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

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REVIEW ARTICLE

Priority scientific areas in sports dances research: the analysis of the scientific resources of Web of Science Core Collection

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Abstract

Background and Study Aim: The increase in the popularity of sports dances recently has been confirmed. Dancing combines sports and aesthetic components. Dances are used for sports, recreational and rehabilitation purposes. The study aim is an analytical analysis of publications devoted to sports dances and the determination of priority scientific areas in this field.

Material and Methods: The bibliometric database Web of Science Core Collection (WoS) is analyzed. For the primary analysis, 618 sources were selected which met the search criteria for 2018–2022. We used bibliometric methods for processing the information received in the context of sports dances for 173 sources. The VOSviewer 1.6.18 program was used: keyword analysis method and direct citation analysis with the construction of bibliometric maps, visualization of cluster density, weights – citations.

Results: The constructed bibliometric maps made it possible to identify the leading thematic areas of research, current areas of research in this field. They can be divided into sports, recreational, medical and rehabilitation areas. The sports context is aimed at studying the performance of technical elements, the development of the physical qualities of athletes, the assessment of physical fitness, the dynamics of the morphofunctional state. Psychophysiological studies are aimed at analyzing balance and equilibrium. Publications of a recreational orientation study the health-improving use of dances, their impact on health. The medical and rehabilitation direction explores the features of sports injuries in dancing, injury prevention and the possibility of using dances in the complex rehabilitation. The use of the VOSviewer program, version 1.6.18, made it possible to conduct a comprehensive analysis of the problem, to determine the priority scientific directions in this area.

Conclusions: The conducted bibliometric analysis of publications confirms the relevance of the problem of sports dances. A constant research interest in this problem has been determined. Research in this area has a pronounced sports and medical focus. Bibliometric analysis of publications allows identification the three following areas: sports, recreation and rehabilitation. Dancing is being explored as a sport, a form of physical activity, and a form of rehabilitation. A fairly high level of sports injuries has led to interest in the analysis of the prevalence and prevention of injuries. Its characteristic feature is the intersection of these directions. The study of athletes' state confirmed the lack of works devoted to a comprehensive study of athletes, predicting success and skill growth. There are not enough works studying the physical state of sports dancers. There are practically no studies aimed at studying the psychophysiological state. These types of studies should be assessed as relevant.

Keywords: sports dances, bibliometric mapping, VOSviewer, sports, recreational, medical, rehabilitation

Introduction

Sports dances attracted the attention of researchers in various areas and fields of science. Dancing combines sports and aesthetic components. Their duality is emphasized in the following studies [1, 2, 3, 4, 5]. There is debate about whether dancers are athletes or whether the sport has aesthetic qualities. They can reveal broader issues of contemporary culture, health, competitiveness and commercial activities. Sports dance is a sports, entertainment and fitness project. It combines sports, music, aesthetics and dance.

The popularity of Sports dances has been confirmed to have increased recently. This is confirmed by a large number of national and international competitions, a significant increase in the number of athletes [4, 6]. The rules of modern dance are constantly being improved and complicated. This increases the requirements for athletes [4, 7].

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Modern dance is characterized by high physical activity. A significant level of physical effort requires athletes to maintain fitness. The unique and complex physical activities in sports dances differ significantly from those in other sports. Sufficient development of basic physical qualities provides an increase in the level of skill and prevention of sports injuries [8, 9, 10]. To determine risk factors for injury in sports dances is essential for the health and career of dancers [11, 12, 13]. Determining injury risk predictors will allow organizing training in such a way as to minimize their probability. A promising way to reduce injuries is to study the correlation between the biomechanical and physiological parameters of athletes [11].

Increased stress levels are another risk factor in Sports dances. Athletes report stress, increased susceptibility to disease, poor mood and performance. These phenomena are observed most often during periods of high training load and competition. Preparation and participation in competitions require great physical and psychological endurance from dancers [14, 15].

The need to perform complex technical elements in dances causes increased requirements for coordination of movements [16, 17, 18, 19]. The study of the psychophysiological characteristics of sports dancers will allow analyzing their condition, predict the growth of sportsmanship, and ensure the prevention of sports injuries by improving the technique of performing elements.

Tovar-Garcia [20] suggests that those who participate in sports/physical exercise obtain higher wages, about 6-10%, in comparison with sedentary individuals. In addition, the intensity of physical exercise is positively linked to wages. Moreover, the empirical strategy pinpointed the specific activities with robust effects: using exercise equipment, swimming, dancing, and aerobics. The findings of this research are a reminder to support public policies on physical activities and sport facilities at the local level and for ordinary people.

Physical activity is closely correlate with a healthy lifestyle. Various types of physical activity can significantly optimize health. Dancing is one of the promising types of physical activity. The importance of sports dances in health-improving activities is emphasized [2, 21, 22]. Dancing is considered a type of organized leisure that can be used to improve the health of the population.

Sports dancing can not only improve the quality of life, but also affect the health of young people. Qi [21] researched and analyzed the impact of sports dancing on the mental health of college students. It is shown that sports dance has a positive effect on the mental health of students. The level of mental health of dancers is much higher than that of ordinary people.

Currently, the adult population uses many sports to perform daily physical activity. One of the leading places among them is occupied by sports dances [22, 23]. Foley et al. [22] evaluated the possibility of using dancing as an additional physical activity. A survey of participants in the dance activity No Lights, No Lycra was conducted. This dance version encourages people to participate in free dancing in the dark for 60 min. It provides a modified opportunity for organized physical activity during free time. No Lights, No Lycra have recorded an increase in attendance at their events over the past decade.

Bibliometric analysis is a method of complex analysis of an array of publications [24, 25]. The content of this analysis was the construction of a bibliometric map [26, 27]. Such an analysis is aimed at assessing the number of citations, identifying the leading trends in the scientific direction under consideration. The graphical representation of the data array allows you to evaluate the relationship between the constituent parts - clusters, to identify the most significant components.

In this context, it was of interest to conduct a bibliometric analysis of scientific publications on Sports dances in the journals of the international base Web of Science Core Collection.

The purpose of the study is an analytical analysis of publications devoted to sports dances and the establishment of priority scientific directions in this area.

Methodology

Data sources

The Web of Science Core Collection (WoS) bibliometric database has been selected to create a sample of studies as of 07/01/2022.

The main criterion for choosing bases was the quality of the information sources. Received 618 records (Web of Science Core Collection). Sources matched the search term “sport dance” in the post subject. The search period was 2018–2022. The number of publications by years was the following: 2018 – 112 (18.12%), 2019 – 135 (21.84%), 2020 – 150 (24.27%), 2021 – 153 (24.77%), 2022 – 68 (11.00%).

TOP-10 different subject areas are presented in Table 1. Given the context of the article, further analysis of publications in the subject area Sport Science (n=173) was carried out. These subject areas of WoS are of the greatest interest in the context of the topic of the article: Sport Science, Orthopedics, Rehabilitation, Physiology.

TOP-10 journals with articles on the research topic: Journal of Dance Medicine Science – 9, Revista Brasileira de Medicina do Esporte – 9, Physical Therapy in Sport – 8, Frontiers in Sports and Active Living – 5, Journal of Sport Medicine and Physical Fitness – 5, Clinical Journal of Sport Medicine – 4, European Journal of Sport Science – 4, Journal of Human Sport and Exercise – 4, Journal of

Table 1. Results analysis table for web of science category field (Web of Science Core Collection)

Category	Items (N; %)
	All subject areas, n=618
Subject area (top 10 items)	Sport Science (173; (27.99 %), Education Educational Research (65; (10.52%), Hospitality Leisure Tourism (64; (10.36 %), Public Environmental Occupational Health (40; (6.47 %), Rehabilitation (34; (5.50%), Orthopedics (33; (5.33%), Psychology Applied (25; (4.05%), Medicine General Internal (24; (3.88%), Neurosciences (24; (3.88%), Social Science Interdisciplinary (24; (3.88%).
	Subject areas, in the context of the topic of the study, n=173
Subject area	Sport Science (173; (100 %), Hospitality Leisure Tourism (23; (13.29%), Orthopedics (22; (12.72%), Rehabilitation (18; (10.40 %), Physiology (13; (7.51 %),

NOTE: the source of information is the authors' own research (07/01/2022).

Orthopaedic Sports Physical Therapy – 4, Journal of Science and Medicine in Sport – 4.

Method of Study

To clarify global trends in Sports dances research, the Web of Science Core Collection database was used: the period of publications for the period 2018–2022 was considered. The search results are presented in Table 1. by the most significant categories (Table 1, 173 sources), we analyzed the most priority scientific research in the field of Sports dances.

Data analysis

To determine the leading trends in the problems of our study, we used bibliometric methods [24, 25] for processing the information received in the context of Sports dances. To do this, we used VOSviewer 1.6.18, a software tool for creating and visualizing bibliometric networks [28]. The most important for the study was the implementation of the keyword analysis method [24] and direct citation analysis [25]. The methodology for calculating the main indicators for the analysis and identification of the most significant research categories is described in detail in the works of van Eck and Waltman [26, 27]. Based on the most cited references, we identified promising areas of research in this category. Distance-based bibliometric maps have been used - these are maps where the distance between two elements reflects the strength of the correlation between the elements. A smaller distance usually means a stronger connection.

Results

The use of VOSviewer 1.6.18 made it possible to create the corresponding bibliometric maps. The analysis of these maps was aimed at identifying trends in the scientific support of sports dances, highlighting priority areas.

The results for the main authors of the publications are shown in Figure 1. Authors with publications devoted to sports dancing in 2018–2022 were selected. The analysis involved 70 authors whose link strength was greater than 0.

The specificity of Figure 1 is its division into 2 clusters. They are characterized by the presence of 1673 links, the total link strength is 1674. The first cluster includes 63 authors, the second – 7 authors.

Analysis of Figure 1 does not allow to single out the most authoritative scientists in the field of sports dances. The two authors of the second cluster have the most links: Kelleher Cecily C (62 links) and Heinen Mirijam M (62 links). It is these authors who are the links between the two clusters. However, these links are formed by only two documents. The rest of the authors have one document each, the number of links varies within 6–57.

Network visualization is presented in Figure 2. The network was created based on the basis of 37 elements - keywords. They are grouped into 4 clusters. The network is characterized by the presence of 310 links, with a total strength of 652. The size of the circles - keywords corresponds to the number of links received. The proximity of these circles to the map reflects the strength of the correlation between objects. According to Figure 1 can highlight the most popular research. They are centered around the keywords "dance", "sport", "physical activity", "injury", "prevalence", "exercise".

The first cluster includes 14 keywords. It is marked in red on the map. The cluster received the conditional title "dance". It is the most significant keyword. It has 35 links with other map keywords, total link strength (TLS) is 148. Then, in decreasing order of the number of links as follows: "prevalence" – 25, (TLS 44), "injury" – 25, (TLS 70), " performance" – 22, (TLS 45), "ballet dancers" – 20, (TLS 33), "ballet" – 19, (TLS 30), "injury prevention" – 18, (TLS 23), "reliability" – 16, (TLS 24), "strength" – 15, (TLS 23), "fitness" – 15, (TLS 25), "athlete" – 14 (TLS 18), "gymnastics" – 14, (TLS 17), " validity" – 10, (TLS 14), "motion" – 7, (TLS 9). The keywords of this cluster reflect the focus of research on the use of dances for recreational and rehabilitation purposes, the analysis and prevention of injuries, the study of the characteristics of movements in dances. The maximum link strength between the keywords "dance" and "injury" confirms this assumption.

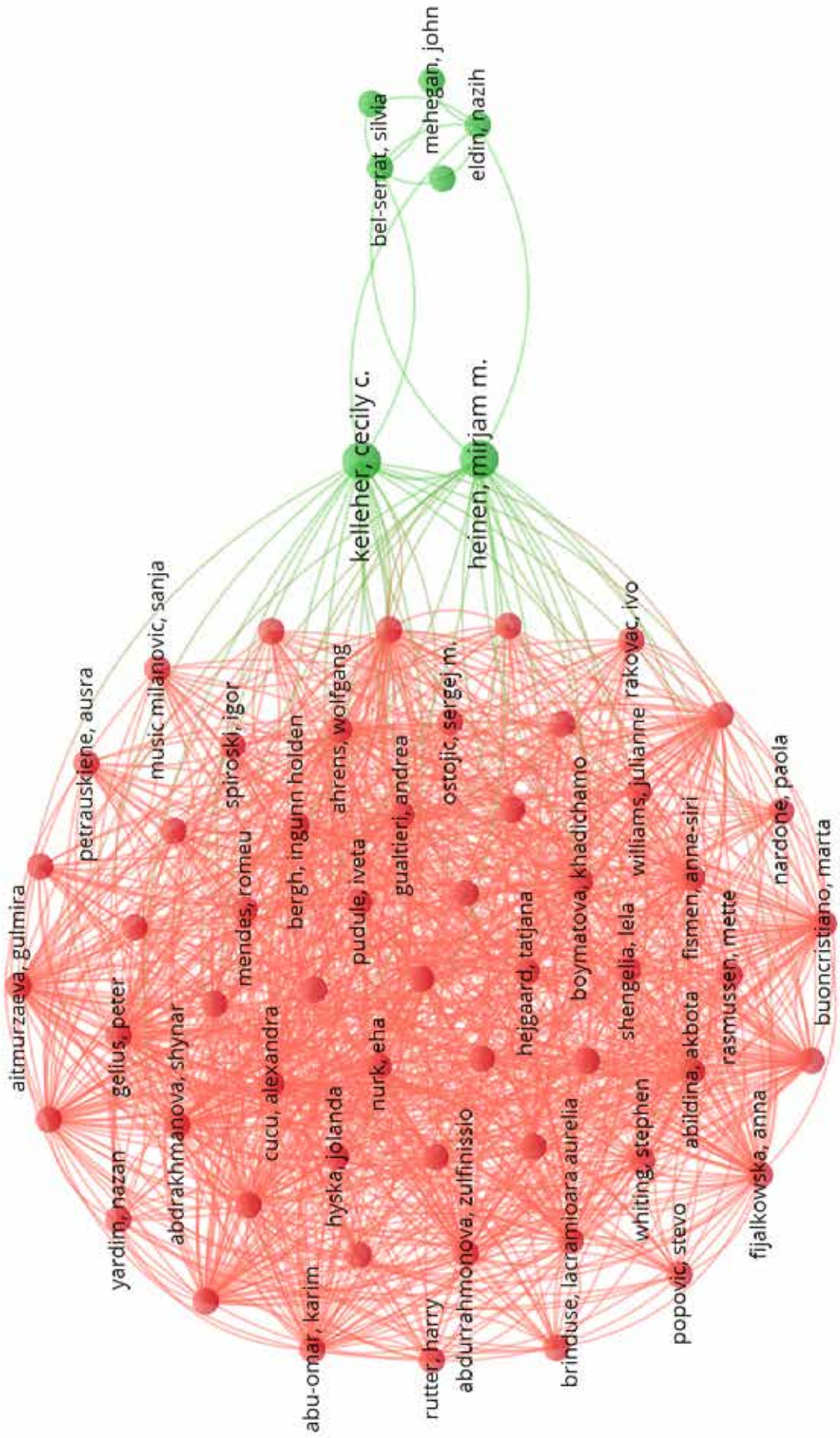

Figure 1. Leading authors of publications devoted to sports dances, network visualization. Source: own research based on data sourced from WoS and analyzed with VOSviewer (07/01/2022).

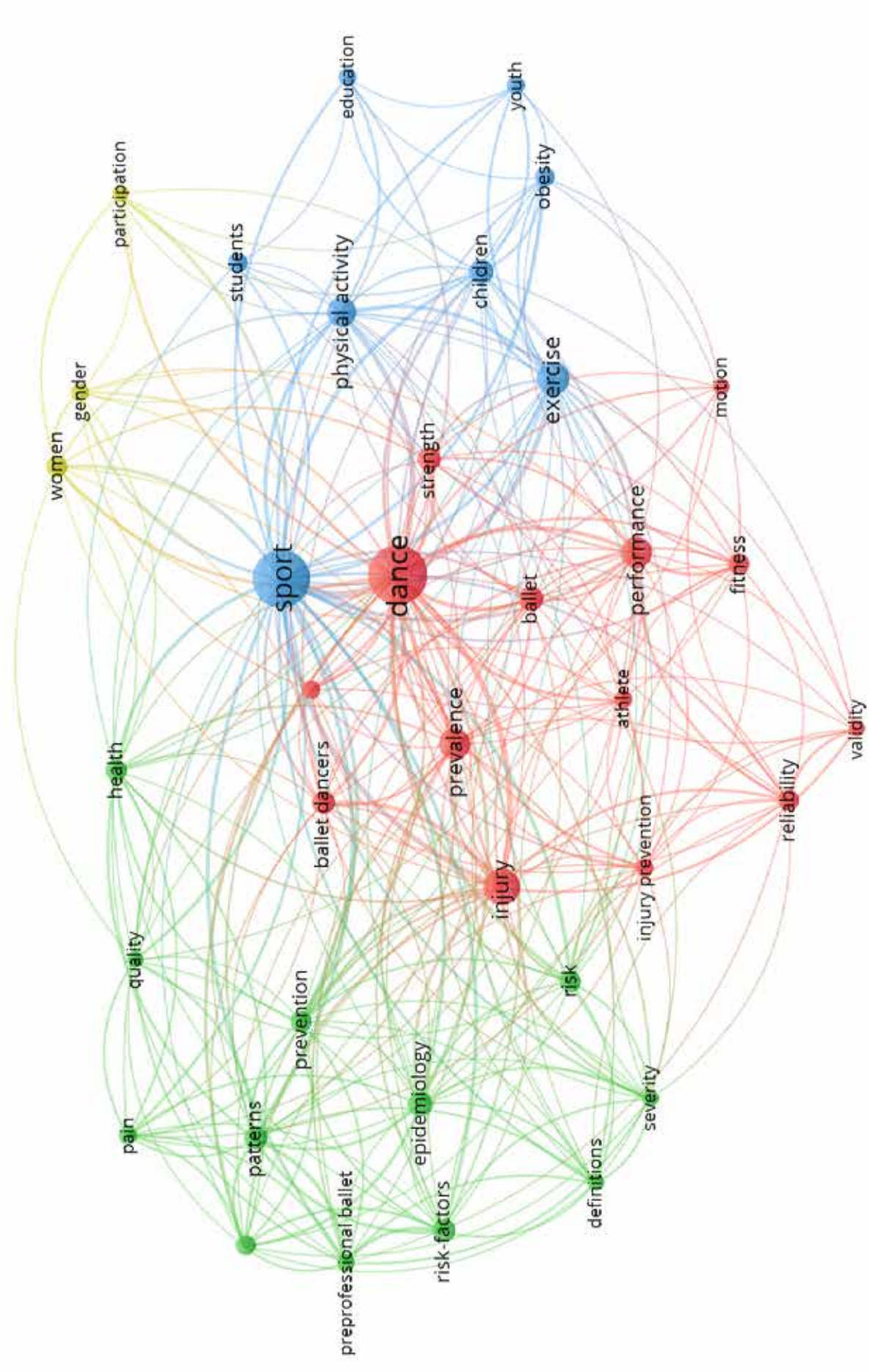

Figure 2. Main keywords in publications devoted to sports dances, network visualization. Source: own research based on data obtained from WoS and analyzed with VOSviewer (07/01/2022).

The second cluster includes 12 keywords. It is marked in green on the map. The conditional name of this cluster is the keyword "health". It is characterized by the presence of 20 links with other words, (TLS 31). We consider that the choice of this word for the title of the cluster is correct because of its integral character. The keywords "prevention", (TLS 36), "epidemiology" (TLS 40) have the same number of links. A feature of this cluster is the absence of sharp differences between the number of links of individual keywords. In descending order of the number of links, the cluster keywords were arranged as follows: "risk" and "patterns" 18 each (TLS 35 and 44), "musculoskeletal injury", "risk-factors", "severity" 17 each (TLS 33, 35 and 27), "definitions" – 16, (TLS 25), "preprofessional ballet" – 15, (TLS 34), "quality" – 15, (TLS 22), "pain" – 14 (TLS 23). An analysis of the composition of the cluster suggests that research is focused on the prevention of injuries and disorders of the musculoskeletal system, and study of the prevalence of risk factors in sports dancing and their neutralization.

The third cluster includes 8 words. It is marked in blue on the map. The most significant word is "sport". It is characterized by 36 links to other keywords (TLS 154). In the decreasing order of the number of links, the words were arranged as follows: "exercise" – 21, (TLS 50), "physical activity" – 20, (TLS 44), "children" – 17, (TLS 36), "education", "obesity" 13 each, (TLS 13 and 21), "students", "youth" 7 each, (TLS 9 and 14). Analysis of the cluster allows us to conclude that it reflects the sports, recreational and educational focus of the articles.

The last cluster includes 3 words and is marked in yellow on the map. The most significant keyword is "women". It is characterized by 12 links (TLS 24). The cluster includes the words "gender" (10 links), (TLS 16) and "participation" (8 links), (TLS 15). The small size of the cluster does not allow making reasonable assumptions about the direction of publications.

The overlay visualization network is shown in Figure 3. Keywords are analyzed by frequency of citation and differ in color. Blue corresponds to the lowest average number of citations, yellow corresponds to the highest.

In the first cluster, this indicator is the highest for "injury prevention" – 10.33, in the second cluster – for "pain" – 15.50, in the third – for "obesity" – 8.29 and in the fourth – for "participation" – 4.00.

The results of density visualization are shown in Figure4.

Data interpretation Figure 4 is similar to Figure 2: the more important is the subject, the larger is its circle and font size. According to Figure 3 can be identified studies that can be categorized as the most popular. These include studies on the topic (in descending order of importance): "sport", "dance", "injury".

Discussion

An analysis of the multiplicity of publications allows us to conclude a constant research interest in the problem of sports dances. The number of publications is quite stable during the analysis period.

The data in Table 1 confirm the pronounced sports and medical orientation of the study on sports dances. Almost every fourth article had a sports focus. Eight of the ten priority subject areas are directly related to medicine. When analyzing subject areas in the context of the article, this trend is confirmed. Four of the five most significant subject areas were also related to medicine. This conclusion is confirmed by an analysis of priority journals. Virtually all journals in the TOP-10 have a medical focus.

The analysis of network visualization allows us to identify three main areas of publications: sports, recreation and rehabilitation. This assumption is confirmed by the characteristics of the most significant keywords in Figure 1. A characteristic feature is the intersection of directions within different clusters. For example, health and sports publications include keywords from other areas.

When studying the state of athletes, there is practically no studies devoted to a comprehensive study of success, forecasting the growth of skill. There is also a lack of articles on classic sports issues such as the study of physical development, physical fitness, psychophysiological characteristics. The range of studies that study the physical condition of sports dancers is rather narrow. They studied only the features of the somatotype.

There are practically no studies aimed at studying the psychophysiological state. The authors studied this problem very narrowly: maintaining balance, range of motion of some joints, biomechanical features of the performance of individual technical elements - jumps. There are no studies on the study of coordination, sense of rhythm, concentration and switching of attention, motor memory capacity. It has been confirmed that these qualities are essential for success in dancing [29].

There are no comprehensive developments for studying and predicting success. A lot of is declared about the intermediateness of dances between sports and art, the presence of physical and aesthetic components, but there is practically no transition to their quantitative analysis.

An important feature of sports dancing is a fairly high level of injuries. Most researchers recognize the existence of an inverse correlation between the level of injuries and the success of a dancer's career. This leads to the study of the prevalence of injuries, the severity of risk factors as actual anti-predictors of success. Most studies of functional status are

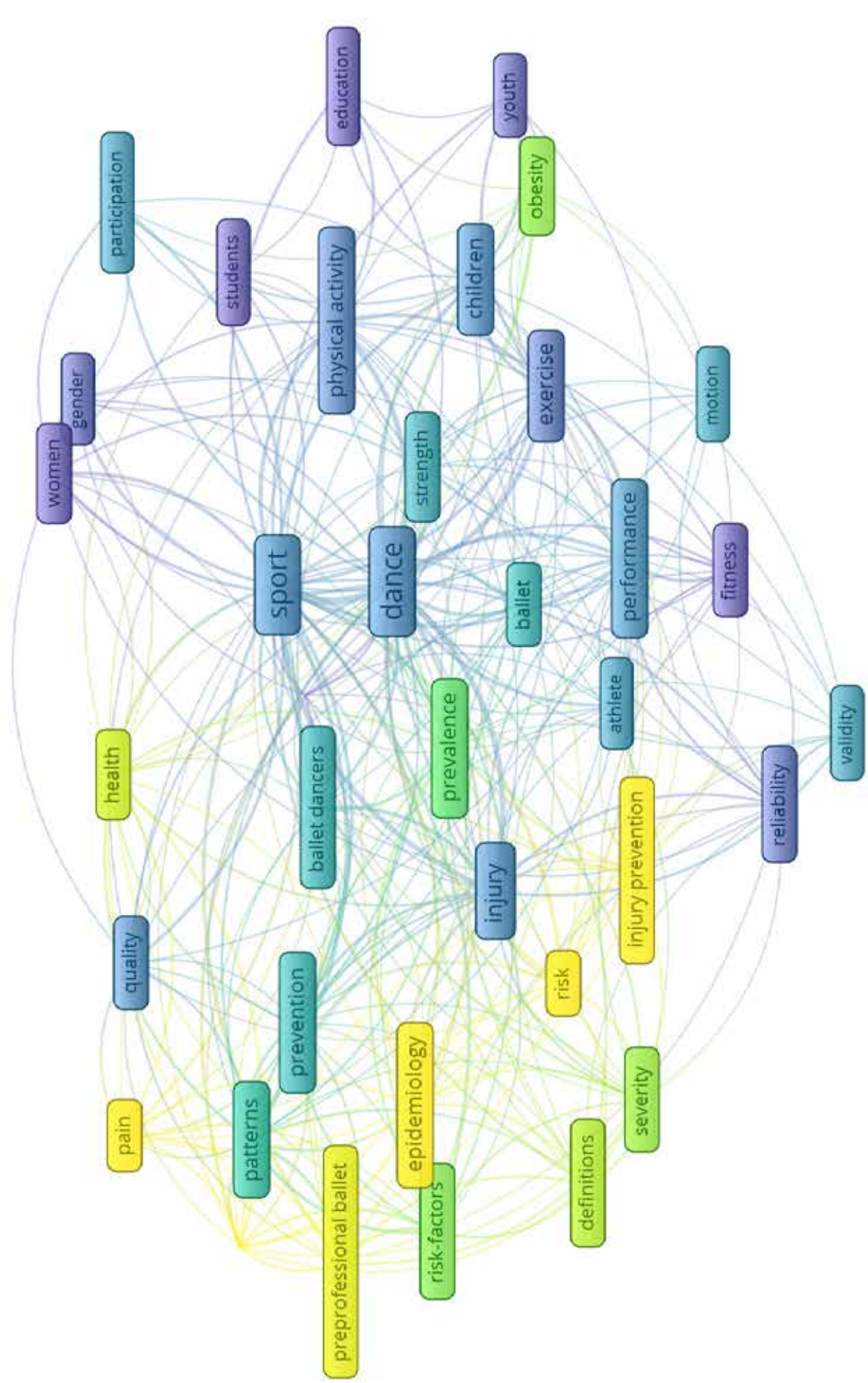

Figure 3. Average number of keyword citations in publications devoted to sports dances, overlay visualization. Source: own research based on data sourced from WoS and analyzed with VOSviewer (07/01/2022).

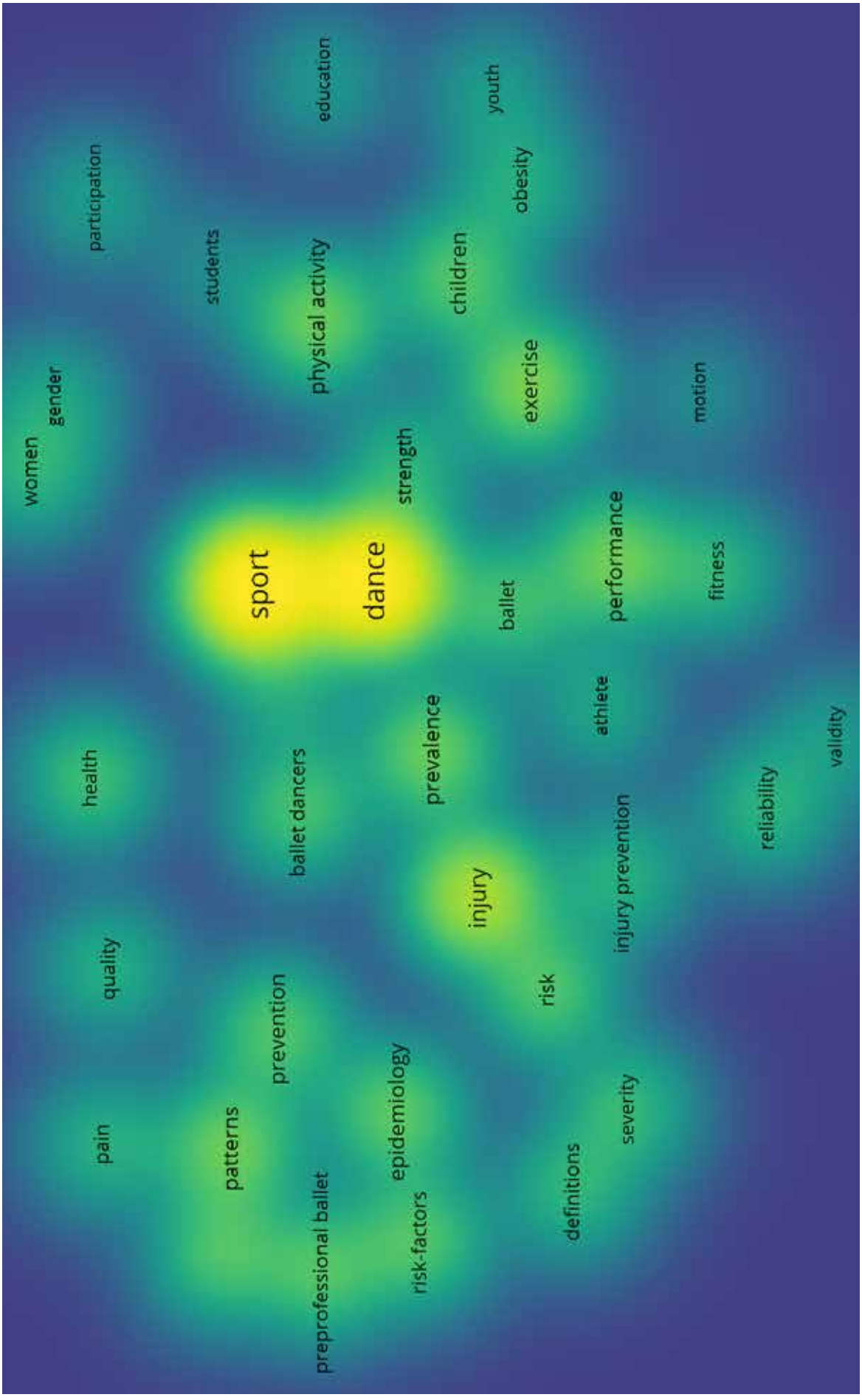

Figure 4. Directions of research in publications devoted to sports dances (direct citation analysis, visualization of cluster density, weight – citations). Source: own research based on data sourced from WoS and analyzed with VOSviewer (07/01/2022).

aimed at identifying risk factors for injuries and ensuring their prevention.

An analysis of the visualization of the overlay allows us to conclude that rehabilitation-oriented publications are the priority in terms of the average number of citations. These studies highlight the possibility of using sports dances to normalize body weight, evaluate the prospects for preventing injuries, reducing pain in dancers.

The density visualization results actually replicate the network visualization results. This should be evaluated as a confirmation of the correctness of the assumptions made.

Exploring dance as a sport

The increase in technical requirements in sports dances occurs constantly, due to an increase in the number of syllabus figures corresponding to each sports category [4]. This study included a survey devoted to sports dances professionals about the importance of physical fitness and its place in a strategy to maximize performance. Physical training programs improve motor skills. This, in turn, raises the level of technical and artistic actions [4, 30].

The development of physical qualities of dancers improves the level of their training, ensures the prevention of health disorders [9, 10]. Changes in the strength, flexibility and functionality of young dancers were assessed during the summer intensive dance program [9]. A battery of tests for strength, flexibility, balance, performance of technical elements was used. Adolescent dancers improved lower abdominal muscle strength as well as functional dance techniques in demonstrating correct alignment and performing demi-plie and passe dance positions despite a decrease in passive lower extremity range of motion. Similar results were obtained in the study [10, 31]. A comparison of physical fitness in the groups of modern (CD) and Irish dance (ID) was carried out using a specialized battery of tests. The CD participants performed significantly better than the ID group on the Star Excursion Balance Test, Plank Hold, and Fitness Test [10].

A battery of tests for general and special physical fitness was used in the study [31]. The period of observation of students in the department of choreography was two years. Positive dynamics of explosive strength, power endurance, coordination, flexibility was confirmed.

The need for special tests and standards of physical fitness for sports dancing is substantiated in the study [8]. It is proposed to use push-ups from the floor and a throw of a stuffed ball. The development of specific standards will significantly improve the process of selection and prediction of success in this sport.

The aim of the study [15] was to determine the degree and nature of the influence of dancing classes on the morphofunctional and psychological state. To predict the adaptation to adverse environmental conditions, the index of functional changes (IFC) was calculated. This indicator reflects the adaptive capacity of the circulatory system. A correlation was determined between the body type of dancers and the main criteria for anxiety. Girls with different somatotypes have different indicators of anxiety, psycho-emotional state and adaptive capabilities. The qualities that provide favorable adaptation and affect success are highlighted.

The quality of the performance of technical elements is a criterion for assessing the level of dancers. Premelc [16] studied the characteristics of movement and performance of dance elements in tango dancers of various levels. Top-level dancers spent less time performing elements, had a greater variety of movements in the dance.

A comparative analysis of coordination in dancers and non-dancers was carried out in [18, 19]. The indicators of coordination among the dancers in different phases of the performance of the elements were less variable. This confirms the higher level of control in athletes compared to non-dancers. The groups being studied were characterized by different hardness landing techniques during jumps. A softer landing technique provides injury prevention due to better cushioning of the foot [19, 32].

Control over the implementation of technical elements in dances predetermines the need to improve the accuracy and quality of video filming. A wireless eye movement measurement device was developed by Sarugaku et al. [17]. The new video recording method simultaneously displays the line of sight and movement of the athlete. In a full-scale experiment, the accuracy of the device was evaluated before and after the high-speed rotation of the dancer. By analyzing eye and body movements, the authors successfully measured the spotting technique used by dancers to suppress dizziness.

A device for improving the flexibility and strength of the muscles of the hip joints was described in the study [33]. Referred to as the Flexibility Trainer (FT), the device is equipped with sensors that measure and evaluate athletes' hip torques. FT uses the lifter's body weight to perform controlled leg extensions. The use of this device allows you to improve the performance of technical elements in dancing.

The optimization of technologies for collecting data on movements during dancing can significantly improve the control of athletes' motor skills. The review [34] is devoted to the analysis of the use of these sensor technologies. Combining two or more types of technologies can improve data reliability and optimize motion performance. A promising direction has been identified – the study of the interaction between muscles and the brain in dancers. The use of quantitative tools allows you to determine the level of skill of the dancers.

A promising scientific direction is the study of body changes under the influence of training and competitive loads. A study of physiological and biochemical changes caused by sports dancing was conducted in the study [5, 30]. Athletes showed individual changes in biochemical parameters with an emphasis on increasing the level of hemoglobin. Physiological parameters also changed significantly. The average reduction in body fat was more than 5%. The dynamics of blood lactate, the level of heart rate and the results of functional tests confirm the gradual development of fatigue.

Informativeness of heart rate variability predetermined interest in its study for predicting sports activity [35, 36]. The review carried in the study [35] confirmed the positive relationship between heart rate variability and the psychophysiological characteristics of athletes.

The heart rate (HR) variability (HRV) is a useful tool for assessing cardiac autonomic function and identifying the potential readiness to perform in athletic populations. HRV may be able to provide valuable insight into the preparedness of dancers and the demands of performance in a dance population [36]. The results suggest dancers responded to concert dance performances similarly to other athletic populations approaching the intense competition by exhibiting decreased parasympathetic activity before the dance performances, which returned to baseline values 36 h after their performances. Given the increase in self-efficacy, these fluctuations may indicate a readiness for a performance comparable to that of athletes.

In competitive ballroom dancing, the assessment of the aesthetics of physique directly affects the result. Physique is an important determinant of selection in this discipline. Banio et al. [37] estimated the dimorphic differences in the distribution of adipose tissue in a group of male and female dancers practicing competitive ballroom dance at the highest level. The obtained results allow concluding that systematic, multi-annual, task-oriented physical activity of dancers eliminates sex differences in the scope of adipose tissue. Most importantly, the obtained data may be helpful in the development and optimization of selection systems of dance partners for couples practicing competitive ballroom dancing.

Success in dance sport is determined not only by physical and aesthetic factors but also by psychological preparation. Motivation is one of the most important aspects of this training. Zaletel et al. [38] studied the motivational structure of athletes in Latin American and ballroom dancing, acrobatic rock and roll, contemporary jazz, and ballet. This study aimed to determine the role of motivation as a performance factor. Male dancers tend to dominate and lead with a strong power motive. Female dancers are more focused on motives such as emotional relaxation, self-control and social understanding.

The use of tests and functional tests allows assessing the development of motor skills. It was proposed to use the Oseretsky-Gilman test for this purpose [39]. This test is a tool for assessing psychomotor age. It evaluates the possibilities of maintaining balance and equilibrium. It is shown that children involved in dancing perform better on this test. Additionally, the correspondence between chronological age and psychomotor age was confirmed.

Postural stability (PS) plays an important role in many sports [40, 41, 42]. Modern dance requires increased PS. This is due to high aesthetic requirements and speed of movement. In the study [40], the static and dynamic PS of young dancers and athletes of other sports were compared. Static PS was assessed using the two-legged test on the Force platform. Dynamic PS was assessed using the Korperkoordinatestest fiir Kinder (KTK), a backward walking test on a bar. It is shown that girls involved in dancing have the best indicators of static and dynamic PS.

Improving the quality of movements is an important component of improving technique in sports dancing [43, 44]. The special tests for balance and a three-dimensional analysis of movement with the determination of biomechanical parameters were used in the study [43] for this purpose. The results confirmed the effectiveness and informativeness of the methods used, the possibility of their application to improve technique, and prevent injuries. The specificity of dance movements predetermined the interest in assessing the motor control of the lumbopelvic region [44]. A battery of special tests was used in dancers and non-dancers. Athletes-dancers were characterized by better control of lumbopelvic motor skills, dynamic stability and lumbar movements.

A comparative analysis of the tests for balance and balance maintenance was carried out in the study [42]. They executed the Star Excursion Balance Test (SEBT), the modified Romberg test, the Airplane test, the BioSway Balance System (Biodex, Shirley, New York, USA), and a dance-specific pirouette test. Spearman's correlation coefficients examined relationships between the measures of the balance tests. The results showed the strongest relationships between some SEBT reach directions and feeble to moderate relationships between some balance tests, including some SEBT directions, Romberg, Airplane, Biosway, and pirouette.

An important predictor of success in sports dances is the ability to control posture and maintain balance [45, 46, 47]. This control is necessary for the correct execution of complex movements in the dance. Gimunova et al. [46] analyzed differences in static postural control among dancers of classical ballet, Slovak folk dances, and sports dances. The

effects of body weight, height, and toe grip strength on postural control were analyzed. Sports dancers showed better postural stability compared with classical ballet and folk dancers. Sports dancers are accustomed to a greater load on the forefoot and to particular rolling of the foot in the dance. This can increase their postural stability. An additional factor influencing PS is the constant change in the environment during the competition.

Similar results were obtained in the study [47]. The aim of this work was to analyze the methods of posture control in sports dancers and to evaluate the effect of functional training on the state of posture. A significant increase in postural control was found in athletes in the functional training group. It is proposed to use the ability of postural control as a test indicator.

The use of cross training from other disciplines is a means of optimizing training in sports dances [48, 49, 50]. The study [48] assessed the effectiveness of the additional training program for developing flexibility and strength of the lower limbs of dancers. The program was based on rhythmic gymnastics exercises. The implementation of the program for 8 weeks provided an increase in the active range of motion of the legs and the strength of explosive dance movements. A similar program lasting 1 year was used in the study [49]. The combination of dance training and rhythmic gymnastics provided an improvement in physical fitness.

Similar results were obtained in the study [50]. The authors have developed and tested programs for optimizing psychomotor abilities in sports dancing. An important component of the programs was the use of exercises borrowed from other sports. The use of the program during the year confirmed its pronounced effect.

Flexibility is another quality essential to success in dancing. Zhang et al. [51] studied the role of functional dynamic stretching in dance sports. Dynamic-stretching training can effectively improve ankle stability in athletic dancers. Simultaneously, this method effectively prevents injuries to the athlete's ankle joint.

The state of the musculoskeletal system is one of the leading predictors of success in sports dancing. It, in turn, depends on bone mineral density (BMD). A comparative analysis of BMD in dancers and non-dancers was carried out in the study [52]. A specific osteogenic effect of pre-professional training in adolescent girls has been determined. It consisted of lowering BMD of the upper extremities compared with the control group of the same age.

The most salient characteristic of ballroom dance is the closed-hold position, during which the upper body segments of partner-dancers are linked. The study investigated the partnering effects on joint motion ranges of the lower extremities and step lengths during the waltz in 13 national level competitive dance couples and a world champion couple [53]. Analysis of the videos showed that the world champion couple demonstrated excellent dancing skills in the waltz. This was especially evident in the champion dancer's stride length and range of motion in female's joints.

A comparative analysis of the physical development and somatotype of female athletes in dance and gymnastic sports was carried out in the study [54]. Most of the participants had an average harmonious physical development. This is due to the peculiarities of sports, their team nature and reflects the aesthetic orientation of the sports being studied. Deviations in physical development are most often associated with lack of body weight. The use of the bioimpedance method determined an increase in the content of muscle mass above the average age standards for all participants.

The intense physical activity in dancing requires adequate recovery [55, 56]. A special technique for the recovery of highly qualified athletes-dancers in the post-competitive period was developed in the study [55]. The technique was based on the use of Pilates, static and dynamic exercises. A purposeful improvement in the adaptive and functional capabilities of athletes has been confirmed.

The use of nutrition is one of the most effective ways to restore the condition of athletes. Challis et al. [56] studied the diet and body composition of Irish dancers. The consumption of fruits and vegetables was low. The energy content of the diet, the content of fiber, iron, magnesium, selenium, iodine and folic acid were below the UK dietary standards. The average body fat percentage measured using DXA was higher than that of the other dance groups. Body composition was not correlated with the intake of any nutrient, but was correlated with nutritional knowledge questionnaire scores.

Rosselli et al. [57] studied the eating habits and body composition of adolescent classical and contemporary dancers during the prepubertal period. The mean BMI was within the normal range in both groups. No significant differences in anthropometric parameters and body composition were found between the two groups. Despite non-compliance with the Mediterranean diet, no risk of developing eating disorders or athlete's triad syndrome has been identified.

Sports dancing as a form of recreational activity

Sports dances are widely known as a type of sport, but they have not been sufficiently studied as a leisure activity for middle-aged and elderly people [2]. The authors studied the effect of regular physical dance exercises on the shape, function and body quality of this age group. The program of classes with various dance styles lasted three months. Women improved in BMI, body fat percentage, waist circumference, diastolic blood pressure, depth of forward bend from a sitting position, and time of standing on one

leg with eyes closed. It is concluded that long-term aerobic sports dance exercises of medium intensity can improve the physical form and function of the cardiovascular system of middle-aged and elderly people.

An analysis of the intensity of loads during various types of dances makes it possible to recommend them as recreational exercises [23, 58]. Indicators of the cardiovascular system were used as criteria for the intensity of loads. Hip-hop dancing is rated a load of medium and maximum intensity. Salsa is a load of moderate intensity. Both dances meet the recommended intensity for the healthy adult population. The weekly duration of hip-hop classes should be 75 min, salsa – 150 min [23]. According to the American College of Sports Medicine (ASCM) guidelines, a 60-min pole dance class can be classified as a moderate-intensity cardiorespiratory exercise. Performing for at least 30 min 5 days a week satisfies the recommended level of exercise for improved health and cardiorespiratory fitness [58].

Similar results were obtained by Longo et al. [6]. An analysis was made of the prevalence of dancing as a recreational activity. It has been established that dancing is one of the three most popular types of physical activity. A third of the respondents work out at least 3 h a week.

Sports activities in adolescence affect health characteristics in later age periods. The work [59] studied the correlation between various types of physical activity and body composition. We assessed the correlation between anthropometric parameters (body length and weight, waist circumference, triceps and thickness of the subscapular skin fold) and jogging, fitness dancing and other sports.

Recreational dance classes are considered a way to develop coordination of movements, improve balance [60]. The presence of a significant correlation between the indicators of balance and BMI was confirmed. Physical activity, which includes performing various balance tasks, offers children more opportunities to improve in this area.

Wang et al. [3] studied the effect of physical dance exercise on serum immunoglobulin and T-lymphocyte subpopulations in college students. After ten weeks of dancing sports, both men and women in the experimental group had a significant increase in serum IgG levels. CD4(+)% and CD4(+)/CD8(+) ratios of T-lymphocytes showed a significant increase. Serum IgM tended to increase. It is concluded that long-term physical dance exercises can improve the body's immune function.

The health-improving orientation of the dance classes suggests their positive impact on well-being. The correlation between dancing and health was studied in the study [12, 13]. It was a negative correlation between improved sleep and general health with the number of days of incapacity for work and the negative consequences of injury. A connection has been determined between the deterioration of health and an increased level of injuries.

Injury prevention in sports dancing and their rehabilitation value

The requirements for dancers have increased significantly recently. Increased physical and mental stress. Professional dance activities significantly increase the risk of illness and injury. Injuries during one season of performance have from 50 to 85% dancers. The reason for the increase in injuries is deemed a significant physical exertion in dancing. Most dancers' injuries are related to the lower extremity (LE) and are chronic [61]. It has been proposed to use the Functional Movement Screen (TM) (FMS(TM)) as a screening tool to determine the risk of injury.

Almasi et al. [62] identified the main criteria for the state of the musculoskeletal system to determine suitability for dancing sports. These criteria should be determined by a professional medical examination. This will reduce the risk of injury and improve the prospects for skill growth.

Sports dancing are quite a traumatic sport [12, 13, 61]. They are characterized by certain injuries. Sugimoto et al. [63] studied the prevalence of big toe injuries in athletes. The most common diagnosis was sesamoiditis. Dancing, running and football were among the top three most traumatic sports. It has been confirmed that women take almost twice as long to recover compared with men.

Injuries of the hip joint are quite common among sports dancers [64, 65, 66]. The aim of the review [64] was to determine the range of active actions of the hip joint. Literature analysis has confirmed that many activities place superphysiological demands on the movement of the hip joint. These kinematic components differ dramatically depending on the specific activity. Rehabilitation should be performed considering the individual characteristics of each patient.

Injuries of ankle and ankle injuries are also common in sports dances. Shi et al. [7] investigated the efficacy of functional rehabilitation for ankle injuries. Special exercises have been proposed for Latin American dancers. A significant reduction in pain compared with the control group was confirmed.

Caine et al. [67] described this status of knowledge on the occurrence and outcome of primary periphyseal stress injuries (PPSIs) affecting the EPM complex in the extremities of children and adolescents involved in youth sports. PPSIs may affect the extremities of children and adolescents engaged in various youth sports, especially at advanced levels of training and competition. The early diagnosis of PPSIs and providing timely treatment of these injuries are needed to ensure the skeletal health of youth sports participants.

Henn et al. [68] reviewed the prevalence of low back pain and injury in ballet, modern and hip hop dancers. The main research instrument was a questionnaire. Dancers are at risk of back pain or injury regardless of gender, age, or skill level. A conclusion was reached about the need for more informative research methods.

The work of Larson et al. [65] studied the effect of artoscopy on the speed of rehabilitation and recovery in dancers of various styles. The high efficiency of this method has been confirmed. A return to dance sport was found in 84% dancers after three years. However, only 63% of the participants reached the competitive level before the injury.

The available results show that joint hypermobility is a predictor of arthralgia, dislocations, and subluxations [69]. A special Beighton scale was used to assess the condition of the joints. Comparison of dance, rugby, netball athletes with non-athletes confirmed the possibility of predicting disorders in athletes.

Low energy availability (LEA) is a medical condition observed in athletes, with higher prevalence in aesthetic sports. Dancers must be considered at risk for developing LEA. These nutritional features require a targeted rehabilitation strategy [70, 71]. For the first time, this study evaluated the relative prevalence of LEA in female elite athletes (ELA) and recreational athletes (REA) in aesthetic sports in China [71]. The results show that there is a risk of LEA in Chinese female athletes involved in aesthetic sports. This risk is significantly higher in elite athletes than in amateurs. More than 40% of participants had an increased risk of LEA, and more than 50% of participants were classified as high risk for eating disorders. Elite female athletes at an increased risk of LEA had significantly lower levels of estradiol and MOC.

A promising way is to use dancing in the rehabilitation of patients after therapy. An example is the Dancing with Health (DWH) project. It is funded by the ERASMUS+ SPORT program of the European Union and is intended for patients after breast cancer treatment. Cerulli et al. [72] studied the effectiveness of this protocol on the dynamics of fitness and quality of life. It has been shown that the DWH protocol has a positive effect on psychological well-being and physiological parameters, improving the quality of life of patients after breast cancer.

Conclusions

The conducted bibliometric analysis of publications confirms the relevance of the problem of sports dances. A constant research interest in this problem has been established. Research in this area has a pronounced sports and medical focus. Bibliometric analysis of publications allows us to identify three areas: sports, recreation and rehabilitation. Dancing is being explored as a sport, a form of physical activity, and a form of rehabilitation. A fairly high level of sports injuries has led to interest in the analysis of the prevalence and prevention of injuries. A characteristic feature is the intersection of these directions. When studying the state of athletes, there are practically no studies devoted to a comprehensive study of athletes, predicting success and skill growth. There are lacks of studies devoted to the physical state of sports dancers. There are also lacks of studies aimed at studying the psychophysiological state. These types of studies should be assessed as relevant.

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PHYSICAL EDUCATION OF STUDENTS

ORIGINAL ARTICLE

Physical fitness of students based on a test used to assess the physical fitness of soldiers of the National Reserve Forces

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

Abstract

Background and Study Aim The purpose of this study was to analyze the physical fitness of students based on a test used to assess the physical fitness of soldiers of the National Reserve Forces.

Material and Methods The study included 30 students majoring in Physical Education, specializing in Physical Education in the Uniformed Services. The average age of the subjects was 23.53 years, where the youngest subject was 21.92 years old and the oldest was 28.67 years old (SD = 1.513). The National Reserve Forces (NSR – abbreviation using in Polish language) physical fitness test was used to assess the level of physical fitness of professional soldiers. Students completed a proprietary research questionnaire to investigate the level and type of additional physical activity of the subjects, their future career plans related to the uniformed services, and their level of satisfaction with their performance on the fitness tests.

Results It was shown that students who rated their level of preparation for uniformed service and satisfaction with their performance higher scored better on the NSR test. It was proven, equally, that students having a higher weekly volume of additional physical activity obtain higher scores in the fitness test. In addition, it has been demonstrated that better results in the fitness test are achieved by students who engage in physical activity at the level of active athletes.

Conclusions The recommendation to introduce classes similar to sports training under battlefield conditions into schools and universities preparing future uniformed officers is justified. This would give a simultaneous improvement in physical fitness along with an increase in the level of self-efficacy for combat operations. Those wishing to enter the selection process for uniformed formations should practice regular physical activity, preferably at an intensity and volume close to the competitive level. This significantly affects the result achieved in the fitness test.

Keywords: level of physical fitness, physical education students, physical education, military education, military fitness test

Introduction

Physical activity is one of the determinants of human functioning in daily life. Regular physical activity is supportive in the treatment and prevention of infectious diseases, delays dementia, contributes to the maintenance of normal body weight, and has a beneficial effect on mental health [1, 2, 3, 4]. In order to develop and function healthily, it is necessary to maintain an adequate level of activity and physical fitness throughout life, matching it with lifestyle and work [5, 6, 7, 8]. Previous studies have shown that physical activity is at a much lower level in schoolchildren and students on days when they do not have mandatory physical activity, and that problems with proper body weight are increasingly common [3, 4, 9, 10]. It has been proven that it would be reasonable to have integrated regulation at the school level, so that school-aged students would incorporate physical activities classified as compulsory into their daily lives and perceive them as routine in their daily lives. This translated into their greater practice in physical activity and level of physical fitness [11]. It has been shown that in college students, the level of extra-curricular physical activity varies according to their gender and cultural backgrounds, and that their physical activity decreases with age [12, 13, 14, 15]. Uniformed formations are an occupational group where physical activity is one of the elements of the work environment, and the level of physical fitness is one of the factors influencing the effectiveness of the job [16]. So far, it has also been shown that, regardless of the uniformed formation, it is advisable for officers to have their own sports training to ensure that they are adequately prepared for duty [17], take care of nutrition during duty [18, 19, 20] and also prepare for fitness tests [21, 22, 23, 24]. In addition, the level of physical fitness has been shown to be related to how one functions in the military environment and positively affects adaptations to the work environment [24, 25, 26].

The authors in the present study set 2 hypotheses:

H1: Students who rate higher their level of preparation for uniformed service and their satisfaction with their performance, score better on

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the fitness test.

H2: Respondents engaged in extracurricular physical activity, with a higher volume, achieve better results in the fitness test.

The purpose of this study was to analyze the physical fitness of students based on a test used to assess the physical fitness of soldiers of the National Reserve Forces.

Materials and Methods

In the present study, the authors analyze the level of physical fitness of students at the majoring in Physical Education (PE), specializing in PE in the uniformed services as individuals who are potentially interested in working in the uniformed services, after graduating from higher education.

So far, the physical fitness of students majoring in physical education, in a specialization that prepares them for work in the uniformed services, has not been analyzed. Therefore, a study was undertaken to analyze physical fitness as measured by the directional fitness test for the National Reserve Forces of the Polish Army. The relationships between the results achieved in the fitness test and the self-assessment of the level of fitness preparation for service in the uniformed formations and the level of satisfaction with the results achieved in the test, as well as the extracurricular activity practiced by students, its volume and nature, were examined.

Participants

The study involved 30 men, students of the Poznan University of Physical Education, majoring in Physical Education, specializing in Physical Education in the Uniformed Services. The study was conducted as part of field classes during the subject of fitness all-round events. The average age of the subjects was 23.53 years, where the youngest, tested was 21.92 years old and the oldest was 28.67 years old (SD = 1.513). The mean body height was 182 cm (SD = 0.072), the mean body weight was 79.2 kg (SD = 11.238), and the mean BMI of the subjects was 23.823 (SD = 2.269).

Research Design

The physical fitness test of professional soldiers of the National Reserve Forces (NSR - abbreviation using in Polish language) was used to assess the level of individual fitness [27].

To assess the fitness level of the students, based on the NSR test, the subjects had to perform four fitness tests:

1) a 3000-meter cross-country run,

2) pull-ups on a high bar, keeping arms straight during the descent and crossing the bar line with the chin while flexing the arms,

3) shuttle run over a distance of 10 x 10 meters (during which the test subject must cross each line to pass the test)

4) sit-ups for two minutes.

The results of each test were recorded and converted into points, according to the guidelines written in the Ordinance. A total of 100 points could be earned for all attempts. The respondents, for their tests, were evaluated as Z-category subjects, i.e., persons fit for professional military service or service as a candidate for professional soldier [28].

In addition, the respondents completed the author's research questionnaire. It included questions about the subjects' level of additional physical activity, their future career plans related to the uniformed services, and their level of satisfaction with their performance in fitness tests (Table 1).

Statistical Analysis

In the study, the mean and standard deviation (SD) were calculated. An analysis of the normality distribution of the data was performed using the W Shapiro-Wilk test. Based on its results, Pearson's r correlation was used to analyze the relationships involved, between the fitness trials. Spearman's rank correlation was employed to analyze the results obtained in the fitness tests and the subjects' responses from the research questionnaire. Statistica 13.3 software was used to analyze the results.

Ethical issue

The tests were performed as part of the Fitness All-Round Event subject, within which students are required to perform the analyzed samples of the NSR test to get a pass from the subject. The subject of All-Round Event is compulsory in the course of study of Physical Education, specialty "Physical Education in Uniformed Services".

Results

During the NSR test in the 3,000-meter cross-country run trial, the subjects scored an average of 13.22 minutes (SD = 1.729) and 36.4 points (SD = 7.232). 90% of the subjects passed this test. In the 10 x 10 m shuttle run test, the subjects scored an average of 26.43 sec (SD = 1.869) and 18.36 points (SD = 1.715). The pass rate for this trial was 100%. In the sit-ups test, the subjects obtained an average of 79 repetitions (SD = 15.605) and 14.72 points (SD = 2.268) and 96.67% of them passed this test. In the pull-up bar test, an average of 9 pull-ups (SD = 4.683) and 14.09 points (SD = 3.636) were obtained. The pass rate for this test was 76.67%. On average, 83.57 points (SD = 10.911) were obtained in the NSR test. The lowest score was 58 points, and the highest was 97.6 points. The pass rate for the entire fitness test was 66.67% (Table 2).

Responding to the research questionnaire, 30% of the students indicated a desire to work in uniformed services formations in the future, and 50% of the participants said they were satisfied with the result they received during the physical fitness tests. On a scale of 1 to 10, the respondents rated their level of fitness preparation at an average of 6.23 (SD =

Table 1. Research questionnaire

	Please answer at the following questions. Your answers are completely anonymous and will be used only for scientific research. **Thank you very much.**
1	Age (years and months) ……
2	Do you associate your future with work in uniformed services? YES NO
3	Are you satisfied with the results obtained during the fitness tests? YES NO
4	On a scale of 1-10, rate your level of physical preparation for service in uniformed formations, where 1 is completely unprepared and 10 is fully prepared. 1 2 3 4 5 6 7 8 9 10
5	At what level do you engage in physical activity in your daily life in your spare time? (you can choose two answers) - not involved in any physical activity apart from compulsory classes - recreation level - active athletes
6	How many days a week do you do additional (own) physical activity? - 0 - 1-2 - 3-4 - 5- 6 - everyday

Table 2. Results of fitness tests of students of specialization Physical Education in uniformed services

Variables	Average	Minimum	Maximum	Standard Deviation [SD]	Test passing [%]
A 3000 m cross-country run [min]	13.217	10.220	16.580	1.729	-
A 3000 m cross-country run [points]	36.400	20.000	44.000	7.232	90.0
Shuttle run 10x10 m [sec]	26.436	23.500	30.000	1.869	-
Shuttle run 10x10 m [points]	18.360	13.400	19.000	1.715	100.00
Sit-ups [numbers]	79.267	45.000	115.000	15.605	-
Sit-ups [points]	14.720	6.000	16.000	2.268	96.67
Pull-ups on a high bar [numbers]	9.267	2.000	19.000	4.683	-
Pull-ups on a high bar [points]	14.093	8.200	21.000	3.636	76.67
Sum of points in the NSR test [points]	83.573	58.000	97.600	10.911	66.67

1.716). 29 of the 30 respondents engage in additional (non-compulsory) physical activity, averaging 2.867 days per week (SD = 1.042). The least is 1 day and the most is 4 days per week. Detailing the nature of additional physical activity, 3.33% of respondents report that they do not do any physical activity at all outside of compulsory activities, 40% do physical activity at a recreational level, and 56.67% are active athletes (Figure 1).

In analyzing the results obtained by the respondents in the fitness test, due to the fact that the respondents belonged to different age groups, for which they were entitled to a different grading scale in the NSR test, only the point scores and the respondent's obtaining a passing grade for a given test were used for statistical analysis. In addition,

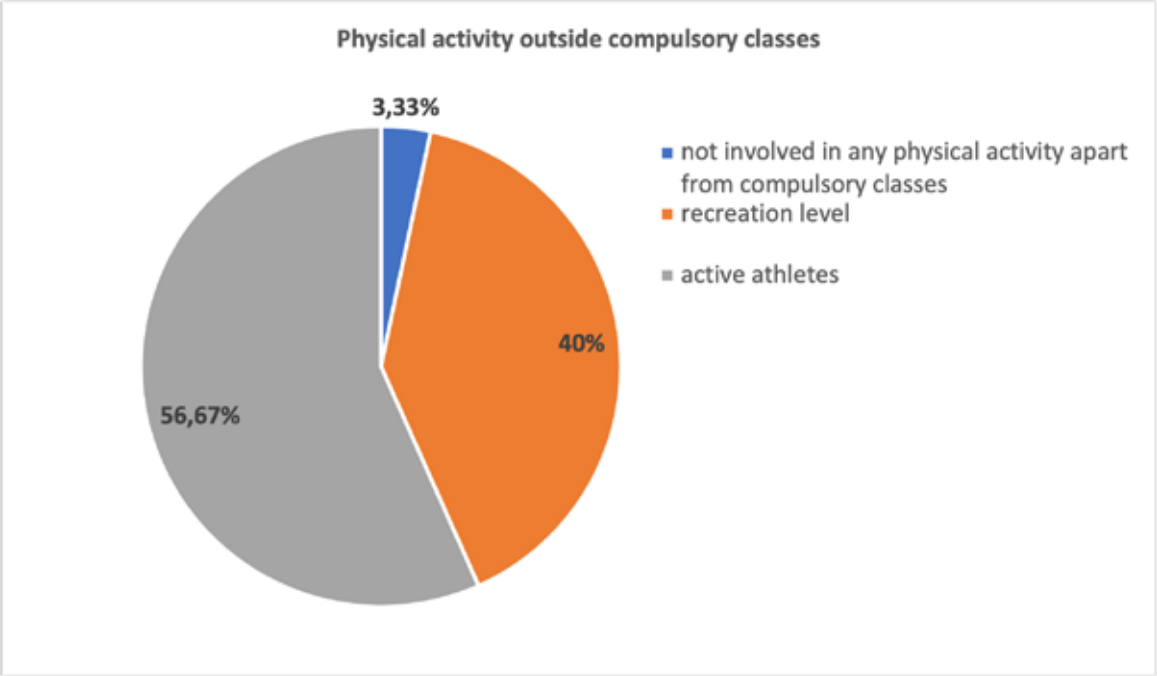

Figure 1. The nature of the physical activity practiced by the respondents outside of compulsory physical activities in their studies

due to the fact that all subjects passed the 10 x 10m shuttle run test, the variable of passing this test was not included in the statistical analysis. Based on the results obtained in the analysis, it was shown that students with a higher body weight obtained better results in the 3,000-meter cross-country run ($r=(0.6626)$; $p<0.000$). At the same time, it was shown that subjects with lower body weight performed worse in the backward bending test (($r=(-0.4455)$; $p<0.14$), the pull-up bar ($r=(-0.4382)$; $p<0.015$), the entire fitness test ($r=(-0.5414)$; $p<0.002$) and failed the test more often ($r=(-0.5745)$; $p<0.001$). It was also noted that those with a lower BMI performed more poorly in the 3,000-meter cross-country run ($r=(-0.3970)$; $p<0.030$), backward bending ($r=(-0.4485)$; $p<0.013$), the entire fitness test ($r=(-0.4060)$; $p<0.026$) and failed the test more often ($r=(-0.3820)$; $p<0.037$). Significant correlations were also found between individual fitness tests and between scores on individual tests and the overall test score. There was a correlation between the results obtained in the 3000m cross-country run and the 10 x 10m shuttle run ($r=(0.3896)$; $p<0.033$) and the backward bending ($r=(0.4018)$; $p<0.028$) as well as the 10 x 10m shuttle run and the backward bending ($r=(0.4777)$; $p<0.008$). Students who scored more points or passed individual trials obtained more points from the entire test. This relationship was not shown to be significant with passing the pull-up bar test. There was no significant effect on obtaining a passing score on the NSR test with the 10 x10m shuttle run test (all subjects passed this test, so changes in the differences at this level may have been) and the passing of the backward bending test. The remaining trials showed a significant effect on the final test score, and the highest was shown by passing the pull-up bar ($r=(0.7802)$; $p<0.000$), (Table 3).

Students declaring a higher level of satisfaction with their performance in fitness tests scored more points in the 3000m cross-country run ($r=(0.514)$; $p<0.01$) and more points in the entire NSR test ($r=(0.435)$; $p<0.05$). Respondents with higher ratings of their own fitness preparation for service in uniformed formations scored more points in the 3000m cross-country run ($r=(0.425)$; $p<0.05$) and from the entire fitness test ($r=(0.366)$; $p<0.05$). Those engaged in extra-curricular physical activity, with active status, scored more points in the 3000m cros-country run ($r=(0.448)$; $p<0.05$) and from the entire fitness test ($r=(0.432)$; $p<0.05$). Respondents declaring a greater number of days on which they engaged in additional physical activity scored more on tests such as 3000m cross-country run ($r=(0.468)$; $p<0.01$) and pull-up bar ($r=(0.572)$; $p<0.01$) and scored more on the entire NSR fitness test ($r=(0.481)$; $p<0.01$), (Table 4).

Discussion

The testing confirmed both research hypotheses. It was shown that students who rated their level of preparation for uniformed service and satisfaction with their performance scored higher on the NSR test. The respondents indirectly determined the sense of their effectiveness in the test they took and in relation to the possibility of their getting into the uniformed formation of their choice. It was proven that students who have a higher volume of

Table 3. Correlation of body weight, BMI of the subjects, scores and pass rates in individual tests in the NSR physical fitness test.

Variables	Body weight [kg]	BMI	NSR – A 3000 m cross-country run [points]	NSR - 3000 m cross-country run [passed / failed]	NSR – Shuttle run 10 x 10 [points]	NSR – Sit-ups [points]	NSR – Sit-ups [passed / failed]	NSR - Pull-ups on a high bar [points]	NSR – Pull-ups on a high bar [passed / failed]	NSR - sum of points	NSR – Result of the test [passed / failed]
NSR - A 3000 m cross-country run [points]	.6626 p=.000	-.3970 p=.030									
NSR - A 3000 m cross-country run [passed / failed]	-.2849 p=.127	-.3296 p=.075	.6626 p=.000								
NSR – Shuttle run 10 x 10 [points]	-.1590 p=.401	-.1023 p=.590	.3896 p=.033	.2425 p=.197							
NSR – Sit-ups [points]	-.4455 p=.014	-.4485 p=.013	.4018 p=.028	.5362 p=.002	.4722 p=.008						
NSR – Sit-ups [passed / failed]	-.2483 p=.186	-.3535 p=.055	.3656 p=.047	.5571 p=.001	.5462 p=.002	.7262 p=.000					
NSR – Pull-ups on a high bar [points]	-.3340 p=.071	-.1007 p=.596	.2980 p=.110	-.0472 p=.804	-.0131 p=.945	.2070 p=.272	-.1094 p=.565				
NSR – Pull-ups on a high bar [passed / failed]	-.4382 p=.015	-.1920 p=.310	.1374 p=.469	-.1839 p=.331	-.0131 p=.945	.1004 p=.598	-.1024 p=.590	.4686 p=.009			
NSR – Sum of points	-.5414 p=.002	-.4060 p=.026	.9069 p=.000	.5730 p=.001	.5092 p=.004	.6174 p=.000	.4427 p=.014	.5717 p=.001	.2352 p=.211		
NSR - Result of the test [passed / failed]	-.5745 p=.001	-.3820 p=.037	.5450 p=.002	.4714 p=.009	-.0335 p=.860	.4313 p=.017	.2626 p=.161	.3904 p=.033	.7802 p=.000	.5757 p=.001	

Table 4. Performance in the fitness test vs. research questionnaire (Spearman's R correlation)

Variables	NSR A 3000 m cross-country run [points]	NSR Shuttle run 10x10m [points]	NSR Sit-ups [points]	NSR Pull-ups on a high bar [points]	NSR sum of points [points]
Willingness to work in uniformed services	0.030	0.028	-0.065	0.106	-0.097
Level of satisfaction with the results obtained in fitness tests	0.514 p<0.01	-0.183	-0.081	0.275	0.435
Self-assessment of the level of fitness for service in uniformed formations	0.425	0.015	0.121	0.288	0.366
Lack of physical activity outside of compulsory classes	-0.271	0.073	-0.297	-0.130	-0.290
Additional and physical activity- Recreation	-0.353	-0.266	-0.191	-0.261	-0.330
Additional and physical activity- Active athletes	0.448	0.237	0.296	0.305	0.432
Number of days per week with non-compulsory physical activity	0.468 p<0.01	-0.126	0.053	0.572 p<0.01	0.481 p<0.01

additional physical activity per week obtain higher scores in the fitness test. In addition, a significant relationship on the improvement of scores in the fitness test was shown by physical activity at the level of an active athlete, in the sport practiced.

Previous studies have shown that a higher sense of self-efficacy significantly affects the desire to join the uniformed services [29]. The results obtained in the study show that students who were more satisfied with their performance in the fitness test achieved a significantly higher score in the 3,000-meter cross-country run and in the entire fitness test. Also, in the 3,000-meter cross-country run and in the entire test, higher scores were obtained by respondents who declared a better level of fitness preparation for service in uniformed formations. These results are consistent with a recent study analyzing the training process of applicants for Norwegian Armed Forces officer training. It was shown that cadets with higher feelings of self-efficacy and performance achieved better results on field exercises and were less likely to drop out [30]. In addition, studies indicating that cadets of uniformed formations characterized by higher levels of self-efficacy also have better levels of mental health [31] and are better able to cope with difficult situations, which is one of the elements of the profession, might serve to emphasize the importance of self-efficacy in the work/school environment [26, 32]. This indicates that a higher level of self-efficacy supports the recruitment and effectiveness of cadets in uniformed formations, characterized by a task-oriented and often variable work environment. However, despite the fact that cadets in the uniformed services are taught to cope with such situations from basic training it often still seems insufficient and demanding [33]. This is also supported by studies showing that self-efficacy is linked to cadets' task-based approach to the process of their physical preparation for uniformed service [21, 22, 23, 34]. With the above in mind, according to the Authors, it would be reasonable to introduce into each uniformed formation and civilian University preparing potential candidates for service in such formations classes that shape the sense of self-efficacy in the future work environment. Bearing in mind the specifics of service in uniformed formations, they should combine physical activities with classes in skills for dealing with difficult situations (simulations), providing a basis for acquiring practical skills for acting in non-standard circumstances and raising the level of physical fitness.

It has also been proven that at present, the physical fitness of officers in uniformed formations should be shaped primarily in terms of their aerobic fitness and, typical of the tasks performed in their profession, strength. Since these qualities are opposite to each other, the preparation of recruits requires a specific training program [35]. This fact is confirmed by the results of a study in which the pull-up bar test was the only one that did not correlate with other tests, and the fact that it was the only one passed did not significantly affect the total points obtained in the whole test. This may indicate the need for additional activity dedicated to properly planned training to prepare for the recruitment process of the chosen uniformed formation.

Previous research shows that those wishing to serve in uniformed formations must be characterized by a high level of physical fitness and

maintain this level continuously, through regular training. In addition to maintaining the level of physical fitness, these trainings should be profiled to the work environment and give the greatest possible adaptability to future uniformed officers, while taking care of their health and work efficiency [33, 34, 36, 37, 38, 39]. In the studies conducted, it was proven that those with a higher weekly volume of additional physical activity scored significantly better in the 3,000-meter cross-country run, pull-up bar, and obtained a higher score on the overall test. Importantly, only the nature of the activity of an active athlete showed a significant effect on the test score and on the 3,000m test score. This may mean that in order for the educational process preparing for the uniformed formation to be effective it should be supplemented with one's own physical activity anyway, preferably at the level of sports competition. It has been shown in studies that competition, carrying rewards, can be a form of motivation for physical activity. In Russia, at Krasnoyarsk State Medical University, in order to increase mobilization for physical activity and spread pro-health habits in the academic community, scoring for such activities has been introduced. Both students and employees collected points for activities for various achievements and participation in sports and health-promoting events, which is taken into account by the Rector when awarding prizes and scholarships. At the University of Krasnoyarsk, this worked in the same way as grades and resulted in an improvement among the respondents in their level of physical activity [9]. The students surveyed, however, belong to a group that should be self-directed and aware that both before the selection process and during service this activity will be needed. They should be characterized by attention to their own level of fitness, in order to overcome and pass certain time standards, for the purpose of obtaining a passing grade in the subject (a present task - at college) and passing the selection process for uniformed service (a future task, for which they must be prepared). Confirmation of these suppositions, can be found in a model targeting those who could potentially be a uniformed officer in the future, which was studied in Ukraine. There, the task-readiness model was tested on high school students. It was shown that it is necessary to analyze and create tailored to the fitness, mental, psychophysiological and functional needs of the individual teaching models that are not based on a scheme that has remained unchanged for a long time, but require a significant level of activation of each person. The result of such education is faster adaptation to the future conditions of the professional environment [40]. According to the authors, in the education of students preparing for work in uniformed formations, it would be reasonable to introduce components of the above methodology, so as to teach to perform students to diagnose the trained group and appropriately select adaptive measures to the conditions in the future professional work, such as setting goals and simulations of situations from the future work. In addition, it would give the student the opportunity to independently determine the ranges on which he or she needs to work further to be able to pass the recruitment process for the chosen uniformed formation. This coincides with research indicating the necessity of combining physical workouts with properly conducted education and individualization of the training process, which carries the highest results, even in the uniformed services. There, however, it requires a significant contribution of the cadets' own work who are in the process of implementing the preparatory process for service in the formation [41].

In addition, bearing in mind that the subjects who have a higher body weight and a higher BMI, achieve better results in individual fitness tests, it can be assumed that this is determined by their body composition and greater muscularity relative to body fat. According to the Authors, this may be due to their training volume and the nature of their extracurricular sports activities, but it would be advisable to analyze body composition as a form of diagnostic and information for a person preparing for a selection program for a particular uniformed service.

Taking into account the correlations shown in the above study, the authors make the claim that students wishing to serve in uniformed formations in the future should practice additional physical activity and try to acquire skills that give them the fastest possible adaptation to the future work environment. One of the more effective ways, also recommended for implementation in the curricula of schools and universities, will be to combine fitness activities and coping with difficult situations.

Conclusions

It has been shown that students who rate their level of preparation for uniformed service and satisfaction with their performance higher score better in the NSR test. It has been proven, equally, that students having a higher weekly volume of additional physical activity obtain higher scores in the fitness test. It is reasonable to recommend that schools and universities preparing future uniformed officers introduce classes similar to sports training in a battlefield training environment. This would give a simultaneous increase in physical fitness along with an increase in the level of self-efficacy for combat operations. In addition, those wishing to enter the selection process for uniformed formations should practice regular physical activity, preferably at an intensity and volume close to the competitive level, since this significantly affects the result achieved in the fitness test.

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PHYSICAL EDUCATION OF STUDENTS

ORIGINAL ARTICLE

Accentuated eccentric load training: traditional set versus cluster set

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Abstract

Background and Study Aim This study aims to comparatively analyse the effects of cluster set (CS) and traditional set (TS) applications on strength and power outputs in accentuated eccentric load (AEL) training.

Material and Methods Thirty-two amateur male football players with at least 2 years of strength training history participated in the study ($\bar{X}_{age}$: 18,78 ± 0,83 years, $\bar{X}_{height}$:166,73± 8,61 cm., $\bar{X}_{body\ weight}$: 69,59± 6,03 kg.). Participants were randomly divided into two groups: CS (n=16) and TS (n=16). In both groups, the same "AEL Training" was applied and different set models were used. Augmented eccentric load (AEL) training was performed with 3 sets of 8 repetitions, 50% concentric and 80% eccentric of 1 Repetition Maximum (1-RM) and with a fast lifting tempo. The sets were completed with 20 seconds of rest after every two repetitions in the AEL-CS group and without any rest between repetitions in the AEL-TS group, and the training sessions were performed twice a week for 4 weeks. Countermovement jump (CMJ), 50cm drop jump-reactive strenght index (DJ-RSI) test, 1-RM strenght test, 10-20-30m sprint test and Illinois Agility Test (IAT) were performed on the athletes before and after the training.

Results When analysing the data obtained in this study, Skewness and Kurtosis values and Kolmogorov-Smirnov values were examined to determine homogeneity. In order to compare the pre-test and post-test averages between groups, ANOVA was used for Repeated Measures, and Sample T Test was used to compare the pre-test and post-test averages within groups. The statistical significance level was determined as $p<0.05$. When the groups were compared, the difference in the improvement rate averages was tested. At the end of the four-week study, drop jump-reactive strength index (DJ-RSI), countermovement jump (CMJ), Illinois Agility Test (IAT) 10-20-30m sprint values and 1-RM values were improved percentage-wise in both AEL-CS and AEL-TS groups. Between the groups, a significant difference was observed between DJ-RSI, CMJ, and 10-20-m Sprint Test results ($p<0.05$). When we compare the results within groups, it can be concluded that the AEL-CS group showed more improvement in terms of strength, change of direction (COD) skills and Sprint compared to the AEL-TS group.

Conclusions In conclusion, it can be advised to use cluster set in accentuated eccentric load training in order to improve strength, Sprint and COD skills.

Keywords: eccentric training, clustering, power, reactive strength index, vertical jump

Introduction

The most important determinants in resistance training aiming at the improvement of strength and power are the mode of the applied exercise, the intensity of the training and the lifting tempo [1]. The improvement in strength and power can be optimised by appropriate management of acute training variables such as sets, repetitions, rest (recovery) periods and exercise sequence [2]. However, when it comes to athletes with advanced training levels, different applications and different stimuli may be required to go beyond the force plateau. Periodization is recommended considering the nature of the sports branch in question [3, 4].

Coaches use different designs in their training programs to manage fatigue effectively, to unlock performance potential and to achieve more predictable results [5, 6]. The design of the training programme then serves to bring variety to a periodic training programme through the manipulation of one or more training variables (e.g., volume, intensity). Hodges et al. [7], who emphasised the importance of training variation, argued that a novel stimulus results in faster performance improvement, whereas monotonous training slows adaptation. For this reason, it is particularly important for coaches to consider numerous factors in order to maximise preparation and performance potential. Traditional strength training uses the same loads for the concentric and eccentric phases of an exercise. However, compared to concentric muscle movements, skeletal muscle is capable of producing up to 50% more force during maximal eccentric muscle movements [8]. Therefore, a more popular way of providing variation within a resistance training programme is the manipulation

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of exercise phase-specific overload. Recently, the method called accentuated eccentric load (AEL), in which the eccentric phase is applied with a higher load when compared to the concentric phase, has gained popularity [9].

AEL is an advanced training method that aims to benefit from the ability of the muscle to produce more force during eccentric muscle movements compared to isometric and concentric actions [8, 10]. This method is intended to be used during exercises that use eccentric loads that exceed the concentric load (e.g. back squat, bench press). Ideally, this is achieved by minimising disruption to the natural mechanics of the chosen exercise [9]. AEL has shown favourable effects on concentric performance in both upper [11, 12, 13] and lower trunk [13, 14, 15] exercises compared to traditional loading patterns [11, 15]; however, not all studies agree [12, 13, 14].

Recent literature on maximal strength has shown inconsistent results regarding acute responses and chronic adaptations in AEL training using supramaximal loads. Doan et al. [16] reported increases of 2.27-6.80 kg in bench press 1-RM in subjects using supramaximal AEL with 105% of concentric 1 RM during the eccentric phase compared to traditional loading. Ojasto et al. [11, 12] reported that subsequent 1-RM and concentric force production were significantly reduced when a series of supramaximal AEL (105-120%) eccentric overloads were used in the bench press [11]. The biggest reason for the inconsistent results of AEL training with supramaximal loads [11, 12, 17, 18] has been reported as fatigue caused by training with heavy loads [11, 17].

The inconsistent nature of the available evidence may be largely attributable to the variability of both eccentric and concentric loads, and the differences in application tools and exercise selection. Furthermore, since typically AEL requires time between repetitions in order to re-lift the load in eccentric training, it would be even more possible for inter-repetition recoveries to explain some of the aforementioned benefits of AEL [19].

Regardless of its potential impact on AEL, the inter-repetition recovery method, typically referred to as the cluster method, is an efficient programming method. Previous literature shows that various cluster method arrangements can compensate for the loss in movement speed and preserve power outputs [20, 21, 22]. Interestingly, the strengthening effects of the cluster method show effective results when applied to athletes with advanced training age [23]. This suggests that the cluster method can be performed in a more appropriate way [24]. Although some researchers suggest that this may also be true for AEL [9], such a hypothesis requires further study.

Purpose of the Study. Therefore, the main purpose of this study: To comparatively analyse the effects of cluster set (CS) and traditional set (TS) applications on strength and power outcomes in AEL training using submaximal loads.

Materials and Methods

Participants.

While determining the sample size for experimental studies, it is stated that a sample size as small as 10-20 for simple experimental studies would be appropriate for the conduct of successful research. On the other hand, it is stated that the sample size should be 15 or more people in order for the results obtained in experimental studies to be valid [25, 26]. Therefore, the sample group in our study was planned to be 32 people. Gpower [27] is used to calculate the sample size from the determined population.

Thirty-two amateur male football players with at least 2 years of strength training history participated in the study ($\bar{x}_{age}$: 18,78 ± 0,83 years, $\bar{x}_{height}$:166,73± 8,61 cm., $\bar{x}_{body\ weight}$: 69,59± 6,03 kg.).

Criteria For Being Included In The Study:

(a) Absence of known cardiovascular, pulmonary, metabolic, bone or joint diseases;
(b) Absence of muscle and joint injuries in the last six months;
(c) Being a licensed football player.

Criteria For Being Excluded From The Study:

(a)Failure to attend two consecutive training sessions;
(b)Diseases and Injuries.

Before data collection, participants were informed about all study procedures and about the possible risks or benefits of participation. All participants signed an institutionally approved informed consent form. The study meets the requirements of the Declaration of Helsinki and is approved by the Marmara University Non-Interventional Clinical Research Ethics Committee (Protocol No: 09.2020.739)

Procedures

In order to comparatively analyse the effects of cluster set (CS) and traditional set (TS) applications on strength and power outputs in accentuated eccentric load (AEL) training, CS and TS Protocol Groups were created. At the beginning of the study, each participant underwent a 1-RM (1 Repetition Maximum) strength Test. Then, the participants were divided into two groups: CS (n=16) and TS (n=16) by using a randomised method for the execution of the exercise protocol consisting of hip thrust and back squat exercises. After 48 hours from the 1RM test and after a four-week training period, the participants were subjected to a post-test 1RM strength test protocol 10-20-30 m sprint, drop jump-reactive strength index (DJ-RSI), countermovement jump (CMJ), Illinois Agility Test (IAT).The study plan is presented in table 1.

Research Design

Lifting tempo

Each of the four numbers associated with the exercise in the training programme indicates how long, in seconds, the specific "phase" (eccentric, isometric, concentric and cluster) should be performed. For example, a Back Squat might be performed at the following tempo: 6:0:0:0. The first number (6) represents the eccentric phase of the exercise. The second number (0) represents the isometric phase of the exercise. The third number (0) represents the concentric phase of the exercise. Finally, the last number (0) represents the number of repetitions that should be followed by a rest (Cluster Set) [28].

Training Program

This study is considered as intervention training and is integrated into the participants' on-going training programmes. Since the study group is chosen from the same team, there are no differences between the training programmes. All other elements of the resistance training programme used in the eccentric phase of the selected exercises, such as intensity of load, exercise selection, sets, repetitions, tempo and frequency, were the same between the groups. Only the AEL-CS group rested for 20 seconds after every two repetitions while performing the exercises [29].

After measuring the 1-RM strength value of all participants who performed back squat and hip thrust exercises, the participants were randomly divided into two groups: AEL Cluster Set (CS) (n=16) and AEL Traditional Set (TS) (n=16). After 48 hours following the 1-RM test, 50cm Drop Jump (DJ), Countermovement Jump (CMJ), 10-20-30 m Sprint Test, and Illinois Agility Test (IAT) were performed for both groups. After 48 hours following the tests, the training protocol, which was going to be applied

Table 1. The Study Plan

1 RM Test	**(After 48 Hours) Pre-Test**	**The Training Process 4 Weeks**	**1RM Test**	**(After 48 Hours) Pre-Test**
-Hip Thrust	-50cm-DJ-RSI	AEL-TS	-Hip Thrust	50cm-DJ-RSI
		-Hip thrust & Back Squat		
-Back Squat	-CMJ	-Concentric: 50% 1RM	-Back Squat	-CMJ
		-Eccentric: 80% 1RM		
	-10-20-30m Sprint	-8 Repetitions x 3 Set		-10-20-30m Sprint
		- lifting tempo: 0.0.0.0		
	-Illinois Agility Test	AEL-CS		-Illinois Agility Test
		Hip thrust & Back Squat		
		-Concentric: 50% 1RM		
		-Eccentric: 80%1RM		
		-8 Repetitions x 3 Set		
		- lifting tempo: 0.0.0.2		

AEL-TS: accentuated eccentric load traditional Set; AEL-CS: accentuated eccentric load cluster Set; DJ-RSI: drop jump reactive strength Index; CMJ: countermovement Jump; CON: concentric; ECC: eccentric

Table 2. Accentuated eccentric load traditional set training protocol

Back Squat (eccentric/concentric -80%-50% 1RM)				
1. Set		2. Set		3. Set
	180 seconds of rest (recovery period)		180 seconds of rest (recovery period)	
8 (repetitions)		8 (repetitions)		8 (repetitions)
5 Minutes of rest (recovery period)				
Hip Thrust (eccentric/concentric -80%-50% 1RM)				
1. Set		2. Set		3. Set
	180 seconds of rest (recovery period)		180 seconds of rest (recovery period)	
8 (repetitions)		8 (repetitions)		8 (repetitions)

two days a week and which would last for 4 weeks, was initiated in both groups. The training protocol is presented in table 2 and table 3.

For both groups, the load to be used during the training application was determined as Concentric 50% 1-RM and Eccentric 80% 1-RM for back squat and hip thrust exercises. The bar and the eccentric hook were adjusted in terms of height according to the lowest landing point of each participant during the back squat and hip thrust exercises [15]. Due to the angle of its base, the eccentric hook mounted on the bar (Figure 1) was designed to detach from the barbell at its lower part during the performance of the back squat and hip thrust exercises. Thus, the eccentric part of the exercise undergoes more load when compared to the concentric phase [16, 30].

The AEL-CS and AEL-TS training programme include the rapid execution of each phase (eccentric, isometric, concentric, cluster) according to the exercise tempo without any rests in between. For the back squat and hip thrust exercises, participants performed a fast eccentric phase with 1-RM 80% with 1-RM 50% already loaded on the bar and 1-RM 30% loaded on the eccentric hook. Immediately, after the eccentric hook was detached from the bar, a concentric phase with 1 RM 50% was quickly performed. Assistants started the second repetition by attaching the hook onto the bar within 3 seconds [19]. CS and TS groups performed the back squat and hip thrust exercises in 3 sets of 8 repetitions.

Table 3. Accentuated eccentric load cluster set training protocol

Back Squat (eccentric/concentric - 80%-50% 1RM)						
1. Set 2 (repetitions)	20 seconds of rest (recovery period)	1. Set 2 (repetitions)	20 seconds of rest (recovery period)	1. Set 2 (repetitions)	20 seconds of rest (recovery period)	1. Set 2 (repetitions)
120 Seconds of rest (recovery period)						
2. Set 2 (repetitions)	20 seconds of rest (recovery period)	2. Set 2 (repetitions)	20 seconds of rest (recovery period)	2. Set 2 (repetitions)	20 seconds of rest (recovery period)	2. Set 2 (repetitions)
120 Seconds of rest (recovery period)						
3. Set 2 (repetitions)	20 seconds of Rest (Recovery Period)	3. Set 2 (repetitions)	20 seconds of rest (recovery period)	3. Set 2 (repetitions)	20 seconds of rest (recovery period)	3. Set 2 (repetitions)
5 minutes of rest (recovery period)						
Hip Thrust (eccentric/concentric - 80%-50 % 1RM)						
1. Set 2 (repetitions)	20 seconds of rest (recovery period)	1. Set 2 (repetitions)	20 seconds of rest (recovery period)	1. Set 2 (repetitions)	20 seconds of rest (recovery period)	1. Set 2 (repetitions)
120 Seconds of rest (recovery period)						
2. Set 2 (repetitions)	20 seconds of rest (recovery period)	2. Set 2 (repetitions)	20 seconds of rest (recovery period)	2. Set 2 (repetitions)	20 seconds of rest (recovery period)	2. Set 2 (repetitions)
120 Seconds of rest (recovery period)						
3. Set 2 (repetitions)	20 seconds of rest (recovery period)	3. Set 2 (repetitions)	20 seconds of rest (recovery period)	3. Set 2 (repetitions)	20 seconds of rest (recovery period)	3. Set 2 (repetitions)

Figure 1. Adjustable eccentric hook device

In the AEL-CS group, the sets were performed with 20 seconds of rest after every two repetitions, 120 seconds of rest between sets, for a total of three minutes, and five minutes of rest between exercises. In the AEL-TS group, the sets were performed without any rests between repetitions, with 180 seconds of rest between sets and five minutes of rest between exercises.

One repetition maximum (1-RM) strength test

Participants warmed up before the test by cycling for 5 minutes on a stationary bike. After a one-minute rest (recovery) period, participants familiarized themselves with the Back Squat and Hip Thrust exercises by performing 8-10 repetitions using a light load (~50% of the estimated 1-RM). After a three-minute recovery period, participants performed the exercise with a certain load (~80% of the estimated 1-RM) through the entire range of motion. After each successful performance, the weight was increased gradually until failure. Between each trial, participants rested for three minutes, and 1-RM was reached after 6 trials. And, the participant was allowed to rest for five minutes after each test. Exercises were alternated to facilitate recovery and reduce the effect of fatigue [31].

10-20-30 Meter sprint test

To measure speed performance, a 30 m Sprint Test was performed using sensor gates every 10 meters (0-10, 0-20 and 0-30 m). The Sprint Test was performed outdoors on a hard surface. Participants started running in a standing position at the Start Line, approximately 0.5 m behind the first gate. Photocells were placed 0.6 m above the ground (approximately at hip level) to capture the movement of the trunk instead of a false signal due to limb movements. Intermediate values were measured through 2 infrared photoelectric infrared gates (Fusion Sport Smart Speed) that were placed every 10 meters and recorded horizontal speed. Measurements were made in 2 trials. The participant was allowed to rest for five minutes between repetitions. The best time was recorded in seconds [32].

Illinois Agility Test

The participants' sudden change of direction speed performance was measured through the Illinois Agility Test. Participants were asked to run at maximum speed and this application was repeated twice. And, they were allowed to rest for three minutes between these two applications. The best value was recorded in seconds. Participants' running speed was measured via photocells (Smartspeed, Fusion Sport,) with a margin of error of 0.01/sec [33].

Drop Jump Test

The depth jump test was performed bilaterally from a height of 0.50 meters [34]. Participants completed the test by performing 3 maximal trials with a three-minute recovery between each trial.

Participants were instructed to perform depth jumps with hands on the waist and to step forward from the box before starting the movement. They were clearly asked to try to maximize their jump height while minimizing their ground contact time. Thus, a short ground contact time was prioritized. If trials were rejected due to severe failure of technique, the test was repeated. All jumps were recorded simultaneously via an iPhone 8plus Smartphone (Balsobre, Spain) with a 240 Hz High-Speed Video Capture feature [35, 36, 37]. Video footage was captured in the frontal plane, focusing on the toes of the jumping participant at a distance of approximately 1.5 meters. The recorded videos were analysed by using the MyJump Smartphone App [35, 36, 37].

Countermovement Jump Test

Participants were fixed with legs hip-width apart, hands on the hips. Later, they performed a quick squat to approximately 90^0 knee flexion and then

Table 4. Repeated Measures Anova Results Regarding The Difference Between RSI, CMJ, IAT, Speed And Maximal Strength Values Between Groups

Variable	Group	Pre-Test (Mean ± SD)	Post-Test (Mean ± SD)	$F_{(1-31)}$	P	η^2
DJ-RSI	Cluster Set	1.45±.246	1.62±.259	4.787	**.037***	0.13
	Traditional Set	1.33±.164	1.45±.157			
CMJ (CM)	Cluster Set	32.02±2.11	35.21±1.91	9.951	**.004***	0.24
	Traditional Set	29.88±2.56	31.80±2.72			
IAT (Seconds)	Cluster Set	15.74±.295	15.47±.312	.985	.329	0.03
	Traditional Set	15.70±.276	15.48±.283			
10 m Sprint (Seconds)	Cluster Set	1.87±.071	1.80±.081	4.235	**.048***	0.12
	Traditional Set	1.89±.113	1.86±.095			
20 m Sprint (Seconds)	Cluster Set	3.16±.139	3.07±.101	5.224	**.032***	0.14
	Traditional Set	3.20±.126	3.17 ±.97			
30 m Sprint (Seconds)	Cluster Set	4.42±.255	4.24±.176	3.468	.072	0.10
	Traditional Set	4.47±.202	4.36±.182			
1RM-BS (KG)	Cluster Set	91.43±14.28	106.93±16.24	2.134	.154	0.06
	Traditional Set	93.43±13.62	111.81±17.80			
1RM-HT (KG)	Cluster Set	80.62±15.28	95.93±14.96	2.152	.153	0.06
	Traditional Set	79.43±13.12	96.12±15.41			

DJ-RSI: drop jump-reactive strength index; CMJ: countermovement jump; IAT: illinois agility test; 1RM-BS: 1 repetition maximum back squat; 1RM-HT: 1 repetition maximum hip trust; SD: standard deviation, CM: centimetre; KG: kilogram; SN: seconds; *Statistically significant differences (P< 0.05).

a vertical jump upwards as fast as possible without waiting.

Attention was paid not to bend the knees during take-off and to ensure that both feet were within the contact area when landing. Three repetitions with three-minute recovery periods were performed and the best result was recorded. Participants, who performed the movement with a faulty technique, were made to repeat the test [38].

All jumps were recorded simultaneously via an iPhone 8plus Smartphone (Balsobre, Spain) with a 240 Hz High-Speed Video Capture feature [35, 36, 37]. Video footage was captured in the frontal plane, focusing on the toes of the jumping participant at a distance of approximately 1.5 meters. The recorded videos were analysed by using the MyJump

Smartphone App [35, 36, 37].

Statistical Analysis

In accordance with the sub-problems determined within the scope of the study, the collected data set was recorded electronically. When analysing the data obtained, Skewness and Kurtosis values and Kolmogorov-Smirnov values were examined to determine homogeneity. In order to compare the pre-test and post-test averages between groups, ANOVA was used for Repeated Measures, and Sample T Test was used to compare the pre-test and post-test averages within groups. The statistical significance level was determined as $p<0.05$. Statistical Analyses were performed using the SPSS 26.0 (Armonk, NY: IBM Corp, 2019) Package Program [39].

Results

After AEL training, a statistically significant difference was observed between AEL-CS and AEL-TS groups in terms of DJ-RSI, CMJ, 10m and 20m Sprint values ($P<0.05$). There was no significant difference between the groups in terms of pre-test and post-test values of the IAT, 30 m Sprint, Back Squat 1-RM and Hip Thrust 1-RM ($P>0.05$) (table 4).

As for the intra-group assessments, a statistically significant difference was observed between the pre-tests and post-tests, DJ-RSI, CMJ, 10m, 20m, 30m Sprints, IAT, Back Squat 1RM and Hip Thrust 1RM results of AEL-CS and AEL-TS groups ($P<0.05$). When analysed in terms of percentage improvement, the percentage improvement of the AEL-CS group in terms of DJ-RSI, CMJ, IAT, 10m, 20m and 30m Sprint measurements was higher than the AEL-TS group.

In 1RM measurements, it was observed that the percentage improvement rate was higher in the AEL-TS group compared to the AEL-CS group (table 5).

Discussion

This study aims to comparatively analyse the effects of cluster set (CS) and traditional set (TS) applications on strength and power outputs in accentuated eccentric load (AEL) training. For this purpose, 10-20-30 Sprints, Illinois Agility Test (IAT), Drop Jump- Reactive Strength Index (DJ-RSI) Countermovement Jump (CMJ) and 1-RM Tests were applied in the form of pre and post-tests.

In this study, which was conducted with a standard method, it is revealed that maximal strength improvement was observed in both methods in terms of maximal strength improvement. But, the improvement differences between the two groups are not found to be statistically significant.

Maximal Strength (1-RM): In this study using submaximal loads (Eccentric: 85%-Concentric: 50% 1 RM), when intra-group changes were compared in terms of maximal strength improvement, pre-test and post-test evaluations were statistically significant in both groups ($p<0.05$). When we consider the intra-group percentage differences: In the AEL-TS group, *Back Squat* improvement was 20% and *Hip Thrust* improvement was 21%, while in the AEL-CS group, *Back Squat* improvement was 17% and *Hip Thrust* improvement was 19%. In this study, it is concluded that using the Cluster Set method in AEL Training is not superior to the Traditional Set method in terms of maximal strength improvement. Although it is seen that there is no superiority of the set methods used in this study, the results obtained are consistent with the results of studies [11, 40, 41] that recommend the use of submaximal loads in AEL Training for strength improvement.

Ojasto and Hakkinen [11] reported that maximal power and neuromuscular activity increased with submaximal AEL. The submaximal Loading Strategy is generally used in AEL Training when changes in explosive and plyometric performance are expected [39, 40, 41]. Many different Submaximal Load Methods were used in AEL studies (Eccentric/Concentric: 60/50% 1RM, 70/50% 1RM, 80/50% 1RM, 90/50% 1RM). However, there is no certainty about the optimal submaximal load (eccentric/concentric) ratio for performance improvement [11].

Power, sprint and change of direction: In our study, 10 m, 20 m, 30 m Sprint Test, Illinois Agility Test (IAT), Drop Jump Reactive Strength Index (DJ-RSI), Countermovement Jump (CMJ) Tests were used in order to assess explosive performance. It is observed that AEL Training with submaximal loads produced statistically significant improvements in both groups. When we consider the intra-group comparisons of the two different set methods used throughout the study, improvement is observed in all tests. These results support the studies indicating that using the submaximal load in AEL training improves explosive and plyometric performance [11, 40, 41].

Power (CMJ, DJ-RSI): When we compare the vertical jump performance of AEL CS and AEL TS groups under the roof of this study, we can say that the DJ-RSI and CMJ Test results were statistically significant both within and between the groups. When we compare the percentage improvements between the two groups, we observe that the percentage improvements of the CS group were 10% in the context of CMJ and 12% in the context of DJ-RSI, while the percentage improvements of the TS group were 6% in the context of CMJ and 9% in the context of DJ-RSI. In both measurements, the percentage changes were higher in the CS group compared to the TS group.

In their study to evaluate the effects of accentuated eccentric load on CMJ performance, Aboodarda et al. [42] showed that vertical ground reaction forces increased by 6.34%, the power output by 23.21%, impulse impact by 16.65% and jump height by 9.52% in the group where they used

Table 5. T-Test Results Regarding The Difference Between Pre-Test And Post-Test, RSI, CMJ, IAT, Speed And Maximal Strength Values Within Groups

Variable	Group	Pre-Test (Mean ± SD)	Post-Test (Mean ± SD)	t	Improvement %	P
DJ-RSI	Cluster Set	1.45±.246	1.62±.259	-10.058	12	**.000***
	Traditional Set	1.33±.164	1.45±.157	-9.563	9	**.000***
CMJ (CM)	Cluster Set	32.02±2.11	35.21±1.91	-9.350	10	**.000***
	Traditional Set	29.88±2.56	31.80±2.72	-8.928	6	**.000***
IAT (Seconds)	Cluster Set	15.74±.295	15.47±.312	10.920	2	**.000***
	Traditional Set	15.70±.276	15.48±.283	5.834	1	**.000***
10 m Sprint (Seconds)	Cluster Set	1.87±.071	1.80±.081	3.696	4	**.002***
	Traditional Set	1.89±.113	1.86±.095	3.216	2	**.006***
20 m Sprint (Seconds)	Cluster Set	3.16±.139	3.07±.101	5.693	3	**.000***
	Traditional Set	3.20±.126	3.17±.97	2.736	1	**.015***
30 m Sprint (Seconds)	Cluster Set	4.42±.255	4.24±.176	6.522	4	**.000***
	Traditional Set	4.47±.202	4.36±.182	3.730	2	**.002***
1RM-BS (KG)	Cluster Set	91.43±14.28	106.93±16.24	-17.513	17	**.000***
	Traditional Set	93.43±13.62	111.81±17.80	-10.452	20	**.000**
1RM-HT (KG)	Cluster Set	80.62±15.28	95.93±14.96	-26.616	19	**.000***
	Traditional Set	79.43±13.12	96.12 ± 15.41	-22.550	21	**.000***

DJ-RSI: drop jump-reactive strength index; CMJ: countermovement jump; IAT: illinois agility test; 1RM-BS: 1 repetition maximum back squat; 1RM-HT: 1 repetition maximum hip trust; SD: standard deviation, CM: centimetre;KG: kilogram; SN: seconds; *Statistically significant differences (P< 0.05).

elastic bands providing additional load equivalent to 30% of body mass.

This time, in their study, where they employed a drop jump method, Aboodarda et al. [42] used elastic bands that provided an additional load equivalent to 30% of the body mass and obtained a higher The rate of force development (RFD).

Following a 4-week study by Bridgeman et al. [43] on two groups using Bodyweight and Bodyweight +20% Additional Load, although significant individual improvements in speed occurred in the AEL groups, the size of the improvement across all groups was small compared to the improvements seen in Vertical Jump Performance (2.2% at 10 and

2% at 30m).

Sprint and Change of Direction (COD): When we consider the results of the sprint test, we can say that the 10-20m test performance of the AEL-CS group was statistically better. On the other hand, there was no statistical difference between the 30m sprint and Illinois Agility Test results between the two groups.

Although the results of the 30m Sprint Test and IAT Test between the groups were not statistically significant, when we evaluate the percentage improvement values, the results of the 30m Sprint Test showed a 2% improvement in the AEL TS group and a 4% improvement in the AEL CS group. IAT Test results showed 1% improvement in the AEL TS group and 2% improvement in the AEL CS group. Although there were significant individual improvements in the speed of both groups participating in this study, the vertical jump performance was higher. These improvement values put forth similar results with the studies in the literature [44, 45].

On the other hand, in one of the limited studies on change of direction (COD) skills, Lockie et al. [44] applied a training program including speed and agility training elements that provided eccentric muscle movements in male (23 years old) and female (25 years old) athletes, who were recreationally engaged in team sports. As a result of this study, similar to our study, an improvement was observed in terms of COD speed performance after 6 weeks of training.

Hoyo et al. [45] examined the effects of a 10-week strength training program on the COD by designing AEL training differently. They used an iso-inertial flywheel training device to measure kinetic parameters during COD in 17-year-old young football players. The results obtained from this study reported significant improvements in COD speed kinetics after training.

Similarly, Tous-Fajardo et al. [46] examined the effects of an 11-week strength training program (applied on 17-year-old elite young football players) (including additional iso-inertial eccentric muscle movements and additional whole-body vibration) on COD Speed Performance compared to traditional combined training that includes plyometrics, linear velocity and weight-loaded exercises. The findings of this study show that strength training with AEL in combination with vibration stimuli improves change of direction (COD) speed performance more than traditional training does.

Spiteri et al [47] studied the relationship between eccentric force and COD performance and reported a strong correlation between them. The authors reported that the ability to tolerate larger eccentric loads may result in improved COD performance [47]. If we analyse the results of this current study, we see that the subjects in the AEL group had the greatest increase in Eccentric Peak Force (13.8% vs. 7.3%) and also the greatest improvement in COD Performance. In conclusion, while it is stated that different applications of the AEL method in COD training will provide improvements, we can say that, in our study, CS application also brought similar advantages.

When the effects of AEL training on the development of power [48, 49, 50], change of direction [45, 46, 47] and speed [43, 46, 47] are examined, it is seen that the use of AEL reveals better results than the traditional set method. Hansen et al. [51] showed that: following a training program involving squats or squat derivatives, when compared to the use of traditional sets [52, 53, 54], the use of cluster sets caused greater changes in post-activation strength development and peak velocity characteristics of the jump squat exercise.

As we also revealed in our study, cluster set practice stands out in many studies as a practice to improve speed and power characteristics [51, 55, 56]. In the limited number of studies using the cluster method in AEL training, we see that cluster set practice was used as an effective method, especially for speed and power improvement [51]. Acutely, such a method is reported to result in higher power outputs while exposing the athlete to less metabolic stress and fatigue [57].

On the other hand, recent AEL studies have found that the application of the cluster set method in a single repetition or in all repetitions of eccentric overloading significantly increases eccentric work (W_{Eks}) compared to the traditional loading [11, 16, 58, 59].

Wagle et al. [59] compared four different training methods 1. Traditional strength training (TST), 2: Traditional strength training with Cluster Sets (TSTCS), 3: Accentuated eccentric load Training Traditional Sets (AELTS), 4: Accentuated eccentric load Training Cluster Sets (AELCS). In the study, they used 1RM 80% as concentric load and 1RM 105% as eccentric load. When the four groups were compared, in terms of concentric outcomes, the Average Speed Average Power accentuated eccentric load Cluster (AELCS) group showed superior effects compared to the other groups ($p<0.001$), especially on Average Power and Average Speed.

Conclusions

In conclusion, this study revealed that the Cluster Set and Traditional Set methods produce similar results in terms of maximal strength improvement in AEL training using submaximal loads. And, the Cluster Set method is not superior to the Traditional Set method in terms of maximal strength improvement. It is also consistent with the studies that recommend the use of submaximal loads in AEL training because working with supramaximal loads causes fatigue [11, 17, 18]. To summarize the effect of using submaximal loads on

explosive power performance; when we analyse the results in terms of the percentage improvements of the pre-test and post-test measurements between the groups: Percentage improvements in DJ-RSI, CMJ, 10-20-30m Sprint, IAT measurements in AEL-CS Group were higher when compared to AEL-TS Group. As a result, the use of the Cluster Set method in accentuated eccentric load training can be recommended for the development of strength, change of direction (COD) skills and sprint.

Conflict of interest

The authors declare no conflict of interest.

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ORIGINAL ARTICLE

The effect of athletic mental energy on wrestlers' sports courage and attitudes toward wrestling

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

Abstract

Background and Study Aim: This study aimed to determine whether athletic mental energy played a mediating role between wrestlers' sports courage and attitudes toward wrestling.

Material and Methods: The study developed an original theoretical model, which was tested using the Sobel test. The sample consisted of 247 wrestlers in the Freestyle and Greco-Roman Wrestling Leagues, U-23, 1. League, 2. League, and Stars Wrestling Leagues of the 2021-2022 Turkish Wrestling Federation. Participants were recruited using random sampling. Data were collected using a sociodemographic characteristics questionnaire, the Guttman Attitude Scale Towards Wrestling (GAS), the Sports Courage Scale-31 (SCS-31), and the Athletic Mental Energy Scale (AMES).

Results: There was a positive correlation between attitudes toward wrestling and athletic mental energy. There was a positive correlation between athletic mental energy and sports courage. There was a positive correlation between attitudes toward wrestling and sports courage. Moreover, athletic mental energy played a fully mediating role between sports courage and attitudes toward wrestling.

Conclusions: The results confirmed the theoretical model. Our results also point to the effects of athletic mental energy on sports performance. Athletic mental energy plays a fully mediating role between sports courage and attitudes toward wrestling. Authorities should inform wrestlers about the relationship between athletic mental energy, mental training, and sports courage. Wrestlers should practice developing positive attitudes toward wrestling and build up the courage to show high performance during competitions. Researchers should recruit different samples to investigate the mediating role of athletic mental energy between wrestling attitude and sports courage.

Keywords: sports courage, attitudes toward wrestling, athletic mental energy, wrestling.

Introduction

Wrestling is a symbol of the struggle put up by communities for survival. It is a part of human life. It takes place in parallel with the emergence and progress of civilization [1]. Wrestling is an ancient sport that dates back to Greco-Roman Times [2, 3]. It is a popular sport among Turks. It constitutes an undeniable part of the rich traditions that make up Turkish society [4]. Therefore, Turkish people call wrestling an "ancestral sport" [5]. Turks value wrestlers very much and view them as brave, strong, and gentlemanly athletes [6]. Wrestling is a high-contact sport in which two athletes compete against each other to secure an advantageous position over their opponents. It is a combination of strategic, technical, and tactical movements. The objective of wrestling is to win the match by pinning the opponent's back on the ground or getting more scores [7].

Sports courage is one of the most important topics in sports psychology [8]. Although it is regarded as an important virtue [9], sports psychology researchers have paid little scientific attention to it [10]. Sports psychology focuses on different psychological variables to maximize performance [11]. Courage is a way to manage fear and stress while winning over internal and external resistances [10]. Sports courage is a dynamic process affected by numerous factors (fear, danger, risk, etc.) such as tasks, personal characteristics, and experiences [12]. We cannot give one answer to the change and development of sports courage because it has a complex structure [13]. In their moral courage model, Sekerka and Bagozzi [14] ask, "How can we develop self-regulation in sports courage and take action against threats?". This model focuses on internal influences, referred to as tools, for initiating bold action. Those tools are linked to internal processes and personal goals, such as expectations, feelings, and moral standards. Emotions evoked by experiences and how one thinks under pressure play an important role in these situations [15]. The model considers and identifies several self-regulation variables related to decisions to take action. Sekerka and Bagozzi's process model is akin to other self-regulation models, such as Heckhausen's Rubicon Model of Action Phases [16, 17]. The first step of the Rubicon Model of Action Phases focuses on motivation and willingness to act. The second step involves a firm commitment to take action. According to these models, a firm

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commitment is essential to taking action against challenges [15, 18].

Although the concept of mental energy emerged in the nineteenth century, it has not been scientifically defined [19]. Mental energy is the main factor for high performance. It is defined as thinking hard about problems and insisting on solving them [20]. There is a small body of research on mental energy [21]. It is mostly associated with such factors as fatigue, alertness, etc. [22]. Athletic mental energy is defined as an athlete's energy status. It also involves cognitive, affective, and motivational components. Sports psychology experts focus on the sub-dimensions of tirelessness, vigor, and calmness. Motivation, concentration, and confidence are also important features for high performance [23]. Mental energy is an important factor that all athletes should take into account [20, 21, 23].

Attitude cannot be observed directly. There should be a behavior for us to evaluate the presence or absence of an attitude [24]. Attitude is a state of readiness for people to accept or reject people, opinions, attitudes, or objects. Therefore, readiness is also affected by perceptual differences and changes [25]. Attitude is a personality trait learned through conditioning, imitation, and observation [26]. Attitudes can be positive or negative [27].

There is a small body of research on athletic mental energy [23, 28]. Researchers in different fields focus on courage: football, [15, 29, 30] wrestling, [31], students [32, 33, 34], skiing [35] etc. which helps us better understand sports courage. There is a growing body of research on attitudes [25, 36, 37]. However, there is limited research on sports courage. Although researchers address different branches of wrestling, there are no studies investigating athletic mental energy, courage, and attitude in wrestling. Therefore, this is the first study in that regard. This study investigated whether athletic mental energy played a mediating role between sports courage and attitudes toward wrestling. Research shows that athletic mental energy, sports courage, and attitudes toward wrestling affect wrestlers' psychological status. The following are the research hypotheses:

Research Hypotheses

$H_{1:}$ Wrestlers' attitudes toward wrestling positively affect their athletic mental energy.

$H_{2:}$ Wrestlers' athletic mental energy positively affects their sports courage

$H_{3:}$ Wrestlers' attitudes toward wrestling positively affect their sports courage.

$H_{4:}$ Wrestlers' athletic mental energy plays a mediating role between their sports courage and attitudes toward wrestling

Materials and Methods

Research Model and Type

This study adopted a cross-sectional and correlational research design to develop an original theoretical model. It employed the model to determine the mediating role of athletic mental energy between sports courage and attitudes toward wrestling. In the model, sports courage (SCS-31) was the dependent variable, wrestling attitude (GAS) was the independent variable, and athletic mental energy (AMES) was the mediating variable. Mediation analyses that add new information to the literature are theoretical studies [38]. The model was assessed using the Sobel test [39]. The model in question is as follows.

This cross-sectional and descriptive study adopted a survey model to reveal a situation as it is. The survey method aims to describe a situation as it is or as it was in the past [38, 40].

Research Purpose

This study aimed to determine whether wrestlers' athletic mental energy mediated between their attitudes toward wrestling and sports courage.

Participants.

The study population consisted of all wrestlers from the Freestyle and Greco-Roman Wrestling Leagues, U-23, 1. League, 2. League, and Stars Wrestling Leagues of the 2021-2022 Turkish Wrestling Federation [41]. Participants were recruited from Ordu and Trabzon Metropolitan Municipalities Wrestling Training Centers, Amasya, Kavak, and Korkuteli Wrestling Training

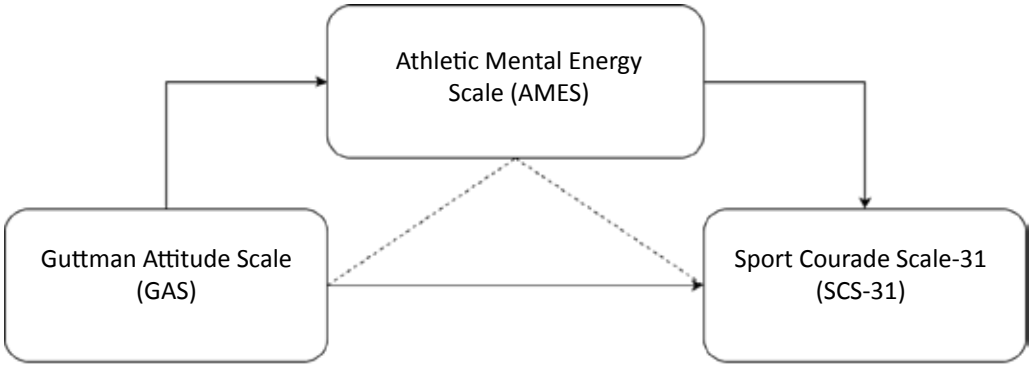

Figure 1. Sobel Test Model

Centers, Vezirköprü and Muğla Youth and Sports, Ladik Municipality Sports, Ankara ASKI, Istanbul Metropolitan Municipality, and Pendik Wrestling Specialized Clubs. A common rule of thumb for scale studies is to have a sample size five times the number of items on the scale [42]. The sample consisted of 247 active wrestlers (⩾17 years of age). Participants were randomly recruited using disproportionate element sampling.

Research Design.

Data were collected using a survey method. Participants were briefed about the research purpose, confidentiality, and procedure. The data were collected between December 2021 and January 2022. The data were collected using a sociodemographic characteristics questionnaire, the Athletic Mental Energy Scale (AMES), the Sports Courage Scale-31 (SCS-31), and the Guttman Attitude Scale (GAS).

Sociodemographic Characteristics Questionnaire

The sociodemographic characteristics questionnaire was based on a literature review conducted by the researcher. The questionnaire consisted of five items on age, gender, professional experience, category, and the status of being a national athlete.

Guttman Attitude Scale Toward Wrestling

The Guttman Attitude Scale Toward Wrestling (GAS) was developed by Bardakçı and Caz [43]. The instrument consists of five items rated on a two-point Likert-type scale (Agree = 1 and Disagree = 0). Three items are positive, while two items are negative statements regarding attitudes toward wrestling. The scale has a coefficient of reproducibility of 0.937 and a coefficient of scalability of 0.64 [43].

Athletic Mental Energy Scale

The Athletic Mental Energy Scale (AMES) was developed by Lu et al. [23] and adapted to Turkish by Yıldız et al. [28]. The instrument consists of 18 items rated on a six-point Likert-type scale. The instrument consists of six subscales: vigor (Items 1, 12, and 15), confidence (Items 3, 9, and 13), motivation (Items 4, 8, and 16), tireless (Items 7, 11, and 12), concentration (Items 2, 5, and 10), and composed (Items 14, 17, and 19). The subscales of the original scale "vigor," "confidence," "motivation," "tireless," "concentration," and "composed" have a Cronbach's alpha (α) of 0.75, 0.82, 0.86, 0.89, 0.87, and 0.90, respectively (23). The subscales of the Turkish version of the scale have a Cronbach's alpha of 0.78 to 0.91 [28].

Sports Courage Scale-31

The Sports Courage Scale-31 (SCS-31) was developed by Konter and Ng [44]. The instrument consists of 31 items rated on a five-point Likert-type scale ("1= Strongly Agree" to "5= Strongly Disagree"). The instrument has five subscales: mastery (α = .82; Items 1, 6, 11, 16, 21, 24, and 27), determination (α = .82; Items 2, 7, 12, 17, 20, 22, 25, 28, and 30), venturesome (α = 0.72; Items 3, 8, 13, 18, 23, 26, and 29), assertiveness (α = 0.72; Items 4, 9, 14, and 19), and self-sacrifice behavior (α = 0.61; Items 5, 10, 15, and 31) [44].

Statistical Analysis.

Participants' sociodemographic characteristics were presented using frequency (n) and percentage (%). The reliability of the SCS-31, GAS, and AMES was analyzed. The relationship between scale scores was analyzed using correlation tests. Mean ($\bar{x}$) and standard deviation (SD) were used for descriptive statistics. Analysis was performed to determine whether athletic mental energy (AMES) played a mediating role between sports courage (SCS-31) and wrestling attitude (GAS). Based on the work of Michael Sobel, a professor of statistics at Columbia University in New York, the Sobel test is used to test the significance of the effect of a mediator [39, 45]. A mediation model examines whether the relationship between independent and dependent variables occurs through a third variable. The Sobel test examines and interprets the relationship between dependent and independent variables by including a mediating variable in the model [39, 45, 46]. Three simple linear regression models were developed to test the assumptions. In the first model, athletic mental energy (AMES) was the dependent variable, while wrestling attitude (GAS) was the independent variable. In the second model, sports courage (SCS-31) was the dependent variable, while athletic mental energy (AMES) was the independent variable. In the third model, sports courage (SCS-31) was the dependent variable, while wrestling attitude (GAS) was the independent variable. The results of the models showed that the conditions for investigating the mediating effect of athletic mental energy (AMES) were met. In the last stage, a fourth model was developed. In the model, attitudes toward wrestling (GAS) and athletic mental energy (AMES) were the independent variables, while sports courage (SCS-31) was the dependent variable. The fourth model showed that athletic mental energy (AMES) fully mediated between attitudes toward wrestling (GAS) and sports courage (SCS-31). The significance of the change in Beta values was tested to determine the validity of the full mediation effect of athletic mental energy (AMES) [47]. In Monte Carlo simulations, the Sobel and Aroian tests yield the best results for samples larger than 49 [48]. Sobel, Aroian, and Goodman's test statistics evaluated the significance of the change in beta values. The margin of error in the statistical analyses was 5%. All analyses were carried out using the R-Project program [49] and the bda [50] package.

Results

Table 1 shows the participants' sociodemographic characteristics. Most participants were men (79.8%).

More than half the participants were 17 to 19 years of age (54.3%). More than a quarter of the participants were 20 to 25 years of age (27.1%). Less than a quarter of the participants were 26 years of age or older (18.6%). Half the participants had 0 to 5 years of professional experience (49.4%). Less than half the participants had 6 to 11 years of professional experience (44.2%). Sixteen participants had more than 11 years of professional experience (6.5%). Half the participants were Greco-Roman wrestlers (51.8%), while the other half were freestyle wrestlers (48.2%). Most participants were not national athletes (76.1%).

Table 2 shows the Cronbach's alpha of the scales. Item 2 was removed from the analysis because there was a significant increase in the reliability coefficient when it was deleted. Reliability analysis was performed again for the remaining items. The results showed that the AMES, SCS-31, and GAS had a Cronbach's alpha of 0.919, 0.865, and 0.655, respectively.

Table 3 shows the descriptive statistics and correlation test results. Participants had a total mean AMES, SCS-31, and GAS score of 64.506, 81.377, and 3.802, respectively. The AMES total score was negatively correlated with the SCS-31 total score ($r=-0.375$, $p<0.05$) and positively correlated with the GAS total score ($r=0.149$, $p<0.05$). The SCS-31 total score was also negatively correlated with the GAS total score ($r=-0.179$, $p<0.05$).

Table 4 shows the simple linear regression analysis where athletic mental energy (AMES) was the dependent variable, while wrestling attitude (GAS) was the independent variable. The results showed that wrestling attitude significantly affected athletic mental energy ($p<0.05$).

Table 5 shows the simple linear regression analysis where sports courage (SCS-31) was the dependent variable, while athletic mental energy (AMES) was the independent variable. The results showed that athletic mental energy significantly affected sports courage ($p<0.05$).

Table 6 shows the simple linear regression analysis where sports courage (SCS-31) was the

Table 1. Sociodemographic Characteristics

Variable	n	%
Gender		
Woman	50	20.2
Man	197	79.8
Age (years)		
17-19	134	54.3
20-25	67	27.1
26	46	18.6
Professional experience (year)		
0-2	26	10.5
3-5	96	38.9
6-8	77	31.2
9-11	32	13.0
>12	16	6.5
Style		
Greco-Roman	128	51.8
Freestyle	119	48.2
Being a national athlete		
Yes	59	23.9
No	188	76.1

Table 2. Reliability Test Results

Scales	Item No	Cronbach's Alpha
AMES	18	0.919
SCS-31	31	0.865
GAS	4	0.655

AMES: Athletic Mental Energy Scale, SCS-31: Sports Courage Scale-31, GAS: Guttman Attitude Scale

Table 3. Descriptive Statistics and Correlation Test Results

Variable	x̄	SD	1	2	3
1. AMES	64.506	17.437	1	-0.375*	0.149*
2. SCS-31	81.377	15.764		1	-0.179*
3. GAS	3.802	0.609			1

x̄: Mean, SD: Standard Deviation, AMES: Athletic Mental Energy Scale, SCS-31: Sports Courage Scale-31, GAS: Guttman Attitude Scale, *p<0.05

Table 4. Simple Linear Regression Analysis (Model 1)

Variable	Beta	Std. Error	t	p
Constant	46.147	8.810	5.238	<0.001
GAS	4.793	2.271	2.111	0.036
R	0.145			
R2	0.021			

Beta: Coefficient, Std. Error: Standard Error, GAS: Guttman Attitude Scale

Table 5. Simple Linear Regression Analysis (Model 2)

Variable	Beta	Std. Error	t	p
Constant	103.266	3.577	28.872	<0.001
AMES	-0.339	0.054	-6.339	<0.001
R	0.375			
R2	0.141			

Beta: Coefficient, Std. Error: Standard Error, AMES: Athletic Mental Energy Scale

Table 6. Simple Linear Regression Analysis (Model 3)

Variable	Beta	Std. Error	t	p
Constant	93.626	6.174	15.165	<0.001
GAS	-3.392	1.609	-2.108	0.036
R		0.140		
R^2		0.020		

Beta: Coefficient, Std. Error: Standard Error, GAS: Guttman Attitude Scale

dependent variable, while wrestling attitude (GAS) was the independent variable. The results showed that wrestling attitude significantly affected sports courage ($p<0.05$). All models met the conditions to determine the mediating role of athletic mental energy between sports courage and wrestling attitude.

Table 7 shows the multiple linear regression analysis where athletic mental energy (AMES) was added to Model 3 as an independent variable. Wrestling attitude (GAS) did not significantly affect sports courage (SCS-31) ($p>0.05$). However, athletic mental energy (AMES) significantly affected sports courage (SCS-31) ($p<0.05$). These results showed that athletic mental energy played a fully mediating role between sports courage and wrestling attitude. However, the significance of the change in beta values should be considered to determine whether the effect of the mediating role of athletic mental energy is significant [47].

Table 8 the showed that the Sobel, Aroian, and Goodman test values were statistically significant ($p<0.05$), indicating that athletic mental energy played a fully mediating role between sports courage and wrestling attitude.

Discussion

In recent years, there has been a growing body of research on psychological structures. However, there is limited research on athletic mental energy, wrestling attitude, and sports courage. This is the first study to address those three components. Therefore, the results were discussed within the scope of the hypotheses.

The first result showed that the AMES total score was negatively correlated with the SCS-31 total score ($r=-0.375$, $p<0.05$) and positively correlated with the GAS total score ($r=0.149$, $p<0.05$). The results also showed that the SCS-31 total score was negatively correlated with the GAS total score ($r=-0.179$, $p<0.05$). These results indicated that participants' athletic mental energy did not significantly predict their attitudes toward wrestling. Our results are consistent with the literatüre Konter, [30, 51, 52]. However, our results showed that the higher the athletic mental energy, the higher the sports courage. Our results are consistent with the literature [29, 53, 54]. Therefore, wrestlers with high confidence, motivation, and concentration can take risks and execute their movements skillfully, affecting their courage positively.

The second result showed that participants' attitudes toward wrestling significantly affected their athletic mental energy ($p<0.05$). This result suggests that wrestlers with more positive attitudes toward wrestling are likely to have higher levels of athletic mental energy. Therefore, we can state that wrestlers with more positive attitudes toward wrestling have higher motivation and concentration, affecting their performance positively. Islam and Imamoğlu [25] found that students receiving sports education had moderate-level attitudes toward physical education and sports teaching. Balaban et al. [55] reported that oil wrestlers had high attitudes toward leisure time. Yıldız [19] determined a positive relationship between attitudes and athletic mental energy. Our results are consistent with the literature. Our results confirmed Hypothesis I. Kaynar et al. [56] reported that trainers, lack of training, and social environment affected wrestlers' performance adversely. Demirtaş and Çıplak [57] determined that organizations, opponents, and training adversely affected wrestlers, while the COVID-19 pandemic adversely affected young wrestlers. Our results are inconsistent with the literature. More research is warranted to better understand the relationship between wrestlers' attitudes toward wrestling and athletic mental energy.

The third result showed that athletic mental energy significantly affected sports courage ($p<0.05$), suggesting that the higher the athletic mental energy the wrestlers have, the more courageous they are. Motivation and confidence make wrestlers more courageous, resulting in them performing better. Our result confirmed Hypothesis II. The first step of Heckhausen's Rubicon Model of Action Phases [16, 17] is about motivation, which is similar to the motivation mood of athletic mental energy. According to Kuhl's action control theory [58, 59, 60], athletic mental energy is a set of voluntary processes required to take action in the face of challenges. According to Konter and Beckmann [15], the mood of insisting on the solution in athletic mental energy shows similar characteristics. Yıldız [19] also reported a positive correlation between athletic mental energy and sports courage, which is consistent with our result. More research is warranted to better understand the relationship between athletic mental energy and sports courage.

The fourth result showed that participants' attitudes toward wrestling significantly affected sports courage ($p<0.05$). This result suggests that wrestlers with more positive attitudes toward wrestling are likely to be more courageous. Wrestlers with positive attitudes toward wrestling are assertive, self-sacrificing, and determined risk-takers with high courage. Our result confirmed Hypothesis III. Wrestlers with high-level motor skills (strength, speed, endurance, etc.) and positive psychological characteristics are likely to have higher physical performance. Athletes must persevere in the face of challenges and act decisively and boldly to achieve their goals [44]. Wrestlers interested in developing their self-efficacy and mastery must develop self-regulation skills to build up the courage to face challenging tasks [61]. Konter [62] and Güvendi et al. [31] also reported a positive correlation between wrestling attitude and sports courage. On the other hand, Islam and Imamoğlu [25] and Güvendi et al. [31] did not find a positive correlation between wrestling attitude and sports courage.

The fifth result showed that participants' athletic mental energy played a fully mediating role between their sports courage and attitudes toward wrestling. Wrestlers should possess athletic mental energy because it turns them into assertive, self-sacrificing, and determined risk-takers. Our result confirmed Hypothesis IV. Peterson and Seligman [63] argue that it refers to the attainment of the self as a whole, which is related to autonomy and the intention to take responsibility. We can state that wrestlers must be persistent, determined, and aggressive risk-takers to win. Coaches and trainers should give young wrestlers responsibility because more responsibility means more courage [64]. Yıldız [19] also determined a positive correlation between athletic mental energy and sports courage. Konter [65] argues that injuries prevent soccer players from developing courage. One handicap of high determination and assertiveness is that young athletes take the risk of getting yellow or red cards. More research is warranted to better understand the relationship between athletic mental energy, sports courage, and attitudes toward wrestling.

Conclusions

Our results indicate that wrestlers must develop positive attitudes toward wrestling and build up the courage to show optimal performance. Our results also point to the effects of athletic mental energy on sports performance. Athletic mental energy plays a fully mediating role between sports courage

and attitudes toward wrestling. In conclusion, the theoretical model was evaluated using three models based on the data and was confirmed by the hypotheses. Authorities should inform wrestlers about athletic mental energy and sports courage to help them develop positive attitudes toward wrestling. They should also provide them with appropriate settings and time to help them develop those components. Wrestlers must be bold, determined, and courageous risk-takers to be successful. High motivation and concentration help them perform optimally. Coaches and trainers should encourage wrestlers to take bold action. Wrestlers should practice developing positive attitudes toward wrestling and build up the courage to show high performance during competitions. Researchers should recruit different samples to investigate the mediating role of athletic mental energy between wrestling attitude and sports courage.

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Ethical Considerations

The study was approved by the Social and Human Sciences Research Ethics Committee of Ordu University Rectorate (Date: 02.12.2021 & No: 2021/214).

Conflict of interest

The author have no conflicts of interest to declare.

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PHYSICAL EDUCATION OF STUDENTS

ORIGINAL ARTICLE

The functional state of students depending on the ethno-territorial factor

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Abstract

Background and Study Aim Integration processes in education provide for increased mobility of students from different countries. The related change in environmental parameters, cultural and social standards require additional tension in the work of regulatory mechanisms. This can lead to exhaustion of the body's reserve capabilities, disruption of adaptation and loss of health. The purpose of the work is to investigate the ethno-territorial variability of the functional state and adaptation potential of foreign students studying at Ukrainian universities.

Material and Methods Students of the medical university (n = 488, age 18–25) who came to study in Ukraine from different countries took part in the study. Data were obtained from cross-sectional surveys from 2014 to 2019. Anthropometric measures included body length (LT), body mass (MT). Functional status was assessed by Robinson, Rufier, vital capacity and strength indices. Adaptation capabilities and the level of physical condition of students were also determined. Experimental data were processed using the SPSS program.

Results It was established that the vast majority of students had Robinson index values: low and below average (students from Poland, Bulgaria, Jordan, Egypt); below average level (students from Ukraine, Malaysia and Tunisia); medium (students from India and China). Students from Poland, Jordan and Egypt are characterized by the lowest vital capacity index (52.7 – 54.9 ml·kg^{-1}). Among the residents of India and China there were the most students with above average and high levels of vital capacity index. Most of the students (with the exception of students from Malaysia and Egypt) had a power index at the level of average and above average. The Ruffier index for students was: weak level – students from Poland, Bulgaria, Egypt and Jordan; satisfactory level – students of Tunisia, Ukraine, India and Malaysia; moderate level – students from China. The majority (40–44%) of the examined contingent from Poland, Bulgaria and Jordan was in a pre-diagnostic state. There were14–27% of such students among students from Egypt, China, India and Tunisia. There were about 10% of such students among Ukrainian students. From 6% to 11% of all foreign students were in a pre-morbid state. This condition is characterized by a decrease in the functional reserves of the circulatory system. Among Ukrainian students, there were 2.04% of such students. From 2.44% to 7.69% of foreign students had asthenization of regulatory systems; such a state was not observed among Ukrainian students.

Conclusions The obtained results of the study expand the data on the peculiarities of the physiological state of students of foreign countries and their adaptation capabilities. It is important that students with strained adaptation mechanisms or an unsatisfactory level of adaptation are able to reveal high functional capabilities with individualized physical exercises. An unsatisfactory state of functional systems can stimulate students to increase the body's adaptive resources. This contributes to increasing the level of motor activity and improving physical education courses with training according to an individualized educational program.

Keywords: adaptation potential, ethnic group, population, functional state.

Introduction

Integration processes in education provide for increased mobility of students from different countries. This approach should help improve the employment system of university graduates and raise the status of these countries in the field of education [1, 2, 3]. It is known that the place of residence is closely related to the state of the

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environment. Characteristics of the environment significantly affect the type and dynamics of functional development of human vegetative organs. The current stage of the development of world society is characterized by tendencies towards the deterioration of physiological and psychofunctional characteristics in young people. This leads to an increase in dissatisfaction with the quality of life [4, 5, 6]. The educational process is accompanied by hypodynamia, educational and emotional stress, and informational stress. All these factors contribute to the emergence and development of various diseases in young people [4, 7, 8, 9, 10]. It is also known that complex determinants of the environment place increased demands on the adaptive capabilities of the human body [11].

Currently, it has been established the relationships between: environmental parameters and the state of human health [12, 13, 14, 15]; geographical latitude of residence and morbidity of the population [16, 17, 18]. Such relationships are due to the fact that any adaptation process requires homeostatic restructuring of the human body. This becomes possible as a result of additional stress in the work of regulatory mechanisms and can lead to exhaustion of the body's reserve capabilities, disruption of adaptation and loss of health [11, 14, 19, 20]. When living in the territory with a changed photoperiod, a change in daily and seasonal rhythms of physiological processes, deterioration of sleep quality was noted [21, 22, 23, 24].

It is typical for foreign students to move for study from one climatic zone to another. Therefore, adaptation to the educational process is combined with adaptation to new climate-geographical conditions. All this creates prerequisites for the emergence or exacerbation of various diseases [25, 26, 27] and disruption of the adaptation process [19, 20, 28, 29, 30, 31]. At the same time, changes on the part of the lungs to the greatest extent reflect the dynamics of adaptive changes in the body as a whole [32]. In this context, many studies [33, 34, 35] note that men are the most vulnerable. They are more prone to "restrictive emotionality" and tolerate chronic stress worse. Adaptation to the environment in men takes place in the energy-consuming way of ensuring homeostatic functions. Central nervous system occurs due to increased activity of the sympathetic division of the autonomic nervous system.

Thus, when studying at a university outside the territory of residence, the combined influence of natural factors and intensive educational activities puts additional demands on the life support systems of students. In turn, this leads to the tension of adaptation mechanisms, which is reflected in the change of objective and subjective indicators of the functioning of body systems [36, 37, 38].

The purpose of the work is to investigate the ethno-territorial variability of the functional state and adaptation potential of students studying at Ukrainian universities.

Materials and Methods

Participants

Students (n = 488, age - 18–25 years; only male) from 9 countries of the world participated in the study (Table 1). All students agreed to participate in the experiment. The research protocol was approved by the Biomedical Ethics Commission of Ivano-Frankivsk National Medical University (Ukraine, protocols No. 85177 dated 10.24.2014, No. 89198 dated 10.22.2015, No. 92850 dated November 23, 2016, No. 96311 dated October 24, 2017 and No. 112/19 dated 12.24.2019).

Table 1. Distribution of study participants

Country	n
Poland	45
Bulgary	62
Malaysia	34
India	41
Jordan	68
China	38
Egypt	26
Tunisia	35
Ukraine	49
Totals	**488**

Research Design

Data were obtained from cross-sectional studies from 2014 to 2019 on the basis of Ivano-Frankivsk National Medical University (Ukraine). Somatometric physical development indicators were studied on the basis of body height (BH), body weight (BW). The functional state was estimated by using Robinson's index [39, 40], which indicates myocardial coronary reserve, vital capacity index (VCI), which reflects respiratory system reserves and strength indexes (SI). The Ruffier Test was carried out to measure the aerobic resistance to short-term effort and the cardiac recovery capacity, and therefore the level of physical fitness in students [41, 42]. Maximum hand grip strength was measured using a digital Takei Hand Grip Dynamometer (range 5–100 kg, precision of 100 g), through two attempts per every hand. Blood pressure (BP, mmHg) was measured by a mechanical tonometer Microlife BP AG 1–30, heart rate (HR) – using a Polar 800 RS heart rate monitor. The spirometry test is performed using spirometer in standing position (precision of 100 ml). After 2-3 measurements with 15-20 s pauses the highest result was fixed.

Physiological indicators were calculated by formulas [43]:

$$\text{Robinson index IR} = (HR_{rest} \cdot SBP)/ 100,$$

where, HR_{rest} – resting heart rate (beats·min^{-1}); SBP – systolic blood pressure (mmHg);

$$\text{vital capacity index VCI} = [VC(ml)]/[BM(kg)],$$

where, VC – vital capacity (ml); BM – body mass (kg);

$$\text{strength index SI} = [\text{handgrip dynamometry(kg)} \cdot 100\%)]/[BM(kg)];$$

Baevsky adaptive capacity was also determined [39, 44]:

$$AD_B = 0.011 \cdot HR_{rest} + 0.014 \cdot SBP + 0.008 \cdot DBP + 0.014 \cdot age + 0.009 \cdot BM - 0.009 \cdot BH - 0.273,$$

where, DBP – diastolic blood pressure (mmHg); BH – body height (cm).

Level of physical condition (PCL, units) follows the formula [45]:

$$PCL = [700 - 3 \cdot HR_{rest} - 2.5\ ABP - 2.7 \cdot age + 0.28 \cdot BM]/[350 + 21 \cdot BH - 2.6 \cdot age],$$

where, ABP – average of SBP and DBP.

Expert evaluation of all indices was carried out by comparing the obtained result with standard values.

Statistical analysis

The experimental data were processed using SPSS Statistics 17.0 program. Checked the data series for compliance with the normal distribution law. Arithmetic mean ($\bar{x}$), standard deviation (SD), standard error (SE) and variation coefficient were determined. Determining the statistical significance of obtained research results required Student's *t*-test and Chi-squared test (χ^2-test). Statistical significance was set at $p \leqslant .05$.

Results

The results of the research are given in table 2. Functional reserves of the respiratory system (average value of VCI) are the lowest in students of the Asian continent (3600±500) ml. Representatives of Europe (3900 ± 600) ml and the African continent (4100 ± 500) ml are characterized by statistically significantly higher VCI values. Among the representatives of student youth of European countries (Poland, Bulgaria, Ukraine), Bulgarian students had statistically significantly higher VCI values ($t = 4.69–3.18$, $p < .05$). Among representatives of student youth from Asian countries (Malaysia, India, China, Jordan), representatives of Jordan differed statistically significantly in terms of the value of this indicator ($t = 2.98–8.59$, $p < .05$). There was no statistically significant difference in VCI values between students from African countries.

Indicators of hand dynamometry also show statistically significant differences in average values among students of Asian countries ($t = 5.87–13.60$, $p < .05$), with the exception of representatives of Jordan (tab. 2). It should be noted statistically significant differences in hand dynamometry indicators for right and left hands: in European students, it was on average 8.5–15.5%; among students of Asian countries (with the exception of representatives of China, 5.0%) – 13.7–21.5%; among students from

Table 2. Physiometric indicators of students, $\bar{x}$ (SD)

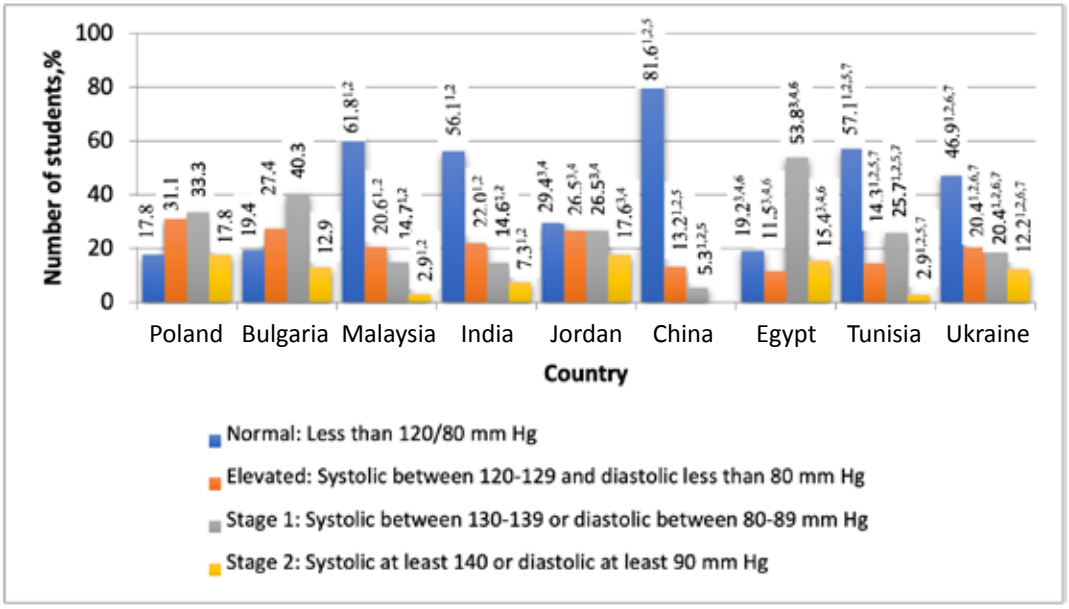
Indicators	Country								
	Poland	Bulgaria	Malaysia	India	Jordan	China	Egypt	Tunisia	Ukraine
VCI (l)	3.7(0.5)	4.2(0.6)^{1}	3.2(0.5)^{12}	3.7(0.6)^{23}	4.0(0.3)^{1234}	3.5(0.4)^{1235}	4.1(0.3)^{1346}	4.0(0.6)^{1346}	3.8(0.7)^{2367}
Right handgrip dynamometry (kg)	35.5(4.0)	38.8(5.6)^{1}	27.0(2.9)^{12}	29.8(4.0)^{123}	37.2(4.6)^{134}	30.1(4.1)^{1235}	36.7(4.7)^{346}	35.8(3.8)^{2346}	35.5(5.2)^{2346}
Left handgrip dynamometry (kg)	31.4(3.8)	35.5(4.8)^{1}	21.2(3.0)^{12}	25.6(4.6)^{123}	32.1(4.0)^{234}	28.6(4.2)^{12345}	29.9(4.5)^{2345}	29.2(4.1)^{12345}	30.0(4.3)^{2345}
HR_{rest} (beats·min^{-1})	79.7(5.2)	80.1(4.1)	72.6(9.1)^{12}	70.4(11.5)^{12}	78.7(9.1)^{34}	66.0(4.3)^{12345}	72.8(18.4)	70.6(7.2)^{1256}	75.4(5.2)^{124568}
SBP (mm Hg)	130.2(18.1)	130.5(15.6)	122.5(12.4)^{12}	120.8(14.4)^{12}	128.9(22.1)^{4}	119.8(21.8)^{125}	132.4(18.3)^{346}	124.6(16.5)	126.2(15.1)
DBP (mm Hg)	82.4(12.2)	82.6(10.6)	70.6(6.5)^{12}	75.8(8.2)^{123}	78.4(10.6)^{23}	70.8(5.2)^{1245}	74.8(6.6)^{1236}	72.2(5.8)^{1245}	79.1(9.6)^{3678}
Ruffier test HR_2 (beats·min^{-1})	40.5(4.1)	38.5(5.0)^{1}	31.1(3.2)^{12}	30.2(3.0)^{12}	36.8(7.5)^{134}	30.0(2.5)^{125}	39.5(3.4)^{3456}	34.3(8.0)^{123467}	33.0(5.5)^{124567}
Ruffier test HR_3 (beats·min^{-1})	30.6(4.0)	29.6(4.8)^{1}	20.5(2.8)^{12}	24.4(3.2)^{123}	30.8(6.7)^{34}	20.5(2.8)^{1245}	30.2(4.1)^{1346}	22.4(6.4)^{12357}	20.1(5.2)^{12357}

Note: HRrest (beats·min-1) – heart rate at rest; Ruffier test HR2 – second pulse measurement; Ruffier test HR3 – third pulse measurement; statistically significant difference ($p < .05$) between data of students from (shown in the form of upper index): 1 – Poland and others; 2 – Bulgaria and others; 3 – Malaysia and others; 4 – India and others; 5 – Jordan and others; 6 – China and others; 7 – Egypt and others; 8 – Tunisia and others (based on t-test)

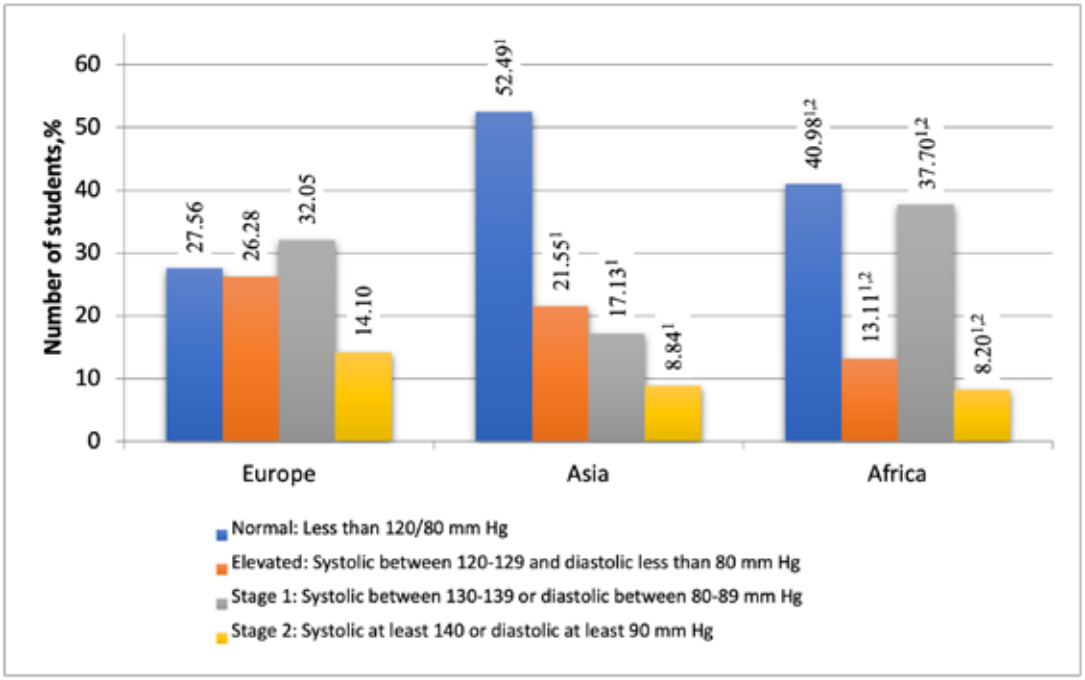
Egypt and Tunisia – 18.5%.

In addition, we determined such parameters as heart rate (HR_{rest}), arterial blood pressure (SBP and DBP) (Table 2). As can be seen from the given data (Table 2), the average heart rate at rest for representatives of European countries is (78.4 ± 4.8) beats·min^{-1}, for students from Asian and African countries, the value of (HR_{rest}) is slightly lower - (71.8 ± 5.8) beats·min^{-1}. The average arterial systolic pressure in students of European and African countries does not differ reliably and is (129.0 ± 16.3) mm Hg and (128.5 ± 17.4) mmHg, respectively. Representatives of Asian countries have significantly lower values of systolic pressure - (123.0 ± 14.7) mmHg. A similar pattern is observed for diastolic pressure values. Moreover, the largest difference between systolic and diastolic pressure (55 mmHg) is typical for representatives of Egypt and Tunisia.

In students of most countries, with the exception of Malaysia, India, China, blood pressure values exceed the generally accepted norm (fig. 1). It should be noted that from 40% to 54% of foreign students have the first and second stage of hypertension.



a)



b)

Figure 1. Frequency distribution of students by Blood pressure level (mm Hg): a) differences between representatives (shown in the form of upper index): 1 – Poland and others; 2 – Bulgaria and others; 3 – Malaysia and others; 4 – India and others; 5 – Jordan and others; 6 – China and others; 7 – Egypt and others ($p < .05$) (based on χ^2-test); b) (shown in the form of a superscript): 1 – differences between representatives of the countries of Asia and Africa and Europe; 2 – differences between representatives of Asian and African countries ($p < .05$) (based on χ^2-test)

Among Ukrainian students, the percentage of such is 32.6%.

The indicators of the Robinson index (criterion of the reserve and economy of the functions of the cardiovascular system) are presented in table 3. As can be seen from table 3, the Robinson index was very weak for students from Poland, Bulgaria, Jordan and Egypt. Among the representatives of these countries, 73 to 93.5% of students had low and below average levels of Robinson index (Fig. 2). Students from Ukraine, Malaysia, and Tunisia had below Robinson index, while those from India and China had an average (fig. 2).

The distribution of students by VCI level is shown in Figure 3. The lowest VCI indicators (below the average) are characterized by students from Poland, Jordan and Egypt (52.7 – 54.9 ml·kg^{-1}).

Students from Malaysia (44.1%), Bulgaria (45.2%), China (57.9%), Ukraine (61.2%), Tunisia (62.9%) and India (64.3%) had VCI values that corresponded to average and above average levels (fig. 3). It should be noted that among the representatives of India and China there were the most students from above average (14.6% and 18.4% respectively) and high (9.8% and 13.2% respectively) levels.

As for the strength index, the majority of students (with the exception of students from Malaysia and Egypt) had values corresponding to the average and above average levels (Fig. 4). 58.8% of students from Malaysia and 65.4% of students from Egypt had strength index values that corresponded to low and below average levels.

As for the Ruffier index (characterizing the body's performance), for students from the following countries it was the following: Poland – 16.4 units (95% CI 15.32–17.48); Bulgaria – 15.3 units (95%

Table 3. Indicators of express assessment of students' somatic health,

Country	Indicators					
	Robinson index (c.u. units)	Vital capacity index (ml·kg^{-1})	Strength index (%)	Ruffier test (units)	Baevsky adaptive capacity (units)	Level of physical condition (units)
Poland	103.8(12.5)	52.7(5.6)	50.6(6.0)	16.4(3.6)	2.48(.32)	0.243(0.051)
Bulgaria	104.5(11.8)	55.9(6.0)^{1}	51.7(5.4)	15.3(4.0)^{1}	2.52(.21)	0.241(0.032)
Ukraine	95.1(18.2)^{12}	59.7(4.1)^{12}	55.8(5.0)^{12}	8.9(2.9)^{12}	2.02(.32)^{12}	0.275(0.026)^{2}
Malaysia	88.9(16.5)^{12}	55.7(4.8)^{13}	47.0(5.5)^{123}	7.9(2.5)^{12}	2.29(.25)^{123}	0.319(0.045)^{123}
India	85.0(17.1)^{123}	70.9(5.1)^{1234}	57.1(6.4)^{124}	8.9(1.9)^{12}	2.23(.41)^{123}	0.319(0.031)^{123}
China	79.1(16.9)^{1234}	67.2(4.0)^{12345}	57.8(7.2)^{124}	6.8(1.4)^{1235}	2.07(.38)^{124}	0.377(0.047)^{12345}
Jordan	101.4(22.4)^{456}	54.7(3.8)^{13456}	50.9(6.5)^{3456}	14.9(4.2)^{13456}	2.48(.50)^{3456}	0.262(0.042)^{456}
Egypt	96.4(17.5)^{256}	54.9(4.9)^{356}	49.1(6.1)^{356}	15.2(4.8)^{3456}	2.47(.47)^{356}	0.292(0.031)^{126}
Tunisia	87.9(18.0)^{1267}	64.7(8.1)^{1234578}	57.9(5.9)^{12478}	9.7(3.5)^{124678}	2.19(.46)^{1278}	0.316(0.080)^{12367}

Note: differences between representatives (shown in the form of upper index): 1 – Poland and others; 2 – Bulgaria and others; 3 – Ukraine and others; 4 – Malaysia and others; 5 – India and others; 6 – China and others; 7 – Jordan and others; 8 – Egypt and others ($p < .05$) (based on -test)

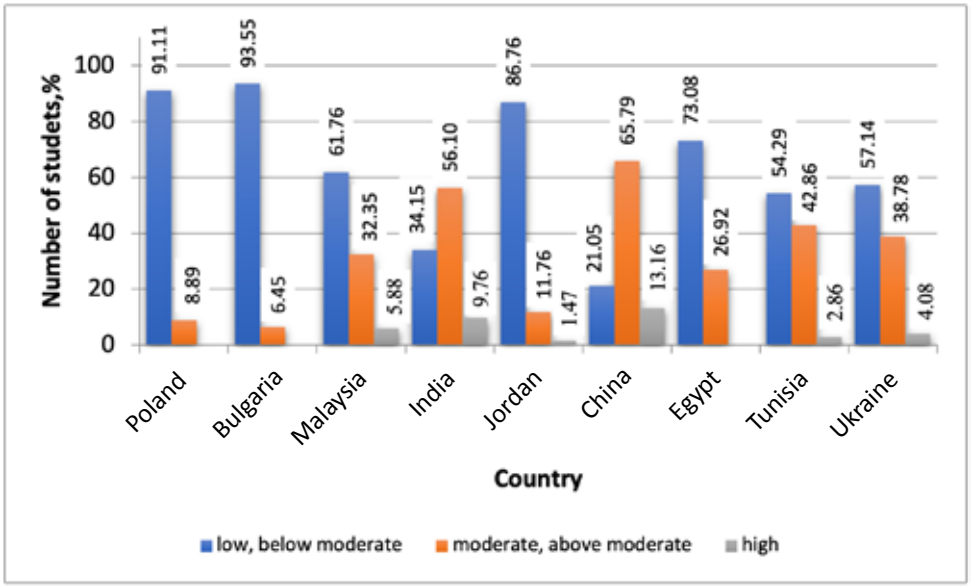


Figure 2. Distribution of students by Robinson index level (units)

CI 14.28–16.32); Egypt – 15.2 units (95% CI 13.26–17.14); Jordan – 14.9 units (95% CI 13.88–15.92). This corresponds to the weak (moderate heart failure) level (Fig. 5). For students from Tunisia, Ukraine, India, and Malaysia, the value of the Ruffier index was, respectively: 9.7 units (95% CI 8.50–10.90), 8.9 units (95% CI 8.07–9.73), 8.9 units (95% CI 8.30–9.50), 7.9 units (95% CI 7.03–8.77). This corresponds to the satisfactory level. For students from China, the value of the Ruffier index was 6.8 units (95% CI 6.34–7.26), which corresponds to the moderate level.

Only for representatives of Ukraine and China Baevsky adaptive capacity values corresponded

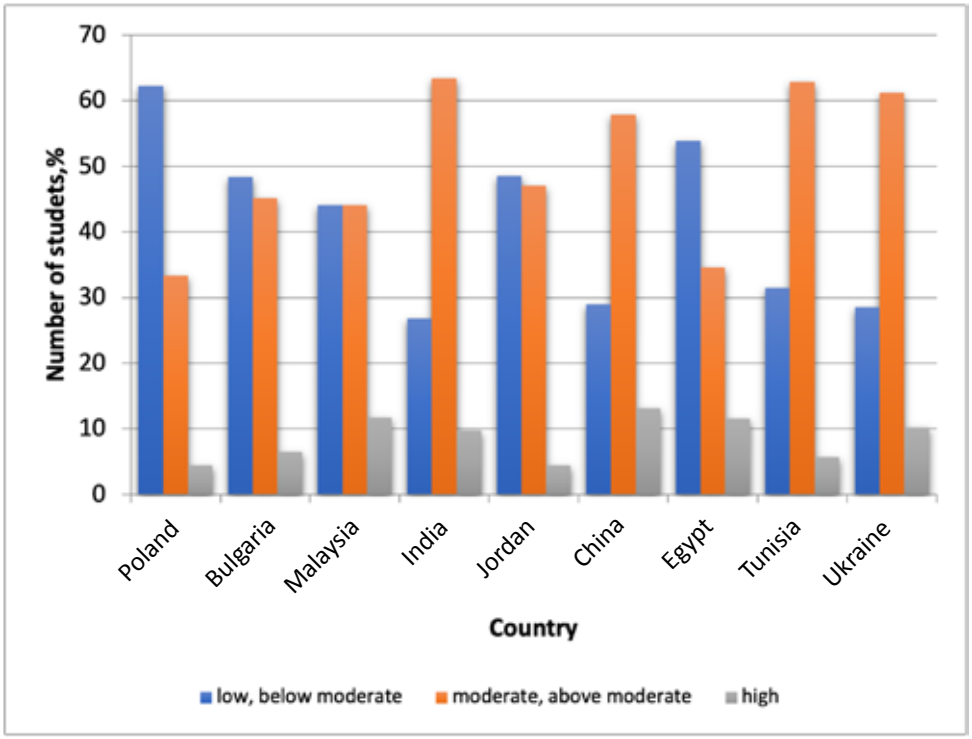


Figure 3. Distribution of students by Vital capacity index level (units)

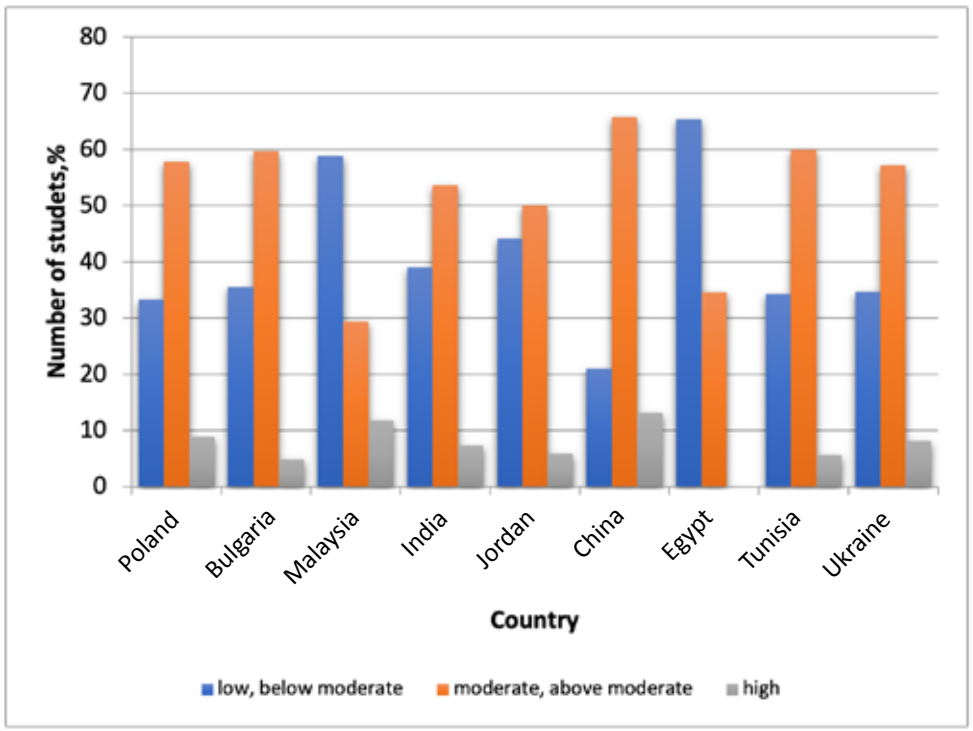


Figure 4. Distribution of students by handgrip strength index level (%)

to satisfactory adaptation, and the cardiovascular system of students of other countries was characterized by the tension of adaptation mechanisms (Fig. 6).

The majority (40–44%) of the examined contingent from Poland, Bulgaria, and Jordan was in a pre-diagnostic state (fig. 6). Among students from Egypt, China, India and Tunisia, the share of such was 14–27%. There were about 10% of such students among Ukrainian students. From 6% to 11% of all foreign students were in a premorbid state characterized by a decrease in the functional reserves of the circulatory system. Among Ukrainian students, the share of such was 2.04%. From 2.44% to 7.69% of foreign students had asthenization of regulatory systems (disruption of adaptation processes, inability of the body to maintain balance with the environment). Such a situation was not observed among Ukrainian students.

The research results obtained by us in the majority

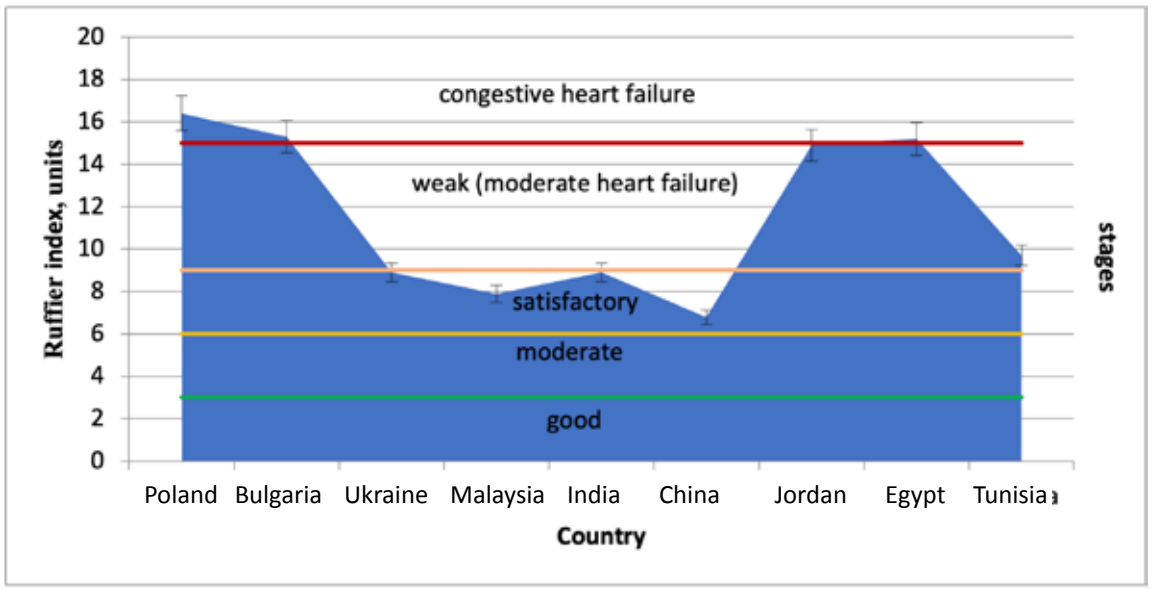


Figure 5. Value of Ruffier index for students

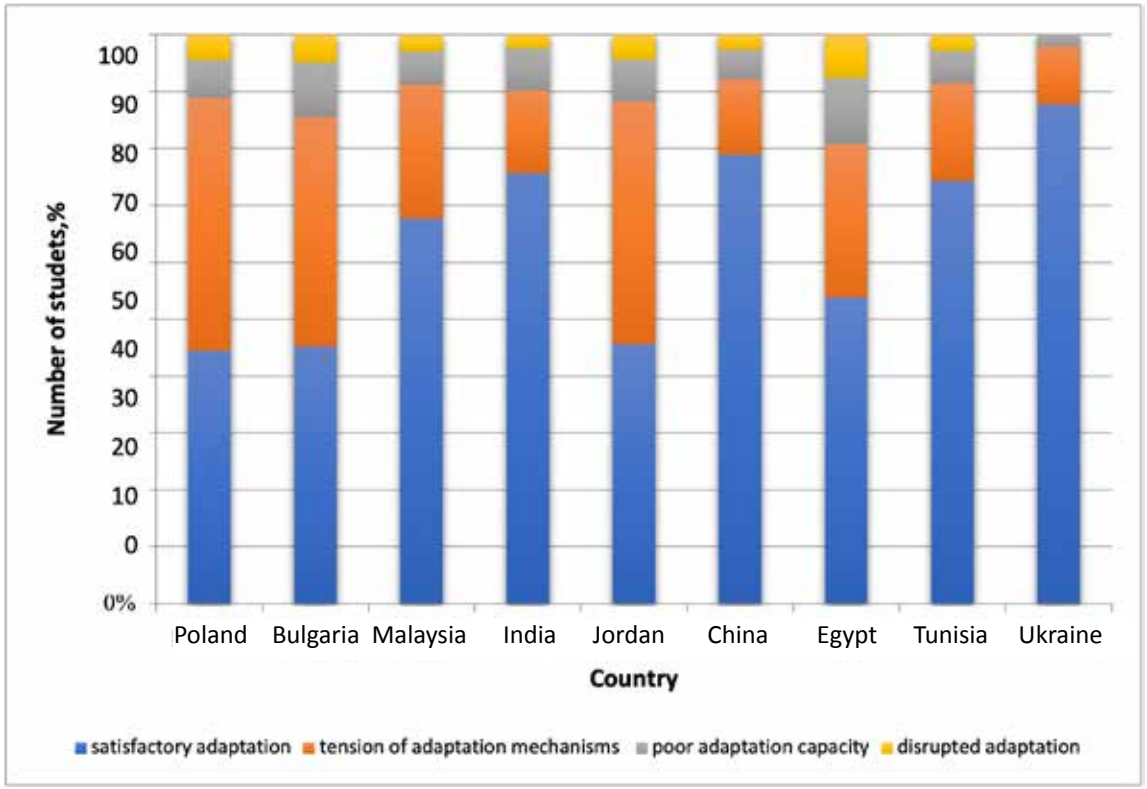


Figure 6. Distribution of students according to Baevsky adaptive capacity values

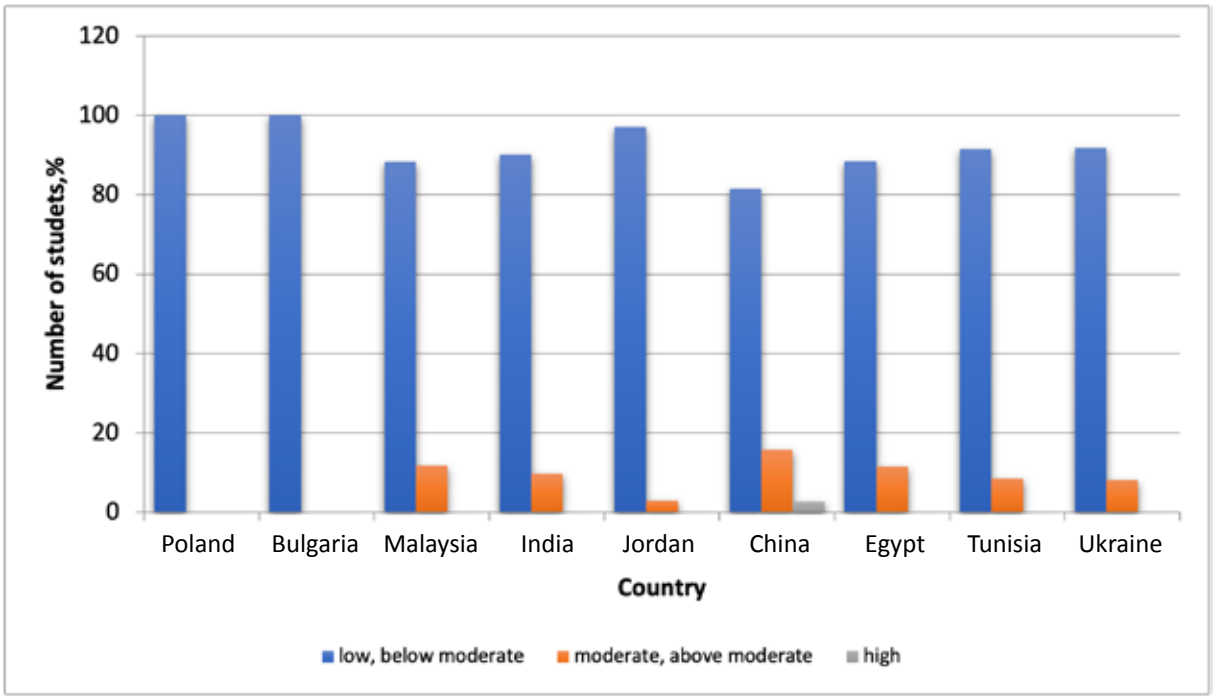


Figure 7. Distribution of students by Level of physical condition (PCL, units)

of students (81–100%) were below physiological norms, as evidenced by the integrative indicator of the level of physical condition (PCL, units) (fig. 7).

Students from China were characterized by the best PCL indicators: among them, 15.79% had an average and above average level, and 2.63% had a high level (fig. 7). From 8 to 12% of students from Ukraine, Tunisia, Egypt, India, Jordan and Malaysia had an average and above average level of physical condition, and 100% of students from Poland and Bulgaria - only low and below average.

Discussion

The current state of health of the global population is characterized by an increase in morbidity [46]. It can be stated that the priority direction of work for institutions of a medical profile and for institutions of physical education is the formation of special programs. These programs should be aimed at preventing various diseases and improving the general health of students. This is especially relevant for young people, who in the near future will form the basis of the working population of the planet [7, 8, 9, 46].

Physiometric indicators of students aged 18-25 years of different ethnic groups differ significantly among themselves, as well as within ethnic groups. In our opinion, this reflects the diversity of demographic, socio-economic, behavioral, cultural and other characteristics between ethnic groups.

Thus, a number of researchers pointed out significant differences in the capabilities of the respiratory system. Based on the results of research by Donnelly et al. [47] the mean total lung capacity and vital capacity in the Caucasian group were 5–10% higher than in the Chinese group and 17–20% higher than in the Indian group and Chinese values were 10–12% greater than Indian. They noted that chest circumferences, height and race explained 90% of the variation in forced vital capacity and 86% of the variation in total lung capacity.

Bhakta et al. [48] found highest values of FVC **(**Forced vital capacity, or the full amount of air that can be exhaled with effort in a complete breath**)** and FEV_1 (Forced expiratory volume in one second, or the volume of breath exhaled with effort in one second) in EAs, intermediate values in Asians, and lowest values in blacks for the same height, age, and sex. The same results were obtained by Korotzer et al. [49] among 65,000 subjects (82% whites, 14% blacks, and 4% Asians), especially, they found FVC and FEV_1 to be highest in EAs and lowest in blacks.

Quanjer et al. [50] noted that Caucasians have had the largest lung size for equivalent height and age, compared with African and Asian populations. For example, African American and Southeast Asian populations have forced expiratory volume in 1 s (FEV_1) that is approximately 13% less than Causasian [50, 51]. Similar, though generally slightly smaller, reductions (~11%) have been observed among South Asian (Indian subcontinent) [52, 53] and Southeast Asian (e.g., China, Thailand, Malaysia) subjects [54]. Since these 'ethnic' reductions in FEV_1 and FVC are proportional, the FEV_1/FVC ratio, which is the most commonly used outcome to assess airways obstruction, is independent of ethnic background [55].

Braun et al. in reviews [56, 57] grouped all

explanations of this fact into seven categories: 1) inherent differences between racial/ethnic groups; 2) anthropometric differences; 3) environmental and social factors; 4) mechanical factors; 5) technical factors; 6) other; 7) no explanation. Mostly ethnic differences in lung function have been well reported between blacks of African and whites of European descent and it has been explained by anthropometric differences between these ethnic groups, particularly by larger trunk-to-leg ratio at a given height [58, 59, 60]. Few authors [61, 62, 63] were investigated ethnic differences in lung function taking into account anthropometric, socioeconomic and psychosocial factors and made a conclusion that differences in the length of upper body segment explained more of the ethnic differences in lung function than height. Social correlates had a smaller but significant impact too. This is also agreed with results obtaining in our research [64, 65].

According to our data, the blood pressure values of students in most countries (with the exception of Malaysia, India, China) exceed the generally accepted norm. This confirms the fact that over the last decade, an increase in blood pressure and HR_{rest} values has been established in the global population [66, 67, 68, 69].

An evaluation of children aged 8–17 years found that systolic blood pressure was 2.9 mmHg and 1.6 mmHg higher in black boys and girls compared to age-matched white boys and girls [70]. Also, estimates based on the Demographic and Health Surveys (DHS) Program (2016) show that South Africans (who identify as colored) are approximately 1.67 times more likely to have hypertension than those who identify as black/African [71].

Lane et al. [72] was to examine the prevalence of hypertension and mean blood pressures among Afro-Caribbeans (16%) and South-Asians (8%) in England compared with Caucasians (76%). The authors shown that the prevalence of hypertension was greater in both Afro-Caribbean men (31%) compared with Caucasians (19%), while South-Asian men had a similar overall prevalence to Caucasians (16%).

According to the data obtained by Hardy et al. [73] among US adults mean SBP was 4.1 and 3.8 mmHg higher among non-Hispanic Black compared with non-Hispanic White adults, in 1999 to 2002 and 2015 to 2018, respectively. Modesti et al. [74] found that Sub-Saharan Africans had higher BP values than Europeans men for both SBP (3.38 mmHg) and DBP (3.29 mmHg). On the contrary, South Asians had SBP values lower than Europeans (-4.57 mmHg). They also tended to have lower, albeit not significantly, DBP values (-0.56 mmHg). This is consistent with our data. In our study, students from Poland, Bulgaria and Ukraine had 7.67 mmHg higher SBP values and 7.64 mmHg higher DBP values than representatives of Asian countries. Mostly of scientists postulated that the risk of hypertension increased with BMI and waist circumference [74, 75]. It is interesting that the authors also conducted a study of the dependence of blood pressure on religious preferences. The authors note that participants from Muslim countries showed significantly lower BP values than EU for both SBP (-9.22 mmHg) and DBP (-3.23 mmHg). Differences between Muslim and non-Muslim participants were significant for both SBP and DBP ($p < .001$ for all comparisons) regardless of gender. But these data deny the results we obtained. From our point of view, it can be explained by the fact that the adaptation to the educational process of students from the countries of Asia, Africa, the Near and Middle East is combined with adaptation to new climate-geographic and social conditions. This leads to a significant tension of the body's physiological systems, and sometimes to their breakdown and deviations in the state of health.

Seitova et al. [76] received analogical to our research data. She investigated of 350 participants aged until 25 years old and adapted within 1 year to the study at medical faculties of Osh State University and divided them into 4 groups. The groups were randomized by gender, age, time and examination conditions, and lifestyle of all students in the medical faculties of Osh State University. Comparative functional studies of male and female students the main and control groups revealed higher systolic and diastolic blood pressure and heart rates in students from India in all seasons. Similar changes in autonomic functions in the form of increased blood pressure and heart rate were noted in first year students who came from humid and sub-tropical countries [77]. Foreign students have less functional reserves, which is leads to more frequent development of maladaptive reactions, as well as more frequent detection of acute respiratory and intestinal infections in their first year. This was confirmed in the values of the Robinson index (criterion of reserve and economy of functions of cardiovascular systems) obtained by us for students of Poland, Bulgaria, Jordan and Egypt. Unexpectedly, the Robinson index values of students from China, India and Tunisia were approximately the same as those of Ukrainian students. Although more pronounced climate-geographical differences are observed. From the obtained values of the physical condition level indicator, it follows that only for representatives of China they are at a below average level. For the population of other countries, this indicator corresponds mostly to a low level. This confirms the assumption of global health problems that exist in modern society [8, 9, 78, 79, 80, 81, 82].

Psychoemotional stress in foreign students precedes physiological adaptation disorders in their systems and organs. As it was established in our study, the majority of foreign students

from Poland, Bulgaria, Jordan and Egypt were in prenosological, pre-morbid states and state of astenization of regulatory systems. Among students from China, India, Tunisia and Malaysia, the share of such students was 20–30%. The presence of these conditions at rest indicates an inadequate response of the body to environmental factors. The presence of constant stress leads to the accelerated use of vital resources and the occurrence of diseases. Such reactions of the organism for a long time can lead to the disruption of adaptation and nosological symptoms and to the formation of new levels of adaptation of the organism to the changing conditions of the external environment [11, 83].

On the opinion of a lot of researchers there still is an additional reserve for adaptation process acceleration, which lies in the field of physical activity [84, 85, 86, 87, 88, 89]. Authors note that physical activity is a powerful tool of recovery from mental and physical health problems, which, as is already known today, is helpful in coping with problems of adaptation to new living conditions and educational activities [90, 91, 92]. Physical activity indirectly influences adaptation performance via stress reduction, lowering anxiety and depression, and boosting self-esteem [93, 94, 95]. Regular physical exercise also reduces a risk of the appearance and progression of various illnesses [88, 89, 96, 97].

Another scientists concluded that the adaptation of different races to varied environments provides them with a number of physical and psychological advantages and disadvantages in relation to each other in various sports. Differing levels of racial accomplishment in sports requiring different physical and psychological abilities reflect these adaptations [98, 99].

Conclusions

The obtained results of the study broaden the data about peculiarities of foreign students' physiological state and their adaptation capabilities. To our mind, what are important, students with tensed adaptation mechanisms or its unsatisfactory level are able to reveal high functional capabilities under individualized physical activity. The obtained results regarding the own state of functional systems can stimulate students to increase the adaptive resources of their own body through motor activity on the one hand, and help to improve physical education courses with individualized education program training on the other hand.

Further work is required to determine the peculiarities of fitness state versus ethnicity as a prescription of training programmes for university male students.

Conflict of interest

The authors state that there is no conflict of interest.

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