrespective of the factor training surface. Further, the pairwise comparison reveals that the overall CMJHT of all three training surface groups increased significantly from the pre-test to the post-test and the percentage change was 10.50 ($p\leq0.05$, Δ %= 10.50). For the variable CMJTOF, the overall measurement increased significantly from the pre-test to the post-test and the percentage change was 11.11 ($p\leq0.05$, Δ %= 11.11). A similar trend was also observed for the variable CMJMCP, which indicates that the overall measurement increased significantly from the pre-test to the post-test and the percentage change was 11.41 ($p\leq0.05$, Δ %= 11.41).

The results also revealed that the *F* value for the between-subject factor 'Training Surface' (main effect) is not significant (CMJHT: $F(2, 21)=2.37$, $p=0.118$, $\eta_p^2=0.184$; CMJTOF: $F(2, 21)=1.28$, $p=0.299$, $\eta_p^2=0.109$; CMJMCP: $F(2, 21)=0.061$, $p=0.941$, $\eta_p^2=0.006$) which indicates that there is no difference of mean scores of measurements for all the variables for different training surface irrespective of the factor time duration. The results also indicate that the *F* value for the interaction (Time Duration × Training Surface) for the variable CMJHT is significant and meaningful (CMJHT: $F(2, 21)=5.16$, $p=0.015$, $\eta_p^2=0.329$) with large effect size ($\eta_p^2 \geq 0.14$). But, for the other two variables, i.e., CMJTOF and CMJMCP; (CMJTOF: $F(2, 21)=3.11$, $p=0.066$,

Table 3. Statistical test results to test the main effect and simple effect of the independent variables on the dependent variables with pairwise comparisons

Variables		Synthetic track surface (N=8)	Δ %	Cinder track surface (N=8)	Δ %	Sand surface (N=8)	Δ %	Overall	Δ %	ANOVA Results		
										Training Surface ($F(2, 21)$ =value, p=value, η_p^2= Partial Eta Squared)	Training Duration ($F(1, 21)$ =value, p=value, η_p^2= Partial Eta Squared)	Training (Training Surface×Training Duration $F(2, 21)$ =value, p=value, η_p^2= Partial Eta Squared)
CMJHT	Pre	27.35±3.94	16.36*	26.10±2.26	9.15*	25.94±2.30	5.68*	26.46±2.88	10.50*	$F(2, 21)=2.37$, $p=0.118$, $\eta_p^2=0.184$	$F(1, 21)=50.45$, $p=0.000$, $\eta_p^2=0.706$	$F(2, 21)=5.16$, $p=0.015$, $\eta_p^2=0.329$
	Post	31.83±3.21		28.49±3.53		27.41±2.13		29.24±3.46				
CMJTOF	Pre	0.71±0.25	17.50*	0.68±0.26	5.87	0.90±0.29	2.00	0.76±0.27	11.11*	$F(2, 21)=1.28$, $p=0.299$, $\eta_p^2=0.109$	$F(1, 21)=10.25$, $p=0.004$, $\eta_p^2=0.328$	$F(2, 21)=3.11$, $p=0.066$, $\eta_p^2=0.228$
	Post	0.88±0.28		0.74±0.17		0.92±0.25		0.85±0.24				
CMJMCP	Pre	2.44±0.62	17.99*	2.57±0.42	10.33*	2.67±1.00	6.45	2.56±0.69	11.41*	$F(2, 21)=0.061$, $p=0.941$, $\eta_p^2=0.006$	$F(1, 21)=11.11$, $p=0.03$, $\eta_p^2=0.346$	$F(2, 21)=0.79$, $p=0.465$, $\eta_p^2=0.070$
	Post	2.88±0.52		2.83±0.29		2.85±0.61		2.85±0.47				

#: Sphericity assumed.
*: The mean differences are significant at the 0.05 level.

η_p^2=0.228; CMJMCP: F(2, 21)=0.79, p=0.465, η_p^2=0.070) no significant interaction was found (p>0.05). Since significant interaction was found for one of the variables, therefore simple effects were required to be checked to explore the exact nature of the interaction. The testing of simple effect using paired t-test revealed that for the Synthetic Track Surface group; the CMJHT improved significantly and the percentage change was 16.36 (p≤0.05, Δ %= 16.36), the CMJTOF improved significantly and the percentage change was 17.50 (p≤0.05, Δ %= 17.50) and the CMJMCP improved significantly and the percentage change was 17.99 (p≤0.05, Δ %= 17.99). The testing of simple effect for the Cinder Track Surface group revealed that the CMJHT of the group improved significantly and the percentage change was 9.15 (p≤0.05, Δ %= 9.15) and for the variable CMJMCP, the significant percentage change was 10.33 (p≤0.05, Δ %= 10.33). However, for the variable CMJTOF, even though a 5.87 per cent improvement was reported, it was not significant (p>0.05, Δ %= 5.87). The testing of simple effect for the Sand Surface group revealed that the CMJHT of the group improved significantly and the percentage change was 5.68 (p≤0.05, Δ %= 5.68). However, even though the variables CMJTOF and CMJMCP exhibited 2% ((p>0.05, Δ %=2.00) and 6.45% (p>0.05, Δ %=6.45) improvement respectively, the improvement was not significant (p>0.05).

Discussion

The main experiential result of this investigation is that two sessions per week plyometric training has significant and large effect on the improvement of countermovement jump height, take-off force and maximum concentric power of collegiate athletes, however training surfaces have no significant effect on the improvement of the selected variables.

The increase in countermovement jump height after plyometric training can be attributed to several physiological adaptations, including increases in muscle power and neuromuscular efficiency (Vissing et al., 2008). Plyometric exercises, characterised by explosive, high-intensity movements, are known to enhance muscle strength, power, and elasticity, enabling greater force production during jumping tasks (Davies et al., 2015). Studies have shown that plyometric training can enhance muscle power through increased muscle cross-sectional area (Grgic et al., 2021) and muscle fiber type transformation (Plotkin et al., 2021) towards a more power-oriented fiber type (Fast Twitch Type II fibers). This can lead to a higher muscle power output, resulting in a greater jump height. The high-intensity, explosive jumping movements performed in plyometric exercises place significant demands on the muscles and nervous system, leading to adaptations in both strength and power (Chimera et al., 2004; Martin, 2020). These adaptations can increase the amount of force that can be produced during jumping movements, thereby increasing countermovement jump height. Furthermore, repeated practice of these movements can improve the coordination and reaction time of the muscles and nervous system (Chimera et al., 2004; Davies et al., 2015). This is a result of increased muscle activation, synchronisation, and firing rates during plyometric exercises, further contributing to improved jumping performance. Recent research by Kosova et al. (2022) and Voisin & Scohier (2019) also supports these findings, as they found that plyometric training program resulted in significant improvements in jump performance.

Numerous studies have demonstrated the positive effects of plyometric exercises on counter movement jump related factors (Kons et al., 2023). Study conducted by Ita & Guntoro (2018) and Singh et al. (2018) reported that plyometric training significantly improved muscle power in trained athletes. Other studies by Chimera et al. (2004) and Vissing et al. (2008) reported that plyometric training significantly improved neuromuscular efficiency in untrained individuals. This type of training has been shown to enhance the mechanical and neural aspects of muscle performance, as well as increase muscle activation, leading to greater muscle power output during jumping movements and result in increased efficiency in the muscle activation patterns during a countermovement jump, leading to an increase in take-off force. That may the reason behind the result of the current study which revealed that two sessions per week plyometric training improves countermovement take-off force of collegiate athletes.

Studies have also shown that the adaptations in muscle power and neuromuscular efficiency resulting from plyometric training can result in significant improvements in maximum power output of the lower body (Makaruk & Sacewicz, 2010). Ramirez-Campillo et al. (2018) reported that plyometric training resulted in significant improvements in maximum concentric action related movements in male soccer players. In the present study, it was observed that the high-intensity, explosive movements of plyometric exercises might have increased muscle strength, power, and elasticity, while repeated practice improves neural pathways responsible for coordinating muscle contractions. These adaptations result in improved coordination, control, and power during movements, leading to an increase in maximum concentric power of the lower body.

The training surface has been a topic of discussion in the field of plyometric training and its impact on jump performance. A number of studies have investigated the effect of different training surfaces, such as grass, artificial turf, and rubberised surfaces etc., on jump performance (Çimenli et al., 2016; Länneström et al., 2021; Marzouki et al., 2022; Ojeda-Aravena et al., 2022; Ramlan et al., 2018; A. Singh et al., 2014). Ramlan et al. (2018) compared the effects of plyometric training on grass and concrete surface on jump performance of volleyballers. They found that plyometric training on both surfaces resulted in similar training-induced effects on neuromuscular factors. Another study by Singh et al. (2014) reported no significant difference in jump performance between plyometric training on sand and grass surface in field hockey players. There is some evidence in the literature that suggests that the type of training surface may have an impact on injury risk during plyometric training (Impellizzeri et al., 2008; A. Singh et al., 2014). According to study by Hatfield et al. (2019); Wannop et al. (2020) and Yasamin et al. (2017), landing forces were higher on a synthetic turf surface compared to a natural grass surface. This finding suggests that synthetic turf may increase the risk of injury during plyometric exercises, as the higher landing forces can place greater strain on the joints and muscles. Similarly, a study by Ebben et al. (2010) found that performing plyometric exercises on a soft surface, such as a gymnastics mat, resulted in lower ground reaction forces and impact loading compared to a hard surface, such as a concrete floor. The authors suggest that performing plyometric exercises on a soft surface may help reduce the risk of injury, as the lower impact forces reduce the strain on the joints and muscles. Overall, the scientific literature suggests that the type of training surface does not have a significant effect on the improvement of jump-related variables after plyometric training, however the variations in training surfaces have significant relationship with injury occurrences. The improvement in jump performance is largely dependent on the intensity and specificity of the plyometric exercises and the in-

dividual's training status and adaptations (Ramírez-Campillo et al., 2013). It was concluded that the training surface may not dictate the improvement of jump-related variables after plyometric training, and individuals can choose the training surface that suits their preferences and training goals. For the present study also similar result is observed, which indicates that there is no significant effect of training surface on improvement of the selected variables irrespective of the factor time duration.

Conclusions

The study concluded that two sessions per week of plyometric training significantly improved countermovement jump height, take-off force, and maximum concentric power in collegiate athletes. The improvement was attributed to increased muscle power and neuromuscular efficiency resulting from high-intensity, explosive movements and improved coordination, control, and power during movements. The study also found that variations in training surfaces does not significantly impact the improvement of the selected jump-related variables after plyometric training. However, researchers recommend that future studies should be conducted to evaluate the injury risk associated with plyometric training on different types of training surfaces and identify the most suitable surface for minimising injury risk while maximising performance benefits. It was also opined that further research is needed to identify the most effective plyometric exercises for specific athletic performance goals and to optimise exercise prescriptions for different populations.

Author's contribution

Poli Borah- study design/planning, data collection/entry, manuscript preparation, literature analysis/search;

Lakshyajit Gogoi- study design/planning, data collection/entry, manuscript preparation, literature analysis/search;

Hemantajit Gogoi- study design/planning, data collection/entry, data analysis/statistics, data interpretation, manuscript preparation, literature analysis/search, fundraising;

Karuppasamy Govindasamy- manuscript preparation, literature analysis/search, fundraising;

Sambhu Prasad- manuscript preparation, literature analysis/search, fundraising;

Tadang Minu- manuscript preparation, literature analysis/search, fundraising;

Koulla Parpa- manuscript preparation, literature analysis/search, fundraising;

Abderraouf Ben Abderrahman- manuscript preparation, literature analysis/search, fundraising.

Conflict of Interest Statement

The authors declare that there is no conflict of interest.

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Impact of physical and sports rehabilitation on the level of physical fitness of combatants

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Abstract

The anti-terrorist operation, the operation of the joint forces, and the full-scale war in Ukraine have a significant physical and psychological impact on the participants of the hostilities. One of the negative consequences of war is the loss of physical health which further affects the process of socialization during a peaceful life. At the same time, the process of restoring physical health with the help of physical culture and sports rehabilitation has not been researched enough, which confirms the relevance of the chosen topic.

Objective: to determine the impact of physical culture and sports rehabilitation on the level of physical fitness of combatants.

Material and methods: the research was carried out on the basis of the National Sports Complex "Olympiyskyi" in the group "Veteran Ten" during 2020-2021. The main sports competitions the combatants were preparing for were various marathons.

40 combatants who had completed their military service took part in the research. During the research, there were used the following methods: pedagogical experiment, and methods of mathematical statistics.

Results: During a year, combatants participated in the research in the framework of which they trained and prepared to participate in mass races. The content of the training included both running exercises and exercises aimed at developing strength qualities (mainly strength endurance), flexibility, and coordination. The level of physical fitness of combatants was tested in dynamics (before the start of training and after a year of training). The level of physical fitness of combatants was determined according to the approved tests and standards of the "Annual Assessment of Physical Fitness of the Population of Ukraine". Based on the results of the research, it was established that at the initial stage, 75% of the combatants had a low level of physical fitness, 23% had a medium level, and 2% had a sufficient level. Upon the completion of the pedagogical experiment, the level of physical fitness of the combatants improved: 33% of the combatants had a low level of physical fitness, 50% had a medium level, and 17% had a sufficient level, which demonstrates the effectiveness of training sessions as a means of physical culture and sports rehabilitation.

Conclusions. The positive impact of physical culture and sports rehabilitation on the level of physical fitness of combatants was determined. With the help of the tests and standards of the "Annual Assessment of Physical Fitness of the Population of Ukraine", it was discovered that the indicators of physical fitness of the combatants at the first stage of the research were in the range from 2 to 21 and on average were (11.83; 4.49) points. In the second stage, they ranged from 11 to 24, their average physical fitness score was (11.28; 3.20) points. At the same time, 46.1% of the participants of the research got an observed increase in the indicator which turned out to be statistically significant ($t=13.563$; $df=39$; $p<0.05$). Therefore, it can be stated that running sessions have a positive impact on the level of physical fitness of combatants.

Keywords: physical fitness, physical culture and sports rehabilitation, combatants.

Анотація

Наталія Крушинська, Ірина Когут, Євген Гончаренко. Вплив фізкультурно-спортивної реабілітації на рівень фізичної підготовленості учасників бойових дій. Антитерористична операція, операція об'єднаних сил, повномасштабна війна в Україні чинить значний фізичний та психологічний вплив на учасників бойових дій. Одним із негативних наслідків війни є втрата фізичного здоров'я, що в подальшому

впливає на процес соціалізації до мирного життя. Разом з тим, досліджень, що висвітлювали б процес відновлення фізичного здоров'я за допомогою фізкультурно-спортивної реабілітації недос-татньо, що підтверджує актуальність обраної теми.

Мета: визначення впливу фізкультурно-спортивної реабілітації на рівень фізичної підготовленості учасників бойових дій.

Матеріал і методи: дослідження здійснювались на базі Національного спортивного комплексу «Олімпійський» у групі «Ветеранська десятка» протягом 2020 – 2021 рр. Основними спортивними змаганнями до яких готувались учасники бойових дій були різновиди марафонів.

У дослідженні взяли участь 40 учасників бойових дій, які завершили військову службу. Під час проведення дослідження застосовувались наступні методи: педагогічний експеримент, методи математичної статистики.

Результати: учасники бойових дій протягом року брали участь у дослідженні, в межах якого вони тренувались і готувались до участі в масових забігах. Зміст тренувальних занять передбачав як бігові вправи, так і вправи, спрямовані на розвиток силових якостей (переважно силової витривалості), гнучкості, координації. Тестування рівня фізичної підготовленості учасників бойових дій відбувалось в динаміці (до початку тренувальних занять та після року занять). В учасників бойових дій рівень фізичної підготовленості визначався за затвердженими тестами і нормативами «Щорічного оцінювання фізичної підготовленості населення України». Виходячи з результатів дослідження, встановлено, що на початковому етапі у 75% учасників бойових дій був низький рівень фізичної підготовки, в 23% − середній рівень та 2% − достатній. По завершенню педагогічного експерименту було покращено рівень фізичної підготовленності в учасників бойових дій: низький – 33%, середній – 50%, достатній – 17%, що свідчить про ефективність тренувальних занять як засобу фізкультурно-спортивної реабілітації.

Висновки. Визначено позитивний вплив фізкультурно-спортивної реабілітації на рівень фізичної підготовленості учасників бойових дій. За допомогою тестів та нормативів «Щорічного оцінювання фізичної підготовленості населення України» досліджено, що показники фізичної підготовленості учасників бойових дій на першому етапі дослідження знаходились в діапазоні від 2 до 21 і в середньому становили (11,83; 4,49) балів. На другому етапі вони коливались від 11 до 24, їх середня оцінка фізичної підготовленості склала (11,28; 3,20) балів. При цьому спостережуваний приріст показника у 46,1 % учасників дослідження виявився статистично значущим (t=13,563; df=39; p<0,05). Отже, можна стверджувати, що заняття бігом позитивно впливають на рівень фізичної підготовленості учасників бойових дій.

Ключові слова: фізична підготовленість, фізкультурно-спортивна реабілітація, учасники бойових дій.

Introduction

Since 2014, the anti-terrorist operation, the operation of the joint forces, and the full-scale war in Ukraine have been affecting the physical and psychological state of combatants. One of the negative consequences of the war is a significant decrease in the level of health of combatants, which makes it difficult for them to socialize and return to a peaceful life.

One of the effective means of improving the physical and psychological state of combatants is physical culture and sports rehabilitation which involves the use of physical exercises to restore health and is aimed at restoring and compensating the body's functional capacities through the means of physical education and sports. In addition, the physical culture and sports rehabilitation directs and motivates the combatants to achieve results in sports activities, and participation in competitions of various levels which in its turn encourages not only other participants in hostilities but also members of their families to regularly engage in physical activity, bringing people together, supporting and inspiring which contributes to recovery from combat.

Domestic and foreign scientists have studied the issue of restoring and increasing the level of physical fitness of combatants using various methodological approaches. For example, Yu. Bryndikov (2018) considered the rehabilitation of military personnel from the point of view of a medical-psychological and social-psychological approach. Blavt O. (2021) singled out innovative pedagogical approaches in the development of an inclusive environment for war veterans in institutions of higher education through adaptive physical culture. Prykhodko, I., Matsehora, Y., Kolesnichenko, O., Stasiuk, V., Bolshakova, A., Bilyk, O. (2021) studied the psychological ways of recovery of combatants after returning to a peaceful life. Melnyk, O., Lukomska, S. (2019) analyzed the age-specific features of the adaptation of combatants to the conditions of a civil life. At the same time, scientific works devoted to the research of the influence of physical culture and sports rehabilitation on the level of physical fitness of combatants are practically absent in the available literature which confirms the relevance of the chosen topic.

Relationship of research with scientific or practical tasks, plans, and programs. The scientific work was carried out in accordance with the Research Plan of the National University of Physical Education and Sports of Ukraine for 2021-2025. on topic 1.4. Theoretical and methodological foundations for the development of professional, non-Olympic, and adaptive sports in Ukraine in the context of reforms in the sphere of physical culture and sports (state registration number 0121U108294).

Objective. Determination of the impact of physical culture and sports rehabilitation on the level of physical fitness of combatants.

Material and Methods of the research

Participants

The research involved 40 combatants (men, the average age of the participants was 42.35±8.98), who during 2020-2021 were engaged in physical culture and sports rehabilitation and preparation for all-Ukrainian and international competitions in the running disciplines of athletics. The participants' training program included the use of athletics (in particular, running), and consisted of both running exercises and exercises aimed at developing strength qualities (mainly strength endurance), flexibility, and coordination. The combatants were informed about all the specifics of the research and gave their consent to participate in it.

Methods

In the framework of the research, there were applied pedagogical observation, pedagogical testing, and methods of mathematical statistics. The research program includes tests and standards for persons whose annual assessment of physical fitness is conducted voluntarily, approved by the Order of the Ministry of Youth and Sports of Ukraine No. 4607 under

date of October 4, 2018 (https://ips.ligazakon.net/document/RE32659).

Procedure (research organization)

Pedagogical testing was conducted on the basis of the National Sports Complex "Olympiyskyi". 40 combatants having completed military service took part in the research. The testing was carried out by the coach at the first training session and then after a year of the physical culture and sports rehabilitation sessions, during the preparation for international and all-Ukrainian competitions in the running disciplines of athletics. All the participants were informed about the use of test materials and gave consent for their processing.

Since the combatants were no longer classified as active military personnel and were not required to meet the standards of physical fitness of military personnel, besides, the majority of combatants had combat injuries, the tests and standards for the civilian population approved by the Ministry of Youth and Sports were chosen for the research.

The research program included tests and standards of the "Annual Assessment of the Physical Fitness of the Population" in accordance with the Resolution of the Cabinet of Ministers of Ukraine under date of December 9, 2015 No. 1045 "On Approval of the Procedure for the Annual Assessment of the Physical Fitness of the Population of Ukraine".

The testing program included running at medium and long distances; flexion and extension of arms at the push-up position; pulling up on the crossbar; pulling up on a low crossbar; performing sit-ups during 1 minute; standing long jump; kettlebell snatch; squat; running for 30 m, 60 m, 100 m; shuttle run 4 x 9 m; bending the body forward from a sitting position.

There were additional points for calculating the body mass index (BMI) for participants aged 36–50.

The tests used during the research corresponded to the age category of the participants, for persons of mature age (21–70 years). The obtained results were assessed according to the scale of the results of the performed tests and standards (Table 1).

Table 1. Scale of the results of completed tests and standards for persons of mature age (21–70 years)

Points	Level of physical fitness	Assessment of the level of physical fitness
30-26	High	Excellent
25-21	Sufficient	Good
20-16	Medium	Satisfactory
15 and less	Low	Unsatisfactory

The final assessment of the level of physical fitness of participants aged 21 to 70 years is based on the sum of the points obtained for the performance of 5 types of optional tests and additional points for calculating the body mass index.

Statistical analysis

In order to process the scientific materials, the methods of mathematical statistics were used for the quantitative analysis of the obtained results. The research results were processed with the help of "Excel 2016" (Microsoft, USA).

The Shapiro-Wilk W-test was used to check the hypothesis concerning the submission of empirical data to the normal law of distribution. Since the assessments of the levels of physical fitness of the combatants, regardless of the testing stage, corresponded to the normal law of distribution (W=0.982; p=0.758 and W=0.972; p=0.413 for the first and the second stages, respectively), the average indicators were presented in the form ($\bar{X}$; SD), where $\bar{X}$ is the medium, SD is the standard deviation, and the comparison of medium scores was carried out using the Student's parametric t-test for dependent samples. At the same time, the degrees of freedom of df were calculated using the formula df = n – 1, where n is the number of observations.

Pearson's $\chi 2$ consistency criterion was used to assess the compliance of divisions of athletes by levels of physical fitness with the uniform distribution law (Shynkaruk, O., 2019). It should be noted that during the use of frequency analysis, different levels of physical fitness were considered (low, medium, and sufficient).

The level of significance was $\alpha = 0.05$ ($p < 0.05$). At the same time, if the value of the p-level exceeded 0.001, its value was indicated by an approximate number, and in other cases, it was presented as "$p < 0.05$".

Results of the research

The research was carried out in two stages (before the beginning of physical culture and sports rehabilitation sessions and after 1 year of training sessions). As a result of the first test, it was found that the indicators of the level of physical fitness of the combatants were in the range from 2 to 21 and on average were (11.83; 4.49) points. In the second stage, there was found a probable improvement in the dynamics of the results ($p<0,05$) which ranged from 11 to 24, their average assessment of physical fitness was (11.28; 3.20) points. At the same time, 46.1% of the participants of the researchgot an observed increase in the indicator which turned out to be statistically significant ($t=13.563$; $df=39$; $p<0.05$). Therefore, it can be stated that running sessions havea positive impact on the level of physical fitness of combatants.

At the same time, the analysis of the results obtained during the first stage of the research shows that 75%of combatants (30 people) had a low level of physical fitness, 23%(9 people) had a medium level of physical fitness, and 2% (1 person) had a sufficient level. There was no research participant with a high level of physical fitness. It has been proven that the numberof participants with a low level of physical fitness is statistically significantly higher than the number with medium and sufficient levels ($\chi 2=10.0$; $df=1$; $p=0.002$).

During a year, the combatants trained to prepare for all-Ukrainian and international competitions in the running disciplines of athletics: "MARATHON NO ONE WANTS TO RUN", the race "I respect soldiers, I run for the Heroes of Ukraine", "Veteran's Ten", "MILITARY RUN UA", "Veteran's mile in Kołyice", the Marine Corps Marathon in the USA, the peace marathon in Kołyice and others (Krushynska N. and others (2021). The training sessions were held three times a week under the supervision of a coach, and combatants also trained individuallytwice a week.

According to the results of the second (control) testing, a significant increase in the level of physical fitness of the combatants was recorded. 33% of combatants (13 people) had a low level of physical fitness indicators. 50% of combatants (20 people) showed a medium level, and 17% of combatants (7 people) showed a sufficient level (Fig. 1). It should be noted that at this stage, the number of research participants with a medium and sufficient level was statistically significantly higher ($\chi 2=16.9$; $df=1$; $p<0.05$) compared to the number of combatants with a low level of physical fitness.

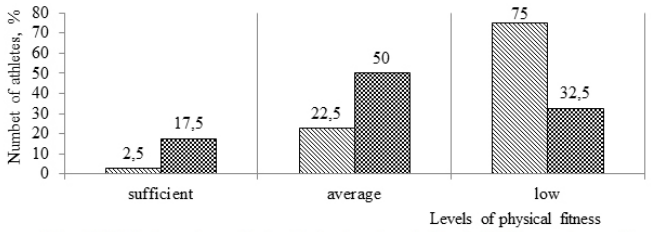

Fig. 1. Division of combatants by levels of physical fitness depending on the stage of the study(n=40):

▧ - first stage; ▩ - second stage

Therefore, based on the data obtained upon carrying out the testing of the "Annual Assessment of the Physical Fitness of the Population of Ukraine", it was established that at the second stage of the research, the number of combatants with a low level decreased by 42.5% ((χ^2=14,5; df=1; p=0,0001)) due to an increase in the number of research participants with a medium level by 27.5%, and those with a sufficient level - by 15%. It should be noted that among the participants, regardless of the stage, there was found no one with a high level of physical fitness. In our opinion, this may be related to the short period of time to reach a high level of physical fitness. However, it can be stated that the results of the second stage of testing testify to the effectiveness of the chosen means of physical culture and sports rehabilitation and their positive impact on the physical fitness of the combatants.

It should be noted that the content of training sessions aimed at preparing for participation in mass races included both running exercises and exercises aimed at developing strength qualities (mainly strength endurance), flexibility, and coordination. Also, it is important to note that the better dynamics of improvement in physical fitness indicators was demonstrated by those participants who attended training sessions regularly, showed responsibility for completing the tasks of the coaches, performed additional exercises at home, and followed the sleep and nutrition regime. As a result of the survey of combatants, conducted regularly during training sessions, it was found that the opportunity to participate in competitions both in Ukraine and abroad became an important factor in forming a responsible attitude to training sessions and the main motive for regular training for the majority of the research participants. This fact allows us to assume that purposeful preparation for various competitions (races) significantly increases interest in sports in general and contributes to increasing motivation for regular training.

Discussion

Analyzing the literary sources by Kogut I. (2022), Kravchenko O. (2022), Sergienko V. (2022), and Shidelko A. (2022), we can conclude that regular sessions within the framework of physical culture and sports rehabilitation have a positive effect not only on the level of physical fitness, general condition and level of health but also play a decisive role in the socialization of combatants.

The physical culture and sports rehabilitation contribute to the formation of value orientations to health, encourage to engage independently in sports and physical activity, and use them for self-improvement, recreation, and organization of leisure. Scientists Sergienko V., Kogut I., Matveev S., and Jagiello M. consider physical culture and sports rehabilitation as a versatile activity of a person in the field of physical culture and sports that should be aimed at the realization of social and personally significant needs for strengthening health and a healthy lifestyle.

To determine the level of physical fitness of the combatant and control the dynamics of indicators, there were used tests and standards for persons whose annual assessment of physical fitness is carried out voluntarily, approved by the Order of the Ministry of Youth and Sports of Ukraine No. 4607 under date of October 4, 2018.

The purpose of the annual assessment is to determine and increase the level of physical fitness of the population of Ukraine, to create appropriate conditions for the physical development of various population groups, to improve their health, to ensure the ability for highly productive work, to protect the sovereignty and territorial integrity of Ukraine, as well as to promote patriotic education and the formation of public position. The main tasks of the annual assessment are: determining the level of physical fitness of the population of Ukraine; promoting the development of physical culture among the population of Ukraine; formation of the need for physical activity among the population of Ukraine; directing the activities of educational institutions to the physical development of youth, physical culture and sports organizations to ensure the proper level of physical fitness of the population of Ukraine; enabling the population of Ukraine to independently assess the level of physical fitness; determination of military personnel's most important physical and special qualities, military-applied skills taking into account their physical fitness, which are primarily necessary for the effective performance of their tasks; promoting the formation of a healthy lifestyle, patriotism and national consciousness of the population of Ukraine, increasing the level of interest in serving in the Armed Forces and other military units formed in accordance with the laws, the State Service of Special Communications, law enforcement agencies, in particular the National Police, emergency and other special services, readiness for protection of the Motherland; promoting the creation of appropriate conditions for the preparation and conducting of the annual assessment of various population groups of Ukraine (https://ips.ligazakon.net/document/RE32659).

Analyzing the research of domestic scientists, it was found that they mostly consider the recovery of combatantsusing a medical-psychological and social-psychological approach. For example, Yu. Bryndikov (2018) in most of his studies pays attention to social, psychological, and medical rehabilitation. At that time, in his works, he does not emphasize the important role of the positive dynamics of the level of physical fitness in improving the condition of combatants. The research carried out by us shows that the regular use of physical culture and sports rehabilitation has a positive effect on increasing the level of physical fitness of combatants.

Scientists Prykhodko, I., Matsehora, Y., Kolesnichenko, O., Stasiuk, V., Bolshakova, A., Bilyk, O. (2021) consider the issue of first psychological aid for combatantsupon returning to a peaceful life. However, in their research,they do not take into account the influence of physical fitness on their socialization. In our research, to improve the condition of the combatantsupon returning to a peaceful life, it was suggested to use the means of physical culture and sports rehabilitation, in particular: regular training "Open training of ATO veterans at the NSC Olimpiyskiy"; various competitive events: Invictus Games, "Marathon in New York that no one wants to run" (2021), "I respect the soldiers, I run for the Heroes of Ukraine" race (2018), "Veteran's Ten" (2018), "Military Run UA " (2021), "Veteran Mile in Kолice" (2021), thatcancontribute to accelerating the pace of their social integration.

Researcher Blavt O. suggests using the means of adaptive physical culture as an innovative pedagogical approach in the development of an inclusive educational environment for war veterans. At that time, our research emphasized the importance of organizing and conducting joint training sessions and focused on the continuity of the training process and the continuous improvement of physical culture and sports rehabilitation measures for combatants.

Therefore, the analysis of the professional literature and our research shows that the anti-terrorist operation, the operation of the joint forces, and the full-scale war in Ukraine cause significant injuries tocombatants and are reflected in their socialization upon returning toa peaceful life. Therefore, it is high time to develop and introduce the tools of physical culture and sports rehabilitation, such as running sessions to prepare for all-Ukrainian and international competitions, which positively affect the physical fitness and integration of the combatantsinto society, into their training process.

Conclusions

1. The positive impact of physical culture and sports rehabilitation on the level of physical fitness of combatants was determined using the tests and standards of the “Annual Assessment of Physical Fitness of the Population of Ukraine”. The conducted research has shown that combatants aged 40-60 improve their physical fitness more slowly. At the same time, the physical fitness of combatants depends on their responsible attitude to the training process. Athletes who did not attend training sessionssystematically have significantly lower rates of improvement in physical fitness.

2. The results of the conducted research made it possible to determine that physical culture and sports rehabilitation (in particular, running and general physical training) have a positive effect on the level of physical fitness of combatants having completed military service. At the initial stage, 75% of combatants had a low level of physical fitness, 23% had a medium level, and 2% had a sufficient level. It was established that at the first stage of the research, among its participants, there was a statistically significant ($p<0.05$) prevalence of combatants with a low level of physical fitness. After the introduction of physical culture and sports rehabilitation tools into their training process, in particular running classes (within 1 year), the level of physical fitness of combatants improved and their division by the level of physical fitness became as follows: low - 33%, medium - 50%, sufficient - 17%, which indicates the effectiveness of the use of means ofphysical culture and sports rehabilitation. It should be emphasized that at the second stage of the research, there was recorded a statistically significant ($p<0.05$) smaller number of combatants with a low level of physical fitness. At the same time, there was proven a statistically significant ($p<0.05$) increase in the assessment of the level of physical fitness of combatants under the influence of physical culture and sports rehabilitation tools. The obtained results prove the effectiveness of the selected means and the expediency of their use in the training process of combatants.

Further research is planned to be aimed at establishing the dynamics of the stress level of combatants under the influence of physical culture and sports rehabilitation means.

Author Contributions

Krushynska Nataliia– research planning, data collection;
Kohut Iryna– data interpretation, data analysis;
Goncharenko Ievgen– literature analysis, manuscript preparation.

Conflicts of Interest

The authors declare no conflict of interest.

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The influence of loads of various magnitudes and directions on the visual acuity of high-qualified visually impaired sprinters

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Abstract

Purpose: determine the impact of loads of different magnitudes and directions on the visual acuity of a highly qualified female athlete with visual impairments, specializing in sprinting.

Material & methods. The study was conducted in the general preparatory period of the annual training cycle with the participation of the Honored Master of Sports of Ukraine in athletics among athletes with visual impairments. The following research methods were used: analysis of documentary materials (diaries and preparation plans of the studied athlete), pedagogical observation; Pedagogical experiment (author's experiment), visometry, methods of mathematical statistics.

Results. It has been established that an increase in the load has a negative effect on visual acuity. The results obtained in the course of the study indicate a general trend in the response of both eyes to a load of a different nature.

Conclusions. The use in the preparatory period of loads of a strength orientation, complex for endurance, coordination and flexibility, leads to an increase in visual acuity, which in turn has a positive effect on the functional state of the visual analyzer. Large loads aimed at speed endurance and having a speed-strength character lead to a decrease in visual acuity and, as a result, negatively affect the functional state of the visual analyzer.

Key words*:* visual acuity, visual impairment, visometry, preparatory period.

Анотація

Лейля Аджаметова, Людмила Шестерова. Вплив навантажень різної величини та спрямованості на гостроту зору висококваліфікованих спринтерів з порушенням зору. Мета: визначити вплив навантажень різної величини та спрямованості на гостроту зору висококваліфікованої легкоатлетки з порушеннями зору, яка спеціалізується у спринтерському бігу. **Матеріал і методи**. Дослідження проводилося у загально-підготовчому періоді річного циклу підготовки за участю Заслуженого майстра спорту України з легкої атлетики серед спортсменів з порушеннями зору. Були використані наступні методи дослідження: аналіз документальних матеріалів (щоденники та плани підготовки досліджуваної спортсменки), педагогічне спостереження; педагогічний експеримент (авто експеримент), візометрія, методи математичної статистики. **Результати**. Встановлено, що збільшення величини навантаження, негативно впливає на показники гостроти зору. Результати, отримані під час дослідження, свідчать про загальну тенденцію реагування обох очей на навантаження різного характеру**. Висновки.** Застосування у підготовчому періоді навантажень силової спрямованості, комплексної на витривалість, координацію та гнучкість призводять до підвищення показників гостроти зору, що в свою чергу позитивно впливає на функціональний стан зорового аналізатору. Навантаження великої величини, що спрямовані на швидкісну витривалість та носять швидкісно-силовий характер, призводять до зниження показників гостроти зору і, як наслідок, негативно впливає на функціональний стан зорового аналізатору.

Ключові слова: гострота зору, порушення зору, візометрія, підготовчий період.

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Introduction

The study of the effect of physical activity on the functional state of the visual analyzer began in the late 1970s (Adzhametova & Shesterova, 2018, Barchenko & Bochkovskaya, 2018, Dill, 2005, Evseev et al., 2015, Sharon R. Ong et al., 2018, Ishiko S. et al., 2021). Sargent et al., (1981). found that moderate and intense aerobic exercise reduces intraocular pressure (IOP) in the short and long term (up to 6 months), the degree of reduction does not depend on the physical preparedness of athletes. However, a little later, Avunduk et al., (1999) found that isometric and isotonic exercises also lead to a decrease in IOP, while the magnitude of its decrease is higher with isotonic exercises. At the same time, Kiss et al., (2001), studying the characteristics of choroidal blood flow during isometric exercises, noted that such loads contribute to maintaining a constant blood flow in the choroid, despite changes in perfusion pressure. The author noted that this dependence persists with moderate changes in the level of carbon dioxide in the blood. It should be noted that the above results were obtained with the participation of athletes without violating the functions of the visual analyzer.

Alekseev et al., (2017), Suhr Thukjaer et al., (2017), Limwattanayingyong J. et al., (2022), Hansen M. H. et al., (2020) agree that small-scale physical activity improves the physiological parameters of the eye, increases the efficiency of the ciliary muscle and strengthens the sclera. Shmakov, (2014), Yang Y. et al., (2022) found that the use of adapted games and rhythmic gymnastics for children with visual impairments contributes to an increase in visual acuity and some weakening of eye refraction. But at the same time, according to Goldschmidt & Jacobsen, (2014), environmental factors, metabolism, physical activity and outdoor activity influence the fine correlation between the components of ocular refraction.

Arutyunova et al., (2006) showed that physical activity with an arterial pulse up to 175 beats/min. contribute to the improvement of blood supply to the anterior part of the eyeball, and the arterial pulse of more than 175 beats / min leads to a deficiency in the blood supply to the anterior and posterior parts of the eye. Scientists have shown that dynamic physical activity contributes to a decrease in IOP regardless of the degree of training and an increase in perfusion pressure of the eye, depending on the degree of training of the studied athletes. However, Read & Collins (2011), Lundberg K. et al., (2018) found that moderate-intensity dynamic exercise resulted in significant changes in ophthalmic functional parameters. Note that the author, unlike his predecessors, studied the performance of athletes both with visual impairments and with normal vision. Thus, he found that immediately after loading, there was a decrease in the axial length of the eye against the background of a decrease in IOP. At the same time, no significant differences were found in the magnitude of changes between athletes with and without visual impairments. Thus, the author notes that exercise has a short-term effect on the axial length of the eye and intraocular pressure.

Thus, the analysis of modern literature has shown that physical activity has a positive effect on the physiological parameters of the eye, helping to reduce intraocular pressure, improve blood supply to the posterior and anterior parts of the eye, as well as a short-term decrease in the axial length of the eye, which can help reduce the risk of developing and progressing (Cuellar-Partida et al., 2016, Dill, 2005, Shesterova, 2015, Wenbo et al., 2017, Wylęgała, 2016, Zhou et al., 2016, Frike TR et al, 2018, Burton MJ, et al, 2021). However, in the scientific and scientific-methodical literature, the effect of loads on the state of the visual analyzer in Paralympic athletes with visual impairments has not been practically studied. At the same time, the available data open the prospect for further research aimed at studying the effect of physical loads of various magnitudes and directions on the visual acuity of highly qualified sprinters with visual impairments.

Purpose of the study: to determine the effect of loads of different sizes and directions on the visual acuity of athletes with visual impairment, specializing in sprinting.

Material and Methods of the research

The study was conducted during the training camp of the national Paralympic athletics team of Ukraine in Antalya (Turkey). The Honored Master of Sports of Ukraine in athletics among athletes with visual impairments, Paralympic champion, world record holder took part in the study. According to the athlete's individual training plan, the training camp was held at the general preparatory stage of the preparatory period of the annual training cycle and lasted 3 weeks.

An female athlete at the age of 27 had a congenital damage to the visual apparatus: partial atrophy of the optic nerve in both eyes. The percentage of damage to the left eye is higher than the right. The athlete had a leading right eya. The visual acuity of the female athlete was determined by the doctor of the national Paralympic athletics team of Ukraine according to the Sivtsev table. Since the female athlete's vision did not allow seeing the symbols of the table from 5 m, Snellen's formula was used for accounting:

$$VISUS = d/D, \quad (1),$$

where V - visual,

d - distance from which the athlete saw the symbol of the table,

D - tabular value indicated on the left in the Sivtsev table.

Visometry was carried out three times after each training session, the athlete's rest between measurements lasted 10-12 minutes and took place in a sitting position with her eyes closed. According to the international classification, the visual acuity indicators of the athlete corresponded to the T13 class.

The following methods were used in the study: analysis of documentary materials (training diaries and training plans of the studied athlete), pedagogical observation, pedagogical experiment (author's experiment), visometry, methods of mathematical statistics.

Statistical analysis of the obtained data was carried out on a personal computer using Statgraphics Centurion 18 (version 18.1.11), using the quartel method, the Kruskal-Wallis test, the Gamma correlation coefficient and the Spearman coefficient.

Results of the research

The training camp (TC) of the female athlete was held at the general preparatory stage of the preparatory period of the annual training cycle and lasted 3 weeks. The female athlete trained 2 times a day. The female athlete's training week consisted of 4 workouts in the stadium, 3 workouts in the gym and 2 workouts on the sand. The duration of training sessions ranged from 1.5 to 2.5 hours. Rest between exercises ranged from 1 to 3-4 minutes, depending on the direction of the load. So, between exercises of a strength orientation, rest usually was 1-1,5 minutes, and between speed exercises - 3-4 minutes. During the entire training camp, visometry was performed after each training session. The variation in visual acuity indicators is shown in Figure 1 and Table 1.

Table 1. Indicators of visual acuity for the period of TC without taking into account the load

Visual acuity (n=60)	$\bar{X}$ (c. u.)	Me (c. u.)	Min (c. u.)	Max (c. u.)	Q1 (25%)	Q3 (75%)
Right eye	0,070	0,070	0,060	0,084	0,065	0,075
left eye	0,069	0,070	0,060	0,073	0,065	0,070

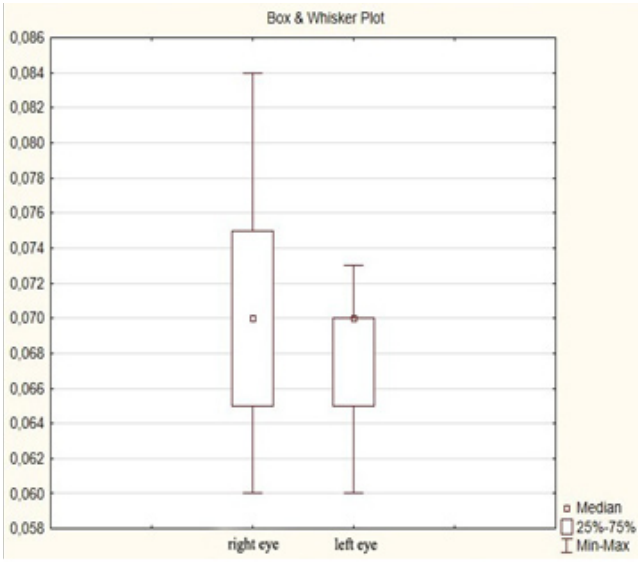


Fig.1. Indicators of visual acuity during TC in the general preparatory period

Figure 1 and Table 1 present a 5-digit summary of visual acuity indicators:

✓ the lower line corresponds to the minimum value of visual acuity in the data sample and is equal to 0.060 for both eyes;

✓ bottom of the box - 1st quartile, which is 0.065 for both eyes;

✓ point inside the box - medians corresponding to 0.070 for both eyes.

✓ the top of the box is the 3rd quartile, which is 0.075 for the right eye, and 0.070 for the left

✓ the upper line corresponds to the maximum value and is equal to 0.084 for the right eye, for the left – 0.073.

In order to determine the effect of loads on the visual acuity of the studied female athlete, all training loads were distributed according to the magnitude and direction according to the Platonov classification (2017). The athlete performed loads of various sizes with a primary focus on speed, strength, speed-strength and coordination abilities and endurance.

Figure 2 shows the variation in the visual acuity of an female athlete with visual impairment, taking into account the magnitude of the load during the TC.

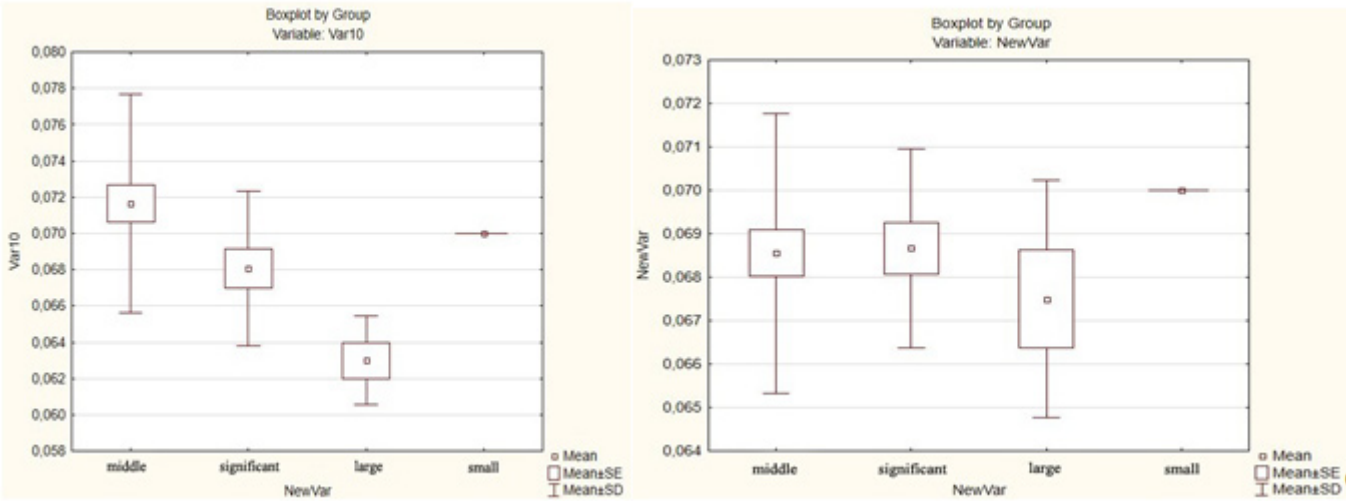
The Kruskal-Wallis (H) test was used to identify the significance of differences between visual acuity indices under the influence of loads of different magnitudes.

Analysis according to the Kruskal-Wallis test was carried out separately for the right and left eyes. It was established that there are significant differences between the indicators of visual acuity of the right eye at different loads H (N=60) =13,60 ($p<0.05$).

Significant differences are observed between the indicators of visual acuity of the right eye under the influence of a large load in comparison with a significant, medium and small one. At the same time, the indicators of visual acuity of the right eye under the influence of significant, medium and small loads do not have a significant difference between themselves (Table 2).

There were no significant differences between the indices of visual acuity of the left eye under loads of different magnitudes H (N=60) =1.96, ($p>0,05$).

The relationship between the magnitude of the load and visual acuity was determined by the Gamma correlation coefficient. This coefficient is used to study the relationship between



a b

Fig. 2. Comparison of visual acuity indicators under the influence of loads of different magnitudes during TC. (a - right eye, b - left eye)

Table 2. Pairwise comparison of indicators of visual acuity of the right eye under the influence of training load of different magnitudes according to the Kruskal-Wallis criterion (H)

Loading value	Small (n=3)	Medium	Significant
Medium (n=36)	H=0,17 p =0,68		
Significant (n=15)	H=0,61 p =0,43	H=3,43 p =0,06	
Large (n=6)	H=5,84 p =0,02	H=10,56 p =0,001	H=6,034 p =0,01

data presented in metric and rank scales. It was established that there is a significant average relationship between the load and visual acuity of the right eye ($p<0,05$), and the left eye has a weak relationship. ($p>0,05$).

Analysis of visual acuity indicators of the right eye under the influence of training load of different directions showed the existence of a significant difference between them (Table 3). According to the average rank and the arithmetic mean value, the highest indicators of visual acuity were observed during the work of strength and coordination orientation, complex speed endurance and strength work on the muscles of the upper limbs; the lowest indicators - during complex work on speed endurance and speed-strength abilities, speed-strength abilities and coordination, strength work on the muscles of the lower extremities.

A significant difference between the indicators of visual acuity of the right eye was found when performing the work of the following direction:

– strength - with all other types of work, except for the complex for speed endurance and strength for the muscles of the upper extremities;

– speed-strength - with complex work on speed endurance and strength on the muscles of the upper limbs, endurance and coordination;

– coordination - with speed-strength, complex speed-strength and coordination, speed, power for the muscles of the lower extremities, complex for speed endurance and speed-strength, complex power for the muscles of the upper limbs and coordination, complex for endurance;

– speed - from complex for speed endurance and speed-strength, complex for speed endurance and coordination;

– complex for speed endurance and strength of the muscles of the upper limbs - with a complex speed-strength and coordination, speed, power for the muscles of the lower extremities, complex for speed endurance and speed-strength;

– complex for endurance and coordination - with a complex speed-strength and coordination, speed, power for the muscles of the lower extremities, a complex for speed endurance and speed-strength.

Analysis of visual acuity indicators of the left eye under the influence of training load of different directions showed the existence of a significant difference between them (Table 3). According to the average rank and the arithmetic mean, the highest indicators of visual acuity were observed during the work of a strength orientation, complex for endurance and coordination, endurance and flexibility, speed endurance and speed-strength abilities; the lowest indicators in complex work on speed-strength abilities and coordination, power work on the muscles of the upper limbs and coordination. Analysis of the relationship between the average ranks of the right and left eyes according to the Spearman rank coefficient showed that there is a positive relationship of medium strength between them ($r=0,48$). This fact indicates the presence of a general tendency to respond to the load of different directions with the right and left eyes.

Discussion

In the scientific and scientific-methodical literature, there is evidence that physical activity has a positive effect on the physiological parameters of the eye. Most of the studies have

Table 3. Comparison of indicators of visual acuity under the influence of a training load of different directions according to the Kruskal-Wallis criterion (H)

Nature of work	Right eye			Left eye		
	N	Average ranks	Arithmetic mean	N	Average ranks	Arithmetic mean
Coordination	3	53,83	0,078	3	26,00	0,068
Strength	3	57,67	0,081	3	51,83	0,072
Speed-strength	12	22,42	0,067	12	24,00	0,068
Speed endurance, strength on the muscles of the upper extremities	3	51,17	0,077	3	28,50	0,068
Endurance, coordination	9	40,44	0,073	9	37,50	0,070
Speed-strength, coordination	3	14,50	0,065	3	7,50	0,063
High-speed	9	26,83	0,068	9	34,50	0,069
Strength on the muscles of the lower limbs	6	15,67	0,065	6	24,00	0,068
Speed endurance, speed-strength	3	6,83	0,062	3	37,50	0,070
Speed endurance, coordination	3	43,33	0,073	3	44,67	0,071
Hand strength, coordination	3	26,83	0,068	3	16,50	0,065
Endurance, flexibility	3	33,00	0,070	3	37,50	0,070
Kruskal-Wallis test (right eye): H (N= 60) =39,09 p =0,0001						
Kruskal-Wallis test (left eye): H (N= 60) =27,78 p =0,003						

been conducted with athletes without visual impairments and usually studies have been devoted to the study of the effect of exercise on the intraocular pressure of athletes. Unlike previous scientific studies, we analyzed the indicators of visual acuity of a highly qualified athlete with visual impairments.

As a result of the study, the exiting opinion was confirmed that the basis of the training of visually impaired sprinters is the use of various exercises of a speed, speed-power and strength nature.

In the course of the study, the information of Alekseev, Suhr Thukjaer, Lundberg and Grauclund on the effect of small loads on the state of the visual analyzer was supplemented and expanded. But, unlike the above authors, we studied the influence of loads of various magnitudes and directions. We found that with an increase in the load, visual acuity indicators decrease.

In the course of the study, results were obtained that contradict the opinion of Arutunova A.V. and Kiseleva T.M. In contrast to the studies of the above-mentioned authors, in our study, all the loads that were used during training were performed with an arterial pulse not higher than 174 beats / min (on the recommendation of an ophthalmologist). We found that loads performed with an arterial pulse up to 175 beats/min can also lead to a decrease in visual acuity. This can be explained primarily by the congenital pathology of the studied athlete and the level of adaptation to physical activity.

According to the results of a study of a highly qualified female athlete with visual impairments, the relationship between visual acuity indicators and loads of different directions was revealed. The load of strength, complex endurance, coordination and flexibility of orientation contributed to the increase in visual acuity. At the same time, loads aimed at speed endurance and speed-strength abilities led to a decrease in visual acuity.

Conclusions

1. Physical activity is considered as a means of preventing and improving the condition of the visual analyzer. However, no information on the influence of loads of different magnitudes and directions on the functional state of the visual analyzer of highly qualified Paralympic athletes has been found in modern literature.

2. The results of the study indicate that there are significant differences between the indicators of visual acuity of the right eye and the magnitude of the load ($p<0.05$). It was found that with an increase in the load, the visual acuity of the right eye decreases. At the same time, no significant differences were found between the visual acuity indices of the left eye under loads of different magnitudes ($p>0.05$). That is, it can be argued that large loads adversely affect the functional state of the visual analyzer.

3. The general tendency of the response of both eyes to the load of different directions was established. So, loads on strength, coordination, endurance and flexibility have a positive effect on visual acuity. Loads of a speed-strength nature and speed endurance lead to a decrease in visual acuity and negatively affect the functional state of the visual analyzer.

4. The results of the study will allow planning the amount, magnitudes and directions of loads in the training process of visually impaired sprinters. In our opinion, this can lead to further prevention descrease in visual acuity of para-athletes.

Author Contributions

Leilia Adzhametova: collection, data entry, data analysis, manuscript preparation, statistics.

Liudmyla Shesterova: design, data interpretation, research planning.

Conflicts of Interest

The authors declare no conflict of interest.

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