ISSN 2664-9837

PEDAGOGY of Physical Culture and Sports

№1/2023

Pedagogy of Physical Culture and Sports

2023
01

Key title: Pedagogy of Physical Culture and Sports (Abbreviated key-title: Pedagogy phys. cult. sports; ISSN 2664-9837).

Founders: Iermakov Sergii Sidorovich (Ukraine); (doctor of pedagogical sciences, professor).

Certificate to registration: KB 24393-14233ПР 13.03.2020.

Previous title «Pedagogics, psychology, medical-biological problems of physical training and sports» (e-ISSN 2308-7269; p-ISSN 1818-9172; ISSN-L 2308-7269).

Frequency – 6 numbers in a year.

Address of editorial office:

Box 11135, Kharkov-68, 61068, Ukraine,

Tel. 38 099 430 69 22

e-mail: sportart@gmail.com

https://www.sportpedagogy.org.ua

INDEXING

Web of Science Core Collection - [Emerging Sources Citation Index (ESCI)] - http://mjl.clarivate.com/cgi-bin/jrnlst/jlresults.cgi?PC=MASTER&ISSN=*2664-9837

Scopus - https://www.scopus.com/sourceid/21101040604

DOAJ (Directory of Open Access Journals) - https://doaj.org/toc/2664-9837

ERIH PLUS (The European Reference Index for the Humanities and the Social Sciences) - https://dbh.nsd.uib.no/publiseringskanaler/erihplus/periodical/info?id=497967

WorldCat (WorldCat is the world's largest network of library content and services) – http://www.worldcat.org

Scilit (A database of scientific & scholarly literature) – https://www.scilit.net/journal/4323609

OpenAIRE - https://www.openarchives.org/Register/BrowseSites?viewRecord=https://sportpedagogy.org.ua/index.php/ppcs/oai

PBN (Polish Scholarly Bibliography) - https://pbn.nauka.gov.pl/core/#/journal/view/5edbed29ad49b31d36de4021/current

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

Google Scholar – https://scholar.google.com/citations?user=RoS9xrUAAAAJ&hl=en

Dimensions - https://app.dimensions.ai/discover/publication?search_text=10.15561%2F26649837.&search_type=kws&search_field=doi

Crossref - https://search.crossref.org/?q=2664-9837

Open Ukrainian Citation Index (OUCI) - https://ouci.dntb.gov.ua/en/editions/E1DygdjZ/

MIAR - http://miar.ub.edu/issn/2664-9837

ResearchGate - https://www.researchgate.net/journal/2664-9837_Pedagogy_of_Physical_Culture_and_Sports

Hinari Access to Research for Health - http://extranet.who.int/hinari/en/journal_keyword_search.php?query=Pedagogy+of+Physical+Culture+and+Sports

PKP index - http://index.pkp.sfu.ca/index.php/browse/index/9245

Sherpa Romeo - https://v2.sherpa.ac.uk/id/publication/40500

EDITORIAL BOARD

CONTENTS

Julija Andrejeva, Asta Mockiene, Dainora Strazdauskaite, Monika Pociene, Grazina Sniepiene, Elvira Malysko, Natalja Istomina, Vaiva Hendrixson. Effects of dance and movement therapy on physical ability, flexibility and psychological state for individuals under constant stress 4

Djoko Nugroho, Mohammad F. Hidayatullah, Muchsin Doewes, Sapta K. Purnama. The effects of massed and distributed drills, muscle strength, and intelligence quotients towards tennis groundstroke skills of sport students........ 14

Somaia A. Hamed, Mohamed M. ElMeligie, Efrem Kentiba. The effects of Halliwick aquatic exercises on gross motor function of children aged from 3 to 5 years with spastic cerebral palsy........ 24

Denis Čaušević, Erol Kovačević, Semir Mašić, Siniša Kovač, Seth Spicer. Occurrence and trends of musculoskeletal pain among ski instructors 32

Leonid Podrigalo, Vyacheslav Romanenko, Olha Podrihalo, Sergii Iermakov, Anatolyi Huba, Volodymyr Perevoznyk, Olexandr Podavalenko. Comparative analysis of psychophysiological features of taekwondo athletes of different age groups 38

Fabrício Madureira, Thábata V.B. Gomes, Thiago A.C. Oliveira, Andrea M. Freudenheim, Umberto C. Corrêa. Validity and reliability of an assessment instrument of track start in swimming 45

Joseph Lobo, Bryan Dale Bernardo. Mobile Gamers versus Non-gamer students' endurance levels via Beep and 3-minute step test 54

Štefan Adamčák, Michal Marko, Pavol Bartík. Teachers' preferences of teaching primary physical education: curriculum preferences........ 63

George D. Mocanu, Gabriel Murariu, Vladimir Potop. Differences in explosive strength values for students of the faculty of physical education and sports (male) according to body mass index levels 71

Georgiy Korobeynikov, Lesia Korobeinikova, Markus Raab, Mario Baić, Olga Borysova, Ivanna Korobeinikova, Gou Shengpeng, Irene Khmelnitska. Cognitive functions and special working capacity in elite boxers 84

Information 91

ORIGINAL ARTICLE

Effects of dance and movement therapy on physical ability, flexibility and psychological state for individuals under constant stress

Julija Andrejeva[1,2,3ABCD], Asta Mockiene[4AB], Dainora Strazdauskaite[5BC], Monika Pociene[1CD], Grazina Sniepiene[1,2AB], Elvira Malysko[3CDE], Natalja Istomina[2,3CD], Vaiva Hendrixson[3DE]

[1] *Faculty of Health Sciences, Klaipeda State University of Applied Sciences, Klaipeda, Lithuania*
[2] *Faculty of Health Sciences, Klaipeda University, Klaipeda, Lithuania*
[3] *Faculty of Medicine, Vilnius University, Vilnius, Lithuania*
[4] *Vytautas Magnus University, Kaunas, Lithuania*
[5] *Lithuanian Sports University, Kaunas, Lithuania*

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

Abstract

Background and Study Aim Dance and movement therapy defined as culturally creative, unique, but at the same time and a universal phenomenon encompassing bodily movements, bodily self-expression, feelings, stories, body interactions with self and others. Aim of the Study was to evaluate the impact of dance and movement therapy on the physical capacity, flexibility and psycho-emotional state of individuals under constant stress.

Material and Methods The study included 18 – 45 years old females (N=20) who has psycho- emotional disorders and came to this facility for rehabilitation treatment procedures. To assess functional physical capacity was used 6 – minute walk test. For flexibility assessment, to determine the mobility of the lumbar cross section of the spine was used Schober's sample. For psycho- emotional state assessment and for setting the symptoms of depression and anxiety in subjects was used Hospital Anxiety and Depression Symptom (HADS) Scale. The fatigue was measured by Fatigue Impact Scale.

Results Positive statistically significant change in the psycho- emotional state of the subjects was in both groups, however in dance and movement therapy group this state improvement is twice large than in physiotherapy group. The mean values of the HADS scale decreased by 3.1 ± 3.981 points in the first group of subjects treated with physiotherapy and by 6.9 ± 4.62 points in the second group treated with dance and movement therapy. During physical capacity assessment it was observed a statistically significant basic change in both groups. In the first study group the average 6 – minute test increased by 35.2 ± 24.89 meters and in the second study group by 27.5 ± 19.44 meters.

Conclusions Dance movement therapy has a positive effect on psycho- emotional state, flexibility and physical ability of people experiencing constant stress. As observed, dance and movement therapy have a positive effect not only on flexibility or physical ability, but also on psycho- emotional state. Dance and movement therapy can be easily applied among different age population. All this makes physiotherapy a highly essential tool to improve person's well – being and quality of life.

Keywords: dance therapy, movement therapy, flexibility, psycho- emotional state, physical capacity.

Introduction

It was already investigated whether dance therapy was more beneficial for individuals under constant stress than dance therapy for cognitive and mood symptoms [1]. Seven randomized controlled trials with cognitive and mood symptoms in patients under constant stress were identified. There were significant differences in executive function after dance therapy, but no effect was observed in cognitive function, depression and apathy. Dance therapy is helpful in improving the executive function of adults under constant stress. However, a positive effect on global cognitive function, depression and apathy has not been established [2]. There is currently a lack of appropriate rehabilitation programs for individuals experiencing ongoing stress that affects emotion control, flexibility and physical capacity. The potential benefits of dance therapy for balance, flexibility, physical capacity and psychological wellbeing in individuals under constant stress have been explored. Intervention sessions were performed over eight weeks of dance movement training aimed at improving individuals balance, posture, physical capacity, flexibility and psycho-emotional state, as well as emotional control. Individuals demonstrated an improvement in physical capacity, flexibility and psycho-emotional state after dance and movement therapy. In addition, improvements in depressive symptoms and quality of life were observed at the end of the intervention. Dance may be a suitable alternative method of physiotherapy intervention for individuals experiencing constant

doi:10.15561/26649837.2023.0101

stress or having psycho-emotional disorders [1]. The overall progression of a person's body image is a multifaceted functioning system involved in the development of a personality identity that influences satisfaction with a person's quality of life and emotional stability of the person. It stems from body schematics and changes throughout life. Dance therapy creates a connection between mental and physical self- perception. It affects the cognitive, social and personal aspects of personality. The effects of dance therapy treatment on body image, self-esteem and identity development in individuals experiencing constant stress were evaluated and compared with control groups. Dance and movement therapy improve quality of life, self-esteem, body esteem, and mental representations [3].

The causes of mental and behavioral disorders are the most important of all health disorders (they account for 36.9% of all years of disability in the world among people of working age). In order for society to avoid this burden, comprehensive community and medical assistance to these individuals is a necessity [4]. Dance and movement therapy as an official practice of psychotherapy was formed in the 1940 and spread internationally. Dance and movement specialists work in the rehabilitation of patients and the disabled with people of different ages and genders with various physical, emotional and social problems [5]. Disability in all periods of human development was considered a difference, an abnormality, a deviation from the norm, from what is generally accepted. A person's quality of life is greatly influenced by a person's physical health, psychological state, degree of independence, social relations with the environment. Art therapy directs a person's suffering and psycho-emotional experiences to self-expression, stimulating his or her creative abilities and abilities. The artistic abilities of individuals with mental disorders include not only the expression of intuition and feelings, but also intelligence. Different branches of art develop musical, spatial, movement, communication skills, as well as the aspect of perception is revealed in artistic activities [6].

Psycho-emotional disorders are common problems in modern society. Many patients with these disorders also suffer from gastroesophageal reflux [7]. Sensitivity to interception, especially heartbeat, will play a key role in the pathogenesis of anxiety and anxiety disorders. Clinical trials to assess heart rate in the presence of intercepted susceptibility, heart rate due to anxiety – related symptoms (anxiety, sensitivity state), panic disorder and other anxiety disorders, use neurobiological studies of neuronal activation magnetic resonance imaging (fMRI) or electroencephalography (EEG) techniques. Beta – blockers, biological feedback therapy, cognitive interventions, and interoceptive exposure can be used to increase heart rate as a consequence of anxiety and anxiety disorders and to potentially reduce interoceptive sensitivity [8, 9].

Emotional stimulation is very important for person's well-being. Fear, sadness, anger, frustration, high mood, furious, ashamed, disgusted, happy, satisfied, excited, overwhelmed are the terms we use to describe our emotional lives [10]. Psycho-emotional disorders are one of the leading causes of high mortality in individuals. The most common treatment for such disorders is neuroprotective therapy. Indeed, such therapy to some extent facilitates the normalization of the condition and strengthens the physiological tissue activity of the brain. Such treatment can also help repair damage to various types of pathogens in the brain systems shocks (traumatic, inflammatory, vascular, degenerative, etc.) [11]. Research reveals a statistically significant link between physiotherapy and emotional well-being, the nature of which remains little explored. Physical activity changes a person's psycho-emotional state, helps to control negative emotions: anger, resentment, anxiety. Individuals who have difficulty regulating emotions benefit from physiotherapy or other forms of active activity that help regulate neuromuscular processes. Bernstein et al. in a study assessed emotional propensity, mood, and anxiety, and were randomly assigned a 30-minute stretching or dance movement workout. Subjects in both groups then experienced the same positive and negative emotions and named response levers for emotional reactions. The analysis revealed greater difficulties in developing emotion regulation strategies and engaging in behavior – oriented, goal – oriented after induction of negative mood. Respondents who experienced negative emotions predicted a stronger and sustained negative impact in response to stress. The interaction showed that aerobic exercise, dance and movement training attenuated this effect. Moderate aerobic exercise can help alleviate negative emotions in participants who have difficulty regulating emotions [12].

Purpose of the Study. The study purpose was to evaluate the impact of dance and movement therapy on the physical capacity, flexibility and psycho-emotional state of individuals under constant stress.

Materials and Methods

Participants.

The Bio Ethics Committee of Klaipeda University, Faculty of Health Sciences Holistic Medicine and Rehabilitation Department formally approved the research protocol. The study included individuals who has psycho-emotional disorders and came to this facility for rehabilitation treatment procedures. The principle of goodwill was ensured by respectfully informing the patient about future examinations and tests. Subjects were explained that they would be free to choose whether or not to participate in the study and those who decided to participate could terminate the study at any time during the study. A total number of 20 research subjects participated in the study. The research subject were just females. The initial assessment was performed before the research onset and the second assessment was performed after the research was finished.

Research subject selection criteria: 18 – 45 years old individuals under constant stress, subjects who experienced fatigue, high psychological pressure, diagnosed with anxiety disorder, feeling tired, decreased flexibility, decreased physical capacity, psycho-emotional disorders.

Exclusion criteria: unbearable pain (9 – 10 according to Visual Analog Scale for Pain), spinal surgery, high blood pressure, open wounds, patients with epilepsy, arrhythmias, tumors.

Research Instruments.

To assess physical capacity was used *6 – minute walk test* [13]. This walking sample is a simple, easy to repeat test to help assess submaximal functional capacity and response to treatment. It is noted that the results of this sample also have a predictive value. Within 6 minutes, the patient is asked to walk as long a distance as possible. A walking area is prepared for the patient, where the length of one wheel is 84 m. For 80 m + 4 m turns, the turns are marked with a clearly visible marker. The patient, coming in wearing comfortable shoes, walks clockwise. As they go, they can take rest breaks, which will be counted towards the test time. The laps walked are counted aloud so that the subject can hear clearly, and how long the patient is walking and how much time is left is reported. Each lap must be marked in the test report and the distance travelled in a few meters must be calculated. Assessment of physical capacity (based on the results of a six-minute walk sample) Low - <150 meters / 6 min. Medium - 150-425 meters / in 6 minutes. High -> 425 meters / in 6 min. [14].

For flexibility assessment was used *Schober's sample* [15]. This test is used to determine the mobility of the lumbar cross section of the spine. The modified Schober test is measured by marking three points in the back area of the subject. The patient stands upright. The first point is marked in the middle of the straight line joining the hip wings. The second point is marked 10 cm above the first. The third point is 5 cm below the first. This gives a distance of 15 cm. The subject bends forward, bending only the lumbar spine, without bending the knees and without squatting. The distance between the upper and lower point is measured. The result is recorded in centimetres. The test is negative if the difference is 7 cm or more. This means that the mobility of the lumbar spine is good. If the distance is less than 7 cm, the test is positive, the mobility is limited [14]. Back bending. With the subject standing upright with their hands on their sides, they are asked to lean forward as low as possible. If the mobility is normal, then the subject reaches the floor with his fingertips. If the floor is not accessible, measure the distance from the floor to the tips of the big toes with a centimetre tape. However, it should be noted that the muscle groups of the back of the hip joints and legs are still involved in this movement. Back building. The subject is placed on his stomach. Relying on your hands, trying to stretch your back as much as possible without lifting your pelvis. The distance is measured in centimetres from the floor to the upper edge of the sternum handle (to the yoke bay). Lateral bending. When determining the lateral mobility of the spine, the distance from the big toes of the right and left hands to the floor is initially measured directly while the subject is standing. The same distance 22 is then measured by bending to the sides. The distance on both sides should be the same [15].

For psycho-emotional state assessment was used *Hospital Anxiety and Depression Symptom Scale* (HAD) [16]. The HAD scale is a scale for assessing the symptoms of depression and anxiety in patients receiving treatment in general (non – psychiatric) settings. Using the HAD scale, the patient answers fourteen questions, rated from 0 to 3, based on their health over the past week. Seven questions assess the symptoms of depression, seven – the symptoms of anxiety. Estimates can range from 0 to 21. Estimates greater than 8 indicate possible depressive or anxiety disorder.

The fatigue was assessed by *Fatigue Impact Scale* (FIS) [17] (Fisk J.D., 1994). This scale consists of 40 covering wide aspect of fatigue questions in 3 criteria: physical, social, cognitive. Each question is scored from 0 to 4 points. 0 points – no fatigue, 4 point – extremely severe fatigue. The maximum score of points is from 0 to 160. More points are total score means higher fatigue level.

The pain was assessed by *Visual Analog Scale for Pain (VAS)* [18]. The respondent is asked to place a line perpendicular to the VAS line at the point that represents their pain intensity. Using a ruler, the score is determined by measuring the distance (mm) on the 10 cm line between the "no pain" anchor and the patient's mark, providing a range of scores from 0–100. A higher score indicates greater pain intensity. the following cut points on the pain VAS have been recommended: no pain (0 – 4 mm), mild pain (5 – 44 mm), moderate pain (45 – 74 mm), and severe pain (75– 100 mm).

Research Design.

The study was conducted at the Lorna Medical Center, Department of Physical Medicine and Rehabilitation. Total research took 2 weeks. All selected patients consisted of two study groups, one group received physiotherapy exercises sessions and other group received dance and movement therapy sessions. Physical therapy exercises sessions in the gym (10 procedures) and dance and movement therapy sessions (10 procedures) 5 times a week were then started for each patient. The study was conducted in the hospital premises, in the physiotherapy hall, therefore the subjects were provided with a safe, quiet, comfortable environment. The principle of respect for the dignity of the individual was implemented during the study, ensuring conditions that do not degrade the dignity of patients, preserve privacy and freedom of choice. The principle of the right to accurate, complete or any information of interest to the study was ensured by explaining to the subjects the purpose of the study, the method of data collection, the relevance of the study, possible responses to treatment, and answers to pre –, post – and post – study questions. All participants in the study were informed that their anonymity would be ensured, the obtained results and other information related to the patient would not be available to other persons, and the study results would be processed, used for research purposes and published only in research.

The physiotherapy exercises session (Group I): The duration of the exercises was 30 minutes. This program consisted of three parts: introductory, basic, and final. Exercises are performed lying on a mat from various starting positions: lying on your back, lying on your stomach, lying on your side, leaning on your hands and knees, leaning on your forearms and feet. This program includes breathing exercises, torso, upper and lower limb muscle and buttock stretching exercises, stretching exercises aimed at stretching and relaxing shortened muscles, improving psycho-emotional state, flexibility, deep spine muscle activation exercises – local segmental control exercises for muscles kinetic circuit segment control exercises, strength exercises for torso, upper and lower limb muscles using body weight and gravity without aids, dynamic and static spine stability exercises without aids, static endurance training exercises, torso flexors, straight, lateral flexors for static endurance, to improve physical performance using body weight and gravity. Exercise slowly, constantly paying attention to the position of the pelvis (the neutral – middle between bending and stretching the spine must be maintained). During the exercises, the abdominal muscles are kept tense, trying not to hold your breath. The workload was gradually increased, considering the individuals' tolerance to exercise, in an effort to increase physical capacity, flexibility and improve psycho-emotional state. During the program, individuals were trained in proper breathing. Stretching exercises are maintained for 10 – 20 seconds. Strength exercises are repeated 7 – 10 times. Static positions are maintained for 6 – 8 seconds, then – until 10s. Static endurance training strategy – regression pyramid technique: for example, the lateral bridge in support of the forearm and knee: five times performed from the left side, five times from the right side, resting, then four times from the left side and four times from the right side then resting, and so on. Depending on the patient's physical condition, it can be started from three and reduced to one. This technique is designed to increase physical capacity in individuals who experience constant stress, feel physically weakened and tense, an essential provision: to develop physical capacity, flexibility and improve psycho-emotional state without causing a lack of oxygen in the muscles. Instructor was licensed physiotherapist.

The dance and movement program (Group II): Exercise duration 30 minutes. This program consisted of three parts: introductory, basic, and final. The introductory part included stretching exercises for the muscles of the torso, upper and lower limbs, breathing exercises, pelvic floor control exercises to accustom patients to exercise, relaxing the muscles of the pelvis and lower extremities so that patients could easily extract dance steps after relaxing the pelvis. Stretching exercises are maintained for 10 – 20 seconds without holding your breath and maintaining proper anatomical positions. In the main part, dance-movement therapy was used (choosing the main steps of Bachata dance with bachata music): two steps to one side, two to the other, two steps to one side and the other when crossing, two steps forward and two backwards, turning four squares, steps to one side and the other, a light squat is performed by rotating the bowl in one direction and in 4 movements, this combination of slow pace and 4/4 meter is repeated five times while keeping the bowl in a neutral position, protecting patients from excessive lordosis. tense abdominal and pelvic floor muscles. Upper limb movements were also progressively connected while dancing Bachata. The number and complexity of repetitions of Bachata steps and hand gestures performed were progressively increased according to the band's capacity, and the pace was also slightly accelerated. This program designed to increase physical capacity, flexibility, and psycho – emotional status. In the final part, breathing and stretching exercises performed for the whole-body muscle groups: torso, upper and lower limbs. Instructor was licensed physiotherapist.

Statistical Analysis.

The research data was processed with SPSS 21.0.0.0 package version, the mean (X), standard deviation (SD) and significance level ($p<0.05$) were used to calculate the results. Microsoft Office Excel 2007 computer program.

Results

Assessment of psycho-emotional state (HAD scale). From the presented results we can see that HAD scale scores in group I decreased, it is a positive progress, the lower the scores mean the better the psycho-emotional state. After calculating the correlations in the first group, it can be summarized that the visible expression of the correlation strength is 0.969, which indicates the existing strong relationship between the variables and the applied test. The resulting p = 0.00 is less than <0.05, indicating current statistical significance. After calculating the correlations in the second group, it can be summarized that the visible expression of the correlation strength is 0.96, which indicates the existing strong relationship between the variables and the applied test. The resulting p = 0.00 is less than <0.05, indicating current statistical significance. There was a statistically significant change in both groups. From the presented results, we can see that the mean values of the HAD scale decreased by 3.1 ± 3.981 points in the first group of subjects treated with physiotherapy and by 6.9 ± 4.62 points in the second group treated with dance and movement therapy. We can assume that in the dance and movement therapy group, the positive change in the psycho-emotional state of the subjects is twice as large than in physiotherapy group (Fig. 1).

Assessment of physical capacity (6 – minute walking test). After calculating the correlations in the first group, it can be summarized that the visible expression of the correlation strength is 0.94, which indicates the existing strong relationship between the variables and the applied test. The resulting p = 0.00 is less than <0.05, indicating the current statistical baseline. In the second group of computational correlations, it can be summarized that the visible expression of the correlation strength is 0.581, which indicates the current mean strength relationship between the variables and the applied test. The resulting p = 0.05 is equal to 0.05, which indicates the current statistical baseline. In both groups the statistically basic change. From the presented data, we can see that in the 1st study group, who received physiotherapy, the average 6 – minute test increased by 35.2 ± 24.89 meters, and in the 2nd study group, who received dance and movement therapy, by 27.5 ± 19.44 meters. From the obtained data, it can be assumed that in first group, with the application of physiotherapy, the physical capacity increased more than in the second group, which applied a dance-movement program (Fig. 2).

Flexibility Assessment (Schober Test). After calculating the correlations in the first group, it can be summarized that the visible expression of the correlation strength is 0.961, which indicates the existing strong relationship between the variables and the applied test. The resulting p = 0.00 is less than <0.05, indicating current statistical significance. After calculating the correlations in the second group, it can be summarized that the visible expression of the correlation strength is 0.925, which indicates the existing strong relationship between the variables and the applied test. The resulting p = 0.00 is less than <0.05, indicating current statistical significance. There was a statistically significant change in both groups. From the presented results, we can see that in first group, who received physiotherapy, the average flexibility in the bending direction increased by 1.7 ± 0.6 centimetres, and in the second group, who received dance and movement therapy, by 2.4 ± 0.4 centimetres. From these data, we can assume that a greater change in the mean of the flexion direction between groups was observed in the second group (Fig. 3).

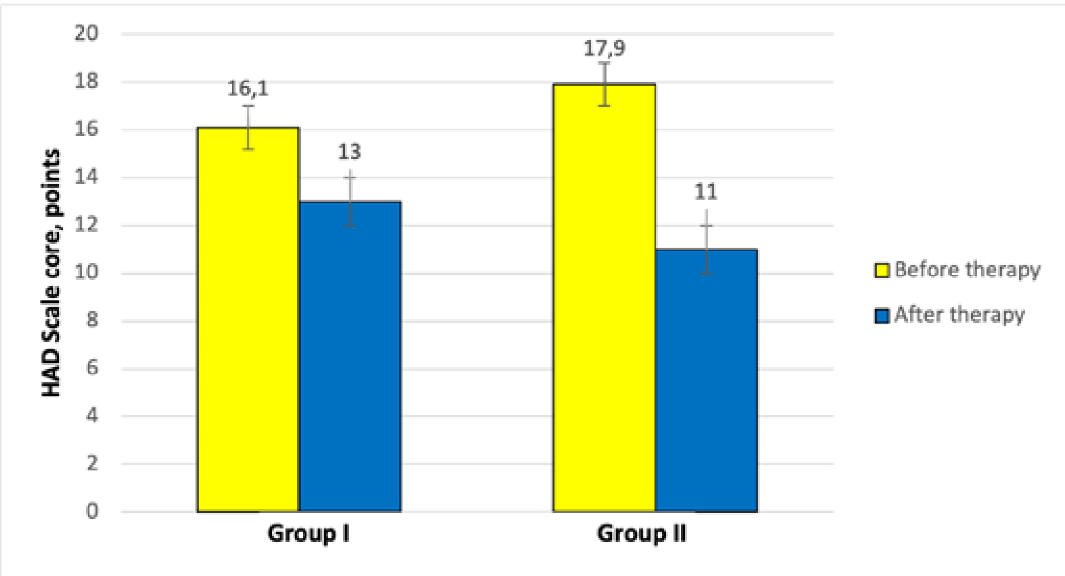

Figure 1. Changes in the HAD scale between group I subjects treated with physiotherapy and group II subjects treated with dance and movement therapy. Statistical significance * p < 0.05

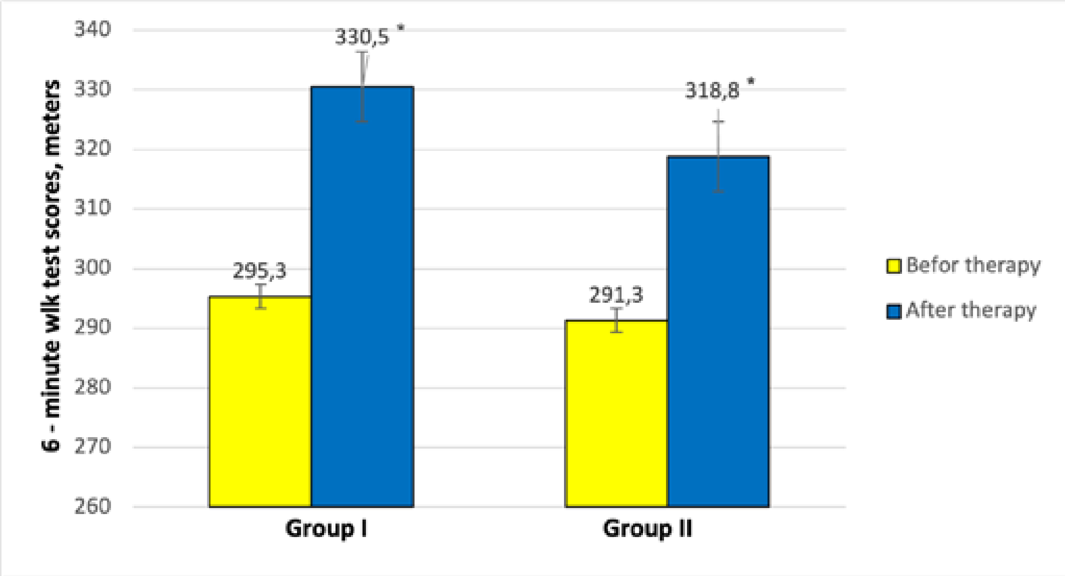

Figure 2. Changes in 6 – minute walk test scores in group I treated with physiotherapy and in group II subjects treated with dance and movement therapy. Statistical significance *p < 0.05

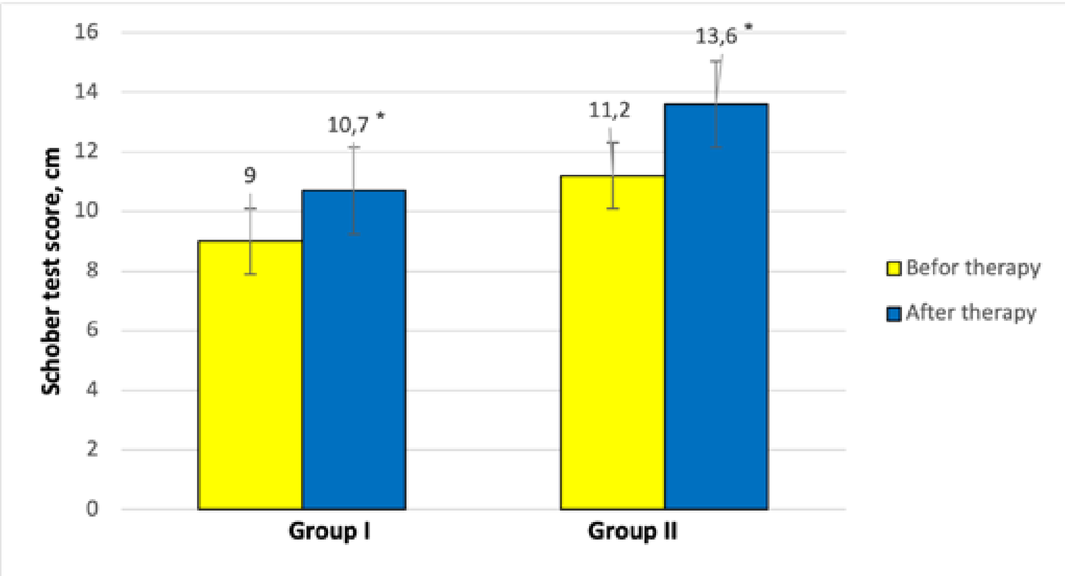

Figure 3. Changes in mean estimates of Schober sample in the direction of bending in groups I (subjects treated with physiotherapy) and in group II (subjects treated with dance and movement therapy) before and after therapy. Statistical significance * p < 0.05.

Discussion

Our study showed that dance and movement therapy significantly improved subjects' psycho-emotional state, physical capacity, and flexibility. A slow bachata dance was chosen for the study. Many authors choose different dance styles used in dance and movement therapy and different dance methodologies: bachata [19], slow dance [20], graceful dance [21], salsa [22] and freestyle dance [23]. Dance is part of a socio-psycho-emotional physical activity program created by Ilse Tutt in Germany in 1974 [24]. It has emerged among therapeutic resources as a preventive strategy to improve quality of life, increase physical activity, and psycho-emotional status. Dancing in different countries is based on different cultures, aspects of music, a game specifically tailored to the capabilities and needs of individuals. Dance can be performed while standing, choosing a fast or slow pace, increasing flexibility, amplitude of joint movements, and agility [25]. Dance therapy has a direct meaning in life. It is defined as integration, development, and existential renovation focused on the expression and exploration of physical and psycho-emotional possibilities brought about by music and dance through group bodily communication exercises and integrative experiences [26]. Graceful dance, characterized by the complexity of fun and relaxing dance exercises, is especially popular with younger people. For this dance mode it is characteristic that it can be done separately [22]. Dance therapy, according to the American Dance Therapy Association is the psychotherapeutic use of movement and dance to support intellectual, emotional, and motor functions of the body. As a modality of the creative arts therapies, dance and moment therapy looks at the correlation between movement and emotion [27]. This means that dance therapy is multifaceted and affects the physical and mental realms [28]. Given the conceptualizations of each dance nomenclature/methodology presented, it is understood that they must all be influenced by the development of physical performance, psycho-emotional, and social aspects during dance.

Kattenstroth et al. found that cardiovascular and respiratory system indicators did not show changes with dance intervention. It should be noted that the protocol adopted by the authors was used once a week [22]. According to Matsudo et al., physical activity is sufficient to describe an individual as physically active, requiring at least 150 minutes per week of at least moderate-intensity physical activity [29]. In contrast, the authors demonstrated significant attention and response time for physical-motor, tactile, and postural parameters and cognitive-sensory parameters involving intelligence.

Our study showed an improvement in the physical ability of the subjects. Similarly, Berbel and Silva found that dancing had a positive effect on mobility, strength, and human coordination [19]. Complementing this idea, Mierzwa et al. showed a significant improvement in spinal rotation and body weight transfer strategies during ankle movements [23]. In addition, the study by Oliveira et al. participants introduced greater physical mood and enjoyment by performing movements and reported less fatigue and greater energy, always requiring more time to train. This study found an improvement in laterality, spatial orientation, and body perception, an improvement in psycho-emotional state [20]. Also, in our study, the psycho-emotional state improved significantly in the dance and movement therapy group. According to D'Alencar et al. reports revealed an increase in physical capacity and a feeling that you are still "strong," as well as a decrease in complaints and an improvement in psycho-emotional status. In addition, D'Alencar et al. noted that physical progress was associated with strong motivation to become more active [21]. Berbel and Silva observed that the decline decreased as balance and skills emerged in a change in situation, as well as improved stability [19]. The results of a Mierzwa et al. study showed a significant improvement in equilibrium skills and stability thresholds, which correlate with a strong reduction in fall risk [23]. In the same sense, Kattenstroth et al. found an improvement in posture and an improvement in balance [22].

We also found in our study that there was a significant improvement in patient flexibility. Therefore, good evidence of equilibrium, stability, and reduced risk of falling was observed in the studies analyzed, which have a positive effect on the results, considering the individual condition of each individual. As a larger number of studies confirm that dance and movement therapy can provide different benefits for physiological and psychosocial functioning in people under stress, appropriate therapy programs need to be defined in terms of appropriate session structure, intervention topic, technique, tools, and tactics. Levine et al. conducted a semi-structured study and examined key elements of therapy related to patient individuality [30]. The study concludes that each session should start with a warm-up, followed by a main part based on the movement theme expressed during the warm – up, and end with an oral therapy to help explain in more detail how the patients felt during the dance and movement therapy. A dance movement therapy guide should include music, dance, and communication so that patients can master the process of movement and exercises by seeing themselves in a mirror, including breathing. Empowerment, confidence, and self-care were also selected as important aspects of dance movement therapy that should be developed in the program. The end of the session focuses on the discussion of feelings experienced, the connections between sensations, insights, and change during therapy. After analyzing the results of the research and comparing them with other authors, we can state that dance and movement therapy has all the benefits for individuals' physical capacity, flexibility and psycho-emotional state.

Conclusions

1. After evaluating the results of the study groups after physiotherapy and dance and movement therapy, it was found that the psycho-emotional state according to the HAD scale improved statistically significantly in both groups ($p < 0.05$).
2. After evaluating the results of the study groups after physiotherapy and dance and movement therapy, it was found that the physical capacity according to the 6 – minute walk test improved statistically significantly in both groups ($p < 0.05$).
3. After evaluating the results of the study groups after physiotherapy and dance and movement therapy, it was found that the flexibility according to the Schober sample in the bending direction improved statistically significantly ($p < 0.05$), and in the construction direction it was not statistically significant.
4. Dance movement therapy has a positive

effect on psycho-emotional state, flexibility and physical ability of people experiencing constant stress. As observed, dance and movement therapy have a positive effect not only on flexibility or physical ability, but also on psycho-emotional state.

Practical Recommendations

Dance and movement therapy can be easily applied among different age population. Because of severe pandemic situation all over the world the applied physiotherapy methods must be complexed, creative, adaptive and flexible. Such physiotherapy method can be used not just for older people but different researches are showing that movement and complex physiotherapy is essential for a person psychological state, physical and emotional health. The essential need for person is to be able independent and to have ability to walk. All this makes physiotherapy a highly essential tool to improve person‘s well – being and quality of life.

Limitations

The main limitation of the study is that men were not included in the study, so the study was conducted only with women. One man participated in only one session, after which the study was discontinued due to discomfort among women. It would be useful to have a study with both genders.

Acknowledgement

Our sincere thanks for study participants.

Conflict of interest

The authors declare no conflict of interest.

References

1. Song YG, Ryu YU, Im SJ, Lee YS, Park JH. Effects of dance – based movement therapy on balance, gait, and psychological functions in severe cerebellar ataxia: A case study. *Physiotherapy Theory and Practice*, 2019;35(8):756–763. https://doi.org/10.1080/09593985.2018.1457119
2. Zhang Q, Hu J, Wei L, Jia Y, Jin Y. Effects of dance therapy on cognitive and mood symptoms in people with Parkinson’s disease: A systematic review and meta – analysis. *Complementary Therapies in Clinical Practice,* 2019; 36:12–17. https://doi.org/ 10.1016/j.ctcp. 2019.04.005
3. Müller Pinget S, Golay A. To improve body image with dance therapy. Revue medicale suisse. *Northoff*, 2019;15(643):640–642. https://doi.org/10.53738/REVMED.2019.15.643.0640
4. Cesar A. Arango-Dávila and Hernán G. Rincón-Hoyos. Depressive disorder, anxiety disorder and chronic pain: Multiple manifestations of a common clinical and pathophysiological core. *Revista Colombiana de Psiquiatría,* 2018; 47(1):46–55. https://doi.org/10.1016/j.rcpeng.2017.12.003
5. Bognar S, DeFaria AM, O’Dwyer C, Pankiw E, Simic Bogler J, Teixeira S, Nyhof-Young J, Evans C. More than just dancing: experiences of people with Parkinson’s disease in a therapeutic dance program. *Disabil Rehabil*. 2017;39(11):1073–1078. https://doi.org/10.1080/09638288.2016.1175037
6. Duboleva Ž, Mačiulaitis R. Meno terapija kaip gydymo metodas asmenims, turintiems specialiųjų poreikių (psichikos sutrikimų). [Art therapy as a treatment method for persons with special needs (mental disorders)]. *Sveikatos Mokslai*, 2012;22(4):23–28.
7. Velanovich V. The Effect of Chronic Pain Syndromes and Psychoemotional Disorders on Symptomatic and Quality-of-Life Outcomes of Antireflux Surgery. *Journal of Gastrointestinal Surgery*. 2003;7(1): 53–58. https://doi.org/10.1016/S1091-255X(02)00136-1
8. Domschke K, Stevens S, Pfleiderer B, Gerlach AL. Interoceptive sensitivity in anxiety and anxiety disorders: An overview and integration of neurobiological findings. *Clinical Psychology Review*, 2010; 1:1–11. https://doi.org/10.1016/j.cpr.2009.08.008
9. Cortes-Salim P, Gonzalez-Barron M, Romero-Gutierrez G. Psycho – emotional disorders in women with unplanned pregnancies. *American Journal of Health Research,* 2014; 2(1): 27–32. https://doi.org/ 10.11648/j.ajhr.20140201.15
10. Gazzaniga MS, Ivry RB, Mangun GR. *Cognitive neuroscience: the biology of the mind*.. Fourth edition. New York, N.Y: W. W. Norton & Company, Inc; 2014.
11. P. Danilov Y, S. Kublanov V, Ju Retjunskij K, S. Petrenko T, V. Babich M. Non-invasive Multi-channel Neuro-stimulators in Treatment of the Nervous System Disorders: In: *Proceedings of the International Conference on Biomedical Electronics and Devices*. Lisbon, Portugal: SCITEPRESS - Science and and Technology Publications; 2015. p. 88–94. https://doi.org/10.5220/0005200000880094
12. Bernstein E, McNally R. Acute aerobic exercise helps overcome emotion regulation deficits. *Cognition & Emotion*, 2017;31(4):834–843. https://doi.org/10.1080/02699931.2016.1168284 4
13. Steffen TM, Hacker TA, Mollinger L. Age- and gender-related test performance in community-dwelling elderly people: Six-Minute Walk Test, Berg Balance Scale, Timed Up & Go Test, and gait speeds. *Phys Ther*. 2002 Feb;82(2):128–37. https://doi.org/10.1093/ptj/82.2.128
14. Pocienė M. *Kineziterapijoje taikomi funkciniai testai*. [Functional tests in physiotherapy]. Leidykla: Vitae Litera; 2013. (In Lithuanian).
15. Magee DJ, Manske RC. *Orthopedic physical assessment*. 7th ed. Philadelphia: Elsevier, Inc; 2020.
16. Mykletun A, Stordal E, Dahl AA. Hospital Anxiety and Depression (HAD) scale: Factor structure, item analyses and internal consistency in a large population. *British Journal of Psychiatry,* 2001;179(6): 540–544.

https://doi.org/10.1192/bjp.179.6.540
17. Fisk JD, Ritvo PG, Ross L, Haase DA, Marrie TJ, Schlech WF. Measuring the Functional Impact of Fatigue: Initial Validation of the Fatigue Impact Scale. *Clinical Infectious Diseases*. 1994;18(Supplement_1): S79–S83. https://doi.org/10.1093/clinids/18.Supplement_1.S79
18. Delgado DA, Lambert BS, Boutris N, McCulloch PC, Robbins AB, Moreno MR, et al. Validation of Digital Visual Analog Scale Pain Scoring With a Traditional Paper-based Visual Analog Scale in Adults. *JAAOS: Global Research and Reviews*. 2018;2(3): e088. https://doi.org/10.5435/JAAOSGlobal-D-17-00088
19. Silva AFG da, Berbel AM. O benefício da dança sênior em relação ao equilíbrio e às atividades de vida diárias no idoso [The benefit of senior dance in relation to balance and daily life activities in the elderly]. *ABCS Health Sciences*. 2015;40(1). (In Portuguese). https://doi.org/10.7322/abcshs.v40i1.698
20. Oliveira,LC, Pivoto EA, Vianna PCP. Análise dos resultados de qualidade de vida em idosos praticantes de dança sênior através do SF-36. [Analysis of quality of life results by using the SF-36 among elderly persons practicing senior dance]. *Acta Fisiátrica*, 2009;16(3):101–104. https://doi.org/10.11606/issn.2317-0190.v16i3a103184
21. D'Alencar BP, Mendes MMR, Jorge MSB, Guimarães JMX. Biodança como processo de renovação existencial do idoso. [Biodance as an existential renovation process of the elderly: an ethnographic analysis]. *Revista Brasileira de Enfermagem*, 2008; 61(5): 608–614. (In Portuguese). https://doi.org/10.1590/S0034-71672008000500013
22. Kattenstroth JC, Kalisch T, Holt S, Tegenthoff M, Dinse HR. Six months of dance intervention enhances postural, sensorimotor, and cognitive performance in elderly without affecting cardio-respiratory functions. *Frontiers in Aging Neuroscience*. 2013;5. https://doi.org/10.3389/fnagi.2013.00005
23. Mierzwa K, Długosz M, Marchewka A, Dąbrowski D, Poznańska A. The effect of dance therapy on the balance of women over 60 years of age: The influence of dance therapy for the elderly, *Journal of Women & Aging*, 2017;29(4): 348–355. https://doi.org/10.1080/08952841.2016.1194689
24. Santos DPMA, Queiroz AC de CM, Menezes RL, Bachion MM. Effectiveness of senior dance in the health of adults and elderly people: An integrative literature review. *Geriatric Nursing*. 2020;41(5): 589–599. https://doi.org/10.1016/j.gerinurse.2020.03.013
25. Carvalho P. Avaliação da qualidade de vida antes e após terapia com dança sênior em pacientes hemiparéticos pós – AVE. [Evaluation of quality of life of post-stroke hemiparetic patients before and after dance therapy for seniors]. *ConScientiae Saúde*, 2012;11(4):573–579. (In Portuguese). https://doi.org/10.5585/conssaude.v11n4.3284
26. Toro R. *Coletânea de textos de Biodanza* [Collection of Biodanza texts]. Fortaleza, Ceará (Brasil). ALAB; 1991. (In Portuguese).
27. American Dance Therapy Association (ADTA). *What Is Dance/Movement Therapy? ADTA defines dance/movement therapy as the psychotherapeutic use of movement to promote emotional, social, cognitive and physical integration of the individual* [Internet]; 2022 [cited 2012 Oct 01]. Available from: https://www.adta.org/
28. Kozlowski T.T. Physiological ecology of natural regeneration of harvested and disturbed forest stands: Implications for forest management. *Forest Ecology and Management*. 2002; 158: 195–221. https://doi.org/10.1016/S0378-1127(00)00712-X
29. Matsudo, Sandra Mahecha; Matsudo, Victor Keihan Rodrigues; Barros Neto, Turíbio Leite. Atividade física e envelhecimento: aspectos epidemiológicos. [Physical activity and aging: epidemiological aspects]. *Revista Brasileira de Medicina do Esporte*, 2001; 7: 2–13. (In Portuguese). https://doi.org/10.1590/S1517-86922001000100002
30. Levine B, Land HM. A Meta-Synthesis of Qualitative Findings About Dance/Movement Therapy for Individuals with Trauma. *Qualitative Health Research*. 2016;26(3):330–344. https://doi.org/10.1177/1049732315589920

Information about the authors:

Julija Andrejeva; http://orcid.org/0000-0001-6604-8742; j.andrejeva@kvk.lt; Faculty of Health Sciences, Klaipeda State University of Applied Sciences, Klaipeda, Lithuania; Faculty of Health Sciences, Klaipeda University, Klaipeda, Lithuania; Faculty of Medicine, Vilnius University, Vilnius, Lithuania.

Asta Mockiene; https://orcid.org/0000-0002-1428-7212; a.mockiene@spc.vdu.lt; Vytautas Magnus University; Kaunas, Lithuania.

Dainora Strazdauskaite; https://orcid.org/0000-0003-3361-6656; strazdauskaite.dainora@gmail.com; Lithuanian Sports University; Kaunas, Lithuania.

Monika Pociene; https://orcid.org/0000-0001-9681-0232; m.pociene@kvk.lt; Faculty of Health Sciences, Klaipeda State University of Applied Sciences, Klaipeda, Lithuania.

Grazina Sniepiene; http://orcid.org/0000-0003-1932-4729; g.sniepiene@kvk.lt; Faculty of Health Sciences, Klaipeda State University of Applied Sciences, Klaipeda, Lithuania; Faculty of Health Sciences, Klaipeda University, Klaipeda, Lithuania.

Elvira Malysko; (Corresponding Author); http://orcid.org/0000-0003-2911-5146; elvira.malysko@mf.vu.lt; Faculty of Medicine, Vilnius University; Vilnius, Lithuania.

Natalja Istomina; http://orcid.org/0000-0002-6562-053X; natalja.istomina@mf.vu.lt; Faculty of Health Sciences, Klaipeda University, Klaipeda, Lithuania; Faculty of Medicine, Vilnius University, Vilnius, Lithuania.

Vaiva Hendrixson; http://orcid.org/0000-0003-2585-3782; vaiva.hendrixson@mf.vu.lt; Faculty of Medicine, Vilnius University, Vilnius, Lithuania.

Cite this article as:

Andrejeva J, Mockiene A, Strazdauskaite D, Pociene M, Sniepiene G, Malysko E, Istomina N, Hendrixson V. Effects of dance and movement therapy on physical ability, flexibility and psychological state for individuals under constant stress. *Pedagogy of Physical Culture and Sports,* 2023;27(1):4–13.
https://doi.org/10.15561/26649837.2023.0101

Received: 26.09.2022
Accepted: 29.11.2022; Published: 28.02.2023

ORIGINAL ARTICLE

The effects of massed and distributed drills, muscle strength, and intelligence quotients towards tennis groundstroke skills of sport students

Djoko Nugroho[ABCDE], Mohammad F. Hidayatullah[ABCDE], Muchsin Doewes[ABCDE], Sapta K. Purnama[ABCDE]

Faculty of Sports, University of Sebelas Maret, Indonesia

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

Abstract

Background and Study Aim Basic forehand and backhand technical skills are the main requirements that must be mastered in playing tennis. Physical condition and intellectual intelligence were found to be the factors that affect the quality of tennis. On the other hand, limited learning time, and the number of teaching staff and facilities are classic challenges in the implementation of learning. This study describes the different effects of massed and distributed exercise, arm strength, and intellectual on the forehand and backhand skills of sports students.

Material and Methods A quasi-experimental method with two group pretest and posttest design approached the 64 volunteers of male sports students (age 19.3±1.7, BMI 20.17±1.47), who had attended the tennis course. The sample is divided into 2 groups of Massed Practices (MP) and Distributed Practices (DP) according to the score of the upper-arm strength and intelligence test. The anthropometrics were evaluated through digital microtome stature, the arm strength was evaluated with a push-up test and the kinesthetic perception was confirmed with the intelligence quotient (IQ) test. The prerequisite test employed Kolmogorov-Smirnov, while Bivariate analysis utilized the Independent Sample T-test and Paired Sample T-test of the SPSS 20.0 version.

Results The study showed that MP and DP had different positive contribution values to the tennis drive ($p=0.003$, $p<0.05$), while distributed gave a better contribution to the tennis drive with a significant value ($p=0.001$, $p<0.05$). The high arm muscle strength provides high accuracy in groundstroke ($p=0.003$, $p<0.05$), also for the high score on the intelligence test significantly affect the accuracy of tennis strokes ($p=0.000$, $p<0.05$).

Conclusions The results showed that there are differences in exercise methods, arm muscle strength, and intelligence quotient against tennis drive punches.

Keywords: massed, distributed, arm strength, intelligence quotient, tennis

Introduction

Tennis is one of the most popular racket sports across ages and genders [1]. It requires the linkage of bio-motor components including strength, speed, power, agility, and coordination [2], which is applied in a short-term and continuous explosive action that lasts for a long match duration [3]. Tennis has similar characteristics in competition load, intensity, and duration with other racket games [4], therefore, it is categorized as a high level of sports competition [5]. A tennis match can be played individually and in pairs, and has no time limit, so a four-hour match is possible [6]. In line with the statement, therefore high levels of physical, psychological, and technical efficiency are very crucial [7].

The basic technique of tennis stroke is divided into two groups of techniques, namely defensive punch, and attack punch techniques [8]. Defensive techniques are classified as push or slice and block punches, while attack punch techniques include drive, lob, spin, and overhead punches/smashes [9]. The serve, forehand drive, backhand drive, and volley are included in the basic techniques of stroke that must be mastered in tennis [10] through an appropriate training method [11]. The type of strokes is divided into groundstrokes, volleys, and overhead strokes [12]. The groundstroke is a crucial technique made by swinging a racket to produce a striking controllable force with high accuracy target, against a ball that has bounced off from the ground. The groundstroke can be done through forehand or backhand style on the side of the body [13], which is stated in the current study it requires a high level of footwork coordination and swing accuracy [14]. Forehand strokes are defined as strokes made to the right of the player for a right-handed hitter, while Backhand is a stroke made by swinging the racket from the player's left [15]. The implementation of forehand and backhand strokes in court tennis on groundstroke is carried out in three stages, namely backswing, forward swing, and follow-through [16].

doi:10.15561/26649837.2023.0102

The findings of the current study explain that there is a positive relationship between training methods based on each individual's physical, psychological, and technical abilities towards improving the forehand and backhand abilities of beginner athletes [17]. It is understood that the training model which is based on the characteristics of each individual, provides better effectiveness. However, due to the limitation of learning time provided in 1 meeting session, accompanied by a large number of students, many obstacles were found in the learning process. In addition, the classic problem the form of limited teaching staff and training facilities, makes students have a long waiting time in carrying out independent practicum tasks one by one so that learning outcomes cannot be obtained optimally. Based on the facts, learning with effective strategies is needed to develop backhand and forehand drive skills in students.

Several studies illustrate the existence of training methods that can be used to improve tennis skills with limited time, a minimal number of coaches, and facilities, including Massed practice (MP) and Distributed Practice (DP). Massed practice (MP) is known as a method of setting a practical presentation turn for students in performing basic technical movements repeatedly without interspersed with rest periods [18]. Meanwhile, practice (DP) distributed is a method of practicing the various form of basic technique movements learned by providing a break between execution and rest time to alternate with other training partners through simultaneous instructions [19]. The study of movement skills explained that the massed practice method gave students more advantages in a longer implementation time to carry out basic technical exercises continuously. However, differences in physical conditions, movement skills, and other individual aspects were found to be obstacles to achieving learning outcomes. Therefore, another study concluded that the massed practice method will get optimal results for groups of students who have the same quality of physical condition and skills, but unfortunately are less than optimal for novice students [20]. The study of motion learning explains the positive results of distributed practice implemented in classes that have heterogeneous physical conditions and abilities, one of the findings is that the intensity of the exercise starts from low according to the ability of each student. On the other hand, several motor learning studies have confirmed that the implementation of distributed practice requires a long training time, and it is found that the results are less effective to be given to classes that have limited time, trainers, and facilities [21].

Coaches can use a variety of training methods and approaches to independently improve their tennis skills. However, the selection of learning methods should also pay attention to other supporting aspects such as differences in the characteristics of physical conditions, skills, and intelligence. The study of biomechanics explains that there is a significant effect between the strength of the swing force produced on the arm and wrist, the speed of the ball, and the level of accuracy produced [22]. Another study confirmed that according to the principle of impulse-momentum, the swing strength of a tennis racket can be optimally produced by transferring the force through contraction of the knee joint on the fulcrum, leg, hip, and shoulder followed by swinging the arm, and wrist which is carried out by synchronizing the movement simultaneously [23]. This illustrates that the strength of the swing force on the racket is largely determined by several aspects, one of which is the strength of the hand muscles.

In line with this explanation, another study confirmed that a series of simultaneous coordination movements in running, followed by hitting the ball firmly toward the desired target, requires high kinesthetic perception which is influenced by intellectual intelligence [24]. Neurophysiology studies explain that the ability and speed of the brain in understanding and interpreting stimuli received in the central nervous system, to be immediately transmitted to the motor nerves in producing motor movements, is largely determined by cognitive abilities [25]. Several measuring instruments described in the literature to determine a person's level of cognitive intelligence are through the intelligence quotient (IQ) test [26]. In line with this opinion, human movement studies explain the findings of the motor learning process of basic skills, where students who have low cognitive levels experience problems in understanding the basic movement tasks given [27], so have difficulty displaying the motion tasks into the form of psychomotor basic movements optimally [28]. Based on the explanations of several studies above which confirm that the basic forehand and backhand movement abilities are determined by elements of physical condition, biomechanical motion, and cognitive intelligence [11], hence the study to identify the difference in influence between massed and distributed methods in cases of learning with limited time, trainers and existing facilities at the Universitas Sebelas Maret is indispensable. This research aims to investigate the influence of training methods, arm muscle strength, and intelligence quotient (IQ) on tennis groundstroke skills in forehand and backhand of sports students at Universitas Sebelas Maret Surakarta. The results of this study are expected to provide additional literature regarding tennis coaches in schools in designing and modifying training models to improve basic technical skills for forehand, and backhand, including serve and smash.

Materials and Methods

Participants

This research was conducted at the Faculty of Sport Science, Universitas Sebelas Maret (UNY) which is located at Manahan Surakarta. The population taken in this study were 80 male sports student volunteers (age 19.3±1.7, BMI 20.17±1.47, RHR 63.4±8.2bpm), who have attended tennis lectures, passed the inclusion criteria and had no injury reports for the exclusion criteria. The sampling technique used purposive sampling which was carried out by taking subjects based on arm strength and intellectual quotient (IQ) score. The study begins with filled-out research approvals on anthropometric, health and physiological aspects, including the absence of cardiovascular risk, then signed a written consent under Indonesian law and university policies approved by the University Research Ethics (Approval Number KE/FK/112/EC/2021).

Research Design

The samples were categorized into 2 experimental groups namely the Massed Practices (MP) and Distributed Practice (DP) groups using ordinal pairing techniques based on the T-score of the arm muscle strength test and Intellectual Question test at the pre-test. Subsequently, all groups performed training drills of forehand and backhand groundstroke based on a training zone in moderate intensity at the initial stage, then increasing to the sub-maximum intensity at the final intervention according to the training guidelines of 5 minutes x 7-repetitions x 60%-80 % Intensity, with a rest between sets of 3 minutes and a rest set of 5 minutes repetitively. Upon completing the 6-week training drills, all groups were given the post-test intervention of the tennis drive test according to the *Hewitt Tennis test protocol* delivered for 3 times attempts, then the score recorded is the highest. The initial phase of the study began by providing the participants with informed consent, and the Physical Activity Readiness Questionnaire (PAR-Q) [29], to identify injury recording profiles and readiness for physical intervention at Sports Court, followed by the anthropometrical measurements, such as age, height, weight, and body mass index (BMI) using a digital microtome stature with an accuracy of 0.1 mm [30] and the resting pulse rate was taken under the palpation method in a sitting position by the Polar-H10 Chest Heart *Rate Monitor*

The tennis drive as a dependent variable was measured using the *Hewitt Tennis test protocol* [31], while the arm strength as an independent variable was tested using the 60 seconds Push-up test protocol [32], and intelligence quotient (IQ) was conducted using the *Intelligent Structure Test (IST)* 2000-Revised by a psychological specialist [33]. The forehand and backhand drive was conducted 3 times with 10 ball shots each attempt toward the selected target area to achieve the scores that have been determined according to the Hewitt test protocol. The push-up test was conducted in 60-seconds with 3-times attempts respectively. The IST consists of nine sub-tests that have a total of 176 question items. Each sub-test has a different time limit and is carried out briefly and administered manually [34]. One of the sub-tests that is relevant to a person's IQ in tennis is the WU sub-test, which consists of exercises in the form of blocks, and aims to measure spatial imagery, three-dimensional, analytical, and constructive technical abilities.

At the scoring stage, each sub-test is checked using the answer key provided. For all subtests (SE, WA, AN, RA, ZR, FA, WU, & ME), except for the 04-GE subtest, each correct answer will be given a score of 1, and incorrect answers will be given a score of 0. The provision of different score ranges is given specifically to the 04-GE sub-test, where several values are provided including 2, 1, and 0. The total score will be classified as a Raw Score (RW), then compared with the norms that have been provided to produce a Standardized Score (SW), which will become the standard of interpretation. The score will be classified as a Raw Score (RW), then compared with the norms that have been provided to produce a Standardized Score (SW), which will become the standard of interpretation. These nine subtests are interrelated with each other; therefore, the implementation of the test must be carried out quickly accompanied by the overall interpretation of the results.

Statistical Analysis

The data description employed the Statistical Product and Service Solution (SPSS) program for Windows, while the prerequisite test was performed using the Shapiro-Wilk method, homogeneity of variances. A Three-way ANOVA design with a 2x2x2 factorial design was used to determine the difference in influence between groups pre-and post-treatment and to identify which variable has the greatest impact on the treatment groups. The data were delivered as mean ± of standard deviation (SD), with a 95% confidence interval and statistical significance was accepted as $p < .05$.

Results

The profile of anthropometrical-, health, nutritional, physiological, as well as psychological respondents, can be seen in the following results.

The above result (Table 1) concluded that the respondents are in a healthy and fit state as indicated in the productive age group (18.27±1.09 yr.), have a normal level of body mass index (21.45±1.13kg/m^2), were not in fatigue (pulse 65.75±7.35bpm) and had normal intellectual scale as reported in the normal values for (102.8±3.63) and a normal distribution for muscular strength with (31.8±2.58) respectively. Simultaneously, a qualitative measurement was also conducted to obtain characteristics of the discrimination of arm muscle strength, intelligence quotient (IQ), and tennis drive including average grades, standard deviations, minimum values, maximum values, range of values, and the total number of acquisitions from measurement test results of each variable. The descriptive analysis of expected variables could be seen in the following table 2.

The results showed (Table 2) the different values of the research variables' mean and standard deviation with a significance level. The mean of Intelligence Quotient (IQ) differences in the pretest and post-test showed a value (r=90.50±13.11,) for Massed Practices (MP) group, while the group of Distributed Practice (DP) shows a mean value pretest and post-test with (r=90.82±12.25), thus could be concluded that the different value of Intelligence Quotient (IQ) for both groups in pretest are distributed in a similar level. In the Arm Strength variables, the MP group showed a mean value of (r=26.2±4.06), while the DP group's mean value was (r=25.85±3.74). It implies that there is no contrast difference in the mean value for both groups as shown in the similar value.

On the backhand drive value, the MP group showed a mean value (r=16.85±5.74), while the DP group had a mean of pretest and post-test value (r=16.17±2.49). Thus, it explains a significant difference in mean value both in the pretest and posttest for both groups have no significantly different value. For the Forehand drive, the MP group had a mean value of (r=13.85±1.21), while the DP group had a mean value (r=15317±1.91). It indicates that both groups have no significantly different mean of value in the pretest and posttest for forehand drive. In addition, Prerequisite calculations were also carried out in this study to identify whether the data were normally distributed. The following are the results of the normality calculation for

Table 1. Characteristics of Age, BMI, Resting Heart Rate, IQ, and Strength

Variable	n	Massed (MP)	Distributed (DP)
		Mean±SD	Mean±SD
Age (years)	64	18.23±1.17	18.31±1.02
BMI (kg/m^2)	64	21.12±1.56	21.78±1.25
Resting Heart Rate (pulse/minute)	64	63.4±8.2	68.1±6.4
Intellectual Scale (Score)	64	102.18±3.43	103.23±3.84
Arm Strength	64	31.37±2.32	32.23±2.84

MP - Massed Practices group; DP - Distributed Practice group

Table 2. Profile of Arm Strength, IQ, and Tennis Drive.

Variable	Groups	Number (n)	Mean±SD
Intelligence Quotient (IQ)	MP Posttest	64	92.83±12.51
	MP Pretest		88.17±13.71
	DP Posttest	64	91.71±11.98
	DP Pretest		89.93±12.52
Arm Strength	MP Pretest	64	29.8±4.40
	MP Posttest		22.5±3.73
	DP Pretest	64	28.6±4.17
	DP Posttest		23.1±3.32
Backhand Drive	MP Pretest	64	21.63±3.97
	MP Posttest		12.27±6.26
	DP Pretest	64	20.89±3.35
	DP Posttest		13.52±5.98
Forehand Drive	MP Pretest	64	21.73±4.38
	MP Pretest		11.98±5.76
	DP Posttest	64	20.98±4.61
	DP Posttest		12.27±5.15

MP - Massed Practices group; DP - Distributed Practice group hypothesis testing using the Kolmogorov–Smirnov Z (KS-Z) test with a significance level of α=0.05 as follows (Table 3).

Based on the results of the normality test (Table 3) using the Kolmogorov–*Smirnov Z* (KS-Z) test can be concluded that the variables including the arm muscle strength, intelligence *quotient* (IQ), and forehand dan backhand drive are shown in the normal distribution indicating the value greater than 0.05 *(p >0.05)*. Thus, the sample and variables in this study were indicated as a normally distributed population. The Paired Sample T-test was conducted to identify the different values of a variable before and after manipulation in the groups as well as to examine the different values between the two research groups. The result can be seen in the following table 4.

Table 4 shows the statistical calculation of 2x2x2 factorial on variable arm muscle strength, Intelligence quotient (IQ) on forehand and backhand abilities. In general, it can be found that there are differences in the degree of significance of the Arm Strength, Intelligence quotient (IQ) profile on the Forehand and Backhand abilities in both the Massed Practice (MP) and Distributed Practice (DP) groups. The results in the MP group in the sample with low arm strength and IQ showed low forehand results with a significance value of p = 0.017. Similar results were also shown in the MP group in the sample with high arm strength and IQ, showing also high forehand results with a significance of p=0001. Furthermore, the MP group in the sample with high arm strength and low IQ showed low forehand skills with a significance of p=0.007. Meanwhile, students with high arm strength, however, have a low scale IQ, and showed forehand skills on a moderate scale,

Table 3. The Normality of Forehand, Backhand drive, arm strength, and Intelligence Quotient (IQ)

Variable	Groups	Number (n)	Significance (p>0.05)
Forehand Drive	MP Pretest DP Pretest	64	0.556
	MP Posttest MP Posttest	64	0.917
Backhand Drive	MP Pretest DP Pretest	64	1.207
	MP Posttest MP Posttest	64	0.109
Push-Up	MP Pretest DP Pretest	64	0.009
	MP Posttest MP Posttest	64	0.671
Intelligence Quotient (IQ)	MP Pretest DP Pretest	64	0.062
	MP Posttest MP Posttest	64	0.724

*Significance (p >0.05)

Table 4. Paired T-Test

Variables	Group	Arm Strength	IQ	Tennis Skill	Significance (p<0.05)
Forehand	MP	Low	Low	Low	0.017
	MP	High	High	High	0.001
	MP	Low	High	Low	0.007
	MP	High	Low	Moderate	0.001
Backhand	DP	Low	Low	Low	0.024
	DP	High	High	High	0.001
	DP	Low	High	Low	0.002
	DP	High	Low	Low	0.001

Significance (p<0.05)

with a significance of 0.001. In addition, in the DP group, it was also seen that the sample with low strength and IQ was found to have low backhand skills with a significance of 0.024. The same pattern was also shown in the group of students with high arm strength and IQ, confirmed to have high backhand skill with a significance of 0.001. In the case of the group of students with low strength and high IQ, it was found to have low backhand skill with a significance of 0.002, as well as students with low strength and high IQ, were proven to have low backhand with a significance of 0.001.

Based on the statistical calculations above, it can be concluded that there are scientific evidence findings regarding differences in the strength of influence and the correlation between arm muscle strength, and intelligence quotient on forehand and backhand groundstroke abilities in the exercise group using the Massed Practice and Distributed Practice Group methods. The calculation of the significance value shows that high arm strength and intelligence quotient give significantly better results for forehand skills, compared to the group that has hand strength and low intelligence quotient in both study groups of Massed Practice and Distributed Practice. However, it can also be recommended that the results of this study can be generalized to groups of samples in the population with different numbers to obtain additional new data.

Discussion

The results showed that arm strength significantly influences the accuracy of groundstroke drive in tennis. The result is also strengthened by a similar study that states there is a significant contribution of the differences in training methods, and arm muscle strength towards the groundstroke ability in tennis drive. Similar finding is also stated by the current study that describes arm muscle strength as known to be an important factor to obtain optimal propulsion when making strokes in court tennis [1]. The study on Human Kinetics explained that greater arm muscle strength produces a strong hit with a high ball speed, the effect of the ball's gravity becomes low, and hence the ball is more controlled to be directed at the desired target [4]. In line with the findings, the effect of arm strength on force production was also explained in a biomechanical study which confirmed a positive correlation between a high level of arm strength on providing greater racket swing force [35], shortening the braking force of the ball while contact with the strings, thus produce in a greater ball bounce effect with a faster ball velocity [13]. It is expressed by the strength and conditioning study confirms that a high arm strength level provides a stable handgrip and stronger swing force on the racket [36], hence producing better racket control in both attacking and defending a position [21].

On the other hand, the findings of this study which state that there is no relationship between IQ scores of sports students on forehand and backhand skills are interesting to study further. These findings are debilitating neuro-cognitive studies that stated the existence of a positive influence between the level of intelligence on tennis skills. It is stated that intellectual intelligence has a prominent influence on the psychomotor intelligence of athletes [37]. Cognitive intelligence plays a role in the process of understanding and interpreting stimuli captured by the central nervous system [38], activating motor sensors, and executing movements as a reaction to stimuli with high coordination movements [39]. In this regard, neurophysiological findings also confirm that team sports athletes with high IQs tend to have good basic sports movement skills [40], and have a better quality of movement coordination in performing complex sports skill movements. It is highlighted by the motor learning study that the intelligence of students both during practice and competing proves to have a significant impact as a performance-determining factor for students in displaying a high level of movement skills [41].

Similar study confirmed that arm power can be significantly improved through the direct groundstroke drill that involves an arm muscle contraction in both directions of forehand and backhand alternately in the proper dose continuously [42]. Human motion study illustrated that a forehand drive movement skill in tennis is anatomically also influenced by antagonist muscle including a backhand motion that involves a posterior extension and abduction movement [43]. Consequently, it is required to implement an agonist and antagonist training method that continues to activate intramuscular coordination in both massed and distributed methods [44]. In line with the findings, the groundstroke skill is necessary for further review in the perception of the training methods, arm strength profile, and intelligence quotient that is assumed to be one of the scientific breakthroughs in training to improve the ability of tennis skill effectively and efficiently.

The study findings that explained there was no significant effect between intellectual intelligence on forehand and backhand abilities in this study, it was assumed that due to the limitations of the dependent variable, which only involved an intelligence test (IQ), contrarily does not involve other variables such as the Emotional Intelligence test (EQ). This opinion is based on growth and development studies which explain that intellectual intelligence has a significant reciprocal relationship to psychomotor abilities, and has a dominant role in forming mental attitudes, concentration, and focus when displaying motor skills [45]. The sports psychology study also explains that sports movement skills are not only influenced by IQ but also positively correlated to emotional intelligence [46]. Since tennis skills are affected by other variables including psychological domains that were not included in this study [47], it can be said that the measurement of tennis skills that only involves intellectual intelligence in this study is assumed not significantly correlated. This opinion is reinforced by the recent finding, which reveals that students with good IQ, supported with EQ and optimal muscle strength, have better groundstroke abilities [48].

The differences effect of exercise methods, arm strength, and IQ against tennis drive, however, require further scientific study. Another research expresses that traditional training drills improve the accuracy and stability more significantly of adolescent tennis players' strokes [49], meanwhile, the effect of machine-assisted training drills improves the stability of backspin strokes more significantly than topspin strokes [50]. It is strengthened by a current study that found significant differences in the groundstroke forehand ability between the drill training model employing a machine and a feeder [51]. In terms of the biomechanical aspects, a study shows a significant difference that athletes who use the foot position in a close stance provide better hitting accuracy and control compared with an open stance position during the groundstroke forehand driver [52]. This biomechanical approach can be used as a reference for learning basic stroke techniques by involving other bio-motor aspects, besides distributing proper methods of training according to the athlete's characteristics.

In the implementation of tennis training, it is necessary to pay attention to supporting factors such as the type of training method that is suitable for the athlete's characteristics, physical condition profile [53], and basic skills to be able to provide training loads according to abilities.

Determination of the right training method, cannot be separated from a series of learning processes or training processes that have been carried out in the form of special exercises, then gradually increased according to the development of the athlete's ability. The achievement of the quality of motion in groundstroke skills is influenced by several factors, namely basic movement abilities, exercises that have been experienced, a training environment with conducive feedback, and responsive trainers packaged with repetition of exercises and strengthening techniques [54]. In essence, groundstroke skills can only be learned or trained with certain requirements, including practicing these skills continuously for a certain sufficient period. This means that mastering tennis skills certainly takes time in practice and must be done continuously and systematically. One of the novelties and uniqueness of this study is that there is no correlation between IQ on forehand and backhand groundstroke abilities, while several studies explain that IQ is one of the determinants of the success of groundstroke skills. This difference in findings certainly cannot be generalized, therefore research involving more comprehensive samples and variables is needed to find out whether there are new findings related to the relationship between these variables and the tennis groundstroke ability of sports students.

Conclusions

The results of this study can be concluded that there is a correlation between exercise methods and arm muscle strength, but there is no correlation with intelligence quotient against tennis drive punches. But in this study, it is necessary to further identify the quality of physical condition, and the psychology of students to determine the achievement of court tennis according to the characteristics of the gender.

Conflict of interest

The authors declare no conflict of interest.

References

1. Fett J, Ulbricht A, Ferrauti A. Impact of Physical Performance and Anthropometric Characteristics on Serve Velocity in Elite Junior Tennis Players. *Journal of Strength and Conditioning Research*. 2020;34(1): 192–202. https://doi.org/10.1519/JSC.0000000000002641
2. Putri A, Ardisasmita MN. Gambaran kekuatan, daya tahan otot, power, kelentukan, kecepatan reaksi, dan daya tahan jantung paru atlet cabang olahraga tenis meja Jawa Barat pon XVIII/2012 riau berdasarkan standar koni pusat [Description of strength, muscular endurance, power, flexibility, reaction speed, and cardiopulmonary endurance of athletes in table tennis, West Java, pound XVIII/2012 Riau based on the central koni standard]. *Jurnal Ilmu Faal Olahraga Indonesia*. 2021;2(2): 40. (In Indonesian). https://doi.org/10.51671/jifo.v2i2.101
3. Sawali L. Drills forehand training strategy on the stroke of forehand drive ability in tennis. *International Journal of Physical Sciences and Engineering (IJPSE)*. 2018;2(2):11–20. https://doi.org/10.29332/ijpse.v2n2.133
4. Martínez-Gallego R, Guzmán JF, Crespo M, Ramón-Llin J, Vučković G. Technical, tactical and movement analysis of men's professional tennis on hard courts. *The Journal of Sports Medicine and Physical Fitness*. 2018;59(1). https://doi.org/10.23736/S0022-4707.17.07916-6
5. Saavedra JM, Porgeirsson S, Kristjansdottir H, Halldorsson K, Gudmundsdottir ML, Einarsson IP. Comparison of training volumes in different elite sportspersons according to sex, age, and sport

practised. Montenegrin J Sport Sci Med. 2018;7(2). https://doi.org/10.26773/mjssm.180906
6. Leite JV de M, Barbieri FA, Miyagi W, Malta E de S, Zagatto AM. Influence of Game Evolution and the Phase of Competition on Temporal Game Structure in High-Level Table Tennis Tournaments. *Journal of Human Kinetics*. 2017;55(1): 55–63. https://doi.org/10.1515/hukin-2016-0048
7. Zhang S, Mao H. Optimization Analysis of Tennis Players' Physical Fitness Index Based on Data Mining and Mobile Computing. Wu W (ed.) *Wireless Communications and Mobile Computing*. 2021;2021: 1–11. https://doi.org/10.1155/2021/9838477
8. Behzat Turan M, Dişçeken O, Kaya M. The Impact of Cognitive-based Learning and Imagery Training on Tennis Skills. *Universal Journal of Educational Research*. 2019;7(1): 244–249. https://doi.org/10.13189/ujer.2019.070131
9. Đurović N, Dizdar D, Zagorac N. Importance of hierarchical structure determining tennis performance for modern defensive baseliner. *Coll Antropol*. 2015;39:78–85.
10. Basiri F, Farsi A, Abdoli B, Kavyani M. The Effect of Visual and Tennis Training on Perceptual-Motor Skill and Learning of Forehand Drive in Table Tennis Players. *Journal of Modern Rehabilitation*. 2020;14(1): 21–32. https://doi.org/10.32598/JMR.14.1.3
11. Avilés C, Las Heras S, Ávila A. Motor learning and tennis basic stroke teaching for 3 and 4-year-old boys and girls. *ITF Coaching & Sport Science Review*. 2019;27(77): 3–6. https://doi.org/10.52383/itfcoaching.v27i77.101
12. Colomar J, Baiget E, Corbi F. Influence of Strength, Power, and Muscular Stiffness on Stroke Velocity in Junior Tennis Players. *Frontiers in Physiology*. 2020;11: 196. https://doi.org/10.3389/fphys.2020.00196
13. Suprunenko M. Biomechanical substantiation of motor and punch action formation in tennis by taking into account the formation of promising skills and abilities. *J Phys Educ Sport.* 2021;21(1):25–30.
14. Delgado-García G, Vanrenterghem J, Muñoz-García A, Molina-Molina A, Soto-Hermoso VM. Does stroke performance in amateur tennis players depend on functional power generating capacity? *The Journal of Sports Medicine and Physical Fitness*. 2019;59(5). https://doi.org/10.23736/S0022-4707.18.08518-3
15. Larson EJ, Guggenheimer JD. The effects of scaling tennis equipment on the forehand groundstroke performance of children. *J Sport Sci Med*. 2013;12(2):45–51.
16. Genevois C, Reid M, Rogowski I, Crespo M. Performance factors related to the different tennis backhand groundstrokes: A review. *Journal of Sports Science and Medicine*. 2014;14:45–52.
17. Yahya Y, Ali K, Tuba B. The effect of differential learning method on the international tennis number level among young tennis player candidates. *Educational Research and Reviews*. 2020;15(5): 253–260. https://doi.org/10.5897/ERR2020.3919
18. Fuentes-García JP, Pulido S, Morales N, Menayo R. Massed and distributed practice on learning the forehand shot in tennis. *International Journal of Sports Science & Coaching*. 2022;17(2): 318–324. https://doi.org/10.1177/17479541211028503
19. Alfonso-Asencio M, Gea-García GM, Menayo R. Induced variability, speed of the ball, and learning backhand shot for amateur tennis players. *J Sport Heal Res*. 2021;13(1):100–108.
20. Murphy AP. Methods of external and internal training load monitoring in elite tennis environments. *J Aust Strength Cond*. 2013;21(213):34–40.
21. Nanang Himawan Kusuma M. Mathematical simulation approach to diagnose performance limiting factor of shot put technique. *Journal of Physics: Conference Series*. 2021;1778(1): 012038. https://doi.org/10.1088/1742-6596/1778/1/012038
22. Abdelkader G, Arguz A, Himawan Kusuma MN, Erkmen N, Calişkan O, Madani R. Kinematical characteristics of accurate penalty-kicking for turkish football players in goalkeeper confrontation. *Acta Kinesiol.* 2021;2:112–9. https://doi.org/10.51371/issn.1840-2976.2021.15.2.15
23. Kusuma MNH. *Biomekanika olahraga* [Sports biomechanics]. Unsoed Press; 2019. (In Indonesian).
24. Spampinato D, Celnik P. Multiple Motor Learning Processes in Humans: Defining Their Neurophysiological Bases. *The Neuroscientist*. 2021;27(3): 246–267. https://doi.org/10.1177/1073858420939552
25. Furley PA, Memmert D. The role of working memory in sport. *International Review of Sport and Exercise Psychology*. 2010;3(2): 171–194. https://doi.org/10.1080/1750984X.2010.526238
26. Bowman JK, Boone RT, Goldman S, Auerbach A. The Athletic Intelligence Quotient and Performance Outcomes in Professional Baseball. *Frontiers in Psychology*. 2021;12: 629827. https://doi.org/10.3389/fpsyg.2021.629827
27. Himawan Kusuma MohN, Hidayat R, Listiadi AD, Widanita N, Anggraeni D, Komarudin. The effectiveness of multilateral drills on cognitive and psychomotor ability for male sport students. *Annals of Tropical Medicine & Public Health*. 2021;24(03). https://doi.org/10.36295/ASRO.2021.24347
28. Sönmez V. Association of Cognitive, Affective, Psychomotor and Intuitive Domains in Education, Sönmez Model. *Universal Journal of Educational Research*. 2017;5(3): 347–356. https://doi.org/10.13189/ujer.2017.050307
29. Society C. *Physical activity readiness questionnaire*. ACSM's Guidel Exerc Test Prescr.; 2002.
30. Markowitz JS. Body Mass Index (BMI). In: *Mortality and Its Risk Factors Among Professional Athletes*. Cham: Springer International Publishing; 2018. P. 39–49. https://doi.org/10.1007/978-3-319-77203-5_5
31. Yapıcı A, Akyüz Ö, Doruk M. The Relationship Between Biomotoric Properties and Hewitt Test Performance in 13-15 Years Old Tennis Players. *Journal*

of Education and Training Studies. 2018;6(12a): 13. https://doi.org/10.11114/jets.v7i1.3685
32. Hashim A, Ariffin A, Hashim AT, Yusof AB. Reliability and Validity of the 90° Push-Ups Test Protocol. *International Journal of Scientific Research and Management*. 2018;6(06). https://doi.org/10.18535/ijsrm/v6i6.pe01
33. Haqiyah A, Mulyana M, Widiastuti W, Riyadi DN. The Effect of Intelligence, Leg Muscle Strength, and Balance Towards The Learning Outcomes of Pencak Silat with Empty-Handed Single Artistic. *JETL (Journal of Education, Teaching and Learning)*. 2017;2(2): 211. https://doi.org/10.26737/jetl.v2i2.288
34. Shvetsova MN, Dolinskaya LA, Lukinova AV, Sotnikova MS, Solntseva AS. Design of The Learning Environment Considering the Gender Characteristics of Students. Ryabov VV (ed.) *SHS Web of Conferences*. 2020;79: 03013. https://doi.org/10.1051/shsconf/20207903013
35. Egesoy H, Oksuzoglu AY, Ilhan A. The effect of static and dynamic core training on some motoric charactristic and tennis service velocity of tennis athletes. *Int J Life Sci Pharma Res*. 2021;1:45–50.
36. Kwon S, Pfister R, Hager RL, Hunter I, Seeley MK. Influence of tennis racquet kinematics on ball topspin angular velocity and accuracy during the forehand groundstroke. *J Sport Sci Med*. 2017;16(4):56–62.
37. Winter DA. *Biomechanics and Motor Control of Human Movement*. 1st ed. Wiley; 2009. https://doi.org/10.1002/9780470549148
38. Cioncoloni D, Rosignoli D, Feurra M, Rossi S, Bonifazi M, Rossi A, et al. Role of brain hemispheric dominance in anticipatory postural control strategies. *Experimental Brain Research*. 2016;234(7): 1997–2005. https://doi.org/10.1007/s00221-016-4603-y
39. Cheron G, Petit G, Cheron J, Leroy A, Cebolla A, Cevallos C, et al. Brain Oscillations in Sport: Toward EEG Biomarkers of Performance. *Frontiers in Psychology*. 2016;7. https://doi.org/10.3389/fpsyg.2016.00246
40. Mutha PK, Haaland KY, Sainburg RL. The Effects of Brain Lateralization on Motor Control and Adaptation. *Journal of Motor Behavior*. 2012;44(6): 455–469. https://doi.org/10.1080/00222895.2012.747482
41. Rogasch NC, Dartnall TJ, Cirillo J, Nordstrom MA, Semmler JG. Corticomotor plasticity and learning of a ballistic thumb training task are diminished in older adults. *Journal of Applied Physiology*. 2009;107(6): 1874–1883. https://doi.org/10.1152/japplphysiol.00443.2009
42. Dovletmizovich Chermit K, Gennadievich Zabolotniy A, Vladimirovna Shakhanova A, Khangireevich Agirov A, Vasilyevna Chelyshkova A. Symmetry and Asymmetry of Kinematic Structure of Natural Human Locomotion. *Indian Journal of Science and Technology*. 2016;9(39). https://doi.org/10.17485/ijst/2016/v9i39/103427
43. Kolínský R, Zháněl J. Lateral differences in maximal grip strength in Czech male tennis players aged 11 – 12 in the context of injury prevention. *Studia Sportiva*. 2019;13(1): 55–62. https://doi.org/10.5817/StS2019-1-6
44. Salonikidis K, Zafeiridis A. The Effects of Plyometric, Tennis-Drills, and Combined Training on Reaction, Lateral and Linear Speed, Power, and Strength in Novice Tennis Players. *Journal of Strength and Conditioning Research*. 2008;22(1): 182–191. https://doi.org/10.1519/JSC.0b013e31815f57ad
45. Moura D, Oliveira da Silva T, Garcia V, Santos J. Effects of a functional training program in physical qualities of futsal athletes. *Rev Bras Futsal E Futeb*. 2018;124–9.
46. Hayashi CT. Foundations of Sport and Exercise Psychology. *J Sport Exerc Psychol*. 2016;2:34–41.
47. Kusuma MNH. Effect of cold water and contrast immersion on physiological and psychological responses of elite athletes after high-intensity exercises. *J Phys Educ Sport*. 2021;21(6):3278–87.
48. Kichenok N. Methods of physical training of tennis players for competitions. *Scientific Journal of National Pedagogical Dragomanov University. Series 15. Scientific and pedagogical problems of physical culture (physical culture and sports)*. 2021;6(137): 71–75. https://doi.org/10.31392/NPU-nc.series15.2021.6(137).16
49. Yeh IL, Elangovan N, Feczer R, Khosravani S, Mahnan A, Konczak J. Vibration-Damping technology in tennis racquets: Effects on vibration transfer to the arm, muscle fatigue and tennis performance. *Sport Med Heal Sci*. 2019;1(1):49–58. https://doi.org/10.1016/j.smhs.2019.09.001
50. Cao Z, Xiao Y, Lu M, Ren X, Zhang P. of Eye-closed and Weighted Multi-ball Training on the Improvement of the Stroke Effect of Adolescent Table Tennis Players. *Journal of Sports Science and Medicine*. 2020;19:34–42.
51. Fekih S, Zguira MS, Koubaa A, Masmoudi L, Bragazzi NL, Jarraya M. Effects of Motor Mental Imagery Training on Tennis Service Performance during the Ramadan Fasting: A Randomized, Controlled Trial. *Nutrients*. 2020;12(4): 1035. https://doi.org/10.3390/nu12041035
52. Martin C, Sorel A, Touzard P, Bideau B, Gaborit R, DeGroot H, et al. Influence of the forehand stance on knee biomechanics: Implications for potential injury risks in tennis players. *Journal of Sports Sciences*. 2021;39(9): 992–1000. https://doi.org/10.1080/02640414.2020.1853335
53. Nanang M, Fuad N, Didik R, Topo S, Panuwun J. Effect of Alkaline Fluids to Blood pH and Lactic Acid Changes on Sub Maximal Physical Exercise. *IOP Conference Series: Earth and Environmental Science*. 2018;197: 012049. https://doi.org/10.1088/1755-1315/197/1/012049
54. Krakauer JW, Hadjiosif AM, Xu J, Wong AL, Haith AM. Motor Learning. In: Terjung R (ed.) *Comprehensive Physiology*. 1st ed. Wiley; 2019. P. 613–663. https://doi.org/10.1002/cphy.c170043

Information about the authors:

Djoko Nugroho; (Corresponding Author); https://orcid.org/0000-0002-0350-7873; komarudinuny2022@gmail.com; Faculty of Sports, University of Sebelas Maret; Solo, Jawa Tengah, Indonesia.

Mohammad F. Hidayatullah; https://orcid.org/0000-0002-6870-6195; furqonhidayatulloh22@gmail.com; Faculty of Sports, University of Sebelas Maret; Solo, Jawa Tengah, Indonesia.

Muchsin Doewes; https://orcid.org/0000-0003-4799-2353; muchsindws@gmail.com; Faculty of Sports, University of Sebelas Maret; Solo, Jawa Tengah, Indonesia.

Sapta K. Purnama; https://orcid.org/0000-0002-4598-2090; Saptakuntapurnama60@gmail.com; Faculty of Sports, University of Sebelas Maret; Solo, Jawa Tengah, Indonesia.

Cite this article as:

Nugroho D, Hidayatullah MF, Doewes M, Purnama SK. The effects of massed and distributed drills, muscle strength, and intelligence quotients towards tennis groundstroke skills of sport students. *Pedagogy of Physical Culture and Sports,* 2023;27(1):14–23.
https://doi.org/10.15561/26649837.2023.0102

Received: 26.09.2022
Accepted: 29.11.2022; Published: 28.02.2023

ORIGINAL ARTICLE

The effects of Halliwick aquatic exercises on gross motor function of children aged from 3 to 5 years with spastic cerebral palsy

Somaia A. Hamed[1ABCDE], Mohamed M. ElMeligie[2ABCD], Efrem Kentiba[3CD]

[1]*Department of Physical Therapy for Paediatrics and Women Health, Faculty of Physical Therapy, Ahram Canadian University, Egypt*

[2]*Department of Basic Sciences, Faculty of Physical Therapy, Ahram Canadian University, Egypt*

[3]*Department of Sports Science, Arba Minch Education College, Arba Minch, Ethiopia*

Contribution of authors: A - Research design; B - Data collection; C - Statistical analysis; D - Preparation of the manuscript; E-Funds Collection.

Abstract

Background and Study Aim Cerebral palsy is a broad term for a variety of non-progressive, resulting in physical impairment, movement dysfunction, and poor posture. The purpose of the study was to compare the effectiveness in the Halliwick aquatic exercise versus conventional land-based therapy on gross motor function of children aged from 3 to 5 years with spastic cerebral palsy.

Material and Methods In this randomized controlled trial, (n=34) children diagnosed with spastic Cerebral palsy were randomly assigned into either the Halliwick concept group (n=17) or active control (conventional exercising group) (n=17). A physiotherapist performed the sessions with participants three times a week, 45 minutes duration over 12 weeks. An independent pediatric rehabilitation specialist assessed the children's gross motor function using the gross motor function measures (sitting, crawling and kneeling, standing, walking, running, and jumping).

Results After the intervention, both Halliwick concept group and conventional exercising group significantly improved activities of sitting, crawling & kneeling, standing and walking, running and jumping. Besides, the estimate of the effect of the Halliwick exercises on sitting, standing and walking, running & jumping activities was more clinically significant than conventional exercises, with sitting; MD = -0.06 [95%, CI; -0.19 to 0.32], standing; MD = 0.14 [95%, CI; -0.15-0.31], and walking, running & jumping activities; MD = -0.09 [95%, CI; -0.11 to 0.20]. None of the between-group differences for any remaining outcomes was significant.

Conclusions Aquatic exercises based on the Halliwick concept are better than conventional exercises to improve sitting, standing and walking, running and jumping activities in children aged 3 to 5 years with spastic cerebral palsy.

Keywords: Halliwick concept, conventional exercises, spastic cerebral palsy, aquatic exercises, walking

Introduction

Cerebral palsy (CP) is a diverse group of non-progressive, early-onset neuromotor disorders that impair the fetal or infant brain, resulting in physical disability, movement dysfunction, and poor posture [1]. The overall prevalence of CP is 2.11 per 1000 live births, rising to 111.80 per 1000 live births in children born before the 28th week of gestation [2]. The prevalence of CP varies by country, with Africa having the highest rates (2-10 cases per 100 births) [3].

Poor gross and fine motor function, abnormal motor control, muscle tone abnormalities, which may lead to lower joint range of motion, reduced muscle flexibility, and limited activities of daily living (ADL) such as walking, feeding, and dressing are all musculoskeletal symptoms of CP [4]. As a consequence, the child with CP can experience limitations on social integration, participation in activities, and reduced quality of life [5]. It is a dynamic disability that can be affected by regular physical exercises [6]. However, children with CP have limited ability to exercise due to the motor impairments associated with it [7]. Various forms of exercise therapy for CP exist in the literature, such as strengthening, stretching, balance training, and functional task oriented training [8]. Most of these exercises are land-based exercises which have been shown to improve gross motor function in children with CP [9, 10]. Despite the effectiveness of these exercises, there are certain environmental and psychological barriers to their use, such as discomfort, a lack of energy, and concern about an increased risk of injury [11].

Aquatic-based exercises are one of the most popular supplementary treatments for children with neuromotor impairments, particularly CP [12]. Aquatic exercises provide a safe and low-impact substitute for land-based workouts [9]. The Halliwick concept [13, 14, 15] is a task-based approach for aquatic exercises. Exercises following the Halliwick concept focus on restoring postural

doi:10.15561/26649837.2023.0103

control, reducing muscle stiffness and facilitating the movements using active and passive movements to achieve performance goals on the ground [16, 17]. According to the Halliwick idea, patients first learn how to balance in a stable posture before learning how to balance while traveling through the water in an unstable position [18, 19]. The idea has been shown to improve motor function in children with CP, although the evidence supporting this claim is poor and primarily based on observational studies [20, 21, 22, 23]. In recent years, parallel therapeutic approaches are gaining ground, which in combination with physiotherapy treatment contribute to the increase of therapeutic results in early and post-intervention for children with cerebral palsy. Therefore, the purpose of the study was to compare the effectiveness of the Halliwick aquatic exercise versus conventional land-based therapy on gross motor function of children aged 3 to 5 years of age with spastic cerebral palsy.

Material and Methods

Participants

The study was conducted in an outpatient physical therapy clinic of a University Hospital in Giza, Egypt, from June 2021 to October 2021. Participants were recruited from three hospitals in Cairo, Egypt (National institute of neuromuscular disorders, October 6 University hospital and Al-Hosary hospital).

Participants must exhibit the following characters to be considered for inclusion: diagnosed with spastic cerebral palsy (SCP) according to worldwide CP diagnosis guidelines [24], have spasticity of grade two or less on the modified Ashworth scale [25], were between the ages of three and five years and able to understand and follow commands. Exclusion criteria were:

1) use of oral antispastic medication or botulinum toxin injections.
2) surgery performed less than 90 days before enrollment.
3) severe visual or auditory impairment.
4) uncontrollable epilepsy (defined as the occurrence of seizures despite the use of at least one antiepileptic drug).
5) children with severe psychosocial or behavioral problems, such as high aggression or risk of self-harm cognitive disorders during the pediatric evaluation of disability inventory.
6) presence of open wounds, active infection, or severe cardiopulmonary issues that prevent the practice of exercises.

Ethical Approval and Informed Consent

Ethics committee of faculty of physical therapy, Kafr ElSheikh University approved the study protocol and issues approval code P.P/WH/3/2021/9. The protocol for this study was registered under the number NCT05094921 at clinicaltrials.gov registry platform. Parents of the participating children gave their informed consent.

Research Design

In this randomized controlled trial eligible participants (n=34) were randomly assigned into either the Halliwick concept group (HCG, n=17) or active control (conventional exercising group) (CEG, n=17) using a computer-generated randomization list, which was maintained in sealed numbered envelopes to maintain anonymity (Figure 1). A single physiotherapist performed the sessions with each participant individually for all sessions over the 12 weeks. The 45-minute sessions were conducted three times a week on non-consecutive days.

Conventional exercises aimed to improve motor function based on different approaches:

1) use of neuro-developmental techniques aiming to improve the pattern of normal movement through muscle tone normalization, inhibition of abnormal reflexes, and facilitation of normal postural response.
2) Back and abdominal exercises to improve postural control and correct spinal deformities.
3) Postural response improvement using facilitation of righting, balance, and protective reactions from sitting on a roll and ball, and standing on balance board by tilting the child in different directions forward, backward, and sideways.
4) Flexibility exercises for Achilles tendon, hamstrings, hip flexors, and hip adductors elasticity.
5) Strengthening exercise for knee extensors, hip abductors, and ankle dorsiflexion muscles using graduated active exercise.
6) Functional exercises to improve standing, weight transfer, shift, and facilitation of normal walking patterns.

The Halliwick exercises were based on the 10-point program of the Halliwick Concept [13, 14, 15, 16] (Table 1). An experienced aquatic therapist certified by International Aquatic Therapy Faculty (IATF) supervised the exercises which included water adjustment skills, longitudinal rotations, sagittal rotations, and swimming skills. The therapist instructed the child to perform the exercises properly while ensuring the child's safety by using floatation devices, body boards, or float belts when necessary. Water exercises were performed on a heated pool equipped with ramps, chair lifts, stairs, and handrails to facilitate a child's ability to access the pool. The 30-min session comprised a 5-min warm-up, followed by a 20-min session based on the Halliwick Concept [14, 15, 21] and ended with a 5-min cooldown period. During the warm-up period of the first session the

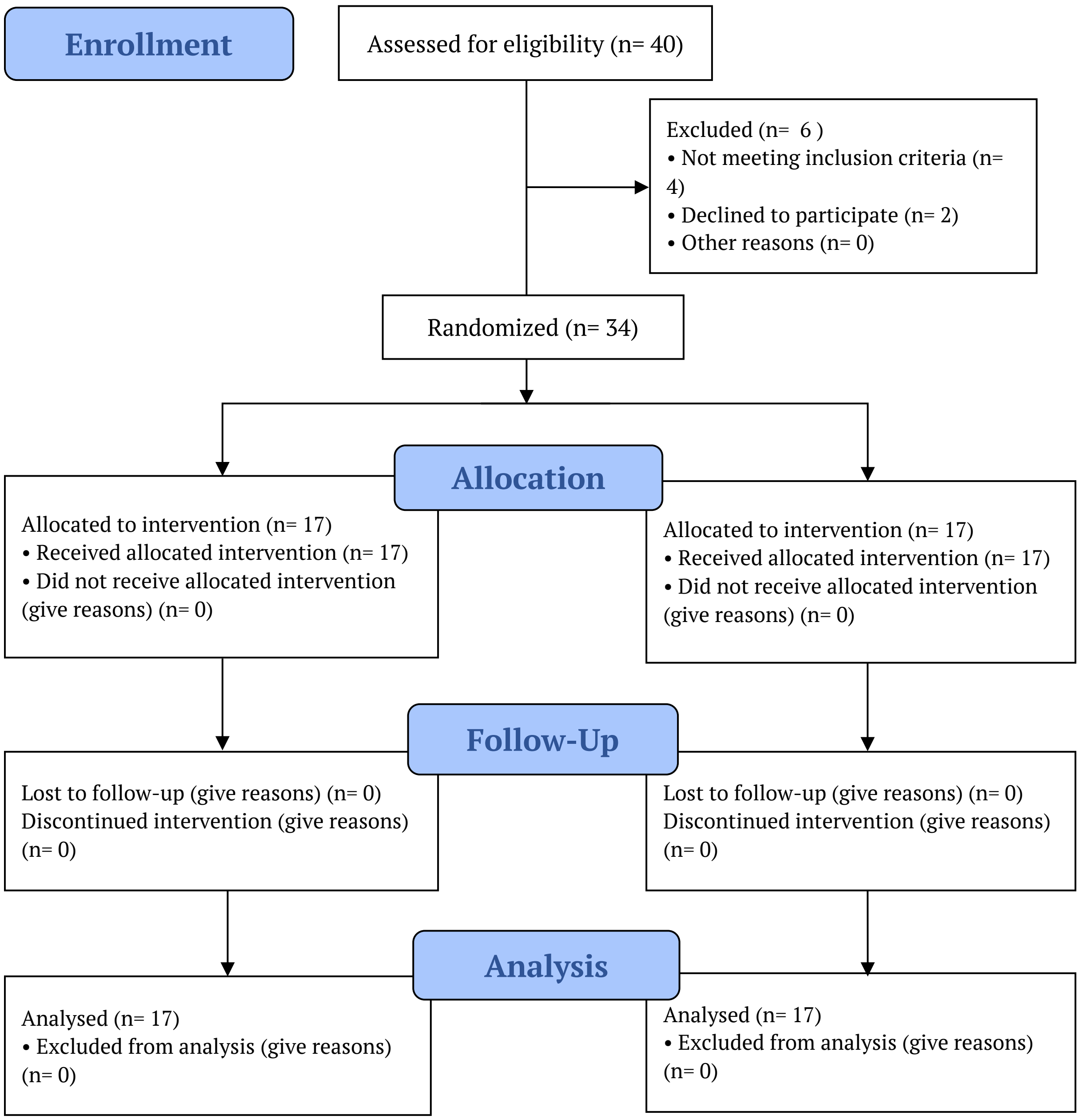

Figure 1. Study Flow Diagram

child received water orientation to get used to the water. In the subsequent sessions, the warm up consisted of a quick recap of the previous session, before moving on to the next point in the program. The cool-down period consisted of free play such as splashing and jumping in the water as well as diving down under the water [21].

An experienced pediatric physician observed all participants for adverse reactions such as seizures, nausea, behavioral changes, or severe discomfort. At the end of each treatment session, the children and/or their caregivers in the SG were consulted about potential side effects.

Outcome measurements

An independent pediatric rehabilitation specialist assessed the child's gross motor function. The evaluator was blinded to participants' allocation and did not participate in the treatment of the patients. The gross motor function measure (GMFM) test included 88 items that evaluated five dimensions. All items in lying and rolling, sitting, crawling and kneeling was performed on a mat. All items in (5) standing, walking, running and jumping were performed on the floor [26]. Scoring of each item was determined according to a study by Ko and Kim [27] (i.e., 0 = no initiation; 1 = task initiation <10%; 2 = complete the task partially 10% < 100%; or 3= task completion).

Statistical analysis

We employed descriptive methods to summarize the data, mean (SD) for continuous data and frequency (percentage) for categorical data. Data were screened by conducting Shapiro-

Table 1. Detailed description of the Halliwick concept points of progression [13, 21].

Points	Description
Point 1 - Mental adjustment	The stage in which the swimmer learns to be in the water with sufficient confidence to experience water positively. The process includes learning to blow out or hum when the mouth or nose comes in contact with the water.
Point 2 – Disengagement	The process allows the swimmers further develop their confidence and which allows them to start exploring the environment, moving away from the poolside, pool floor or the support of the therapist.
Point 3 - Transversal rotation control	Development of the ability to control rotation around a transversal axis. For example, the sequence of floating on the back to reaching a vertical position in the water, pivoting around an axis which passes through both hips.
Point 4 - Sagittal rotation control	Development of the ability to control rotation around a sagittal axis. For example, remaining vertical when reaching for an object placed to the side of the body and preventing pivoting around an axis perpendicular to the frontal plane of the body.
Point 5 - Longitudinal rotation control	Development of the ability to control rotational movements taking place around a longitudinal axis. For example, preventing the rotation to the right side generated when turning the head to the right while floating horizontally on the back. In this example, the person is preventing rotation around an axis perpendicular to a transversal plane.
Point 6 - Combined rotation control	Process for controlling any combinations of the above described rotations. At this point, the swimmer initiates or prevents several rotations at once. For example, moving forward from a vertical position to achieve a position floating on the back.
Point 7 - Up-thrust	Process by which the swimmer learns that the water can help him or her to stay at the surface. Having this experience increases the swimmer's confidence to cope with less or no support.
Point 8 - Balance in stillness	Development of the ability to respond in a controlled way when unsupported in the water and balance is challenged.
Point 9 - Turbulent gliding	Development of the ability to move through water with no direct support from the instructor and without making propulsive movements. For example, in a back float, the swimmer's body is in motion thanks to the turbulence generated by the instructor's hands and/ or body. This helps the swimmer to maintain balance in stillness while experiencing increasing forces disturbing the position of his body in the water.
Point 10 - Simple progression or basic swimming strokes	Development of the ability to use simple movements to create propulsion; for example, clapping the hands on the thighs when in a back float to propel the body through the water. From the use of simple movements, more sophisticated swimming movements or strokes can be learned.

Wilks normality tests as a pre-requisite for parametric analysis. As all variables were not normally distributed, nonparametric tests were used.

For the GMFM before and after therapy, a mixed design multivariate analysis of variance (MANOVA) was used to compare the two groups. The α level was set at 0.05 to determine statistical significance. Stata for Windows, version 11 was used for statistical analysis (StataCorp, LLC).

Results

Thirty-four children aged between 3 to 5 years with cerebral palsy fulfilled the eligibility criteria. The age, weight, height and sex distribution of the participants did not significantly differ between groups ($p > 0.05$; Table 2), so the groups were well-matched at the entry-level.

Both groups showed statistically significant improvements on all items of the gross motor function measure except total GMFM scores of the conventional exercising groups when the baseline score compared with the end line ($p<0.05$; Table 3). Before the intervention, no significant difference in any of the measures was observed between the two groups ($p > 0.05$). Whereas, after the intervention, the estimate of the effect of the Halliwick exercises on sitting, standing and walking, running & jumping activities was more clinically significant than conventional exercises, with sitting; MD = -0.06 [95%, CI, -0.19-0.32], $p<0.045$, standing; MD = 0.14 [95%, CI-0.15-0.31], $p<0.017$ and walking, running & jumping activities; MD = -0.09 [95%, CI-0.11-0.20], $p < 0.008$. None of the between-group differences for any remaining outcomes was statistically significant ($p>0.05$; Table 3).

Table 2. Baseline characteristics of participants from both groups.

Values	HCG		CEG		p-value
	Mean±SD	Frequency (%)	Mean±SD	Frequency (%)	
Female		12 (70.6)		10 (58.8)	
Male		5 (29.4)		7 (41.2)	
Age (years)	4.62 ±0.41		4.51±0.40		0.434
Height (cm)	102.14± 2.93		101.82 ± 3.90		0.589
Weight (Kg)	16.24 ± 0.71		16.05 ± 0.66		0.211
Cerebral Palsy Subtype					
Diplegia		6 (35.3)		9 (53)	
Hemiplegia		11 (64.7)		8 (47)	

HCG= Halliwick concept group, Conventional exercise group (CEG), SD= Standard deviation

Table 3. Mean ±SD the five GMFM dimensions before and after treatment in both groups

Variables	HCG	CEG	MD, 95%,CI	p-value
	Mean ±SD	Mean ±SD		
Sitting				
Pre-test	0.35±0.30	0.41 ±0.32	-0.06 [-0.27-0.16]	0.587
Post-test	0.63±0.36	0.64±0.33	-0.01[-0.25-0.23]	0.045*
MD	-0.28	-0.23		
p-value	0.010*	0.024*		
Crawling and kneeling				
Pre-test	0.29±0.29	0.25 ±0.27	-0.04 [-0.15-0.24]	0.902
Post-test	0.52±0.37	0.46±0.36	-0.06 [-0.19-0.32]	0.660
MD	-0.23	-0.21		
p-value	0.020*	0.004*		
Standing				
Pre-test	0.13±0.27	0.04 ±0.06	-0.09 [-0.14-0.23]	0.624
Post-test	0.39±0.34	0.25±0.26	0.14 [-0.15-0.31]	0.017*
MD	-0.26	-0.22		
p-value	0.039*	0.003*		
Walking, jumping, running				
Pre-test	0.07±0.19	0.01 ±0.03	-0.06 [-0.14-0.15]	0.280
Post-test	0.14±0.21	0.05±0.07	-0.09 [-0.11-0.20]	0.008*
MD	-0.08	-0.04		
p-value	0.023*	0.026*		
Total GMFM				
Pre-test	0.19±0.15	0.18 ±0.11	-0.11 [-0.08-0.10]	0.807
Post-test	0.29±0.22	0.22±0.11	-0.07 [-0.14-0.19]	0.221
MD	-0.011	-0.04		
p-value	0.035*	0.205		

*Significant at 95% Confidence interval, CI= Confidence interval, SD=standard deviation; MD, mean difference, $p < 0.05$, HCG= Halliwick concept group, Conventional exercise group (CEG)

Discussion

This study aimed to compare the effectiveness of the Halliwick aquatic exercise with conventional land-based therapy on gross motor function of children aged from 3 to 5 years with spastic cerebral palsy. We found that both Halliwick aquatic exercises and conventional exercises significantly improved activities of sitting, crawling and kneeling, standing, walking, running and jumping. Besides, there is evidence of a beneficial effect of the Hallwick aquatic method on sitting, standing, walking, running & jumping activities compared to conventional exercises.

Few studies had examined the effectiveness of aquatic therapies for patients with CP providing limited and weak evidence [28]. The reported evidence reveals that the Halliwick concept improves basic movement skills like sitting, walking, running, jumping, kneeling, crawling, etc. This finding is in agreement with our study regardless of age. A beneficial effect of the Hallwick aquatic method on sitting, walking, running & jumping activities compared to conventional exercises might be attributed to the fact that children engaged in aquatic activities using the Halliwick Concept learn on their own and, they always work at one to one with a personal instructor who knows when and how to progress [22]. Besides, the Halliwick concept teaches independence allowing the child to move and swim without the help of others, which contributes to improving self-esteem and self-awareness [29]. Children may see the activity on water as a recreational or sporting activity, increasing adherence to the program [22].

Furthermore, the Halliwick concept focuses on trunk rotation and core stabilization that may provide changes in trunk control which enhances the majority of the fundamental movement skills mentioned above [29]. Such changes may be mediated by plastic changes at the motor cortex or elsewhere in the motor system. Moreover, people performing aquatic exercises are exposed to the thermal and mechanical effects of the water, influencing various body systems [23, 30]. While the thermal properties help with pain and spasticity, the mechanical properties of the water decrease the gravity effect and joint loading, providing postural support and resistance, contributing to increasing muscular strength [23]. In addition, the water viscosity prevents the individual from falling immediately during the exercises, allowing them to experience a movement pattern with a temporary displacement of the center of gravity outside the base of support without the fear of falling [31]. This mechanism aid in the explanation of the effects of the Halliwick aquatic exercises on sitting, walking, running & jumping activities because a stable trunk is a requirement to perform these activities properly [32], which may facilitate the initiation of movements that are restricted on land exercises.

This study provides a rationale for why those in the Halliwick group, who had trunk and core stabilization training underwater, experienced more improvements in sitting, walking, running & jumping activities than those in the conventional exercise group, who had no such training. Although the Halliwick concept is based on rotational movements, balance and floating activities, the carry-over effects to land activities are higher than other aquatic exercises that mimic land-based exercises [21].

This study was performed in an outpatient university hospital. Thus, the results of this study should be generalizable to groups of patients with similar characteristics (i.e., patients with spastic cerebral palsy without any severe psychosocial or behavioral problems, such as high aggression or risk of self-harm). The implementation of a well-defined age-appropriate Halliwick Concept for 3 to 5 years old children with spastic cerebral palsy is the main strength of this study. Also, we hope that aquatic therapists with appropriate training would be able to perform this intervention similarly for other age groups or populations. Besides, our study has no follow-up assessments, due to that, we were unable to evaluate retention of the effects in the medium or long term.

Conclusions

This study provides evidence that aquatic exercises based on the Halliwick concept are better than conventional exercises to improve sitting, standing and walking, running & jumping activities in children aged from 3 to 5 years with spastic cerebral palsy.

Conflict of interests

There are no conflicts of interest that are relating to this article.

References

1. Sadowska M, Sarecka-Hujar B, Kopyta I. Cerebral Palsy: Current Opinions on Definition, Epidemiology, Risk Factors, Classification and Treatment Options. *Neuropsychiatric Disease and Treatment,* 2020; 16: 1505–1518. https://doi.org/10.2147/NDT.S235165
2. Oskoui M, Coutinho F, Dykeman J, Jetté N, Pringsheim T. An update on the prevalence of cerebral palsy: a systematic review and meta-analysis. *Developmental Medicine & Child Neurology,* 2013;55(6): 509–519. https://doi.org/10.1111/dmcn.12080
3. Donald KA, Samia P, Kakooza-Mwesige A, Bearden D. Pediatric Cerebral Palsy in Africa: A Systematic Review. *Seminars in Pediatric Neurology*, 2014;21(1): 30–35. https://doi.org/10.1016/j.spen.2014.01.001
4. Akinola BI, Gbiri CA, Odebiyi DO. Effect of a 10-week aquatic exercise training program on gross motor function in children with spastic cerebral palsy. *Global Pediatric Health,* 2019; 6: 2333794X19857378. https://doi.org/10.1177/2333794X19857378
5. Makris T, Dorstyn D, Crettenden A. Quality of life in children and adolescents with cerebral palsy: a systematic review with meta-analysis. *Disability and Rehabilitation,* 2021; 43: 299–308. https://doi.org/10.1080/09638288.2019.1623852
6. Jorgić B, Dimitrijević L, Lambeck J. Effects of aquatic programs in children and adolescents with cerebral palsy: systematic review. *Sport Science,* 2012; 5: 49–56.
7. Aisen ML, Kerkovich D, Mast J, Mulroy S, Wren TA, Kay RM, et al. Cerebral palsy: clinical care and neurological rehabilitation. *The Lancet Neurology*, 2011;10(9): 844–852. https://doi.org/10.1016/S1474-4422(11)70176-4
8. Franki I, Desloovere K, Cat J, Feys H, Molenaers G, Calders P, et al. The evidence-base for basic physical therapy techniques targeting lower limb function in children with cerebral palsy: A systematic review using the International Classification of Functioning, Disability and Health as a conceptual framework. *Journal of Rehabilitation Medicine*, 2012;44(5): 385–395. https://doi.org/10.2340/16501977-0983
9. Fragala MA, Goodgold S, Dumas HM. Effects of lower extremity passive stretching: pilot study of children and youth with severe limitations in self-mobility. *Pediatric Physical Therapy* 2003; 15: 167–175. https://doi.org/10.1097/01.PEP.0000083045.13914.D4
10. Pin T, Dyke P, Chan M. The effectiveness of passive stretching in children with cerebral palsy. *Developmental Medicine and Child Neurology,* 2006; 48: 855–862. https://doi.org/10.1017/S0012162206001836
11. Verschuren O, Wiart L, Hermans D, Ketelaar M. Identification of Facilitators and Barriers to Physical Activity in Children and Adolescents with Cerebral Palsy. *The Journal of Pediatrics*, 2012;161(3): 488–494. https://doi.org/10.1016/j.jpeds.2012.02.042
12. Getz M, Hutzler Y, Vermeer A. Effects of aquatic interventions in children with neuromotor impairments: a systematic review of the literature. *Clinical Rehabilitation,* 2006; 20: 927–936. https://doi.org/10.1177/0269215506070693
13. *Halliwick swimming for disabled people.* 3rd edn. London: Halliwick AST National Education Committee; 2010.
14. Lambeck J, Stanant FC. The Halliwick concept, part II. *The Journal of Aquatic Physical Therapy,* 2001; 9: 7–12.
15. Lambeck J, Gamper U. The Halliwick Concept [Internet]; 2022 Oct 05 [cited 2022 Oct 10]. Available from: https://www.ewacmedical.com/wp-content/uploads/2017/08/The-Halliwick®-Concept-by-Johan-Lambeck-and-Urs-Gamper-2010-1.pdf
16. Rohn S, Novak Pavlic M, Rosenbaum P. Exploring the use of Halliwick aquatic therapy in the rehabilitation of children with disabilities: A scoping review. *Child: Care, Health and Development* 2021; 47: 733–743. https://doi.org/10.1111/cch.12887
17. Gresswell A. The Halliwick Concept: An Approach to Teaching Swimming. *Palaestra*, 2015;29(1):27–31.
18. Brody LT, Geigle PR. *Aquatic exercise for rehabilitation and training*. Human Kinetics; 2009. https://doi.org/10.5040/9781718210691
19. Bolarinwa Isaac Akinola. Aquatic Exercise Intervention Is Effective for Spasticity Inhibition in Children with Cerebral Palsy: A Clinical Controlled Study. *Prog Asp in Pediatric & Neonat.*, 3(2)- 2021;3(2):225–231. https://doi.org/10.32474/PAPN.2021.03.000156
20. Declerck M. *Effect of aquatic intervention on the gross motor function and quality of life of children with cerebral palsy*. [Unpublished Master Thesis]. Faculty Kinesiology and Rehabilitation Sciences; 2010.
21. Ballington SJ, Naidoo R. The carry-over effect of an aquatic-based intervention in children with cerebral palsy. *African Journal of Disability*, 2018;7: 361–361. https://doi.org/10.4102/ajod.v7i0.361
22. Chandolias K, Zarra E, Chalkia A, Hristara A. The effect of hydrotherapy according to Halliwick concept on children with cerebral palsy and the evaluation of their balance: a randomised clinical trial. *International Journal of Clinical Trials*, 2022;9(4): 234. https://doi.org/10.18203/2349-3259.ijct20222656
23. Vascakova T, Kudlacek M, Barrett U. Halliwick Concept of Swimming and its Influence on Motoric Competencies of Children with Severe Disabilities. *European Journal of Adapted Physical Activity,* 2015; 8: 44–49. https://doi.org/10.5507/euj.2015.008
24. Bax M, Goldstein M, Rosenbaum P, Leviton A, Paneth N, Dan B, et al. Proposed definition and classification of cerebral palsy, April 2005. *Developmental Medicine & Child Neurology*, 2005;47(8): 571–576. https://doi.org/10.1017/S001216220500112X
25. Mutlu A, Livanelioglu A, Gunel MK. Reliability of Ashworth and Modified Ashworth Scales in Children with Spastic Cerebral Palsy. *BMC Musculoskeletal Disorders*, 2008;9(1): 44. https://doi.org/10.1186/1471-2474-9-44

26. Nordmark E, Hägglund G, Jarnlo GB. Reliability of the gross motor function measure in cerebral palsy. *Scand J Rehabil Med.,* 1997; 29: 25–28.
27. Ko J, Kim M. Reliability and responsiveness of the gross motor function measure-88 in children with cerebral palsy. *Physical Therapy,* 2013; 93: 393–400. https://doi.org/10.2522/ptj.20110374
28. Salse-Batán J, Suárez-Iglesias D, Sanchez-Lastra MA, Ayán Pérez C. Aquatic exercise for people with intellectual disabilities: findings from a systematic review. *International Journal of Developmental Disabilities*, 2021; 1–13. https://doi.org/10.1080/20473869.2021.1924033
29. Garcia MK, Joares EC, Silva MA, Bissolotti RR, Oliveira S, Battistella LR. The Halliwick Concept, inclusion and participation through aquatic functional activities. *Acta Fisiátrica*, 2012;19(3): 142–150. https://doi.org/10.5935/0104-7795.20120022
30. Mooventhan A, Nivethitha L. Scientific evidence-based effects of hydrotherapy on various systems of the body. *N Am J Med Sci.,* 2014; 6: 199–209. https://doi.org/10.4103/1947-2714.132935
31. Torres-Ronda L, Del Alcázar XSI. The Properties of Water and their Applications for Training. *J Hum Kinet* 2014; 44: 237–248. https://doi.org/10.2478/hukin-2014-0129
32. Shih HS, Gordon J, Kulig K. Trunk control during gait: Walking with wide and narrow step widths present distinct challenges. *J Biomech.,* 2021; 114: 110135. https://doi.org/10.1016/j.jbiomech.2020.110135

Information about the authors:

Somaia A. Hamed; https://orcid.org/0000-0001-9794-7353; somaia.ali@acu.edu.eg; Department of Physical Therapy for Pediatrics and Women Health, Faculty of Physical Therapy, Ahram Canadian University, Egypt.

Mohamed M. ElMeligie; https://orcid.org/0000-0002-3090-5252; Mohamed.elmeligie@acu.edu.eg; Department of Basic Sciences, Faculty of Physical Therapy, Ahram Canadian University, Egypt.

Efrem Kentiba; (Corresponding author); http://orcid.org/0000-0001-7013-2605; efre89@gmail.com; Department of Sports Science, Arba Minch College of Teachers Education; Arba Minch, Ethiopia.

Cite this article as:

Hamed SA, ElMeligie MM, Kentiba E. The effects of Halliwick aquatic exercises on gross motor function of children aged from 3 to 5 years with spastic cerebral palsy. *Pedagogy of Physical Culture and Sports,* 2023;27(1):24–31.
https://doi.org/10.15561/26649837.2023.0103

Received: 03.11.2022
Accepted: 06.12.2022; Published: 28.02.2023

ORIGINAL ARTICLE

Occurrence and trends of musculoskeletal pain among ski instructors

Denis Čaušević[1ABCDE], Erol Kovačević[1ABD], Semir Mašić[1ABD], Siniša Kovač[1,2A], Seth Spicer[3D]

[1] Faculty of Sport and Physical Education, University of Sarajevo, Bosnia and Hezegovina
[2]Ski Trainers and Ski Instructors Association in Bosnia and Hezegovina, Bosnia and Hezegovina
[3]Rowan University School of Osteopathic Medicine, USA

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

Abstract

Background and Study Aim Musculoskeletal disorders (MSD) are incredibly common and are often related to work load. For any occupational or public health intervention, injury prevention is preferred to injury treatment. Occupational health and injury prevention research has the potential to help mitigate MSD in the workplace. The aim of this study was to determine how the work demands of ski instructors may affect the health of their musculoskeletal system.

Material and Methods A cross-sectional study involved the participation of 87 ski instructors (age = 34.61 ±10.67) in Bosnia and Herzegovina (ATUS in Bosnia and Herzegovina). Observed variables were the prevalence of MSD measured using a modified Nordic questionnaire about injuries during the previous ski season (neck, shoulders, elbows, wrist, upper back, lower back, one or both hips, one or both knees, and ankle). Means and standard deviations for each of the variables were calculated, and differences between genders were examined using an independent sample t-test.

Results Prevalence of MSDs in ski instructors was most common in neck (13.8%), shoulders (12.6%), elbows (4.6%), wrist (9.2%), upper back (10.3%), lower back (46.0%), one or both hips (9.2%), one or both knees (29.9%), and ankle (9.2%). The results showed statistically significant differences in MSD between genders in the neck (p=.034); shoulders (p=.017); upper back (p=.027); one or both knees (p=.003) and in the ankle joint (p=.011).

Conclusions MSD's are common in ski instructors, especially in the low back and knees of female employees. Future research or injury prevention programs would benefit these populations.

Keywords: skiing, injuries, health issues, musculoskeletal disorders, occupation, kinesiology

Introduction

Injury prevention and safety is a core tenant of public health programs, especially in occupational contexts. Every work activity carries a certain degree of load and stress, which can be physical, mental, or emotional. The process of teaching and motor learning in kinesiology presents the teacher with the above-mentioned components of stress. The level of the teacher's workload is influenced by several factors, such as the complexity of the movement, the demonstration and explanation of the movement, the level of knowledge required, motivation, number of students, as well as the working environment in which the learning process takes place. Skiing is a very specific and demanding movement activity, which places significant physical and mental demands on the instructors. The process of ski instruction is composed of motor learning principles and hands on work by the teacher. Kinesiology as a science applies to the understanding of both facets of workload in the workplace and the optimization of motor learning. Kinesiology of work is part of general kinesiology, i.e. the science of movement, which integrates all knowledge from the field of kinesiology and adapts it to the specifics of different workplaces. The basic goal of occupational kinesiology is to contribute, as part of a multidisciplinary approach, to the preservation and the improvement of human health in the work process [1].

Considering the very specific working conditions of ski instructors, experience has shown that they, as well as other workers with increased physical loads, experience musculoskeletal disorders accompanied by painful conditions and a decrease in work ability. In the research conducted by Roberts [2] on ski instructors, the results showed that they have poor stability of the lumbar spine, knees, and shoulders. The author further stated that there are other potential factors that contribute to occupational injuries, such as the impact of mild hypoglycemia and dehydration on measures of psychomotor alertness. These included cognition, attention, and motor reaction time. The causes of musculoskeletal disorders and the occurrence of pain are multifactorial, from which endogenous-genetic and exogenous factors of external influence can be distinguished. For this study, exogenous factors are particularly interesting due to the unique nature of the burden of daily work activities involving ski instructors. It is possible to talk about the causes of musculoskeletal disorders

doi:10.15561/26649837.2023.0104

from the aspect of quantity and quality of postural movement habits.

The quantity of work refers to the weight of the load that the worker handles, the number of repetitions of a work task, the speed at which the worker works, the amplitude of movement and the time of holding a certain position of the body, which can be the cause of some form of injury and pain [3]. The quantity of work refers to the total mechanical load of the musculoskeletal system due to performing work activities or taking irregular positions. From the position of a ski instructor, there is certainly the time spent on skis, the number of repetitions of movements such as bending down and/or lifting clients, time spent sitting on the lift, climatic conditions such as exposure to low temperatures, the hardness of the surface, and the choice of ski equipment. Ski instructors and patrollers are most exposed to the risk of injury and have one of the highest classifications of occupational injury rates of all industry sectors [2]. Their increased risk of injury, compared to other participants in winter sports, may be due to more hours and days spent on the track during the season [4]. Haddock [5] states that all factors that contribute to injuries should be considered, such as equipment (design, development and care), environment (weather, terrain, snow conditions), and people (attributes, attitudes, skills). Because occupational kinesiology is a relatively young scientific discipline, there is not much research that has determined the professional load or the frequency of musculoskeletal disorders among skiing instructors. The main goal of this study is to determine the prevalence of symptoms of musculoskeletal disorders among ski instructors. The intent of this study is to determine how the work demands of ski instructors may affect the health of their musculoskeletal system. Considering the impressive demands on ski instructors, insights gained from this study may elucidate possible target areas for future workplace injury preventative programs.

Material and Methods

Participants

A total of 145 mailing addresses of ski instructors who are members of the association in BiH were collected, and the results of 87 ski instructors (age = 34.61 ±10.67) were included in this research. Because this study did not take into account how acute trauma and the consequences of acute trauma affect the health of ski instructors, the processing and interpretation of data did not include subjects who declared that they were injured in a skiing or other accident.

Ethical considerations. Participation in the study was voluntary and anonymous. Participants were provided informed consent.

Study design

A cross-sectional study was conducted. The mailing list of ski instructors in Bosnia and Herzegovina (ATUS in Bosnia and Herzegovina) was obtained from the Management of ATUS. The main instrument in this study was the modified Nordic questionnaire. The respondents were asked the following: Have you at any time during the last ski season had trouble (neck, shoulders, elbows, wrist, upper back, lower back, one or both hips, one or both knees, and ankle) (Yes, No). Data were collected in 2022. An online survey with a cover letter was developed. The cover letter fully explained the purpose of the study and asked for voluntary participation. A survey questionnaire was used on the representation of symptoms of musculoskeletal disorders by self-assessment through a modified Nordic questionnaire (Eng. Standardized Nordic questionnaires for the analysis of musculoskeletal symptoms) [6]. The questionnaire consists of two parts and the modifications related to the appearance of symptoms in the ski season (not in 12 months as in the original). The survey inquired about age, gender, years of ski instruction experience, average number of days of work during the season, time spent in ski training during one day, and questions about injuries during the previous ski season (neck, shoulders, elbows, wrist, upper back, lower back, one or both hips, one or both knees, and ankle). The survey and cover letter were mailed after the 2021/2022 ski season at the last lecture of the Association of Ski Trainers and Teachers in BiH (April 12, 2022).

Statistical analysis

Descriptive statistical analysis was carried out by computing the means and standard deviations for each of the variables of interest. Baseline differences were examined using an independent sample t-test. Data analysis was performed using IBM SPSS Statistics for Windows (Version 21.0. SPSS Inc. Chicago. IL. USA).

Results

The research included 87 instructors, of which 65 were men (74.71%) and 22 were women (25.29%). The average age of the treated group of ski instructors in Bosnia and Herzegovina was 34.61 years, and the average length of service as the instructors was 6.52 years. When it comes to the previous season, the instructors spent an average of 61.21 days (5.72 hours per day) on the mountain doing their instructor work (Table 1).

When it comes to the prevalence of symptoms of musculoskeletal disorders in the previous season, instructors reported symptoms in the following regions: neck (13.8%), shoulders (12.6%), elbows (4.6%), wrist (9.2%), upper back (10.3%), lower back (46.0%), one or both hips (9.2%), one or both knees (29.9%), and ankle (9.2%) (Table 2.).

Table 1. Characteristics of participants

Variables	Total			Male			Female		
	n	Mean	St.dev	n	Mean	St.dev	n	Mean	St.dev
Age	87	34.61	10.67	65	37.58	9.40	22	25.82	9.38
How long have you been working as a ski instructor?	87	6.52	4.14	65	7.23	3.95	22	4.41	4.04
How many days did you work as a ski instructor last season?	87	61.21	35.48	65	61.85	35.54	22	59.32	36.03
How much time do you spend on skis on average during the day?	87	5.72	1.25	65	5.46	1.07	22	6.50	1.40

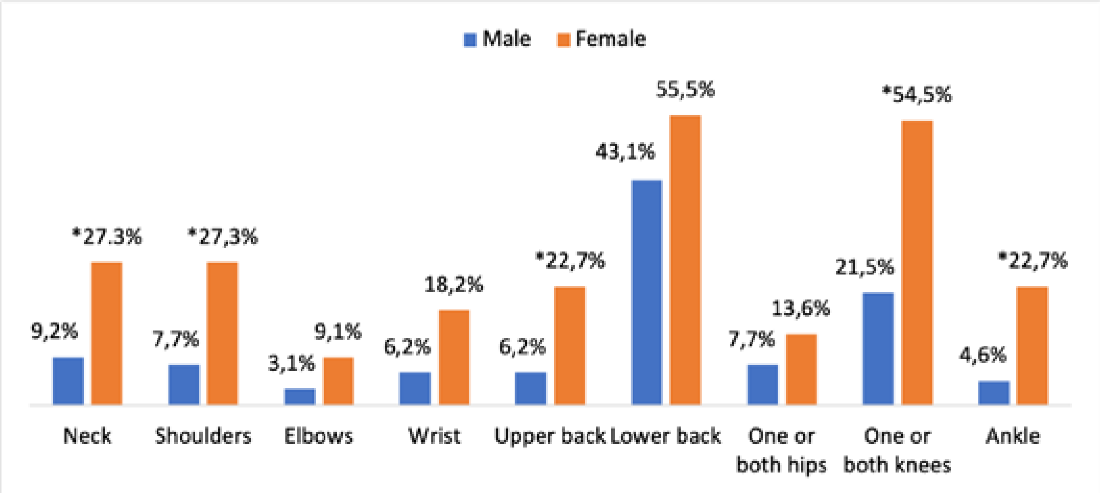

Figure 1. Percentage difference between MSD among male and female ski instructors. "*" Indicates a statistically significant difference.

Table 2. Musculoskeletal disorders among ski instructors

MSD		Total		Male		Female		T - test
		n	%	n	%	n	%	
Neck	**No**	75	86.2	59	90.8	16	72.7	.034*
	Yes	12	13.8	6	9.2	6	27.3	
Shoulders	**No**	76	87.4	60	92.3	16	72.7	.017*
	Yes	11	12.6	5	7.7	6	27.3	
Elbows	**No**	83	95.4	63	96.9	20	90.9	.249
	Yes	4	4.6	2	3.1	2	9.1	
Wrist joint	**No**	79	90.8	61	93.8	18	81.8	.094
	Yes	8	9.2	4	6.2	4	18.2	
Upper back	**No**	78	89.7	61	93.8	17	77.3	.027*
	Yes	9	10.3	4	6.2	5	22.7	
Lower back	**No**	47	54.0	37	56.9	10	45.5	.357
	Yes	40	46.0	28	43.1	12	55.5	
One or both hips	**No**	79	90.8	60	92.3	19	86.4	.410
	Yes	8	9.2	5	7.7	3	13.6	
One or both knees	**No**	61	70.1	51	78.5	10	45.5	.003*
	Yes	26	29.9	14	21.5	12	54.5	
Ankle joint	**No**	79	90.8	62	95.4	17	77.3	.011*
	Yes	8	9.2	3	4.6	5	22.7	

Legend: MSD - musculoskeletal disorders; * - $p \leqslant 0.05$

Discussion

The main purpose of this study was to determine how cumulative trauma caused by the work of ski instructors affects the prevalence of symptoms of musculoskeletal disorders in ski instructors with the intent to direct future injury prevention programs. The results showed that in the past ski season, the incidence of musculoskeletal disorders for certain body segments among ski instructors in Bosnia and Herzegovina was between 9.2% and 46% (Figure 1.). Although there is a very small number of studies that studied this problem, the stated results can be compared with some studies that determined the prevalence of musculoskeletal disorders or the onset of injuries among ski instructors. Thus [7] state that the majority of instructors (67%) experienced a serious injury while skiing or had problems with painful conditions. If we look at the highest incidence of painful conditions in a particular body region, low back pain at 46% is certainly and unequivocally the biggest problem among ski instructors in Bosnia and Herzegovina. No significant differences in frequency between men and women were found. The above data are in accordance with the research by Peacock et al. [8] who state that 75% of ski instructors reported a history of low back pain. These data fit with the results obtained in the general population and the population of working-age people. According to Eurostat [9], during 2013, 8% of the total EU population reported some form of musculoskeletal problems, while 55% of that population was absent from work because of them. Of the total percentage of reported diseases caused or related to work, 60% were related to musculoskeletal disorders and most often MSD was associated with the back. It is estimated that 80% of the population experiences pain in the low back at least once during their lifetime, which recurs in at least 50% of these patients. The problem of "back pain" most often occurs in the most productive period of a person's life, between thirty and fifty years of age, equally often in people of both sexes [10]. For these reasons, in 2020 it launched a campaign called "Healthy Workplaces Lighten the Load".

When talking about the causes of this phenomenon, it was determined that 90% of all low back pain is the so-called mechanical low back pain associated with biomechanical stress [11]. In this sense, Supej et al. [12], among other reasons, state that numerous studies have shown that exposure to vibration is associated with lower back pain. The results of their study showed that all forms of alpine skiing produce vibrations and such observations reveal that WBV (whole-body vibrations) is a significant risk factor for LBP (low back pain) in alpine skiers, and therefore in ski instructors.

The next most common problem among ski instructors is pain in one or both knees (29.9%), which is consistent with research (27% to 41%) [13, 14, 15]. It is interesting to note that there is a statistically significant difference in the incidence of knee pain in women (54.5%) compared to men (21.5%). The cause of this is likely related to anatomical differences between men and women such as an increased Q angle in women. Widening the pelvis reduces the angle between the neck and the trunk of the femur, which alters the kinetics at the knee and hip joints. Consequently, the anatomical position and movement of the lower extremities is slightly different [16]. In particular cases, there is "miserable malalignment syndrome". This represents a combination of three anatomical variations of the lower extremities (anteversion of the femur, external rotation of the tibia, and increased Q angle) that can present in women that likely predisposes them to instability, knee pain, and ultimately more frequent anterior cruciate ligament injury [17]. Rochman [18] states that research has shown that non-contact injuries of the anterior cruciate ligament are 2-3 times more common in female athletes than in male athletes. This syndrome, along with differences in neuromuscular reflex response, hormonal status (the influence of estrogen receptors on ligaments), and of course differences in training, causes up to 7 times higher frequency of anterior cruciate ligament injuries and higher frequency of patellofemoral syndrome in female athletes compared to male athletes [16].

It is interesting that in 5 out of 9 body regions (neck, shoulders, upper back, knee and ankle), women have a significantly higher frequency of painful conditions. There are explanations in the literature that refer to the higher frequency of injuries of women in sports with possible reasons for this. Simek et al. [19] state that women are exposed to a greater risk of injury in training and competition. The reason for this is the anthropological characteristics of women, such as a wider pelvis, less developed strength, greater mobility in the joints, etc. Thus, the ligamentous structures are more frequently put into disadvantageous positions and are more likely to be strained. These conclusions can be taken as relevant in the context of suggesting an explanation for the obtained results of this study. It is possible that female instructors have a greater biomechanical strain on the locomotor apparatus when performing the same tasks relative to men, which puts them in a disadvantageous position in the context of the occurrence of overload and the occurrence of musculoskeletal disorders. If this activity happens every day, overexertion syndrome occurs. Overexertion syndrome is chronic in nature, because repeated trauma over time overcomes the ability to regenerate tissues (tendons, bones, cartilage, mucous membranes or muscles) [20]. In addition, irregular movement patterns that cause cumulative damage to anatomical structures caused by the continuous application of non-physiological positions and non-functional movements are most often cited as the causes of musculoskeletal disorders in the literature. When correcting irregular movement patterns, occupational kinesiology emphasizes intermuscular coordination and joint mobility. Muscle imbalance that occurs in 100% of low back pain can hardly be the cause of low back pain. It is necessary to determine the cause of the muscle imbalance, and then the back pain. The cause of muscle imbalance is improper posture and improper movement patterns. All of the above results in muscle imbalances, a breakdown of intermuscular coordination with a consequent general breakdown of the statics of the whole body, and changes in the relationships between anatomical structures over time. In other words, due to the continuous application of non-physiological positions and non-functional movements, i.e. mechanisms of cumulative trauma, structural and functional changes of anatomical structures occur over time. By correcting improper postural and movement habits, i.e. continuous application of physiological positions and functional movements, it is possible to stop the progression of structural changes in hard tissues [21]. This, combined with the findings, suggests that future workplace health programs or future research into injury prevention may be beneficial for this population.

Conclusions

The incidence of musculoskeletal disorders among ski instructors in the past ski season ranged between 9.2% and 46%. As expected, the largest number of respondents of both sexes stated that they had problems with lower back pain during the past ski season. Lumbar pain syndrome is one of the most common health problems today and the most common cause of absenteeism from work. In the context of occupational safety of ski instructors, it is important to pay attention to the quality of work, which refers to the way the body is held when performing daily work tasks. For example, when lifting clients from a sitting position to an upright position on skis, demonstrating techniques, etc. By determining the primary risk factors when performing professional activities, in this case ski instructors, stressors that lead to the appearance of painful conditions in the musculoskeletal system can be prevented or prepared for accordingly. Aside from the low back findings, it is possible to conclude that there is a statistically significant difference in the frequency of painful musculoskeletal disorders between woman and male ski instructors where women are more afflicted. Specifically, in 5 of the 9 body regions tested, painful conditions of the musculoskeletal system appeared more often in women.

Conflict of interest

No conflict of interest.

References

1. Nakić J, Kovačević E, Abazović E. Kineziologija rada: bolovi u leđima i tehnike dizanja terete [Occupational kinesiology: back pain and load lifting techniques]. *Sigurnost: časopis za sigurnost u radnoj i životnoj okolini,* 2018;60(2):137–48. (In Bosnian). https://doi.org/10.31306/s.60.2.4
2. Roberts D. Injury prevention for ski-area employees: a physiological assessment of lift operators, instructors, and patrollers. *BioMed Research International,* 2013;2013. https://doi.org/10.1155/2013/121832
3. Nakić J. *Occupational Kinesiology: Basics of Correct Manual Handling in the Printing Industry*. Trade Union in Printing and Publishing Industry of Croatia; 2019.
4. Dickson TJ, Waddington G, Terwiel FA. Snowsport experience, expertise, lower limb injury and somatosensory ability. *Journal of Science and Medicine in Sport,* 2019;22:S17–21. https://doi.org/10.1016/j.jsams.2018.08.005
5. Haddock C. *Outdoor safety: risk management for outdoor leaders*. New Zealand Mountain Safety Council; 2004.
6. Kuorinka I, Jonsson B, Kilbom A, Vinterberg H, Biering-Sørensen F, Andersson G, Jørgensen K. Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. *Applied Ergonomics,* 1987;18(3):233–7. https://doi.org/10.1016/0003-6870(87)90010-X
7. Dickson TJ, Terwiel FA. Snowsport Instructors: Their Actual Maximum Speeds, Their Estimation of Maximum Speed and Speed in Slow Zones, and Their Knowledge of Helmet Effectiveness. In: Scher IS, Greenwald RM, Petrone N (eds.) *Snow Sports Trauma and Safety*, Cham: Springer International Publishing; 2017. P. 175–187. https://doi.org/10.1007/978-3-319-52755-0_14
8. Peacock N, Walker JA, Fogg R, Dudley K. Prevalence of low back pain in alpine ski instructors. *Journal of Orthopaedic & Sports Physical Therapy*, 2005;35(2):106–10. https://doi.org/10.2519/jospt.2005.35.2.106
9. Eurostat. *ESS agreement - LFS 2013 ad-hoc module on 'accidents at work and other work-related health problems'*; 2013.
10. Mačak-Hadžiamerović A, Čustović-Hadžimuratović A, Mujezinović A. *Vodič za prevenciju i tretman lumbalnog bolnog sindroma* [A guide to the prevention and treatment of lumbar pain syndrome]. Sarajevo: Ministarstvo zdravstva kantona Sarajevo; 2009. (In Bosnian).
11. Grazio S, Ćurković B, Vlak T. Dijagnostika i konzervativno liječenje križobolje: pregled i

smjernice Hrvatskog vertebrološkog društva [Diagnosis and conservative treatment of low back pain: review and guidelines of the croatian vertebrologic society]. *Acta medica Croatica: Časopis Akademije medicinskih znanosti Hrvatske,* 2012;66(4):259–93. (In Bosnian).
12. Supej M, Ogrin J, Holmberg HC. Whole-body vibrations associated with alpine skiing: a risk factor for low back pain?. *Frontiers in Physiology*, 2018:204. https://doi.org/10.3389/fphys.2018.00204
13. Burtscher M, Gatterer H, Flatz M, Sommersacher R, Woldrich T, Ruedl G, Hotter B, Lee A, Nachbauer W. Effects of modern ski equipment on the overall injury rate and the pattern of injury location in Alpine skiing. *Clinical Journal of Sport Medicine*, 2008;18(4):355–7. https://doi.org/10.1097/MJT.0b013e31815fd0fe
14. Johnson RJ, Shealy JE, Langran M, [eds.]. *Skiing Trauma and Safety: 17th Volume*. 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959: ASTM International; 2009. https://doi.org/10.1520/STP1510-EB
15. Patrick E, Cooper JG, Daniels J. Changes in skiing and snowboarding injury epidemiology and attitudes to safety in Big Sky, Montana, USA: a comparison of 2 cross-sectional studies in 1996 and 2013. *Orthopaedic Journal of Sports Medicine,* 2015;3(6):2325967115588280. https://doi.org/10.1177/2325967115588280
16. Ireland ML, Ott SM. Special concerns of the female athlete. *Clinics in Sports Medicine,* 2004;23(2):281–98. https://doi.org/10.1016/j.csm.2004.04.003
17. Myer GD, Ford KR, Hewett TE. Methodological approaches and rationale for training to prevent anterior cruciate ligament injuries in female athletes. *Scandinavian Journal of Medicine & Science in Sports,* 2004;14(5):275–85. https://doi.org/10.1111/j.1600-0838.2004.00410.x
18. Rochman S. Gender inequity. *Training and Conditioning*, 1996;6(5):10–20.
19. Šimek S, Nakić J, Trošt T. Specifičnosti kondicijskog treninga sportašica [Specifics of fitness training of female athletes]. *Kondicijska priprema sportaša*, 2003;1:64–72. (In Croatian).
20. Borić I, Ivelj R, Leko M, Bojanić I, Roić G. Radiološka dijagnostika sindroma prenaprezanja u djece i adolescenata [Radiological diagnostics of overuse injuries in children and adolescents]. *Paediatria Croatica*, 2007;51(3):97–103. (In Croatian).
21. Nakić J. Kineziologija rada: Povezanost posturalno-kretnih navika i simptoma mišićno-koštanih poremećaja administrativnih radnika [Kinesiology of work: The connection between postural-movement habits and symptoms of musculoskeletal disorders of administrative workers]. Ministry of Labour, Pension System, Family and Social Policy, Directorate for Labor and Occupational Safety, Zagreb; 2022. (In Croatian).

Information about the authors:

Denis Čaušević; (Corresponding Author); https://orcid.org/0000-0003-2400-9352; denis.causevic@fasto.unsa.ba; Faculty of Sports and Physical Education, University of Sarajevo; Sarajevo, Bosnia and Hercegovina.

Erol Kovačević; https://orcid.org/0000-0003-4391-6070; erol.kovacevic@fasto.unsa.ba; Faculty of Sports and Physical Education, University of Sarajevo; Sarajevo, Bosnia and Hercegovina.

Semir Mašić; https://orcid.org/0000-0003-0042-5255; semir.masic@fasto.unsa.ba; Faculty of Sports and Physical Education, University of Sarajevo; Sarajevo, Bosnia and Hercegovina.

Siniša Kovač; https://orcid.org/0000-0003-3496-0272; sinisa.kovac@fasto.unsa.ba; Faculty of Sports and Physical Education, University of Sarajevo; Sarajevo, Bosnia and Hercegovina.

Seth Spicer; https://orcid.org/0000-0001-9309-5923; spicer39@rowan.edu; Rowan University School of Osteopathic Medicine, Stratford New Jersey, USA.

Cite this article as:

Čaušević D, Kovačević E, Mašić S, Kovač S, Spicer S. Occurrence and trends of musculoskeletal pain among ski instructors. *Pedagogy of Physical Culture and Sports,* 2023;27(1):32–37.
https://doi.org/10.15561/26649837.2023.0104

Received: 03.11.2022
Accepted: 06.12.2022; Published: 28.02.2023

ORIGINAL ARTICLE

Comparative analysis of psychophysiological features of taekwondo athletes of different age groups

Leonid Podrigalo[1ABCDE], Vyacheslav Romanenko[1ABCDE], Olha Podrihalo[1,2ABCDE], Sergii Iermakov[3BCD], Anatolyi Huba[1BDE], Volodymyr Perevoznyk[1BDE], Olexandr Podavalenko [1BDE]

[1] *Kharkiv State Academy of Physical Culture, Kharkiv, Ukraine*
[2] *National University of Physical Education and Sport of Ukraine, Ukraine*
[3] *Kharkiv State Academy of Design and Arts, Ukraine*

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

Abstract

Background and Study Aim The importance of psychophysiological features in optimizing the functional state of athletes is beyond doubt. The aim of this study was a comparative analysis of the psychophysiological features of taekwondo athletes of different age groups.

Material and Methods The study involved 42 taekwondo athletes, skill level 2 Gup – 1 Dan. The participants were divided into groups of 14 people. Group 1 – (7.50±0.14) years, Group 2 – (10.07±0.22) years, Group 3 – (13.36±0.27) years. A special computer program for devices with the iOS operating system was used. The Apple iPad, 4th generation with a screen diagonal of 9.7 inches was used. The following tests were used: reaction choice (RC), reaction to a moving object (RMO) and size test (ST). The results of the groups were compared using the nonparametric Rosenbaum test (Q), and the Pearson correlation coefficient (r) was determined.

Results RMO test results in group 2 were significantly better than those in group 1 (Q=12, p<0.01). A similar correlation was determined for RC (Q=14, p<0.01) and ST (Q=15, p<0.01). When analyzing the frequency of incorrect reactions in RMO, it was found that athletes in the 1st group lagged behind more often (Q=6, p<0.05). A comparison of groups 2 and 3 confirmed that senior athletes had better results in RC (Q=11, p<0.01). For all tests used, the best results of group 3 compared with group 1 was determined: for RMO Q=16, (p<0.01), for RC Q=22, (p<0.01), for ST Q=20, (p<0.01). Senior athletes often had an anticipatory reaction in RMO, (Q=7, p<0.05). Significant correlations (p<0.05) were determined in group 1 between age and frequencies of anticipatory (r=-0.57) and lagging reactions (r=0.57), RMO and RC (r=0.63), RC and frequencies of anticipatory reactions (r=0.57) and lagging reactions (r=-0.57). In group 3, significant correlations were determined between age and RC (r=-0.59), RMO and RC (r=0.76), age and ST (r=-0.53), RMO and ST (r=0.65), RC and ST (r =0.79).

Conclusions A change in the speed of reaction to various stimuli of taekwondo athletes of different ages has been confirmed. An increase in age and training experience improves the reaction rate. This dependence is most pronounced when comparing junior and senior athletes. The determined correlations between all tests used also reflect the improvement in the psychophysiological state of the athletes with increasing age. The tests used are characterized by accessibility, specificity, informativeness and financial feasibility. The results obtained allow for recommending their use in monitoring the state of martial arts athletes.

Keywords: combat sports, taekwondo, sensorimotor reactions, age groups, correlation analysis.

Introduction

The importance of psychophysiological features in optimizing the functional state of athletes is beyond doubt. The study by Klymovych et al. [1] describes the developed experimental technology for acquiring professional-applied motor skills. The approbation of the program confirmed a significant improvement in such psychophysiological qualities as strength, mobility, and balance of the nervous system.

The impact of certain sports on cognitive sensorimotor abilities and basic brain functions was assessed in the study [2]. The authors analyzed the features of the psychophysiological state of athletes in martial arts, rock climbing, and racket. People who did not engage in sports were the control group. It is shown that martial arts athletes had the best indicators of reaction time. The test performance was the most stable with the lowest number of errors. These athletes show the best motor readiness. The highest activity associated with postperceptual processing of attention was also determined in martial arts athletes. It is concluded that martial arts can provide the best functional level for athletes.

The speed of reaction to various stimuli occupies a leading place among the success factors in martial arts [2, 3]. It largely determines effective defensive

doi:10.15561/26649837.2023.0105

and attacking actions. We proposed to use this psychophysiological indicator for the classification of paraathletes [3].

It has been confirmed that the reaction time, strength and accuracy of the strike are among the most important factors in the state of martial arts athletes [2, 3, 4]. It is proposed to use them for monitoring the functional state of athletes. Controlling these factors is especially important in terms of preparing for competitions and losing weight [4].

Speed is one of the decisive factors for victory in martial arts. In the study by Yao [5], the influence of various training methods on the reaction rate of fencers was studied. The results confirmed the improvement of this indicator under the influence of the methods used. The selective response test was more informative than the simple response test. A conclusion is reached about the need for specific training to improve the reaction rate.

The effectiveness of attacking movements in fencing was studied in the study of Borysiuk et al. [6]. A set of special tests was used to analyze the condition of elite fencers. The presence of a strong correlation dependence of the reaction time and movement times with the activation time of the limb muscles was determined.

The systematic review synthesized the current evidence on the feasibility of volitional reaction time (RT) tests to evaluate the information processing abilities of athletes [7]. The most important downside of most implemented RT tests is their nonspecific nature (i.e., stimulus and response did not resemble the sports actions). Sports scientists should focus on developing RT tests specific for each sport and refine the testing procedures to obtain accurate, reproducible, and sensitive measurements of RT.

The reliability and sensitivity of the reaction rate test in quasi-realistic football situations were studied in the study of Tomic et al. [8]. The specificity of the sport led to the study of the reaction time of the legs. The states of the athletes and the control groups were compared. The results of the athletes were significantly better. The high reliability of the test used was confirmed.

Thus, the available results confirm the relevance of the study of the psychophysiological characteristics of athletes for monitoring their state, selection, and prediction of the growth of sportsmanship. It is of interest to evaluate the features of the speed of reaction to various stimuli of martial arts athletes of different age groups. Based on the foregoing, the aim of this study was a comparative analysis of the psychophysiological features of taekwondo athletes of different ages.

Materials and Methods

Participants

The study involved 42 taekwondo athletes, representatives of the Vulkan Sports and Youth Sports School in Cherkasy, Ukraine, skill level 2 Gup – 1 Dan. The participants were divided into groups of 14 people depending on age: group 1 – average age (7.50±0.14) years, group 2 – (10.07±0.22) years, group 3 – (13.36±0.27) years.

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

Study design

The design of the study involved a complex of psychophysiological tests to assess the body's sensory systems. A special computer program for devices with the iOS operating system was used. The Apple iPad, 4th generation with a screen diagonal of 9.7 inches was used. The battery of tests included 3 functional tests.

Reaction choice (RC) or a complex visual-motor reaction was assessed by the reaction time to a stimulus with certain qualitative characteristics. In our case, stimuli of the same shape and size were used (5 circles). They appeared on the screen in a certain place simultaneously, but in an arbitrary sequence according to the manifestation of a signal feature (color) and did not move. The person being studied had to choose one circle of a given color as quickly as possible.

The reaction to a moving object (RMO) is to stop the object in a given place at a given speed of the object. The accuracy of performance was estimated by the time of deviation from the specified one. Stopping a moving object before a certain limit was counted as an error.

Size test (ST): it is necessary to fix the moment when the size of the gradually increasing circle matches the size of the template. The test can be performed in two versions – with the use of visual control and without it. The time when a circle changes at a constant speed corresponding to the dimensions of the template (standard) is equal.

Statistical analysis

Statistical analysis of the obtained data was carried out using licensed MS Excel. Descriptive statistics were determined the following: arithmetic mean (X), standard deviation (SD), and error of the mean (m). Considering the small size of the groups, the significance of differences was assessed using a non-parametric indicator – the Rosenbaum criterion

Table 1. Results of psychophysiological tests of taekwondo athletes of different age groups (X±SD)

Indicator	1 group (n=14)	2 group (n=14)	3 group (n=14)
The reaction to a moving object, ms	38.45±14.87	24.48±7.85	20.36±4.50
Anticipatory reaction, %	50.07±10.79	45.82±10.73	42.77±14.77
Lagged behind reaction, %	49.93±10.79	54.18±10.73	57.23±14.77
Reaction choice, ms	877.77±92.57	748.33±83.90	620.09±78.23
Size test, ms	1.26±0.13	1.06±0.10	0.95±0.10

(Q), the differences were considered significant at ($p<0.05$). The Pearson correlation coefficient (r) between the results of each group was determined. The correlation was considered significant at r not less than 0.5 ($p<0.05$).

Results

The obtained results are shown in Table 1.

The use of the nonparametric Rosenbaum test confirmed the presence of significant differences between the groups. RMO results in group 2 were significantly better than those in group 1 (Q=12, $p<0.01$). A similar correlation was determined for RC (Q=14, $p<0.01$) and ST (Q=15, $p<0.01$). When analyzing the frequency of incorrect reactions in RMO, it was found that athletes in the 1st group lagged behind more often (Q=6, $p<0.05$).

A comparison of groups 2 and 3 confirmed only one significant difference. Senior athletes had the best results in RC (Q=11, $p<0.01$).

For all tests used, the best results of group 3 were determined compared with group 1. The Rosenbaum criterion was for RMO Q=16, ($p<0.01$), for RC Q=22, ($p<0.01$), and for ST Q=20, ($p< 0.01$). Senior athletes often had an anticipatory reaction in RMO, (Q=7, $p<0.05$).

Interesting data were obtained from the analysis of correlations between test results. Significant correlations ($p<0.05$) were determined in group 1 between age and frequencies of anticipatory (r=-0.57) and lagging reactions (r=0.57), RMO and RC (r=0.63), RC and frequencies of anticipatory reactions (r=0.57) and lagging reactions (r=-0.57).

There was no significant dependence in group 2.

5 significant correlations were determined in group 3 and group 1. These are the correlations between age and RC (r=-0.59), RMO and RC (r=0.76), age and ST (r=-0.53), RMO and ST (r=0.65), RC and ST (r=0.79).

Discussion

The effectiveness of the analysis of the athletes' state is directly dependent on the chosen assessment method. The selection should be performed by considering the specifics of the sport, the validity, and representativeness of the methods, and the information content of individual criteria. This approach was tested in the study of Rovnaya et al. [9]. Its effectiveness has been confirmed in the analysis of the state of artistic swimming athletes of different skill levels.

Indexes are a simple, visual, and informative tool for assessing the condition of athletes. This method was used for the comparative analysis of athletes of various types of martial arts [10]. The battery of indices included indicators reflecting the specifics of the impact of sports on the body of athletes. The possibility of using these indicators to predict the success and growth of sportsmanship has been confirmed.

The selection and prediction systems in sports should include tests that evaluate attention, reaction speed, and concentration [11]. The reliability of the methods used and the relevance of the applied parameters were confirmed. Another way to improve the efficiency of analysis is to use the principle of complexity. Study by Logan et al. [12] and by Butenko et al. [13] is based on the application of such an approach. Various tests were used to assess the level of motor skills development. The use of complementary tests allows for a comprehensive assessment.

We used a battery of tests on the Apple iPad, 4th generation. This device allows testing directly in training. This significantly increases the information content of the results obtained and allows for effective monitoring of the athletes' state.

The use of multimedia technologies in sports and physical education is a promising direction at present. The use of mobile applications, interactive technologies, and computer tests can significantly increase the effectiveness of training and helps increase motivation.

The use of computer tests is a promising and convenient method for analyzing the state of athletes. The computer training program Rugby-5 is used for this purpose in the physical culture classes [14]. It is proved that this development contributed to an increase in the level of the functional state of the body of pupils.

The distribution of gadgets increases the efficiency and applicability of mobile applications. The effectiveness of the TReaction mobile application was evaluated in the study by Coswig et al. [15]. This is a mobile app developed to determine strike response time at low cost and with easy application in combat sports. The findings suggest that the TReaction app is a valid tool for evaluating the response time in combat sports athletes.

The participation of athletes of different ages in the study makes it possible to assess the dynamics of their readiness, which depends on the training experience. This makes it possible to evaluate the influence of physiological features of development on the functional state of athletes. The study of such influence is important for predicting success.

The analysis of psychophysiological features is widely used when comparing the state of athletes at different levels of training. These qualities make it possible to objectively assess the condition of athletes, predict the growth of sportsmanship and success. Differences between taekwondo athletes with different levels of competition were analyzed in the study by De la Fuente et al. [16]. The winner athletes have the best reaction times. It is concluded that it is necessary to use such an analysis for selection.

Similar data were obtained in the study by Sarmet Moreira et al. [17]. The authors evaluated the performance parameters of the dollyo chagui in elite taekwondo athletes and subelite taekwondo athletes. The reaction time, co-contraction and speed of kicks are discriminant factors concerning the competitive level.

Our results confirm the data presented in the study by Chen et al. [18]. The authors compared the perceptual-motor abilities of karate and taekwondo athletes and those who did not practice martial arts. The speed of perception on the Covert Orienting of Visual Attention (COVAT) task was the best among taekwondo athletes. There were no differences between the groups in terms of the number of test performance errors. The results show that athletes involved in different types of martial arts demonstrate different profiles of perceptual-motor performance.

The results of the tests carried out confirm the improvement in results in direct proportion to the age of the participants. This can be explained by the increase in the experience with sports activities. It is known that the reaction speed is not trained as strength or endurance. However, certain improvements in this quality can be achieved in the process of specific sports. This is confirmed by the results of previous studies [3, 5, 7]. Additionally, the used tests are specific to martial arts. The possibility of using these tests to predict success in martial arts has been confirmed by Romanenko et al. [19].

The RMO test should be regarded as particularly important for the state assessment of martial arts athletes. The task is to stop a moving object in a given place, simulating a typical duel situation. The opponent makes an attack, it is necessary to perform a defensive action. The conditions for performing the test make it possible to evaluate not only the speed, but the ability of the athlete to evaluate his actions. Significantly better results of senior athletes demonstrate a high level of sportsmanship and a better level of tactical training.

An analysis of the frequency of incorrect reactions in the RMO test confirms the assumptions made. The junior participants most often give a lagged reaction, and the senior, in contrast, anticipatory one. In our opinion, this reflects an increased level of readiness in senior athletes. They have a better ability to concentrate and mobilize. This coincides with the available results of the analysis of the psychophysiological characteristics of martial arts athletes [18].

Similar results are given in the study by Gierczuk and Ljach [20]. The authors used computer tests to assess the development of motor skills in wrestlers. In Greco-Roman wrestling athletes, the information content of tests that study reaction speed, frequency of movements, spatial orientation, and adaptation to movements has been proven.

The reaction time of martial arts athletes to static and moving objects was studied in the study by Liu et al. [21]. Martial arts athletes had better reaction times to a moving object and made fewer mistakes compared with controls. The importance of attention and quick reaction in dynamic situations to achieve success in a duel has been confirmed. Our results are close to those obtained in this study.

An interesting fact is that significant differences were obtained in only RC test in all groups. It is a complex visual-motor reaction. The participant must perform several actions: assess the situation, select an object and take action. The performance of this test is quite close to the tasks of a combatant during a duel. More experienced athletes perform this task much better. The improvement in this test with increasing age reflects dependence on training experience.

The determination of the simple reaction time and the reaction of choice were used in the study by Balkó et al. [22]. The authors studied the effect of special 9-week training on the psychophysiological performance of fencers. The information value of the reaction of choice test was confirmed. It is concluded that it is necessary to use specific tests in the training of martial arts athletes, motorsport and ball games.

The RC test illustrates the response to a differentiating stimulus. The performance of this test puts the subject in a state of waiting for a decision. It is not only the speed of reaction that matters, but also the correct performance. This test should be assessed as important in the prediction and selection in martial arts, as it allows you to select athletes not only with a quick reaction, but also with a stable nervous system.

The ST test reflects the ability of athletes to spatial perception. This test allows you to control your own space, distance and movement prediction. All these are important factors for winning in martial arts.

It is necessary to consider the physiological characteristics of the bodies of the participants. Athletes in the third group are in puberty. This period refers to the critical stages in the development of the child. It is characterized by a rapid change in the state of organs and systems, the transition of regulation to a qualitatively new level. This is reflected in the state of psychophysiological characteristics.

Our results confirm this observation by Latyshev et al. [23]. The authors studied the influence of age on success in martial arts. It was confirmed that the greatest influence of the effect of relative age in athletes was revealed at the cadet level.

The analysis of correlation dependencies is widely used in sports science [4, 8]. A comparison of the number and strength of connections allows us to evaluate the dynamics of the functional system, which is formed in the process of sports training.

Correlations between the technical and tactical indicators of taekwondo athletes were studied in the article by Wąsik et al. [24]. There was a moderate correlation between the maximum speeds of both hands in the measured strokes. The highest correlation was noted between the difference in the values of the maximum speeds of both hands and the value of the maximum speed of the allotted (left) hand. Depending on the devices and methods of movement fixation, angular and linear speeds can serve as the main factors in the quality of strikes.

The determined dependencies in group 1 should be assessed as an illustration of the incompletely formed functional status of athletes. The correlations between age and the adverse reactions rate in the RMO test indicate that athletes have not yet reached the optimal level of training. This assumption is also supported by the dependence between the frequency of error tests and the results of the RC test. The correlation between RMO and RC test results should be assessed as evidence of the impact of the sport on the body of the athlete. Both of these tests are specific to martial arts. They allow us to predict the success and growth of sportsmanship of athletes.

An analysis of the dependence between performance indicators and the reaction rate of athletes in sports games was carried out in the study by Šimonek et al. [25]. Low correlation coefficients between these factors have been identified in football. Average values were observed in basketball and handball, whereas high values were observed in volleyball. A negative correlation was observed between triple jump performance and all other tests in all sports games.

The dependences between the level of physical fitness of judo athletes and the peculiarities of training preparation were studied in the study by Rovniy et al. [26]. A linear multiple regression coefficient was used. The level of each factor in the development of physical qualities and indicators of competitive activity of athletes was determined. The calculation of the inverse stepwise regression coefficient allows to determine the most important factors for increasing productivity.

The determined correlations in group 3 confirm the assumptions made earlier. A direct correlation between the tests used reflects the improvement in the psychophysiological state of the athletes. The growth of sportsmanship and an increase in the training experience improve the response to various stimuli. This assumption is also supported by the inverse correlation between age and test scores. The increase in the strength of the connection between RMO and RC compared to group 1 should be evaluated as an illustration of the increase in the level of fitness of athletes.

Conclusions

A change in the speed of reaction to various stimuli of taekwondo athletes of different ages has been confirmed. An increase in age and sports training led to an improvement in the reaction rate. This dependence is most express in comparing junior and senior athletes. The determined correlations between the tests used also reflect the improvement in the psychophysiological state of the athletes as the age increases. The tests used are characterized by accessibility, specificity, informativeness and financial feasibility. The results obtained allow us to recommend their use in monitoring the state of martial arts athletes.

References

1. Klymovych V, Korchagin M, Olkhovyi O, Romanchuk S, Oderov A. The influence of the system of physical education of higher educational school on the level of psychophysiological qualities of young people. *Sport Mont*, 2019; 17(2): 93–97. https://doi.org/10.26773/smj.190616
2. Quinzi F, Modica M, Berchicci M, Bianco V, Perri RL, Di Russo F. Does sport type matter? The effect of sport discipline on cognitive control strategies in preadolescents. *International Journal of Psychophysiology*, 2022;177:230–239. https://doi.org/10.1016/j.ijpsycho.2022.05.016
3. O'sullivan DM, Jeong HS, Won HJ. Functional Reaction Times of a Simulated Blocking Test among Para Taekwondo Athletes. *Healthcare (Switzerland),* 2022;10(7):1231. https://doi.org/10.3390/healthcare10071231
4. Liu Y, Evans J, Wąsik J, Zhang X, Shan G. Performance Alteration Induced by Weight Cutting in Mixed Martial Arts—A Biomechanical Pilot Investigation. *International Journal of Environmental Research and Public Health,* 2015;19(4). https://doi.org/10.3390/ijerph19042015
5. Yao Q. The reaction speed of different types of training on fencing athletes. *Revista Brasileira de Medicina do Esporte,* 2022; 28(2):141–143. https://doi.org/10.1590/1517-8692202228022021_0453
6. Borysiuk Z, Błaszczyszyn M, Piechota K, Balko S, Waśkiewicz Z. EMG structure, ground reaction forces as anticipatory indicators of the fencing lunge effectiveness. *Archives of Budo,* 2022;18:13-22.
7. Janicijevic D, Garcia-Ramos A. Feasibility of Volitional Reaction Time Tests in Athletes: A Systematic Review. *Motor Control*, 2022;26(2):291–314. https://doi.org/10.1123/mc.2021-0139
8. Tomic L, Janicijevic D, Nedeljkovic A, Leontijevic B, García-Ramos A. Reliability and sensitivity of reaction time measurements during quasi-realistic soccer situations. *Motor Control,* 2021; 25(3): 491–501. https://doi.org/10.1123/MC.2021-0002
9. Rovnaya OA, Podrigalo LV, Aghyppo OY, Cieślicka M, & Stankiewicz B. Study of Functional Potentials of Different Portsmanship Level Synchronous Swimming Sportswomen under Impact of Hypoxia. *Research Journal of Pharmaceutical, Biological and Chemical Sciences,* 2016; 7 (4): 1210–1219.
10. Podrigalo L, Cynarski WJ, Rovnaya O, Volodchenko O. Studying of physical development features of elite athletes of combat sports by means of special indexes. *Ido Movement for Culture. Journal of Martial Arts Anthropology,* 2019;19(1):51–57. https://doi.org/10.14589/ido.19.1.5
11. Zhao K, Hohmann A, Chang Y, Pion J, Gao B. Physiological, anthropometric, and motor characteristics of elite Chinese youth athletes from six different sports. *Frontiers in Physiology,* 2019;10(APR):405. https://doi.org/10.3389/fphys.2019.00405
12. Logan SW, Robinson LE, Rudisill ME, Wadsworth DD, Morera M. The comparison of school-age children's performance on two motor assessments: the Test of Gross Motor Development and the Movement Assessment Battery for Children. *Physical Education and Sport Pedagogy,* 2014;19(1):48–59. https://doi.org/10.1080/17408989.2012.726979
13. Butenko H, Goncharova N, Saienko V, Tolchieva H. Use of health tourism as a basis for improving physical condition of primary school age children. *Journal of Physical Education and Sport*, 2017;17(6):34–39. https://doi.org/10.7752/jpes.2017.s1006
14. Ashanin V, Filenko L, Pasko V, Tserkovna O, Filenko I, Poltoratskaya A, Mulyk K. Implementation practices of the rugby-5 into the physical education of schoolchildren 12-13 years old using information technology. *Journal of Physical Education and Sport,* 2018;18(2): 762–768. https://doi.org/10.7752/jpes.2018.02112
15. Coswig V, Sant'Ana J, Coelho MN, Moro ARP, Diefenthaeler F. Development of a mobile phone app for measuring striking response time in combat sports: Cross-sectional validation study. *JMIR mHealth and uHealth,* 2019;7(11):e14641. https://doi.org/ 10.2196/14641
16. De la Fuente A, Gómez-Landero Rodríguez LA. Motor differences in cadet taekwondo athletes according to competition level. *Revista Internacional de Medicina y Ciencias de la Actividad Fisica y del Deporte,* 2019;19(73):63–75. https://doi.org/10.15366/rimcafd2019.73.005
17. Sarmet Moreira PV, Franchini E, Fernandes Ervilha U, Cardozo AC, Gonçalves M. Relationships of the expertise level of taekwondo athletes with electromyographic, kinematic and ground reaction force performance indicators during the dollyo chagui kick. *Archives of Budo,* 2018; 14:59–69.
18. Chen W-Y, Wu SK, Song T-F, Chang Y-C, Goodbourn PT. Perceptual and Motor Performance of Combat-Sport Athletes Differs According to Specific Demands of the Discipline. *Perceptual and Motor Skills,* 2017;124(1):293–313. https://doi.org/10.1177/0031512516681342
19. Romanenko V, Podrigalo L, Cynarski WJ, Rovnaya O, Korobeynikova L, Goloha V, Robak I. A comparative analysis of the short-term memory of martial arts' athletes of different level of sportsmanship. *Ido Movement for Culture. Journal of Martial Arts Anthropology,* 2020;20(3):18–24. https://doi.org/10.14589/ido.20.3.3
20. Gierczuk D, Ljach W. Evaluating the coordination of motor abilities in Greco-Roman wrestlers by computer testing. *Human Movement,* 2012;13(4): 323–329. https://doi.org/10.2478/v10038-012-0037-y
21. Liu Y, Zhang Y, Qin Y, Hou X, Zhao Q, Li J. The Inhibition of Return of Sanda Athletes in Three Dimensional Static and Dynamic Scenes. *Perceptual and Motor Skills*. 2022; 003151252211390. https://doi.org/10.1177/00315125221139001
22. Balkó Š, Rous M, Balkó I, Hnízdil J, Borysiuk Z. Influence of a 9-week training intervention on the reaction time of fencers aged 15 to 18 years. *Physical Activity Review,* 2017;5:146–154. https://

doi.org/10.16926/par.2017.05.19
23. Latyshev M, Tropin Y, Podrigalo L, Boychenko N. Analysis of the Relative Age Effect in Elite Wrestlers. *Ido Movement for Culture. Journal of Martial Arts Anthropology.* 2022; 22(3):28–32. https://doi.org/10.14589/ido.22.3.5
24. Wąsik J, Mosler D, Góra T, Ortenburger D. Application of inertial sensors system for diagnosis of taekwon-do's forms performance – A case study. *Archives of Budo,* 2020;16:195–202.
25. Šimonek J, Horička P, Hianik J. The differences in acceleration, maximal speed and agility between soccer, basketball, volleyball and handball players. *Journal of Human Sport and Exercise,* 2017; 12(1):73–82. https://doi.org/10.14198/jhse.2017.121.06
26. Rovniy A, Mulyk K, Perebeynos V, Ananchenko K, Pasko V, Perevoznyk V, Aleksieiev A, Dzhym V. Optimization of judoist training process at a stage of gradual decline of sporting achievements. *Journal of Physical Education and Sport,* 2018;18(4):2447–24531. https://doi.org/10.7752/jpes.2018.04367

Information about the authors:

Leonid Podrigalo; (Corresponding author); Doctor of Medical Sciences, Professor; http://orcid.org/0000-0002-7893-524X; leonid.podrigalo@gmail.com; Kharkiv State Academy of Physical Culture Klochkovskaya str. 99, Kharkiv, 61022, Ukraine.

Vyacheslav Romanenko; PhD (Physical Education and Sport), Associate Professor; https://orcid.org/0000-0002-3878-0861; slavaromash@gmail.com; Kharkiv State Academy of Physical Culture; Klochkovskaya str. 99, Kharkiv, 61022, Ukraine.

Olha Podrihalo; Doctor of Sciences in Physical Education and Sport, Professor; http://orcid.org/0000-0003-1519-5632; rovnayaolga77@ukr.net; Kharkiv State Academy of Physical Culture; Klochkovskaya str. 99, Kharkiv, 61022, Ukraine; National University of Physical Education and Sport of Ukraine, Phizkultury St, 1, Kyiv, 03150, Ukraine.

Sergii Iermakov; Doctor of Pedagogical Sciences, Professor; http://orcid.org/0000-0002-5039-4517; sportart@gmail.com; Department of Methodologies of Cross-Cultural Practices, Kharkiv State Academy of Design and Arts; Kharkiv, Ukraine.

Anatolyi Huba; Doctor of Pedagogical Sciences, Professor; http://orcid.org/0000-0002-4075-1891; a.v.guba2018@gmail.com; Kharkiv State Academy of Physical Culture; Klochkovskaya str. 99, Kharkiv, 61022, Ukraine.

Volodymyr Perevoznyk; PhD (Physical Education and Sport), Associate Professor; http://orcid.org/0000-0001-6798-1497**;** vperevoznik60@gmail.com, Kharkiv State Academy of Physical Culture; Klochkovskaya str. 99, Kharkiv, 61022, Ukraine.

Olexandr Podavalenko; PhD (Medical Sciences), Associate Professor; http://orcid.org/0000-0001-9143-3351; alekontp@ukr.net; Kharkiv State Academy of Physical Culture; Klochkovskaya str. 99, Kharkiv, 61022, Ukraine.

Cite this article as:

Podrigalo L, Romanenko V, Podrihalo O, Iermakov S, Huba A, Perevoznyk V, Podavalenko O. Comparative analysis of psychophysiological features of taekwondo athletes of different age groups. *Pedagogy of Physical Culture and Sports,* 2023;27(1):38–44.
https://doi.org/10.15561/26649837.2023.0105

Received: 21.11.2022
Accepted: 05.01.2023; Published: 28.02.2023

ORIGINAL ARTICLE

Validity and reliability of an assessment instrument of track start in swimming

Fabrício Madureira[1ABC], Thábata V.B. Gomes[2ABC], Thiago A.C. Oliveira[3BCD], Andrea M. Freudenheim[4BCD], Umberto C. Corrêa[5ABDE]

[1]*Universidade Metropolitana de Santos, Santos, Brazil*
[2]*Universidade Federal de Pelotas, Pelotas, Brazil*
[3]*Universidade Paulista, Jundiaí, Brazil*
[4]*Escola de Educação Física e Esporte, Universidade de São Paulo, São Paulo, Brasil*

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

Abstract

Background and Study Aim The development and validation of assessment instruments are essential procedures for any professional intervention, including in physical education and sports contexts. This study aimed to provide a component-based assessment instrument for track start in swimming. It refers to the act of starting the competitive swim by diving into the water from a raised block (platform) at the edge of the pool.

Material and Methods The content validity involved the participation of sixty-three experienced swimming coaches. They completed a questionnaire about their degree of agreement (Likert scale) with the initial position, impulsion, flight, and entry into the water as the track start's components. Reliability and construct validity involved the participation of seven experienced swimming coaches. The first was verified through test-retest (intrarater) and reproducibility (interrater) procedures. The latter was tested by considering the instrument's ability to assess different track start performances.

Results The concordant answers (strongly agree and agree) ranged from 63% to 95%, with most components above 80%. The Intraclass Correlation Coefficients (ICC) results show from good to excellent interrater and intrarater reliabilities. Specifically, the interrater correlations in the test and intrarater correlations in track start 1 were revealed excellent. In addition, the interrater correlations in the retest and intrarater correlations in track start 2 were revealed good.

Conclusions The obtained validities and reliabilities made possible a component-based assessment instrument that allows: (i) a clear and standardized structure of track start in swimming involving the initial position, impulsion, flight, and entry into the water; (ii) accessing to the practitioners' states in relation to desired start performance; and (iii) a reference for coaches and teachers to provide instruction and feedback for learning and performance improvement.

Keywords: content validity, construct validity, sport of swim, types of starting, performance evaluation.

Introduction

In the last few years, the swimming start has increasingly been focus of concern for researchers, sports coaches and physical education teachers. It refers to the act of starting the competitive swim by diving into the water from a raised block (platform) at the edge of the pool. The basic function of the swimming start is to transfer the speed from diving to swim [1, 2]. Indeed, there seems to be some recognition that an efficient start implies a significant contribution to the reduction of the total time of the swim [2, 3, 4, 5].

Similar to the swimming styles (e.g., butterfly, backstroke, breaststroke, and front-crawl stroke), the start has evolved over time, the main ones being grab and track starts. Other ones (e.g., swing, handle, rear-weighted track, and front-weighted starts) have been conceived as variations of these two [6, 7, 8, 9]. Investigations on swimming start have been developed based on different concerns, mainly to understand the kinematic and kinetic variables of the foregoing start styles [6, 9, 10, 11]. For instance, studies have shown that (i) grab start involves greater flight displacement [12] and smaller reaction [13, 14] than track start; (ii) reduced block time depends on the increase in the vertical and horizontal velocities in the grab and track starts, respectively [15]; (iii) effective starts are related to the higher peaks of force [16, 17]; and (iv) training improves the peak horizontal force, velocity of take-off, and block and flight times [18, 19]. Currently, the track start has been seen as a more efficient than grab start [20].

This study sought to add to the existing body of knowledge about the biomechanical structure of swimming start by providing a component-based assessment instrument of track start. An important assumption here is that the movement

doi:10.15561/26649837.2023.0106

behaviors of the interacting components need to be considered, not only because they are the ones that give rise to these previous biomechanical aspects [10], but also because they constitute the focus of instruction and feedback for learning and performance improvement. Although there is widespread recognition that swimming start unfolds by performing sequential components (e.g., phases), there has also been some distinction as to what they are and how they occur [21]. For example, while Maglischo [5] proposes that it involves preparatory position, pull, block impulsion, flight, entry, and slide, Matúš et al. [8] suggest the phases of block, flight, and underwater.

Over the last few years, several assessment instruments in swimming have been built and validated. For example, Madureira et al. [22] proposed an assessment instrument of beginners' front-crawl stroke efficiency that included ten component items (recovery and entrance; release; stroke synchronization; breathing; stroke and breathing synchronization; 6-downsweep, in-sweep, and upsweep; body positioning; kicking; kick and breathing synchronization; kick and stroke synchronization). On the other hand, Monteiro et al. [23] validated an assessment instrument of pedagogical knowledge in swimming, which comprised the task nature, practice schedule, and feedback regimes. Other instruments have been concerned mainly with children's aquatic readiness. This is the case of Erbaugh [24], who proposed an assessment instrument for the swimming performance of children aged between 2 and 6 years. This instrument comprised the following components: entry by jump; front and back locomotion; breathing; kicking; diving; ring pick-up and retrieval; and hoop obstacle course. In a similar vein, a recent study by Valentini et al. [25] published an instrument that evaluates the aquatic readiness (Aquatic Readiness Assessment - ARA) based on the following components: water orientation and adjustment, water entry, breath control, body position, arm propulsion action, arm recovery action, leg action, and combined movement. Although some of the foregoing instruments have considered entering the water through diving [e.g., 24, 26], to the best of our knowledge, they have focused on readiness, fundamental skills, or adaptation to the aquatic environment.

A component-based assessment instrument will contribute to swimming coaching/teaching processes by making possible: (i) a clear and standardized structure of motor skill (track start); (ii) the access to the practitioners' states in relation to desired start performance; (iii) insights for the elaboration of instructions and feedbacks; (iv) references for practitioners and coaches maintain or modify their expectancies and planning [27, 28, 29, 30].

Materials and Methods

Participants

The content validation involved the voluntary participation of sixty-three swimming coaches, with an average age of 43.3 years (± 12.9) and an average time of professional practice of 20.3 years (±13.0). The participants of the reliability and construct validation were seven swimming coaches, with an average age of 38.7 years (± 10.3) and an average time of professional practice of 17.7 years (± 8.1). Participation required the volunteers' written consent, and the experimental protocol was given ethical approval by the local Institutional Review Board.

Research Design

Regarding the content validity procedures, participants were invited to answer via a Google Forms link a questionnaire about the track start composed of two parts: (1) participants' characteristics without identification of name or any document number; (2) motor skill characteristics. Regarding the first, participants reported the date of birth; gender; time of professional practice with swimming; whether they worked with swimming in the health promotion, education, leisure, or competition dimensions (amateur or professional); whether they worked with babies, children, adolescents, adults, or elderly individuals; and if they worked in a club, academy, school, public agency, private company, or other.

The second part began with the following statement and instructions for filling out: "the track start is efficient when (mark X in the column that represents your degree of agreement)". Therefore, the participant was given the possibility to (i) totally disagree, (ii) disagree, (iii) neither agree nor disagree, (iv) agree, and (v) totally agree with the components of the track start related to the initial position, impulsion, flight, and entry into the water (Table 1). In this part, participant also had the opportunity to provide suggestions about the content or wording of the analysed item.

As for reliability and construct validity, participants were asked to rate two track swimming starts. To do this, they had to access a Google Forms link that contained two videos whose performances differed in relation to the performance errors. The videos were run at 25% of the real velocity. On the right side of the videos was the foregoing assessment instrument. Thus, participants were able to fill the instrument by recording "observed" or "not observed" for each component item while watching the videos. The performer was one of the experimenters who was an expert swimmer and coach who was not identified during performances.

To characterise a test-retest design, these procedures occurred twice with a time interval of one week and in reverse order. It allowed accessing

Table 1. Components of the track start swimming.

Item	Component
1	**INITIAL POSITION**
1.1	One foot pulls the front edge of the block with the toes, while the other supports the back with the front of the sole of the foot.
1.2	The knees are semi flexed
1.3	The trunk flexes over the thigh and the hip remains higher than the head
1.4	Hands grasp the front edge of the block, close to the side
1.5	The head is down
2	**IMPUSION**
2.1	The block is pushed back with the hands and feet so that the trunk, hip, and knee are extended.
2.2	Trunk moves forward accompanied by raising the head above the hips and looking forward
3	**FLIGHT**
3.1	The arms are extended forward so the head is between them; hands overlapping and pointing down
3.2	The legs, initially apart, are joined in an extended position with the feet in plantar flexion.
3.3	There is alignment of the hips with the head and arms, which may be followed by a pike position
4	**ENTRY INTO WATER**
4.1	The overlapping hands enter the water with the elbows extended; the head is between the arms
4.2	The rest of the body enters the water aligned in the same place as the hands
4.3	Feet remain in plantar flexion and legs together and knees extended
4.4	There is hyperextension of the trunk after entering the water

the reliability of the assessment by the same evaluator (test-retest intrarater reliability) and the reproducibility of the evaluation by different evaluators (objectivity or interrater reliability) [31].

Statistical Analysis

Content validity was analysed considering the relative frequency of occurrences of each level of agreement in each assessment item. Concerning the reliability and construct validity, although for single checklist items the Fleiss' Kappa reliability test [17, 32] could be used, we are interested in evaluating the track start performance by considering each component (initial position, impulsion, flight, and entry into water), and how reliable the results could be for multiple raters (evaluators). For this purpose, each component was considered in terms of the number of observed items and subsequently analysed through Intraclass Correlation Coefficients (ICC). In this case, ICC2k (average random raters) was run to verify the interrater reliability, and ICC3k (average fixed raters) was used to analyse the intrarater reliability [33, 34, 35, 36]. These statistical procedures allow us to infer the following categorical levels of correlation [37]: poor = less than 0.5; moderate = between 0.5 and 0.75; good = 0.75 and 0.9; and excellent = greater than 0.90.

Finally, construct validity was tested considering the instrument's ability to assess different performances [31, 38, 39, 40]. For this purpose, the number of observed items was considered the dependent variable in relation to each component and the overall performance of the track start (sum of all observed items). Since the swimming start results from the sequential interaction between four components (initial position, impulse, flight, entry into water), each component was also analysed considering a weight of 25% through the following calculation: C% = (Nio x 25) ÷Ni, where C refers to the component, Nio is the number of observed items, and Ni is the number of items. This procedure allowed accessing each component in terms of relative performance to global performance (100%), in addition to providing subsidies for proposing performance categories (e.g., poor, moderate, good, and excellent). A multivariate analysis of variance (MANOVA) was run to compare starts (1 and 2) x performances (initial position, impulsion, flight, entry into water, and overall) in both measures. The observed significant effects were followed up using Tukey_{HSD} test.

Results

Content validity

Regarding the participants' characteristics, Table 2 shows that most of them (63%) worked with swimming combining health with education, leisure, and competition. It is also possible to note that a significant part of them (81%) worked with babies, children, adolescents, adults, and elderly individuals, with the main places of work being clubs and gyms (65%).

Table 2. Relative frequency of responses related to the swimming professionals' characteristics.

Item	(%)
Swimming dimensions	
Health	6
Education	5
Leisure	5
Competition	16
Health + others	63
Education + others	5
Athletes/Students	
Adolescents	6
Adults	13
Babies, Children, Adolescents, Adults, and Elderly	81
Local	
Private Company	10
Public agency	19
Personal trainer	5
School	2
Club and Academy	65

Table 3 presents the relative frequency of responses in each agreement level and track start component. It shows that "I totally disagree" obtained below 5% of the answers and that "I disagree" was below 10%, except for component 3.3, which obtained 13%. The frequencies obtained in relation to neutrality were also low, ranging from 2% to 22%. The highest relative frequencies of responses were observed in "strongly agree", which ranged from 32% to 65%. In turn, the relative frequencies of "agree" ranged from 25% to 37%. When considering the sum of discordant answers (strongly disagree and disagree) and concordant answers (strongly agree and agree), a significant relative frequency is observed in the latter. These frequencies ranged from 63% to 95%, with most components above 80%. It is interesting to note that component 3.3 was once again highlighted with a value of 63%, which was one of the comments made.

Regarding the comments, they were related to the following components: 1.1 (*support foot between the hands*); 1.2 (*knees close together, hips pointing up and head down*); 1.5 (*head between arms*); 3.3 (*not necessarily pike position*); 4.2 (*where the hands enter the rest of the body. Keep your legs together and extended. Keep the body in streamlined position after entering the water [this is the end of the exit!]*).

The analysis of these comments in conjunction with the percentage results made it possible to verify that they were already clearly included in the instrument. Regarding the item 3.3, it was modified to: "there is alignment of the hips with the head and arms, which may involve the pike position". In addition, item 2.2 was changed to: "the trunk moves forward accompanied by the elevation of the head and looking forward".

Reliability and construct validity

The ICC results show significant interrater and intrarater reliabilities (Table 4). Specifically, the interrater correlations in the test and intrarater

Table 3. Relative frequency (%) of responses at each level of agreement (strongly disagree; disagree; neither agree nor disagree; agree; and strongly agree) in each component of the track start.

Component	Strongly disagree (%)	Disagree (%)	Neither agree nor disagree (%)	Agree (%)	Strongly agree (%)	Total disagreement (%)	Total Neutral (%)	Total agreement (%)
1.1	3	5	6	30	56	8	6	86
1.2	2	3	3	35	57	5	3	92
1.3	2	6	6	32	54	8	6	86
1.4	3	5	17	35	40	8	17	75
1.5	2	3	11	37	48	5	11	84
2.1	3	10	6	37	44	13	6	81
2.2	5	8	17	35	35	13	17	70
3.1	2	6	8	37	48	8	8	84
3.2	0	6	19	25	49	6	19	75
3.3	2	13	22	32	32	14	22	63
4.1	2	0	3	33	62	2	3	95
4.2	2	0	3	30	65	2	3	95
4.3	2	6	2	32	59	8	2	90
4.4	3	0	17	38	41	3	17	79

correlations in track start 1 were revealed excellent. In addition, the interrater correlations in the retest and intrarater correlations in track start 2 were revealed good.

Regarding construct validity, MANOVA revealed significant effects for starts [Wilks' Lambda = 0.19, $F(4; 9) = 9.57$, $p = 0.002$, $\eta p^2 = 0.81$, observed power = 0.98]. The TukeyHSD test showed differences in the initial position ($p = 0.0001$) and overall performance ($p = 0.025$).

Discussion

How efficiently do swimmers perform the start? This is one of the questions often made by coaches to select practice tasks and provide feedback for improving swimming start performance. Notwithstanding the importance of this motor skill, swimming coaches have carried out assessments through nonsystematic observation based on criteria with subjective individual scales built based on common knowledge.

One could say that the validation of an instrument is a complex process as it involves several aspects, from the collection of information taken as true in the professional practice and/or academic environment (e.g., what and how to measure) to its experimental verification of the construct and reliability [41, 42]. This study first developed a content validation by reaching a significant level of relevance to and representativeness of the components of the assessment instrument of track start in swimming [38].

Some aspects were important for that: first, the study sampling allowed robustness to the findings because of its significant size (N = 63). Similar studies on the validation of assessment instruments, including in other sports, have used a significantly smaller sample size [22, 23, 25, 40, 43]. In addition, the robustness was also strengthened by the long and diversified professional experience. It is known that coaches keep building their knowledge about task requirements (e.g., sports of swimming) during their professional practices [30, 44, 45, 46]. As revealed in the method, the participating coaches had an average time of professional practice of 20.3 years and worked with swimming combining health with education, leisure, and competition purposes.

Second, there was significant agreement between the coaches in relation to the instrument's component items. One could say that the content validation has been completed through correction of those few items with low agreement and that had some suggestions for changes. Items 2.2 and 3.3 were modified to "the trunk moves forward accompanied by the elevation of the head and looking forward" and "there is alignment of the hips with the head and arms, which may involve the pike position", respectively.

Once the instrument structure was consolidated, it needed to pass a reliability check, that is, to determine if it could be used by the same and different evaluators. Acceptable agreement allows us to conclude that observed differences did not occur due to the way an evaluator applied the assessment instrument [47]. In this regard, good to excellent correlation values were found, which means that the assessment instrument of track start in swimming was able to be used for the same and different evaluators. These findings corroborate those from studies validating assessment instruments in swimming [22, 23, 24, 25].

Finally, construct validity was assessed as the degree to which an assessment instrument measured the targeted construct [38, 47]. It was made by analysing different performances, namely, *start 1* (superior performance) and *start 2* (inferior performance). The results revealed that these performances reached 57.9% and 34.0% of the optimal performance (100%), respectively. Therefore, the assessment instrument of track start made possible access to different performances. In addition, the instrument allowed us to identify that *starts1* and *2* differed significantly in relation to the initial position.

The analysis of the components in relative terms also makes it possible to identify the contribution of each one (25%) to the overall performance. From this, it is possible to infer the development of each one. For example, based on Figure 1, it could be said that the component of start 1 with the most need of instructional focus is the entry into the water, which has a score of 8.9%, that is, approximately 1/3 of the possible performance.

Finally, although most descriptions of the swimming start include sliding after entering the water, this was not considered in the present study. That is because this would no longer be part of the start, but rather the underwater

Table 4. Results of Intraclass Correlation Coefficients (ICC) for interrater and intrarater reliabilities.

Test	ICC	*F*	df1	df2	*p*	Lower bound	Upper bound
Interrater: test	0.91	12.00	3	39	< 0.01	0.71	0.99
Interrater: retest	0.89	11.90	3	39	< 0.01	0.66	0.99
Intrarater: start 1	0.97	32.00	3	39	< 0.01	0.89	1.00
Intrarater: start 2	0.81	5.40	3	39	< 0.01	0.35	0.99

displacement. A recent study by Gonjo and Olstad [21] showed that there is no consensus on the start components, especially sliding. They point out that the underwater displacement through dolphins' movements decharacterises the start motor skill to characterize a form of underwater swimming.

Conclusions

The obtained validities and reliabilities made possible a component-based assessment instrument (Table 5) that allows: (i) a clear and standardized structure of track start in swimming involving the initial position, impulsion, flight, and entry

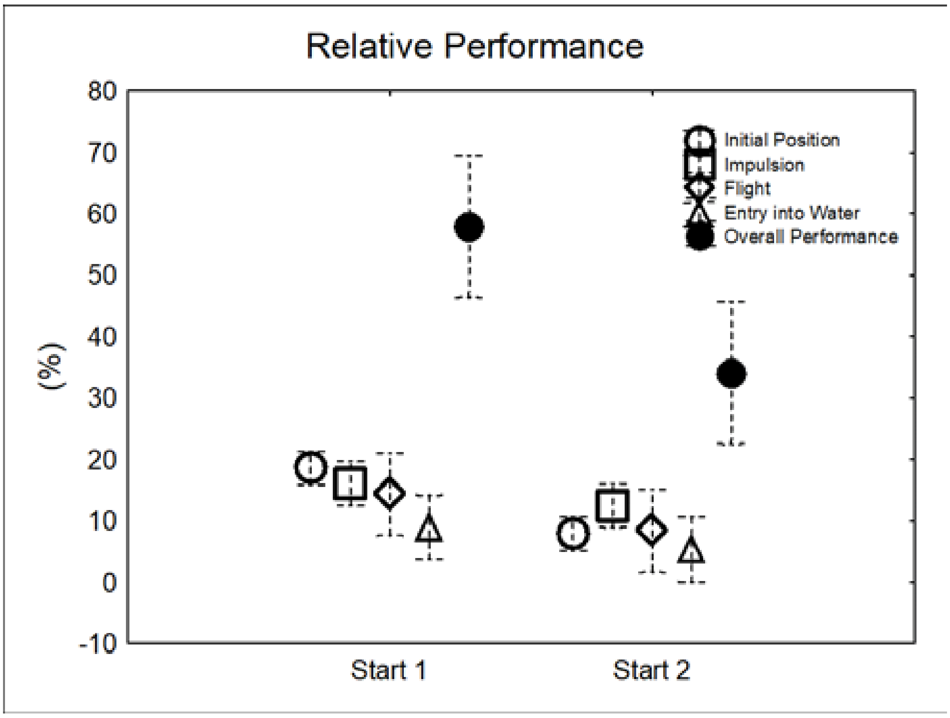

Figure 1. Relative performances of initial position, impulsion, flight, entry into water, and overall performance in track starts 1 and 2.

Table 5. Assessment Instrument of Track Start in Swimming.

Item	Component
1	**INITIAL POSITION**
1.1	One foot pulls the front edge of the block with the toes, while the other supports the back with the front of the sole of the foot.
1.2	The knees are semi flexed
1.3	The trunk flexes over the thigh and the hip remains higher than the head
1.4	Hands grasp the front edge of the block, close to the side
1.5	The head is down
2	**IMPUSION**
2.1	The block is pushed back with the hands and feet so that the trunk, hip, and knee are extended.
2.2	The trunk moves forward accompanied by the elevation of the head and looking forward
3	**FLIGHT**
3.1	The arms are extended forward so the head is between them; hands overlapping and pointing down
3.2	The legs, initially apart, are joined in an extended position with the feet in plantar flexion.
3.3	There is alignment of the hips with the head and arms, which may involve the pike position
4	**ENTRY INTO WATER**
4.1	The overlapping hands enter the water with the elbows extended; the head is between the arms
4.2	The rest of the body enters the water aligned in the same place as the hands
4.3	Feet remain in plantar flexion and legs together and knees extended
4.4	There is hyperextension of the trunk after entering the water

into the water; (ii) accessing to the practitioners' states in relation to desired start performance; and (iii) a reference for coaches and teachers to provide instruction and feedback for learning and performance improvement.

Conflict of interest

No potential conflict of interest was reported by the authors.

References

1. Burkett B, Mellifont R, Mason B. The influence of swimming start components for selected Olympic and Paralympic swimmers. *J ApBiomech,* 2010; *26:*134–141. https://doi.org/10.1123/jab.26.2.134
2. Veiga S, Cala A, Frutos PG, Navarro E. Comparison of starts and turns of national and regional level swimmers by individualized-distance measurements. *Sport Biomech,* 2014; 13:285–295. https://doi.org/10.1080/14763141.2014.910265
3. Cossor J, Mason B. Swim start performances at the Sydney 2000 Olympic Games. In: *ISBS-Conference Proceedings Archive*; 2001.
4. Đurović M, Stojanović N, Stojiljković N, Karaula D, Okičić T. The effects of post-activation performance enhancement and different warm-up protocols on swim start performance. *SciReports*, 2022; 12(1):1–11. https://doi.org/10.1038/s41598-022-13003-9
5. Maglischo EW. *Nadando o mais rápido possível* [Swimming as fast as possible]. 3ed. Barueri, SP: Manole; 2010. (In Portuguese).
6. Blanksby B, Nicholson L, Elliott B. Bechanical analysis of the grab, track and handle swimming starts: an intervention study. *Sports Biomech*, 2002; 1(1):11–24. https://doi.org/10.1080/14763140208522784
7. Breed RV, Young WB. The effect of a resistance training programme on the grab, track and swing starts in swimming. *J Sports Sci*, 2003; 21(3):213–220. https://doi.org/10.1080/0264041031000071047
8. Matúš I, Ružbarský P, Vadašová B. Key Parameters Affecting. Kick Start Performance in Competitive Swimming. *Int J Env Res Public Health*, 2021; 18:2–11. https://doi.org/10.3390/ijerph182211909
9. Welcher RL, Hinrichs RN, George TR. Front- or rear-weighted track start or grab start: Which is the best for female swimmers? *Sports Biomech*, 2008; 7(1):100–113. https://doi.org/10.1080/14763140701683247
10. Bingul B. Bulgan C. Aydin M. The kinematic analysis of the grab, rear track, and front track start in swimming. *Sport Mont.* 2015; 13:57–62.
11. Fischer S, Kibele A. The biomechanical structure of swim start performance. *Sports Biomech,* 2016; 15:397–408. https://doi.org/10.1080/14763141.2016.1171893
12. Galbraith H, Scurr J, Hencken C, WoodL, Graham-Smith P. Biomechanical comparison of the track start and the modified one-handed track start in competitive swimming: an intervention study. *J App Biomech,* 2008; 24:307–315. https://doi.org/10.1123/jab.24.4.307
13. Issurin V, Verbitsky O. Track start vs. grab start: evidence of the Sydney Olympic Games. *Biomech Med Swimming,* 2003; 9(9):213–218.
14. Slawson SE, Conway PP, Cossor J, Chakravorti N. West AA. The categorization of swimming start performance with reference to force generation on the main block and footrest components of the Omega OSB11 start blocks. *J Sport Sci*, 2013; 31(5):468–478. https://doi.org/10.1080/02640414.2012.736631
15. Takeda T, Sakai S, Takagi H, Okuno K, Tsubakimoto S. Contribution of hand and foot force to take-off velocity for the kick-start in competitive swimming. *J Sport Sci,* 2017; 35:565–571. https://doi.org/10.1080/02640414.2016.1180417
16. Qiu X, Veiga S, Lorenzo A, Kibele A, Navarro E. Differences in the key parameters of the individual versus relay swimming starts. *Sports Biomechanics*, 2021; 1–13. https://doi.org/10.1080/14763141.2021.1878262
17. Fleiss JL. Measuring nominal scale agreement among many raters. *Psychological Bulletin*, 1971;76(5): 378–382. https://doi.org/10.1037/h0031619
18. Jesus K, Mourão L, Roesler H, Viriato N, Jesus K, Vaz M, ... Vilas-Boas JP. 3D device for forces in swimming starts and turns. *App Sci*, 2019; 9(17):3559. https://doi.org/10.3390/app9173559
19. Rudnik D, Rejman M, Machado L, Fernandes RJ, Vilas-Boas JP. Does the back plate position influence swimming start temporal characteristics? *Int J Env Res Public Health*, 2022; 19(5):2722. https://doi.org/10.3390/ijerph19052722
20. Thanopoulos V, Rozi G, Okičić T, Dopsaj M, Jorgić B, Madić D.... Batis E. Differences in the efficiency between the grab and track starts for both genders in Greek young swimmers. *J Hum Kinetics*, 2012; 32:43–51. https://doi.org/10.2478/v10078-012-0022-8
21. Gonjo T, Olstad BH. Race analysis in competitive swimming: A narrative review. *Int J Env Res Public Health,* 2021; 18(1): 69. https://doi.org/10.3390/ijerph18010069
22. Madureira F, Bastos FH, Corrêa UC, Rogel T, Freudenheim AM. Assessment of beginners' front-crawl stroke efficiency. *Perceptual and Motor Skills*, 2012; 115(1):300–308. https://doi.org/10.2466/06.05.25.PMS.115.4.300-308
23. Monteiro GN, Ribas S, Jiménez FJ, Mazzardo T, Araújo ND, Aburachid LMC. Development process of content validity of pedagogical knowledge assessment in swimming. *RevBrasCinDesemp Hum*, 2020; 22. https://doi.org/10.1590/1980-0037.2020v22e72071
24. Erbaugh SJ. Assessment of swimming performance of preschool children. *Perceptual and Motor Skills*, 1978; 46(3_suppl2):1179–1182. https://doi.org/10.2466/pms.1978.46.3f.1179
25. Valentini NC, Pereira KRG, Nobre GC. Content, construct, and criterion validity, reliability, and objectivity for aquatic readiness assessment for

Brazilian children. *Int J Aquatic Res Edu*, 2022; 13(4). https://doi.org/10.25035/ijare.13.04.11
26. Morgado LD, De Martelaer K, D'Hondt E, Barnett LM, Costa AM, Howells K.... Jidovtseff B. *Pictorial scale of perceived water competence (PSPWC) testing manual* (pp. 1–26). University of Liege; 2020.
27. Banville D, Rikard L. Observational tools for teacher reflection. *J Phys Edu Recr Dance*, 2001; 72(4):46–49. https://doi.org/10.1080/07303084.2001.10605739
28. Langendorfer SJ, Bruya R. *Aquatic readiness*: developing water competence in young children. Human Kinetics; 1995.
29. Lepore M, Columna L, Lizner LF. *Assessments and activities for teaching swimming*. Champaign, IL: Human Kinetics; 2015.
30. Rink JE. *Teaching physical education for learning*. McGraw-Hill; 2020.
31. Thomas JR, Martin P, Etnier J, SilvermanSJ. *Research methods in physical activity*. Champaign, IL: Human kinetics; 2022.
32. Fleiss JL. *Statistical methods for rates and proportions*. NY: Wiley; 1981.
33. Bartko JJ. The intraclass correlation coefficient as a measure of reliability. *Psych Reports*, 1966; 19(1):3–11. https://doi.org/10.2466/pr0.1966.19.1.3
34. McGraw KO, Wong SP. Forming inferences about some intraclass correlation coefficients. *Psych Methods*, 1996; 1(1):30. https://doi.org/10.1037/1082-989X.1.1.30
35. Shrout PE, Fleiss JL. Intraclass correlations: uses in assessing rater reliability. *Psych Bulletin*, 1979; 86:420–3428. https://doi.org/10.1037//0033-2909.86.2.420
36. Weir JP. Quantifying test-retest reliability using the intraclass correlation coefficient and the SEM. *J Strength Cond Res*, 2005; 19(1):231–240. https://doi.org/10.1519/00124278-200502000-00038
37. Koo TK, Li MY. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *J Chiropractic Med*, 2016; 15(2):155–163. https://doi.org/10.1016/j.jcm.2016.02.012
38. Haynes SN, Richard DCS, Kubany ES. Content validity in psychological assessment: A functional approach to concepts and methods. *Psych Assessment*, 1995; 7(3):238–247. https://doi.org/10.1037/1040-3590.7.3.238
39. Maguire T, Hattie J, Haig B. Construct validity and achievement assessment. *Alberta J Edu Res*, 1994; 40(2):09–126.
40. Oslin JL, Mitchell SA, Griffin LL. The game performance assessment instrument (GPAI): Development and preliminary validation. *J Teaching Phys Edu,* 1998; 17(2):231–243. https://doi.org/10.1123/jtpe.17.2.231
41. Cronbach LJ, Meehl PE. Construct validity in psychological tests. *PsychBulletin*, 1955; 52(4):281–302. https://doi.org/10.1037/h0040957
42. Sullivan GM. A primer on the validity of assessment instruments. *J Grad Med Edu*, 2011; 3(2):119–120. https://doi.org/10.4300/JGME-D-11-00075.1
43. Kapus J, Stibilj J, Košmrlj K, Virag J. Development and validity of the front crawl technique assessment tool: a pilot study. *KinesiologiaSlovenica*, 2022; 28(2):5–19. https://doi.org/10.52165/kinsi.28.2.5-19
44. Kubayi A, Coopoo Y, Toriola A. Knowledge transfer from sport science to coaching: A South African coach's perspective. *South Afr J Res Sport, Phy Edu Recr*, 2019; 41(1):51–61.
45. Roberts AH, Greenwood DA, Stanley M, Humberstone C, Iredale F, Raynor A. Coach knowledge in talent identification: A systematic review and meta-synthesis. *J Sci Med Sport*, 2019; 22(10):1163–1172. https://doi.org/10.1016/j.jsams.2019.05.008
46. Silva Filho AS, Silveira SR, Silva SL, Corrêa UC. Instructional Cues in Futsal Teaching, Coaching and Matches. *Sportis. Sci Tech J Sch Sport, Phy Edu Psych*, 2022; 8(2):210–226. https://doi.org/10.17979/sportis.2022.8.2.9024
47. Page TJ, Iwata BA. Interobserver Agreement. In: Poling A, Fuqua RW (eds.) *Research Methods in Applied Behavior Analysis*, Boston, MA: Springer US; 1986. p. 99–126. https://doi.org/10.1007/978-1-4684-8786-2_6

Information about the authors:

Fabrício Madureira; https://orcid.org/0000-0002-5958-021X; shark_jaws@hotmail.com; Universidade Metropolitana de Santos, Santos, Brazil.

Thábata V.B. Gomes; https://orcid.org/0000-0003-4869-8412; thabatagomes@yahoo.com.br; Universidade Federal de Pelotas, Pelotas, Brazil.

Thiago A.C. Oliveira; https://orcid.org/0000-0002-9765-4283; tacooliveira@yahoo.com.br; Universidade Paulista, Jundiaí, Brazil.

Andrea M. Freudenheim; https://orcid.org/0000-0001-6495-5170; amfreud@usp.br; Escola de Educação Física e Esporte, Universidade de São Paulo, São Paulo, Brasil.

Umberto C. Corrêa; (Corresponding Author); https://orcid.org/0000-0002-3465-0437; umbertoc@usp.br; Escola de Educação Física e Esporte, Universidade de São Paulo, São Paulo, Brasil.

Cite this article as:

Madureira F, Gomes TVB, Oliveira TAC, Freudenheim AM, Corrêa UC. Validity and reliability of an assessment instrument of track start in swimming. *Pedagogy of Physical Culture and Sports,* 2023;27(1):45–53.
https://doi.org/10.15561/26649837.2023.0106

Received: 30.11.2022
Accepted: 04.01.2023; Published: 28.02.2023

ORIGINAL ARTICLE

Mobile Gamers versus Non-gamer students' endurance levels via Beep and 3-minute step test

Joseph Lobo[1ABCDE], Bryan Dale Bernardo[2ADE]

[1] *Academic Coordinator, Physical Education Department, City College of Angeles, Philippines*
[2] *Full-time Lecturer, Physical Education Department, City College of Angeles, Philippines*

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

Abstract

Background and Study Aim College students' activity levels are considerably affected by mobile gaming, according to multiple studies. There have, however, been no studies done to date comparing gamers and non-gamers in terms of their levels of endurance. This present study employed beep and 3-minute step tests to compare mobile gamers' and non-gamers endurance levels. In addition, the difference between demographic variables such as age, gender, and BMI and participants' aerobic capacity is a major area of study.

Material and Methods Students at the City College of Angeles in the Philippines were selected using the Judgement Sampling Technique to take part in the research. Students who participated in the study are enrolled in the 1st Semester of the Academic year 2022-2023. A survey questionnaire consisting of four sections were utilized to obtain information from the respondents. Age, gender, body mass index (BMI), and an endurance test are all part of the personal profile. Both the beep test and the 3-minute step test were administered to the participants. Results from the participants' personal profiles, BMIs, and endurance tests were summarized using descriptive statistics like frequency (f) and percentage (%). The Paired T-Test was also used to find out if there was a significant difference in the participants' endurance between mobile gamers and non-gamers. Finally, the individuals' age, gender, and Body Mass Index (BMI) were validated with their endurance levels by performing Independent Samples T-Test and One-way ANOVA.

Results Beep and 3-minute step tests showed that gamers and non-gamers have very different levels of endurance, with the latter group displaying much more stamina than the former. It was also shown that among the three factors studied, gender was the only one with a relationship to endurance.

Conclusions The study did not take into account factors like health history including nutrition, diet, sleep pattern, lifestyle, health issues, and endurance level on other types of measures. Conducting an inquiry similar to the one that was done, but also taking into account the other variables indicated, is a highly suggested course. Several findings are established, and numerous suggestions for further research, as well as policy and educational applications, are provided.

Keywords: 3-minute step test, beep test, college students, endurance levels, mobile games, physical education

Introduction

People all throughout the world have had their lives profoundly altered as a result of the devastation caused by the COVID-19 virus [1]. It has impacted the government, the health care system, numerous business sectors, but most significantly education [2, 3, 4, 5]. The majority of educational institutions around the world, particularly those in the field of higher education, have been compelled to close their doors and have made a significant transition away from the more conventional classroom setting and toward an online learning environment [6]. These radical shifts in the nature of the educational setting have had a huge influence on the lives of the vast majority of college students, leading to difficulties with both their mental and, more importantly, their physical health [7, 8]. In physical education subjects, the emphasis is placed on student's physical well-being, and efforts are made to encourage students to lead physically active lifestyles even when they are in the comfort of their own homes. Even if convenience and security are the primary benefits of online education, students receive only a marginal increase in the skills and knowledge they possess as a result of their participation in physical education classes. When seen from this perspective, higher education institutions continue to face a wide range of roadblocks. Even if there have been recent breakthroughs in technology, the hands-on and social aspects of physical education cannot be adequately conveyed in an online environment [9]. The monotony of lessons within the restricted environmental conditions, along with the inefficiency of the educational material, makes it extremely difficult to convey the real purpose and value of physical education, resulting in disastrous consequences [10]. Additionally, a lack of skill in administering physical education activities among

doi:10.15561/26649837.2023.0107

the teachers as a result of their having to learn the ropes via repeated trial and error has rendered it hard to carry out systematic evaluations. It has also been shown that motivating students in online classrooms is extremely challenging due to the lack of a visual connection that can be made between the student and the instructor. This is a problem that exists in addition to the challenges that online instructors face in administering these classes. [9]. It has also come to light that taking physical education lessons in an online environment does not seem to be beneficial in terms of enhancing one's ability to acquire motor skills or increasing one's level of physical activity [11]. It is possible that these factors are to account for the students' lack of practical training, disintegration of their drive and interest, as well as their restricted opportunities for interpersonal connections. Even in this post-pandemic era, the pieces of evidence discussed previously has highlighted the challenges that higher education institutions all over the world are today confronted with when it comes to the delivery of online classes. Because of the nature of the subject matter, it is possible that offering quality instruction in an online setting would not seem to be a viable method for lessons in physical education.

The rise of mobile games during and after the pandemic

When offered at no cost for download, mobile games, which are a subgenre of the online video game genre that can be accessed and played via the internet, see massive levels of player engagement and adoption rates [12]. These games are compatible with a wide range of portable devices, and they can be played either by a single player or by multiple players at the same time [13]. In recent years, the popularity of mobile games—also known as *"e-games"*—has skyrocketed as a result of its accessibility to young people [14], especially amongst college-aged individuals, not just in the Philippines but everywhere else around the globe [15,16]. The devastating impact of the COVID-19 pandemic has made it even harder for college students to make connections and has increased their feelings of alienation from their peers [17]. Because of this, in addition to the many other social media platforms that are accessible to college students, some find that playing mobile games provides a higher level of entertainment. College students still place a high value on mobile gaming even in the wake of the recent pandemic. Numerous research has been carried out to investigate the positive and negative impacts that are associated with playing a variety of mobile games. According to recent studies, college students who regularly engage in mobile gaming have a wide range of good effects, including cognitive simulation, social opportunities, and improvements in a variety of mental health indicators [18, 19]. Studies have shown that mobile gaming can lead to addiction, which in turn can lead to poor academic performance, which is in contrast to the beneficial impacts of mobile gaming [20, 21]. In addition to this, there are a variety of behavioral, social, psychological, and health-related hazards that are strongly linked with mobile gaming addiction [22]. These studies, which were carried out over the course of the past few years, are in direct opposition to one another. Even now, educational researchers are still investigating this topic in the hopes of proposing a variety of different practical implications that will help close the gaps that have been identified as a result of playing mobile games.

Emerging study on the relationship of mobile gaming to students' endurance levels

According to a plethora of researchers, endurance may be defined as the capacity of the body to continue participating in an activity for a considerable amount of time, synonymous to an individual's aerobic capacity [23, 24]. Multiple reports have found that college students' levels of physical activity are significantly impacted by COVID-19 and mobile gaming [25, 26, 27], thus resulting to poor physical health. Unfortunately, the association of mobile gaming on the endurance of college students around the world has not been the subject of any research. In this regard, the purpose of this experimental investigation is to determine whether mobile gaming is associated with the stamina of college students. Importantly, the purpose of this research was to compare the endurance levels of collegiate gamers and non-gamers based on their age, gender, and Body Mass Index after completing a series of endurance tests.

Materials and Methods

Participants

Students at the City College of Angeles in the Philippines were selected using the *Judgement Sampling Technique* to take part in the research. Students who participated the study are enrolled in the 1st Semester of the Academic year 2022-2023. It's a form of non-probability sampling in which people take part in the study based on the researcher's subjective assessment of who will produce the most useful data for meeting the goals of the research [28].

Ethical considerations

The respondents had an understanding of the objectives, instruments, and constructs that were going to be measured and evaluated throughout the course of the experiment. In addition, the positive effects that the investigation will have on higher education institutions and the scientific community have been outlined. There was also discussion of the possibility of less significant risks, such as feeling uncomfortable when responding to personal and sensitive survey questions and receiving no financial compensation for the information provided. In light of these considerations, respondents were required to indicate their agreement by checking the box next to the attached agreement in the survey questionnaire.

Research Design

This study used an experimental design to compare the endurance levels of college students who regularly play mobile video games to those who rarely do so, controlling for participants' ages, sexes, and body mass indexes (BMI). A scientific method is a way of conducting a study in a structured and methodical manner, with the goal of achieving the highest possible degree of accuracy and drawing the most precise conclusions possible with respect to a hypothesis [29]. As have mentioned earlier, the participants for the study are selected based on the characteristics that are needed for this experimental study. In this regard, a selection criterion is developed in order to acquire the most reliable data possible from the participants. The following characteristics are desirable in people who play video games on a mobile phone:

- -must be a legitimate City College of Angeles student;
- - must be at least 19 years old;
- - can be either male or female;
- - must have played mobile games for at least 6 months;
- - must play a minimum of fifteen hours per week; and
- - must only play mobile games.
- In contrast, the requirements for non-gamers are as follows:
- - they must be students at City College of Angeles;
- - they must be at least 19 years old; and
- - they can be either male or female.

Additionally, to collect data from the participants, a survey questionnaire with four (4) parts was used. Personal profile such as age and gender, Body Mass index (BMI), and endurance test are all included. The participants were required to do the beep test as well as the 3-minute step test for the purpose of the research. This was done, most critically, so that the researchers could determine the individuals' levels of endurance. The beep or "bleep" test is a multi-stage fitness test that is used to determine an individual's maximum oxygen uptake (VO_{2max}) as well as their cardiovascular fitness [30, 31]. The participants were also asked to perform the three (3) minute step test to which it was used in testing endurance levels. This is an assessment designed to measure a person's aerobic (cardiovascular) fitness of an individual [32, 33].

Statistical Analysis

In this experimental research, descriptive statistics such as the frequency (*f*) and percentage (%) were used in order to summarize the personal profile, Body Mass Index (BMI), and endurance test results of the participants. Also, the study has utilized *T-Test* to determine the difference concerning mobile-gamers and non-gamers' cardiovascular endurance levels. It is a parametric test that compares the means of two groups [34]. In order to understand the relationship and difference of gender, age, and body mass index to endurance level, Independent Samples T-test and One-way ANOVA was used [35].

Results

The personal profiles of the individuals are displayed in Table 1, which includes information about their ages, genders, and Body Mass Indices (BMI). According to the data in the table, there were a total of 20 people that volunteered to take part in the experiment project, with the majority of the participants being males [(N_{male} = *17*(85.00%), N_{female} = *3*(15.00%)]. In addition, the majority of participants are 18 years old, with those aged 19 and 20 coming in second and third, respectively [(N_{18yo} = *15*(75.00%), N_{19yo} = *4*(20.00%), N_{20yo} = *1*(5.00%)]. Last but not least, in terms of the participants' Body Mass Index (BMI), the majority of them fall into the Normal category, followed by those who are underweight and obese [(N_{normal} = *16*(80.00%), $N_{underweight}$ = *3*(15.00%), N_{obese} = *1*(5.00%)].

Table 1. Personal information of the participants

Variables	Items	N(%)
Gender		
	Male	17(85.00%)
	Female	3(15.00%)
Age		
	19	15(75.00%)
	20	4(20.00%)
	21	1(5.00%)
Body Mass Index (BMI)		
	Normal	16(80.00%)
	Underweight	3(15.00%)
	Obese	1(5.00%)

The outcomes of the Beep and 3-minute step test completed by gamers and non-gamers are shown in Table 2. Both gamers and non-gamers, with the exception of gamer "G5" for the beep test, performed very poorly in the study. In addition, 60% of the non-gamer participants scored "very poor" on the 3-minute step test, with the remaining participants' endurance level rating ranging from poor to below average.

Finally, to understand the relationship and difference of gender, age, and body mass index to endurance level, the results of Independent Samples T-test and One-way ANOVA are illustrated in Table 4 and 5. Based on the findings, no significant difference was observed between gender after performing 3-minute step test [t(3.314) = .860, p = .448]. Surprisingly, a significant difference was observed between gender after performing beep test [t(11.670) = 2.341, p = .038], positing that male (5.00 ± 1.90) has higher scores compared to female (3.67 ± .58). It is possible to

Table 2. Contingency table on participants' endurance level based on Beep and 3-minute step test

	Beep Test				3-Minute Step Test		
Non-gamer	**Endurance level**	**Gamer**	**Endurance level**	**Non-gamer**	**Endurance level**	**Gamer**	**Endurance level**
NG1	Very Poor	G1	Very Poor	NG1	Poor	G1	Poor
NG2	Very Poor	G2	Very Poor	NG2	Very Poor	G2	Very Poor
NG3	Very Poor	G3	Very Poor	NG3	Very Poor	G3	Very Poor
NG4	Very Poor	G4	Very Poor	NG4	Very Poor	G4	Very Poor
NG5	Very Poor	G5	Poor	NG5	Poor	G5	Very Poor
NG6	Very Poor	G6	Very Poor	NG6	Average	G6	Very Poor
NG7	Very Poor	G7	Very Poor	NG7	Below average	G7	Poor
NG8	Very Poor	G8	Very Poor	NG8	Very Poor	G8	Very Poor
NG9	Very Poor	G9	Very Poor	NG9	Very Poor	G9	Very Poor
NG10	Very Poor	G10	Very Poor	NG10	Very Poor	G10	Very Poor

Table 3. Gamers versus non-gamers' endurance level difference

		Paired Differences						
	Endurance Test	**M ± SD**	**SE**	**95% Confidence Interval of the Difference**		**t**	**df**	**Sig.**
				Lower	**Upper**			
1	3min_A-3min_B	-1.20 ± 2.09	.663	-2.701	.301	-1.809	9	.104
2	Bleep_A-Bleep_B	1.40 ± .189	.600	.043	2.757	2.333	9	.045

Table 4. Gender in terms of Endurance Level

Endurance Level	**N**	**M ± SD**	**SE**	**df**	**t-test**	**Sig.**	**Decision**
3-minute step Test							
Male	17	127.53 ± 1.97	.478	3.314	.860	.448	Not significant
Female	3	126.67 ± 1.53	.882				
Beep Test							
Male	17	5.00 ± 1.90	.462	11.670	2.341	.038	Significant
Female	3	3.67 ± .58	.333				

Table 5. Age and Body Mass Index in terms of Endurance Level

Endurance Level		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Age (3-minute step test)	Between Groups	9.867	2	4.933	1.423	.268
	Within Groups	58.933	17	3.467		
	Total	68.800	19			
Age (Beep Test)	Between Groups	7.117	2	3.558	1.079	.362
	Within Groups	56.083	17	3.299		
	Total	63.200	19			
Body Mass Index (3-minute step test)	Between Groups	17.696	2	8.848	2.943	.080
	Within Groups	51.104	17	3.006		
	Total	68.800	19			
Body Mass Index (3-minute step test)	Between Groups	5.596	2	2.798	.826	.455
	Within Groups	57.604	17	3.388		
	Total	63.200	19			

define this in such a way that each gender has something to do with the amount of endurance. This particular finding has been supported by various studies that males are predominantly advantageous in terms of VO_{2max} and level of endurance [36, 37]. However, these findings are not conclusive due to the fact that no other research pertaining to this topic has been carried out as of yet. As a result, it is strongly recommended that a study with the same objectives be carried out to either confirm or contradict these findings. In terms of age ($F(9.867, 58.933) = 1.423$, $p = .268$), ($F(7.117, 56.083) = 1.079$, $p = .362$) and body mass index ($F(17.696, 8.848) = 2.943$, $p = .080$), ($F(5.596, 57.604) = .826$, $p = .455$) for both 3-minute step test and beep test, no significant difference was observed between groups. It is possible to deduce from this that the participants' levels of endurance are not differentiated by age and body mass index.

Discussion

The results of this study contradict prior studies that found a link between advancing age and a decrease in people's endurance. Individual differences in lifestyle choices and inactivity mediate the deterioration of physiological function that comes with advancing age [36]. Based from previously conducted scientific studies, at first, performance seems to hold steady until around age 35–40, then it gradually diminishes until age 50, and finally, the biggest drops in performance happen around age 70 [37, 38]. This is because there is mounting data that demonstrates a decline in musculature and function (specifically, muscle strength and power) with age [39, 40]. Achieving and maintaining a high level of physical fitness and activity throughout the life span, on the other hand, may be an effective method to slow the loss in physiological functions that naturally occurs with age [41, 42]. It is important to note that the majority of participants in this study are young adults (aged 18–20), therefore it is reasonable to assume that their current level of endurance has not declined much over time. It's also worth noting that the test subjects' overall endurance performance is relatively low. It's concerning that, at such a young age, the participants are unable to perform at or above the average rating. Teachers of physical education should encourage their students to take part in a variety of physical activities with the goal of increasing their endurance, which will become increasingly important as they grow.

It was also discovered that BMI has no significant statistical difference with physical endurance. It's reasonable to assume that one's stamina doesn't improve as their body mass index declines or increases. This discovery goes against the findings of other scholarly articles that have shown a correlation between the two variables. For example, the findings of [43] have reported that, reduced performance on the 3-minute Burpee test is associated with being overweight or obese. The findings of [44] have also found that BMI was negatively associated with cardiorespiratory fitness. Likewise, the study of [45] have also reported that adolescents whose body mass index (BMI) is either above or below the average range are less physically fit than their normal-weight peers. Contrastingly, the findings of [46] have reported that BMI is not significantly associated with endurance level for volleyball athletes during the COVID-19 pandemic. The results of this study, however, do not apply to mobile gaming players. Students who spend a lot of time on their mobile devices are likely to have higher rates of overweight and obesity, so a comprehensive study on this topic is strongly recommended.

Surprisingly, gender has been observed to have a significant difference with endurance level. This particular finding has been supported by various studies that males are predominantly advantageous in terms of VO_{2max} and level of endurance [47, 48]. Higher body fat (and less muscular mass) and maximum oxygen intake and lower levels of hemoglobin in females explain the absolute disparities in endurance performance between sexes [49, 50]. Sex differences in VO_{2max}, a critical indicator of aerobic performance, have been linked to differences in endurance-exercise performance [47]. Likewise, the findings of [52] have reported that all the fitness tests used in the study showed a substantial difference between the sexes from a sample of university men and women. Therefore, the intensity of exercises are different between males and females [51]. However, these findings are not conclusive due to the fact that no other research pertaining to this topic has been carried out as of yet. As a result, it is strongly recommended that a study with the same objectives be carried out to either confirm or contradict these findings.

To conclude, various published scholarly works have shown that mobile game players are less likely to engage in other forms of physical activity. Such as the online survey conducted by [53], It was discovered that 80.3% of esports players do not get enough exercise to meet World Health Organization guidelines. Consequently, esports participants appear to have a higher rate of inactivity than the wider populace [54]. In this context, teachers of physical education should motivate their students by organizing a variety of endurance-related activities for them to participate in. The goal is to pique the students' interest, specifically, those who play on mobile devices, in these activities in relation to the maintenance of their physical health, which is of critical significance.

Conclusions

In this novel research project, an examination was carried out to compare the levels of endurance possessed by gamers and non-gamers drawn from a population of undergraduate students attending City College of Angeles. Following the completion of the experiment, it is possible to draw the conclusion that there is a considerable gap in the levels of endurance possessed by those students who play mobile games and those students who do not. This research also demonstrated that gender has a significant role in determining the degrees of endurance possessed by gamers and non-gamers alike. Additionally, there was a significant link found between gender and endurance level. This finding might be interpreted as possibly indicating a causal relationship between the two variables. Therefore, it is strongly recommended that an approach to study based on causal relationships be taken. In addition, the Beep test and the 3-minute step may not be suitable for determining the endurance level of particular samples when considering ethnicity and several other biologic requirements. In this regard, this study would like to underline some practical implications that are extremely helpful for both types of participants for policy and educational applications by utilizing such studies as this in the formulation of physical activities meant to improve the endurance of students. Teachers of physical education should strictly monitor the physical fitness of students who have poor cardiovascular endurance. Ergo, a pre-test and a post-test should be used by teachers of physical education to identify students who are at risk and to encourage those students to participate in activities that will improve their fitness levels. Lastly, it is important to take into account the restrictions imposed by this study. Other characteristics such as health history including nutrition, diet, sleep pattern, lifestyle, health issues, and endurance level on other types of measures were not taken into consideration in this study. Therefore, carrying up a similar study but also taking into account the other factors indicated before is a highly proposed course of action.

Acknowledgement

The authors would like to thank the students who voluntarily participated for the study.

Conflict of interest

The authors declare no conflict of interest.

References

1. Haleem A, Javaid M, Vaishya R. Effects of COVID-19 pandemic in daily life. *Curr Med Res Pract*. 2020;10(2):78–9. https://doi.org/10.1016/j.cmrp.2020.03.011
2. Bernacki K, Keister A, Sapiro N, Joo JS, Mattle L. Impact of COVID-19 on patient and healthcare professional attitudes, beliefs, and behaviors toward the healthcare system and on the dynamics of the healthcare pathway. *BMC Health Serv Res*. 2021;21(1):1309. https://doi.org/10.1186/s12913-021-07237-y
3. König M, Winkler A. The impact of government responses to the COVID-19 pandemic on GDP growth: Does strategy matter? Xue B, editor. *PLoS One*. 2021;16(11):e0259362. https://doi.org/10.1371/journal.pone.0259362
4. Donthu N, Gustafsson A. Effects of COVID-19 on business and research. *J Bus Res*. 2020;117:284–9. https://doi.org/10.1016/j.jbusres.2020.06.008
5. Mok KH. Impact of COVID-19 on Higher Education: Critical Reflections. *High Educ Policy*. 2022;35(3):563–7. https://doi.org/10.1057/s41307-022-00285-x
6. Aristovnik A, Keržič D, Ravšelj D, Tomaževič N, Umek L. Impacts of the COVID-19 Pandemic on Life of Higher Education Students: A Global Perspective. *Sustainability*. 2020;12(20):8438. https://doi.org/10.3390/su12208438
7. Nguyen TT, Nguyen MH, Pham TTM, Le VTT, Nguyen TT, Luong TC, et al. Negative Impacts of COVID-19 Induced Lockdown on Changes in Eating Behavior, Physical Activity, and Mental Health as Modified by Digital Healthy Diet Literacy and eHealth Literacy. *Frontiers in Nutrition*, 2021;8: 774328. https://doi.org/10.3389/fnut.2021.774328
8. Ding Y, Ding S, Niu J. The impact of COVID-19 on college students' physical activity. *Medicine (Baltimore)*. 2021;100(35):e27111. https://doi.org/10.1097/MD.0000000000027111
9. Moustakas L, Robrade D. The Challenges and Realities of E-Learning during COVID-19: The Case of University Sport and Physical Education. *Challenges*. 2022;13(1):9. https://doi.org/10.3390/challe13010009
10. Jeong HC, So WY. Difficulties of Online Physical Education Classes in Middle and High School and an Efficient Operation Plan to Address Them. *Int J Environ Res Public Health*. 2020 ;17(19):7279. https://doi.org/10.3390/ijerph17197279
11. Chan WK, Leung KI, Hoc C, Wuc W, Lam KY, Wong NL, et al. Effectiveness of online teaching in physical education during covid-19 school closures: A survey study of frontline physical education teachers in Hong Kong. *J Phys Educ Sport*. 2021;21(4):1622–8. https://doi.org/10.7752/jpes.2021.04205
12. Lopez-Fernandez O, Männikkö N, Kääriäinen M, Griffiths MD, Kuss DJ. Mobile gaming and problematic smartphone use: A comparative study between Belgium and Finland. *J Behav Addict*. 2018;7(1):88–99. https://doi.org/10.1556/2006.6.2017.080
13. Wang JL, Sheng JR, Wang HZ. The Association Between Mobile Game Addiction and Depression,

Social Anxiety, and Loneliness. *Front Public Heal*. 2019;7(SEP):5–10. https://doi.org/10.3389/fpubh.2019.00247
14. Li Y, Xu Z, Hao Y, Xiao P, Liu J. Psychosocial Impacts of Mobile Game on K12 Students and Trend Exploration for Future Educational Mobile Games. *Front Educ*. 2022;7:1–10. https://doi.org/10.3389/feduc.2022.843090
15. Delello JA, McWhorter RR, Roberts P, Dockery HS, De Giuseppe T, Corona F. The Rise of eSports: Insights Into the Perceived Benefits and Risks for College Students. *Int J eSports Res*. 2021;1(1):1–19. https://doi.org/10.4018/IJER.20210101.oa5
16. Markey PM, Ferguson CJ, Hopkins LI. Video game play: Myths and benefits. *Am J Play*. 2020;13(1):87–106.
17. Marston HR, Kowert R. What role can videogames play in the COVID-19 pandemic? *Emerald Open Res*. 2020;2(34):1–10. https://doi.org/10.35241/emeraldopenres.13727.2
18. Barr M, Copeland-Stewart A. Playing Video Games During the COVID-19 Pandemic and Effects on Players' Well-Being. *Games Cult*. 2022;17(1):122–39. https://doi.org/10.1177/15554120211017036
19. Pallavicini F, Pepe A, Mantovani F. The Effects of Playing Video Games on Stress, Anxiety, Depression, Loneliness, and Gaming Disorder During the Early Stages of the COVID-19 Pandemic: PRISMA Systematic Review. *Cyberpsychology, Behav Soc Netw*. 2022;25(6):334–54. https://doi.org/10.1089/cyber.2021.0252
20. Gan Y, Zhang T, Zhang J, Wu X, Shao M. Impact of Mobile Game Addiction Tendency on Chinese University Students: A Hierarchical Linear Modeling Study. *Frontiers in Psychology*, 2022;13: 937446. https://doi.org/10.3389/fpsyg.2022.937446
21. Sunday OJ, Adesope OO, Maarhuis PL. The effects of smartphone addiction on learning: A meta-analysis. *Comput Hum Behav Reports*. 2021;4:100114. https://doi.org/10.1016/j.chbr.2021.100114
22. Elsayed W. Covid-19 pandemic and its impact on increasing the risks of children's addiction to electronic games from a social work perspective. *Heliyon*. 2021;7(12):e08503. https://doi.org/10.1016/j.heliyon.2021.e08503
23. Miyamoto-Mikami E, Zempo H, Fuku N, Kikuchi N, Miyachi M, Murakami H. Heritability estimates of endurance-related phenotypes: A systematic review and meta-analysis. *Scand J Med Sci Sports*. 2018;28(3):834–45. https://doi.org/10.1111/sms.12958
24. Kasović M, Štefan L, Petrić V, Štemberger V, Blažević I. Functional endurance capacity is associated with multiple other physical fitness components in 7–14-year-olds: a cross-sectional study. *BMC Public Health*. 2021;21(1):669. https://doi.org/10.1186/s12889-021-10702-2
25. López-Valenciano A, Suárez-Iglesias D, Sanchez-Lastra MA, Ayán C. Impact of COVID-19 Pandemic on University Students' Physical Activity Levels: An Early Systematic Review. *Front Psychol*. 2021;11:1–10. https://doi.org/10.3389/fpsyg.2020.624567
26. Dunton GF, Do B, Wang SD. Early effects of the COVID-19 pandemic on physical activity and sedentary behavior in children living in the U.S. *BMC Public Health*. 2020;20(1):1351. https://doi.org/10.1186/s12889-020-09429-3
27. Kwok C, Leung P, Poon K, Fung XC. The effects of internet gaming and social media use on physical activity, sleep, quality of life, and academic performance among university students in Hong Kong: A preliminary study. *Asian J Soc Heal Behav*. 2021;4(1):36. https://doi.org/10.4103/shb.shb_81_20
28. Cash P, Isaksson O, Maier A, Summers J. Sampling in design research: Eight key considerations. *Des Stud*. 2022;78:101077. https://doi.org/10.1016/j.destud.2021.101077
29. Miller CJ, Smith SN, Pugatch M. Experimental and quasi-experimental designs in implementation research. *Psychiatry Res*. 2020;283:112452. https://doi.org/10.1016/j.psychres.2019.06.027
30. Magee MK, White JB, Merrigan JJ, Jones MT. Does the Multistage 20-m Shuttle Run Test Accurately Predict VO2max in NCAA Division I Women Collegiate Field Hockey Athletes? *Sports*. 2021;9(6):75. https://doi.org/10.3390/sports9060075
31. Safron C, Landi D. Beyond the BEEPs: affect, FitnessGram®, and diverse youth. *Sport Educ Soc*. 2022;27(9):1020–34. https://doi.org/10.1080/13573322.2021.1953978
32. Iturain Barrón A, Quintana Riera S, Reychler G. The 3 Minute Step Test is a validated field test to evaluate the functional exercise capacity in children aged 6 to 12. *Respir Med Res*. 2021;80:100833. https://doi.org/10.1016/j.resmer.2021.100833
33. Kieu NT Van, Jung SJ, Shin SW, Jung HW, Jung ES, Won YH, et al. The Validity of the YMCA 3-Minute Step Test for Estimating Maximal Oxygen Uptake in Healthy Korean and Vietnamese Adults. *J Lifestyle Med*. 2020;10(1):21–9. https://doi.org/10.15280/jlm.2020.10.1.21
34. Kim TK. T test as a parametric statistic. *Korean J Anesthesiol*. 2015;68(6):540. https://doi.org/10.4097/kjae.2015.68.6.540
35. Prestes PAN, Silva TEV, Barroso GC. Correlation analysis using teaching and learning analytics. *Heliyon*. 2021;7(11):e08435. https://doi.org/10.1016/j.heliyon.2021.e08435
36. Pollock RD, Carter S, Velloso CP, Duggal NA, Lord JM, Lazarus NR, et al. An investigation into the relationship between age and physiological function in highly active older adults. *J Physiol*. 2015;593(3):657–80. https://doi.org/10.1113/jphysiol.2014.282863
37. Lepers R, Rüst CA, Stapley PJ, Knechtle B. Relative improvements in endurance performance with age: evidence from 25 years of Hawaii Ironman racing. *Age (Omaha)*. 2013;35(3):953–62. https://doi.org/10.1007/s11357-012-9392-z
38. Markov A, Hauser L, Chaabene H. Effects of Concurrent Strength and Endurance Training on Measures of Physical Fitness in Healthy Middle-Aged and Older Adults: A Systematic Review with Meta-

Analysis. *Sport Med*. 2022; https://doi.org/10.1007/s40279-022-01764-2
39. Cooper R, Strand BH, Hardy R, Patel K V., Kuh D. Physical capability in mid-life and survival over 13 years of follow-up: British birth cohort study. *BMJ*. 2014;348:g2219. https://doi.org/10.1136/bmj.g2219
40. Vancini RL, dos Santos Andrade M, Andre Barbosa de Lira C, Theodoros Nikolaidis P, Knechtle B. Is It Possible to Age Healthy Performing Ultra-endurance Exercises? *Int J Sport Stud Heal*. 2022;4(1):1–4. https://doi.org/10.5812/intjssh.122900
41. Jackson AS, Sui X, Hébert JR, Church TS, Blair SN. Role of Lifestyle and Aging on the Longitudinal Change in Cardiorespiratory Fitness. *Arch Intern Med*. 2009;169(19):1781–7. https://doi.org/10.1001/archinternmed.2009.312
42. Vajda M, Oreská Ľ, Černáčková A, Čupka M, Tirpáková V, Cvečka J, et al. Aging and Possible Benefits or Negatives of Lifelong Endurance Running: How Master Male Athletes Differ from Young Athletes and Elderly Sedentary? *Int J Environ Res Public Health*. 2022;19(20):13184. https://doi.org/10.3390/ijerph192013184
43. Podstawski R, Bernard K, Tomasz B, Michał B, Dariusz C. Relationship Between BMI and Endurance-Strength Abilities Assessed by the 3 Minute Burpee Test. *Int J Sport Sci*. 2013;3(1):28–35. https://doi.org/10.5923/j.sports.20130301.06
44. Bonney E, Ferguson G, Smits-Engelsman B. Relationship between Body Mass Index, Cardiorespiratory and Musculoskeletal Fitness among South African Adolescent Girls. *Int J Environ Res Public Health*. 2018;15(6):1087. https://doi.org/10.3390/ijerph15061087
45. Chen G, Chen J, Liu J, Hu Y, Liu Y. Relationship between body mass index and physical fitness of children and adolescents in Xinjiang, China: a cross-sectional study. *BMC Public Health*. 2022;22(1):1680. https://doi.org/10.1186/s12889-022-14089-6
46. Syamsuryadin, Suharjana, Laksmi AR, Dewangga MW, Sirada A, Hutomono S, et al. Correlation between Body Mass Index and Cardiovascular Fitness of Volleyball Athletes at Athletes Training Center during the Covid-19 Pandemic. *J Med Chem Sci*. 2022;5(4):631–6. https://doi.org/10.26655/JMCHEMSCI.2022.4.19
47. Santisteban KJ, Lovering AT, Halliwill JR, Minson CT. Sex Differences in VO2max and the Impact on Endurance-Exercise Performance. *Int J Environ Res Public Health*. 2022;19(9):4946. https://doi.org/10.3390/ijerph19094946
48. Cano A, Ventura L, Martinez G, Cugusi L, Caria M, Deriu F, et al. Analysis of sex-based differences in energy substrate utilization during moderate-intensity aerobic exercise. *Eur J Appl Physiol*. 2022;122(1):29–70. https://doi.org/10.1007/s00421-021-04802-5
49. Sandbakk Ø, Ettema G, Holmberg HC. Gender differences in endurance performance by elite cross-country skiers are influenced by the contribution from poling. *Scand J Med Sci Sports*. 2014;24(1):28–33. https://doi.org/10.1111/j.1600-0838.2012.01482.x
50. Baumgart C, Hoppe M, Freiwald J. Different Endurance Characteristics of Female and Male German Soccer Players. *Biol Sport*. 2014;31(3):227–32. https://doi.org/10.5604/20831862.1111851
51. Rascon J, Trujillo E, Morales Acuna FJ, Gurovich AN. Differences in Determining Exercise Intensity in Males and Females. *Med Sci Sport Exerc*. 2019;51(6S):765–6. https://doi.org/10.1249/01.mss.0000562781.85673.6c
52. Busing K, West C. Determining the Relationship Between Physical Fitness, Gender, and Life Satisfaction. *SAGE Open*. 2016;6(4):215824401666997. https://doi.org/10.1177/2158244016669974
53. Trotter MG, Coulter TJ, Davis PA, Poulus DR, Polman R. The Association between Esports Participation, Health and Physical Activity Behaviour. *Int J Environ Res Public Health*. 2020;17(19):7329. https://doi.org/10.3390/ijerph17197329
54. Guthold R, Stevens GA, Riley LM, Bull FC. Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1·9 million participants. *Lancet Glob Heal*. 2018;6(10):e1077–86. https://doi.org/10.1016/S2214-109X(18)30357-7

Information about the authors:

Joseph Lobo; (Corresponding Author); https://orcid.org/0000-0002-2553-467X; josephlobo@cca.edu.ph; City College of Angeles; Angeles City, Philippines.

Bryan Dale Bernardo; https://orcid.org/0000-0003-1498-8390; bryandalebernardo@cca.edu.ph; City College of Angeles; Angeles City, Philippines.

Cite this article as:

Lobo J, Bernardo BD. Mobile Gamers versus Non-gamer students' endurance levels via Beep and 3-minute step test. *Pedagogy of Physical Culture and Sports,* 2023;27(1):54–62.
https://doi.org/10.15561/26649837.2023.0107

Received: 30.11.2022
Accepted: 04.01.2023; Published: 28.02.2023

2023
01

ORIGINAL ARTICLE

Teachers' preferences of teaching primary physical education: curriculum preferences

Štefan Adamčák[1ABCDE], Michal Marko[2ABCDE], Pavol Bartík[1ABCDE]

[1] *Faculty of Arts, Matej Bel University in Banská Bystrica, Slovakia*
[2] *Faculty of Performing Arts, Academy of Arts in Banská Bystrica, Slovakia*

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

Abstract

Background and Study Aim Physical education teachers play an important role in helping students to understand the importance of physical activity. By maximizing physical activity time in physical education, physical education teachers can influence physical activity needs of students. The present study was aimed at analysing and comparing teachers' preferences of teaching primary physical education.

Material and Methods Survey instrument (teachers' preferences) was carried out five months (May – September, 2022) through an intentional sampling with survey group size of 1300 physical education teachers of primary education: (i) Preschool and elementary pedagogy (50.76%, n = 660), (ii) Related pedagogy (49.24%, n = 640). Pearson correlation coefficient (r), chi-square test (χ^2) (inferential) and descriptive statistics were used to analyse and compare the data.

Results Physical education is often viewed as a marginal subject within the curriculum, however after analysing the data, on average, 63.54% (n = 826) of survey group believes that physical education is just as important as any other school subject ($p < .01$). According to 52% (n = 676) of survey group, games are popular teaching activity in physical education ($p < .01$). About 40.50% (n = 526) of survey group does not enjoy teaching dance in physical education ($p < .01$). About 37.55% (n = 488) of survey group considers teaching health and fitness as demanding ($p > .05$) and athletics and gymnastics (36.06%, n = 468) as undemanding ($p < .01$).

Conclusions Primary physical education is an important component of curriculum and provides unique challenges for those involved with its teaching.

Keywords: curriculum preference, physical education, primary education, teacher, teaching preference

Introduction

Education is an important part of life, irrespective of one's gender, race or social class. Education determines the future of each human and each country [1]. Investing in education is an important strategy a country can make in its future, however education level varies among countries for many reasons, in particular economic development, poverty, government corruption and level of democracy [2]. Regardless of which attitudes we strive for in teaching, teachers play an important role in providing the power of education to today's children, therefore giving them the possibility for a better future [3]. Teachers play an important role in achieving high-quality education to children and need to develop their competencies [4]. Demands made of teachers are high, despite of maintaining important role in society. Many of them do not understand what quality teaching requires and do not see quality teaching as a demanding mission that requires rigorous training [5].

Classroom teachers play an important role in helping children (1st – 4th year of study) reading and writing and in developing educational path because of being a foundation of learning and transfer of knowledge [6]. Expected to teach all compulsory subjects, classroom teachers teach all of them with the same criteria, however some of them who specialise in a specific area can influence how a subject is taught and how children gain a view of the subject [7]. Lack of primary physical education knowledge among classroom teachers contribute to uncertainty about what they are doing, however classroom teachers who demonstrate good knowledge can encourage positive attitudes towards physical education in children [8]. Physical education struggles for recognition in relation to other school subjects because of being perceived as a "less important" school subject [6]. Other school subjects higher within the school subject hierarchy receive preferential allocation of resources, in particular equipment funding, staffing allocations and timetabling, however most children express positive attitudes towards physical education, because of subject teacher [9, 10]. Children who have more positive attitudes towards physical education participate more in physical activity [11, 12]. Lack of physical activity among children is of increasing concern, with data showing a decline in participation in physical education [13].

doi:10.15561/26649837.2023.0108

Physical education teachers (classroom teachers) delivering meaningful content and appropriate instruction must become the norm in educational process in order to provide children with positive physical activity attitudes that will lead them to maintain physical activity [14]. Quality teaching, including physical education, is recognised as an important influence in shaping school attainment [15]. Because of importance of physical education in terms of teachers' influence on physical education itself and children' attitudes, the present study was aimed at analysing and comparing teachers' preferences of teaching primary physical education.

Materials and Methods

Participants

In accordance with study aim, the target population consisted of primary physical education teachers (n = 1300) in Slovakia (convenience sample), recruited through an electronic mail [16]. Recruitment process was carried out regularly, in intervals of 2 weeks, aiming for intentional sampling, regarding educational attainment: (i) Preschool and elementary pedagogy (50.76%, n = 660), (ii) Related pedagogy (49.24%, n = 640); average age: (i) ⩾ 30 years (13.08%, n = 170), (ii) < 30 - ⩾ 40 years (24.92%, n = 324), (iii) <40 - ⩾ 50 years (37.54%, n = 488), (iiii) < 50 years (24.46%, n = 318); career level: (i) Beginning teacher (7.84%, n = 102), (ii) Independnet teacher (30%, n = 390), (iii) Attestation - 1 (35.22%, n = 458), (iiii) Attestation - 2 (26.92%, n = 350). Data interpretation process (original) consisted of 1500 debriefing forms, however 13.34% (n = 200) of them did not meet inclusion criteria, containing in recruitment process. After meeting the inclusion criteria (data cleaning), the survey group consisted of 1300 primary physical education male (17.24%, n = 224) and female (82.76%, n = 1075) teachers in Slovakia.

Research Design

Single-measure comparative study (descriptive) was carried out five months (May – September, 2022), in order to analyse and compare teachers' preferences of teaching primary physical education. Creating an effective survey instrument made it easier to analyse and compare the data, which consisted of two sections: (i) Demographic information (e.g., age, gender, region (town), career level, educational attainment); (ii) Survey items, which consisted of five closed questions: (ii-i) Teachers' preferences of teaching primary physical education, (ii-ii) Popular teaching activity in primary physical education, (ii-iii) Unpopular teaching activity in primary physical education (ii-iiii) Undemanding teaching activity in primary physical education, (ii-iiiii) Demanding teaching physical activity in primary physical education. Survey instrument was available online (unlimited time) and collecting data (May – September, 2022). Available feedback (online) did not indicate any issues with comparative design (technical) and survey (e.g., grammar, vocabulary). Financial incentives were not given (voluntary participation), however the survey group (n = 1300) received the final report with their personal results afterwards. Online version of survey was not detecting any data about the identity and chosen due to cost effectiveness, time saving and easy accessibility (Microsoft Forms, Office 365, Microsoft Corp., Redmond, WA, USA) [17].

Statistical Analysis

Available survey data (online) collected through survey (debriefing form) was tabulated and figured in database designed precisely for single-measure comparative study (descriptive). Incidence of responses (each item) of survey group (n = 1300) was analysed and compared by using the Tap3 - Gamo (statistical software) (Banská Bystrica, Slovakia). After cleaning available survey data of survey group (n = 1300), descriptive statistics (e.g., arithmetic mean, percentage frequency) were used to analyse and compare the data (clean). Chi-square test (χ^2), of which the significance level (α) was .01 and .05., evaluated the difference between 1300 physical education teachers of primary education: (i) Preschool and elementary pedagogy (50.76%, n = 660), (ii) Related pedagogy (49.24%, n = 640) [18]. Measuring the strength of linear association between four variables was evaluated by using the Pearson correlation coefficient (r) [19].

Results

According to study aim, Figure 1 illustrates teachers' preferences of teaching primary physical eduction within the survey group (n = 1300) and confirms that 63.54% (n = 826) of survey group (n = 1300) considers primary physical education as important as other school subject. 23.92% (n = 310) of survey group (n = 1300) believes that primary physical education is popular subject, compared to 8.44% (n = 110) of survey group (n = 1300) who believes that primary physical education is unpopular subject. 53 teachers (4.09%) out of 1300 (100%) are not teaching primary physical education. Difference between 1300 physical education teachers of primary education reveals statistical significance ($p < .01$) ($\chi^2_{(3)} = 13.83$; $p = .003$).

Popular teaching activity in primary physical education within the survey group (n = 1300) illustrates Figure 2 and confirms that games are popular in 52% (n = 676) of survey group (n = 1300). Athletics and gymnastics inscribe 260 teachers (19.99%) out of 1300 (100%). Dancing is popular in 188 teachers (14.43%). 130 teachers (10.04%) out of 1300 (100%) inscribe outdoor and adventure. Health and fitness are popular in 3.54% (n = 46) of teachers. Difference between 1300 physical education

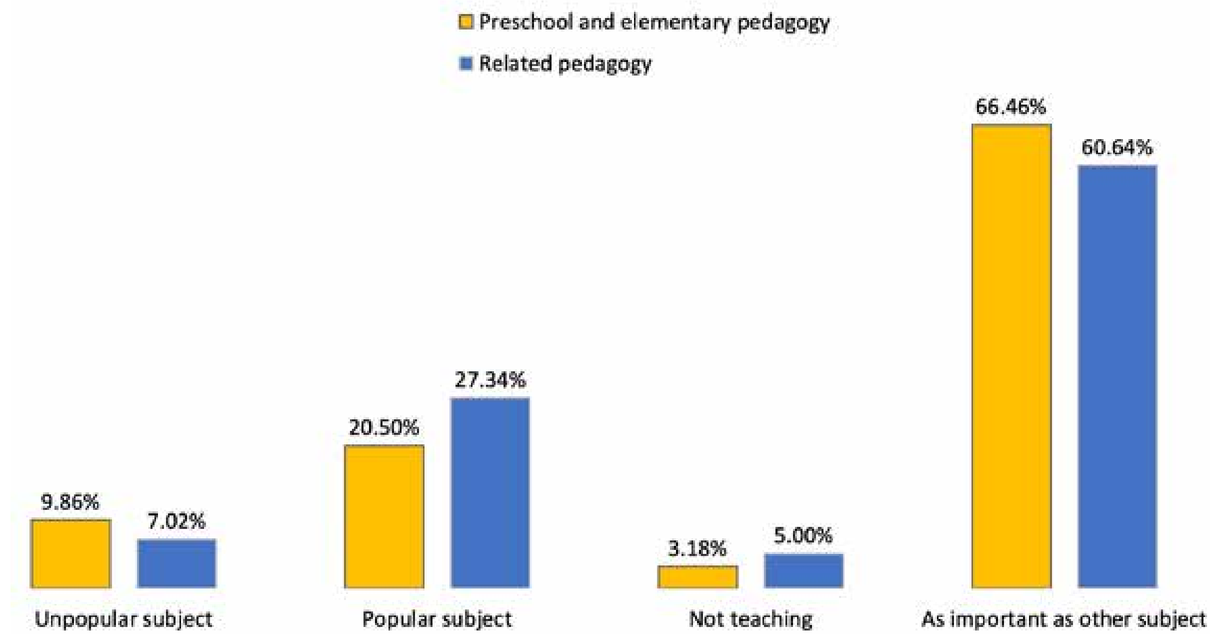

Figure 1. Teachers' preferences of teaching primary physical education

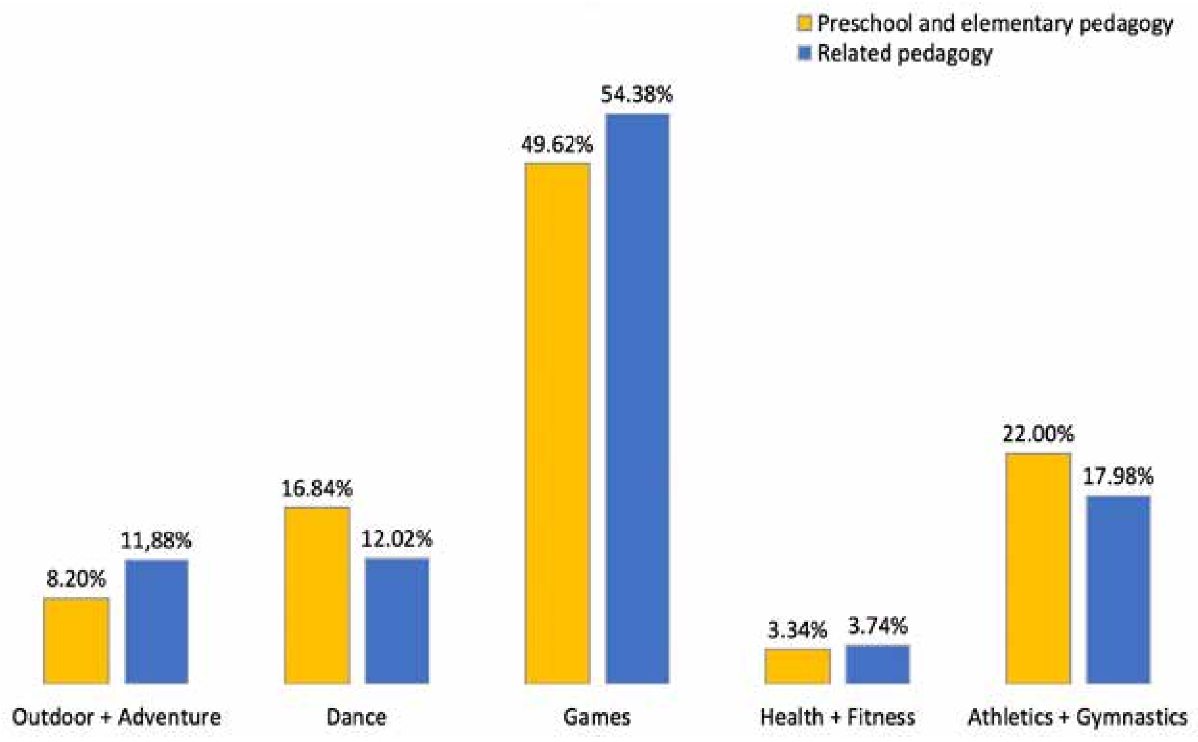

Figure 2. Popular teaching activity in primary physical education

teachers of primary education reveals statistical significance ($p < .01$) ($\chi^2_{(4)} = 13.80$; $p = .007$). Pearson correlation coefficient ($r = .452$) of preschool and elementary pedagogy (50.76%, n = 660) indicates moderate positive correlation between popular teaching activity and undemanding teaching activity and moderate negative correlation between popular teaching activity and unpopular teaching activity ($r = -.303$) and demanding teaching activity ($r = -.340$). Dependence of related pedagogy (49.24%, n = 640) between popular teaching activity and undemanding teaching activity is moderate ($r = .390$), as well as popular teaching activity and unpopular teaching activity ($r = -.412$) and demanding teaching activity ($r = -.448$).

Figure 3 illustrates unpopular teaching activity in primary physical education within the survey group (n = 1300) and confirms that dancing in not popular in 526 teachers (40.49%). Health and fitness inscribe 26.05% (n = 338) of teachers. 2.79%-difference is between games (12.86%, n = 167), athletics and gymnastics (10.54%, n = 138) and outdoor and adventure (10.08%, n = 130). Difference between 1300 physical education teachers of primary education reveals statistical significance ($p < .01$) ($\chi^2_{(4)} = 20.05$; $p = .0004$). Pearson correlation coefficient ($r = -.738$) of preschool and elementary pedagogy (50.76%, n = 660) indicates strong negative correlation between unpopular teaching activity and undemanding teaching activity and strong positive correlation between unpopular teaching activity and demanding teaching activity ($r = .767$). Dependence of related pedagogy (49.24%, n = 640) between unpopular teaching activity and undemanding teaching activity is strong ($r = -.766$), as well as unpopular teaching activity and demanding teaching activity ($r = .896$).

According to 36.05% (n = 468) of teachers, athletics and gymnastics are undemanding teaching activity in primary physical education (Figure 4). 312

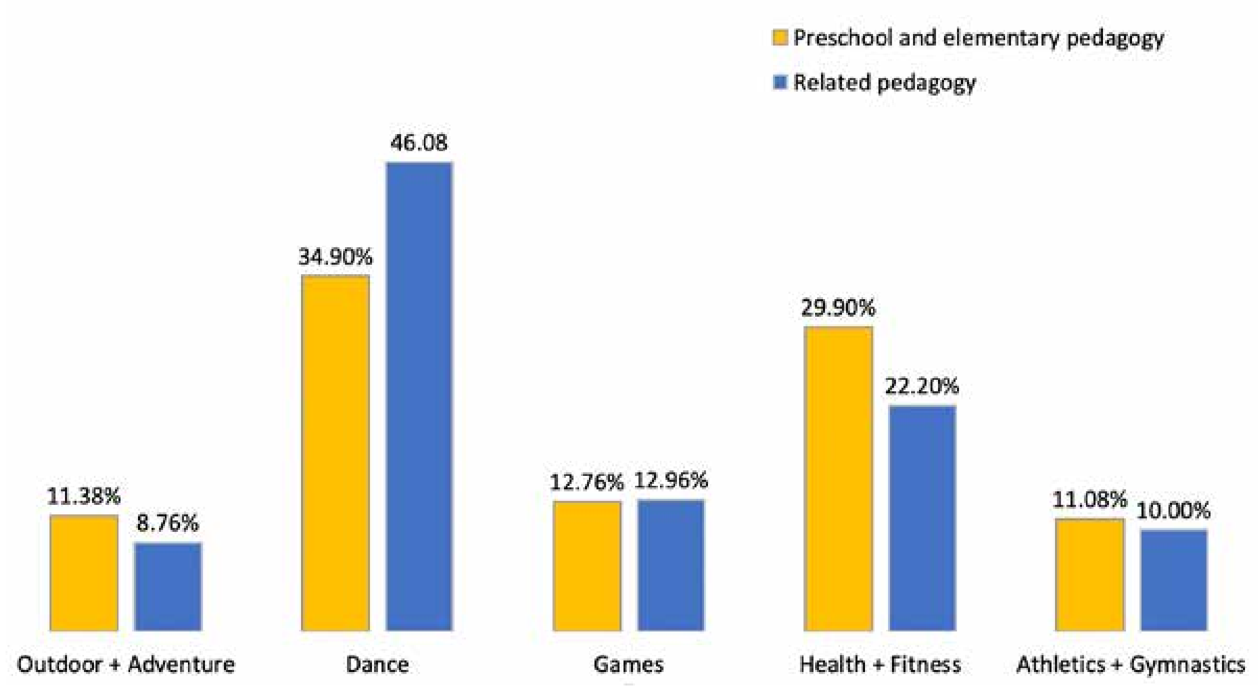

Figure 3. Unpopular teaching activity in primary physical education

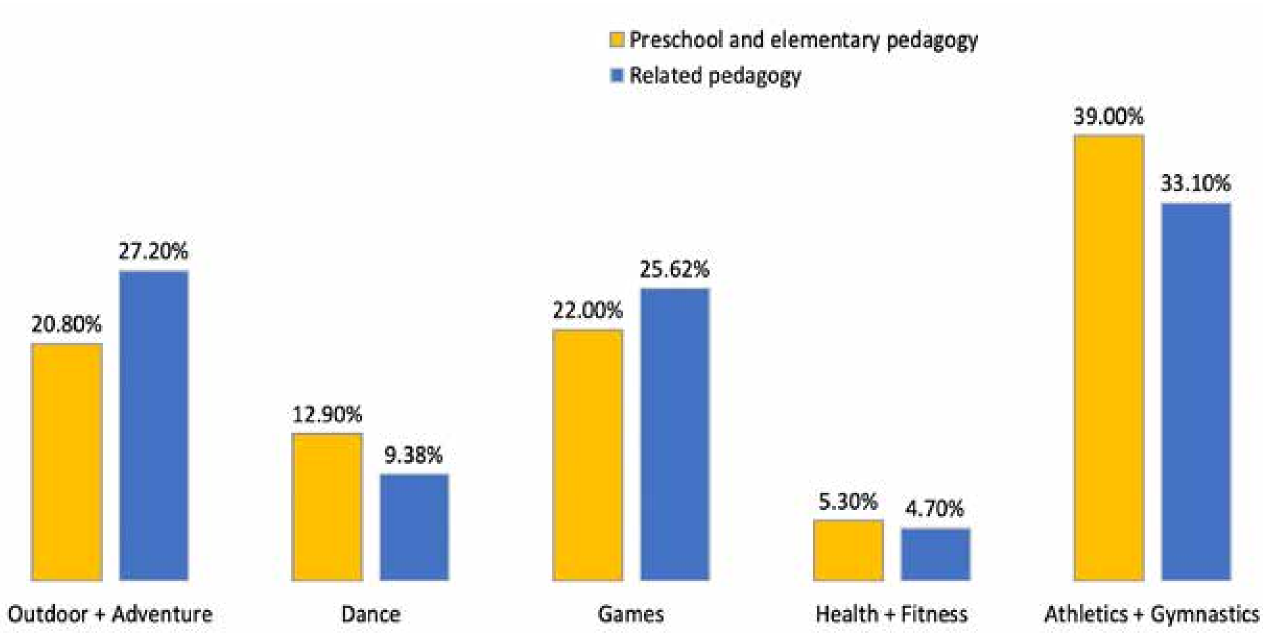

Figure 4. Undemanding teaching activity in primary physical education

teachers (24%) out of 1300 (100%) inscribe outdoor and adventure and 23.82% (n = 310) of teachers consider teaching games as undemanding. Dancing is undemanding in 144 teachers (11.14%), health and fitness in 65 (5%). Difference between 1300 physical education teachers of primary education reveals statistical significance ($p <.01$) ($\chi^2_{(4)} = 14.30$; $p = .006$). Pearson correlation coefficient ($r = -.974$) of preschool and elementary pedagogy (50.76%, n = 660) indicates strong negative correlation between undemanding teaching activity and demanding teaching activity and strong negative correlation between undemanding teaching activity and demanding teaching activity ($r = -.842$) of related pedagogy (49.24%, n = 640).

Demanding teaching activity in primary physical education within the survey group (n = 1300) illustrates Figure 5 and confirms that health and fitness are demanding in 488 teachers (37.55%). 392 teachers (30.20%) out of 1300 (100%) inscribe dance and 14.95% (n = 195) of teachers consder teaching games as demanding. 9.01% (n = 177) of teachers consider athletics and gymnastics as demanding and outdoor and adventure are demanding in 8.29% (n = 107). Difference between 1300 physical education teachers of primary education does not reveal significant difference ($p < .05$) ($\chi^2_{(4)} = 7.14$; $p = .128$).

Discussion

Physical education teachers of primary education (classroom teachers) have an important role in achieving high-quality education. Physical education teachers may occupy a "marginal role" in schools [20], however 63.54% (n = 826) of survey group (n = 1300) believes that physical education is just as important as any other school subject ($p < .01$). Slovak physical education teachers consider physical education as important as other school subject in schools (80.48%, n = 169) and 17% (n = 36) of them consider physical education more important as other school subjects [21]. Romanian school physical education is perceived as important discipline in curriculum and 75% of teachers consider physical education as important in educational system [22]. Hungarian primary pupils, aged 11 -14 years, consider physical education as important school subject in schools (84.8%, n = 910), however 11.6% (n = 124) of them are of different attitudes [23]. With regards the importance of physical education, 51.6% (n = 148) of students consider physical education "at least" as important as other school subject, however 28.8% (n = 82) of them denote physical education as "not so important" school subject in curriculum. Difference between genders is significant ($p < .01$, $\chi^2 = 20.20$). 60.6% of boys consider physical education "at least" as important as other school subject, compared to 42.6% of girls [24]. Becoming more popular among primary pupils, aged 5 - 11 years [25], devaluation of physical education increases as pupils grow [26]. Existing evidence shows that majority of parents consider physical education as important as other academic subjects. Attitudes range from 54% to 84%, depending on subject being compared [14]. Some believe that physical education is an important (the most) component of curriculum [27].

Games are such a large and integral part of content of physical education curriculum [28]. Incorporating fun and meaningful activity like "traditional" games during physical education can serve as alternative strategy to promote physical activity [29]. According

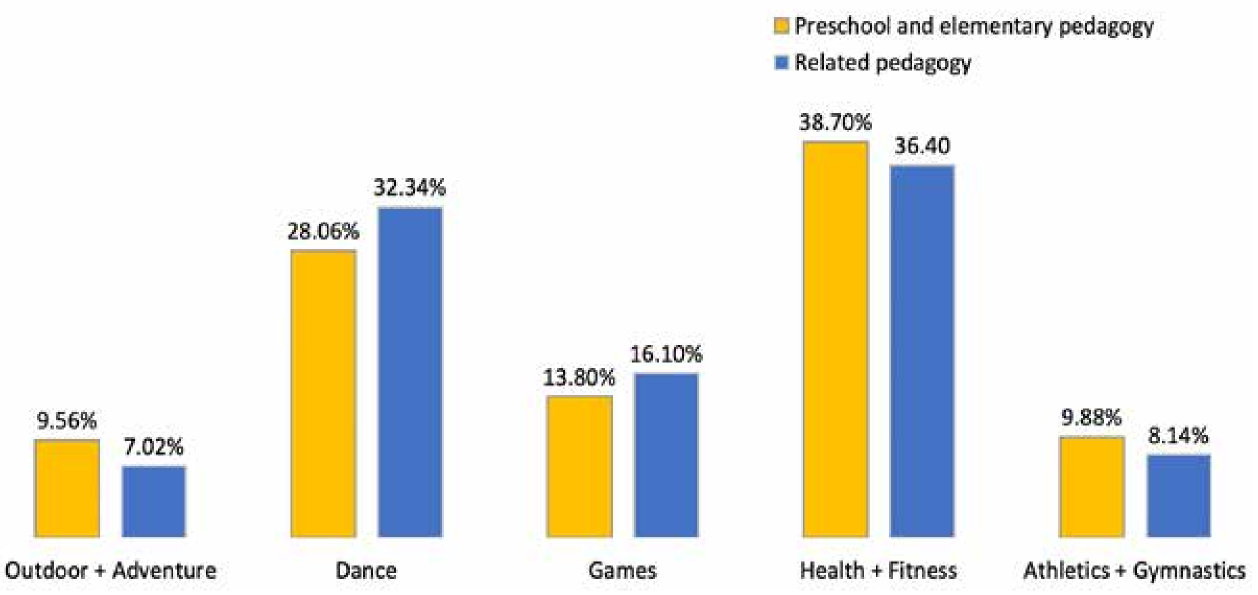

Figure 5. Demanding teaching activity in primary physical education

to 52% (n = 676) of survey group (n = 1300), games are popular teaching activity in physical education. Existing evidence shows that games are popular among male and female physical education teachers in Slovakia (58.02%; n = 653) [30]. Athletics and gymnastics inscribe 260 teachers (19.99%) out of 1300 (100%). Lack of gymnastics instruction is because of physical education teachers' strong focus on other content and their lack of competence and confidence in teaching gymnastics [31]. Many physical education teachers have lack of dance experience and confidence in teaching dancing in school curriculum. 392 teachers (30.20%) out of 1300 (100%) consider teaching dancing as demanding and unpopular (40.49%, n = 526). Almost no attention is given to how physical education teachers approach creative aspects in dance teaching [32]. Teachers of physical education devote almost no time to dancing because they cannot dance themselves and as consequence are limited (pedagogical) in teaching [33]. Outdoor education has positive impacts for children and interest among teachers in this teaching method is growing [34]. 312 teachers (24%) out of 1300 (100%) consider outdoor and adventure as undemanding and popular in 10.08% (n = 130) of teachers. The present study was aimed at analysing and comparing teachers' preferences of teaching primary physical education in Slovakia, therefore it is problematic to compare our results with available foreign literature, however it is important to realise the interconnectedness of "theory and practice".

Conclusions

Current curriculum allows primary (classroom) teachers partial freedom in choosing the content of education to meet the learning needs of pupils, in consultation with their wider school community. Current physical education curriculum inspires pupils to excel and secceed in primary physical education and enhance their lifelong interest in physical activity. We consider it important to devote extra attention to activity of dance and health in terms of future training of physical education teachers of primary education. Demanding factor with unpopularity of them reflects in practice in the teaching quality of primary physical education.

Acknowledgement

Our study received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of interest

The authors have no conflicts of interest to declare.

References

1. Yuliani S, Hartanto D. Perceptions of education role in developing society: Case study at Riau, Indonesia. *Edu. Learn.,* 2017; 6(1): 143–157. https://doi.org/10.5539/jel.v6n1p143
2. L'Roe J, Kimambo NE, Strull R, Kuzaara D, Kyengonzi F, Naughton-Treves L. 'Education is the land I give them' – mothers' investments in children's future livelihoods amid growing land competition in rural Uganda. *J. Land Use Sci.,* 2022; 17(1): 181–194. https://doi.org/10.1080/1747423X.2022.2027533
3. Avramidis E, Norwich B. Teachers' attitudes towards integration/ inclusion: A review of the literature. *Eur. J. Spec. Needs Educ.,* 2010; 17(2): 129–147. https://doi.org/10.1080/08856250210129056
4. Kim S, Raza M, Seidman E. Improving 21st-century teaching skills: Key to effective 21st-century learners. *Res. Comp. Int. Educ.,* 2019; 14(1): 99–117. https://doi.org/10.1177/1745499919829214
5. Milić M, Radić Hozo E, Maulini C, De Giorgio A, Kuvačić G. What is the place of physical education among the teaching priorities of primary school teachers? An empirical study on importance, qualification and perceived teachers' competence. *Educ. Sci.,* 2022; 12(9): 613. https://doi.org/10.3390/educsci12090613
6. De-la-Peña C, Fernádez-Cézar R, Solano-Pinto N. Attitude towards mathematics of future teachers: How important are creativity and cognitive flexibility?. *Front. Psychol.,* 2021; 12: 713941. https://doi.org/10.3389/fpsyg .2021.713941
7. Ökmen B, Şahin Ş, Kılıç A. A critical view to the primary school teaching. *Int. J. Contemp. Educ. Res.,* 2020; 7(1): 54–70. https://doi.org/10.33200/ijcer.633051
8. Tsangaridou N. Educating primary teachers to teach physical education. *Eur. Phys. Educ. Rev.,* 2012; 18 (3): 275–286. https://doi.org/10.1177/1356336X12450788
9. Bleazby J. Why some school subjects have a higher status than others: The epistemology of the traditional curriculum hierarchy. *Oxf. Rev. Educ.,* 2015; 41(5): 1–19. https://doi.org/10.1080/03054985.2015.1090966
10. Iannucci C, Richards KA. Teaching multiple school subjects role conflict. *Kinesiol. Rev.,* 2022; 11(3): 1–11. https://doi.org/10.1123/kr.2021-0039
11. Subramaniam R, Silverman S. Middle school students' attitudes toward physical education. *Teach. Teach . Educ.,* 2007; 23(5): 602–611. https://doi.org/10.1016/j.tate.2007.02.003
12. Zeng H. Attitudes of high school students toward physical education and their sport activity preferences. *J. Soc. Sci.,* 2011; 7(4): 529–537. https://doi.org/10.3844/jssp.2011.529.537
13. Jenkinson KA, Benson AC. Barriers to providing physical education and physical activity in Victorian State secondary schools. *Aust. J. Teach. Educ.,* 2010; 35(8): 1. https://doi.org/10.14221/ajte.2010v35n8.1
14. Masurier GL, Corbin CB. Top 10 reasons for quality physical education. *J. Phys. Educ. Recreat. Dance,*

2006; 77(6): 44 –53. https://doi.org/10.1080/07303084.2006.10597894
15. Griggs G, Fleet M. Most people hate physical education and most drop out of physical activitiy: In search of credible curriculum alternatives. *Edu. Sci.,* 2021; 11(11): 701. https://doi.org/10.3390/educsci11110701
16. Sappleton N, Lourenço F. Email subject lines and response rates to invitations to participate in a web survey and a face-to-face interview: Sound of silence. *Int. J. Soc. Res. Methodol.,* 2016; 19(5): 611–622. https://doi.org/10.1080/13645579.2015.1078596
17. Andrade C. Limitations of online surveys. *Indian J. Psychol. Med.,* 2020; 42(6): 575–576. https://doi.org/10.1177/0 253717620957496
18. Sharpe D. Chi-square test is statistically significant: Now what?. *Prac. Assess. Res. Eval.,* 2015; 20(1): 8. https://doi.org/10.7275/tbfa-x148
19. Turhan SN. Karl Pearson's chi-square tests. *Educ. Res. Rev.,* 2020; 15(9): 575–560. https://doi.org/10.5897/ERR20 19.3817
20. Richards K, Gaudreault K, Starck J, Woods A. Physical education teachers' perceptions of perceived mattering and marginalization. *Phys. Educ. Sport Pedagogy,* 2018; 23(4): 445–449. https://doi.org/10.1080/1740 8989.2018.1455820
21. Balga T, Antala B. Opinions of physical education teachers on the position of physical education among other subjects in Slovakia. *7th International Scientific Conference; 2020 Mar 19-20;* Serbia. Leposaviq: 2020. P.65-70.
22. Liuşnea C. The importance of physical education classes in actual European context. *Ann. Dunarea Jos.,* 2018; 1(1): 21–27. https://doi.org/10.35219/efms.2018.1.04.
23. Fügedi B, Capel S, Dancs H, Bognár J. Satisfaction and preferences of physical education students and head of physical education department: Meeting the new curricular expectations. *J. Hum. Sport Exerc.,* 2016; 11(1): 1–18. https://doi.org/10.14198/jhse.2016.111.01
24. Fintor JG. Everyday physical activity of students in Nyíregyháza. *Prac. Theo. Syst. Educ.,* 2015; 10(2): 115-130. https://doi.org/10.1515/ptse-2015-0011
25. Vasícková J, Neuls F, Svozil Z. Popularity of school physical education and its effect on performed number steps. *J. Phys. Educ. Sport,* 2015: 15(1): 40–46. https://doi.org/10.7752/jpes.2015.01007
26. Pereira RJ, Silva RMF, Assunção JGS, Farinha MG. Devaluation of sports culture in school environment. *Res., Soc. Dev.,* 2022; 11(12): e501111234814. https://doi.org/10.33448/rsd-v11i12.34814
27. Aboshkair KA. The role of physical education in school. *J. Emerg. Technol. Innov. Res.,* 2022; 9(1): 156–161.
28. Martínez RS, Founaud MP, Aracama A, Oiabide A. Sports teaching, traditional games and understanding in physical education: Tale of two stories. *Front. Psychol.,* 2020; 11: 581721. https://doi.org/10.3389/fpsyg.2020.5 81721
29. Alzan AB, Ismail N, Fauzi NFM, Talib R. Playing traditional games vs. free-play during physical edu-cation lesson to improve physical ecitivity: A comparison study. *Pedagogy Phys. Cult. Sports,* 2021; 25 (3): 178–187. https://doi.org/10.15561/26649837.2021.0306
30. Nemec M, Adamčák Š, Marko M. Popularity and common isues of teaching sports games at elementary schools in Slovakia. *J. Sports Sci. Med.,* 2022: 37(1): 89–100. https://doi.org/10.18276/cej.2022.1-08
31. Robinson DB, Randall L, Andrews E. Physical education teacher' (lack of) gymnastics instructions: An exploration of a neglected curriculum requirement. *Curric. Stud. Health Phys. Educ.,* 2020; 11(1): 1–16. https://doi.org/10.1080/25742981.2020.1715232
32. Engdahl C, Lundvall S, Barker D. 'Free but not free-free': Teaching creative aspects of dance in physical education teacher education. *Phys. Educ. Sport Pedagogy,* 2021; 1:13. https://doi.org/10.1080/17408989.2021.201 4435
33. Gibbs B, Quennerstedt M, Larsson H. Teaching dance in physical education using exergames. *Eur. Phys. Educ. Rev.,* 2017; 23(2): 237–256. https://doi.org/10.1177/1356336X16645611
34. Sjöblom P, Eklund G, Fagerlund P. Student teachers' views on outdoor education as a teaching method-two cases from Finland and Norway. *J. Adventure Educ. Outdoor Learn.,* 2021; 1–15. https://doi.org/10.1080/1472 9679.2021.2011338

Information about the authors:

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

Michal Marko; https://orcid.org/0000-0003-0054-0667; michal.marko@aku.sk; Faculty of Performing Arts, Academy of Arts; Banska Bystrica, Slovakia.

Pavol Bartík; (Corresponding Author); https://orcid.org/0000-0002-2087-7876; pavol.bartik@umb.sk; Faculty of Arts, Department of Physical Education and Sport, Matej Bel University in Banská Bystrica; Banska Bystrica, Slovakia.

Cite this article as:

Adamčák Š, Marko M, Bartík P. Teachers' preferences of teaching primary physical education: curriculum preferences. *Pedagogy of Physical Culture and Sports,* 2023;27(1):63–70.
https://doi.org/10.15561/26649837.2023.0108

Received: 15.12.2022
Accepted: 17.01.2023; Published: 28.02.2023

ORIGINAL ARTICLE

Differences in explosive strength values for students of the faculty of physical education and sports (male) according to body mass index levels

George D. Mocanu[1ABCDE], Gabriel Murariu[2ACE], Vladimir Potop[3,4ADE]

[1] *Faculty of Physical Education and Sport, "Dunarea de Jos" University of Galati; Galati, Romania*
[2] *Faculty of Sciences and Environment, "Dunarea de Jos" University of Galati; Galati, Romania*
[3] *Department of Physical Education and Sport, University of Pitesti, Romania*
[4] *State University of Physical Education and Sport, Republic of Moldova*

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

Abstract

Background and Study Aim Explosive strength/muscular strength is demanded at the level of different body segments and regions in most sports. The purpose of the research: is to identify the differences in the manifestation of explosive force between groups of underweight, normal weight and overweight university students; to determine the associations between the anthropometric parameters and the value of the results in the applied tests.

Material and Methods The investigated group consists of 147 students (men) of the Faculty of Physical Education and Sport, divided into 3 distinct groups for the analysis of the results: underweight (age=20.40±1.18, BMI=17.81±0.93), normal weight (age=20.504±1.671, BMI =22.24±1.67) and overweight (age=22.44±2.24, BMI=28.01±2.74). 7 tests were used to evaluate the explosive strength of the lower body (Vertical Jump Test, Standing Long Jump Test, 3-Hop Test, The multiple 5 bounds test, 30s Lateral double leg hop test, 30s Continuous vertical jumps, Speed Test 10m). A number of 6 tests were used to evaluate the explosive strength of the upper body (Overhand ball throw, Shot put, Overhead Medicine Ball Throw-forward, Overhead Medicine Ball Throw-backward, Medicine ball chest throw, 30s Plyometric Push-Ups).

Results Univariate test results indicate F values associated with significant thresholds at the lower body level ($P<0.05$) for tests based on horizontal jumps (Standing Long Jump, 3-Hop Test and The multiple 5 bounds test), where underweight and normal weight have the better average scores. At the level of the upper body, the situation is changed (for Shot put and medicine balls throws), where the overweight have the best average values, followed by the normal weight, and the worst results are found for the underweight group ($P<0.05$). Only for the Overhand ball throw and 30s Plyometric Push-Ups, the superiority of the overweight is not statistically confirmed ($P>0.05$). Correlation calculation (Pearson values) indicates positive associations between body height and vertical and horizontal jumps (except for those repeated for 30s), but negative associations of BMI and body mass with jump-based tests. However, BMI and body mass are moderately, positively and significantly correlated with throw-based tests ($P<0.05$).

Conclusions We can state that the classification of students in different BMI categories generates differences in explosive strength values between the 3 studied groups. The comparisons indicate the superiority of underweight and normal weights over overweight in all lower body explosive strength tests. The comparisons indicate also the significant superiority of overweight in the medicine ball and shot put tests over normal and underweight. The obtained results cannot be generalized, due to the small size of the underweight and overweight samples. Further investigations on larger groups of university students being necessary.

Keywords: muscle strength, university students, explosive efforts, BMI levels, differences, evaluation.

Introduction

In the system of motor skills, muscle strength and power play a major role in the manifestation and exploitation of motor potential in ontogeny [1]. The identification of talent characteristics for elite teenagers (according to the characteristics of 9 different sports) indicates the importance of the explosive strength of the lower limbs and overhead-throwing skills in volleyball and badminton, respectively agility and sprint/speed in soccer, volleyball, badminton and judo [2]. A longitudinal study of children and adolescents from several countries revealed an improvement in Standing long jump performance between 1960 and 1990, then a stagnation until the year 2000, followed by a decline in performance to the present, for most of the analyzed countries. However, no associations were noted between the decrease in functional explosive

doi:10.15561/26649837.2023.0109

strength of the lower body and socio-economic or health indicators [3].

Physical activity, somatic type and body composition are factors that strongly influence the explosive strength of the lower body. Comparative studies between athletic vs. non-athletic university students (22.16 years old) showed higher VJT values for those who were physically active, with an increased percentage of skeletal muscle mass and belonging to the mesomorph/ectomorph types. Endomorphs, non-athletes and those with high body mass values perform poorly in vertical jump tests [4]. The presence of jumping asymmetries for young adolescent athletes (both genders) involved in team sports (basketball, handball and volleyball) is a factor associated with a reduction in short-distance sprint and jumping test performances [5]. Comparison of the motor performance of Hungarian athletic (basketball) and non-athletic university students shows only height variations in favor of basketball players, but they perform better in vertical jump and balance tests, and high BMI values are negatively correlated with physical performances [6]. Research on Nigerian university students, recreational basketball players (19.12 years) indicated strong correlations between the Vertical jump test (VJT) value and a series of anthropometric data (height, weight, BMI values, calf girth and foot length). However, no significant associations were reported between VJT with femoral length, thigh girth, tibial length [7]. Testing the fitness level of Brazilian adolescents identifies poorer performance of overweight and underweight, including SLJ explosive strength and medicine ball throw assessment [8]. Other research (on the level of university students majoring in medicine) reports negative associations of BMI with lower body explosive strength, but also positive associations between the amount of muscle tissue and vertical jump values [9]. A study of Brazilian junior soccer players revealed significant negative associations between VJT performance and agility tests with body fat percentage, so increased body fat percentage affects vertical jump values [10]. Muscle power performances for elite league Greek handball players vary by ranking position/rank. For the team in the first place, better results are obtained in the vertical jump test, compared to the team in the 8th place out of 11 clubs, the situation being similar in the Continuous vertical jumps 30s test. The results can also be explained by the higher average height as well as the greater amount of lean muscle mass of the champion team [11].

For Brazilian adolescent wrestlers, positive and strong associations between horizontal jumps and body height are highlighted, and for judo practitioners, significant associations are reported between body mass and body height with the medicine ball chest throw and VJT tests. Judoka has superior performances in 3 kg medicine ball chest throw, VJT, standing long jump test (SLJ) [12]. The quality of technical executions in different sports disciplines depends on the value/level of the athletes and the values of the explosive force at the level of the muscle chains involved in the effort, the aging of the body and the degeneration of the musculoskeletal system. Increased values of body fat percentage affect motor performance and sports results [13, 14, 15, 16]. At the level of young track and field (shot-put) practitioners, performances in this athletic test are correlated with several factors: the volume of the muscles of the upper and lower body, peak power output (PPO) of arms and legs. Other important factors are work of hand action force (WHAF) and release velocity parameter [17]. Parameters related to fitness level and motor skills are relevant for the selection of elite archers in a Malaysian youth group. The best was found to score higher in balance, strength and other skills, including muscle power, as assessed by the Vertical jump test and Standing long jump [18]. Other authors demonstrate the importance of the psychological factor in achieving performance in muscle strength tests. The use of external stimuli (performance feedback and verbal encouragement) has a beneficial effect on explosive strength test performance (Speed test 10 m and Vertical jump test) for physically active and inactive university students in Saudi Arabia [19].

Sports subjects (team sports games, combat sports, track and field) have higher explosive force values compared to physically active but non-sporting subjects, as a result of adaptive changes of the body [20]. A direct effect of physical effort and systematic training is the improvement of physical performance, as a result of morphological and functional adaptations to various demands [21, 22, 23]. However, the installation of muscle fatigue affects the performance related to the strength of the lower body, being found significantly lower values in the vertical and horizontal jumps after physical effort, compared to those before the effort. The studies were carried out on subjects involved in recreationally trained physical activities, but also on the level of adult groups, according to Cooper et al. and Leister et al. [24, 25]. Studies on athletes have shown that the onset of muscle fatigue generates a limitation of vertical jump height performance. Performing repeated vertical jumps for 30 s with a load of 30% of the body weight value generated a significant decrease in Vertical jump values after 3 minutes of rest. Retesting after 4 minutes and 5 minutes identified an increase in performance, as a result of the effect of PAP/ post activation potentiation that generates an acute production of muscle strength [26].

Regarding the training methodology aimed at increasing explosive strength for various sports and at the level of different muscle chains, specialized studies are numerous. The survey of strength and conditioning coaches (SCCs) from various countries and sports branches identifies that multiple hops/ lunges are most often programmed (84%) as variations of plyometric exercises. About 40% of coaches want to use as much technology as possible in the developed programs for training athletes and training aimed at optimizing muscle strength [27]. Using various medicine ball throws (medicine ball twist throw, medicine ball chest throw, medicine ball forward overhead throw) alleviates shoulder and arm strength deficit for Indonesian students [28]. Studies on Japanese university student athletes (20.2 years old) confirm the usefulness of using training programs that include push-ups (with similar load to 40% 1RM bench press) in terms of muscle hypertrophy and the increase in explosive strength in the medicine ball throw test [29].

Purpose of the Study. Our research aims to verify the following directions:

1. Determining possible differences in the lower and upper body explosive strength tests between the 3 BMI categories (underweight, normal weight and overweight) for (male) students of the Faculty of Physical Education and Sport in Galati
2. Identifying the value and significance of the associations between the somatic parameters and the results of the applied tests.

Materials and Methods

Participants

Our group consists of 147 university students (men) enrolled in undergraduate studies (years 1 and 2), within the Faculty of Physical Education and Sport in Galati - Lower Danube University in Galati. Of these, 99 are performance athletes, and 48 are non-athletes (but physically active in curricular and leisure activities), the division into groups for processing and analysis of the results being made according to BMI levels. These are: underweight (N=15, age= 20.40±1.18), normal weight (N=107, age=20.504±1.671) and overweight (N= 25, age=22.44±2.24). Additional data related to the group structure and anthropometric characteristics are presented in table 1, the numerical imbalance between the 3 formed groups being obvious.

Research Design

Our study is based on a cross-sectional investigation, planned in May 2019, within the Research Center for Human Performance of the Faculty of Physical Education and Sports in Galați (Romania). The participants will receive information related to the purpose of the research and the execution technique of the explosive force evaluation tests. All rules related to scientific research involving human subjects, according to the Helsinki Declaration, were followed [30, 31]. The students were instructed not to engage in demanding efforts before the tests, in order not to affect the obtained performances. The warm-up was based on aerobic demands at reduced intensities and dynamic stretching with the mobilization of the joints and muscle chains required for the tests. The evaluation was scheduled over 2 days, separately for the lower and upper body, due to the large number of samples. 7 lower body (A) explosive strength evaluation tests and 6 upper body explosive strength evaluation tests (B) were planned. Information related to the validity and description of the tests is provided by [32, 33, 34, 35, 36, 37, 38].

(A) 1. Vertical Jump Test/VJT (Sargent Jump test)/*cm*, 2.Standing Long Jump Test/SLJ (Standing Broad Jump)/*cm*, 3. 3-Hop Test (3 double leg jumps)/ *cm*, 4. The multiple 5 bounds test/MB5/(5 forward jumps with alternative left and right leg contacts)/ *cm*, 5. 30s lateral double leg hop test (30-Second Endurance Jump- jumping over an obstacle/rope or fence raised at the height of the knees)/*number of executions*, 6. 30s Continuous vertical jumps / Modified Bosco Repeat Vertical Jump Test 30 s by touching a sign or object raised to 2/3 of the personal best jump/ maximum jump height/ *number of executions*, 7. Speed Test 10m (Sprint test 10m)/*s*.

(B) 1. Overhand ball throw (140 grams and 8cm diameter) *(m),* 2. Shot put-track and field - 4kg women and 7.260kg men/*cm*, 3. Standing Overhead Medicine Ball Throw-forward (3 kg)/*cm,* 4. Standing Overhead Medicine Ball Throw-backward (3kg)/*cm* 5. Standing medicine ball chest throw (3kg)/*cm,* 6. 30s Plyometric Push-Ups/clap push-ups/ *number of executions*.

Statistical Analysis

The data obtained from the tests were statistically processed with SPSS Software (Statistical Package

Table 1. Distribution of students into groups and analyzed anthropometric characteristics (average and standard deviation)

Indicator	Subjects	Athletes	Non-athletes	Height	Weight	BMI
Underweight	15(10.22%)	8(5.44%)	7(4.78%)	180.333±8.861	58.3000±7.936	17.816±0.935
Normal weight	107(72.78%)	75(51.02%)	32(21.76%)	178.602±6.328	71.102±7.8751	22.249±1.670
Overweigh	25(17.00%)	16(10.88%)	9(6.12%)	178.460±6.597	89.040±6.3507	28.016±2.741

for the Social Sciences/IBM Vers.24 Chicago, IL, USA). ANOVA parametric techniques were used (multivariate and univariate test, highlighting the values of F, significance thresholds and size effect/ Partial eta squared /η^2_p , Levene's Test of Equality of Error Variances. Were calculated data related to the averages of the 3 BMI groups in the tests, the differences between them and their significance with the application of Bonferroni Post Hoc Tests. The Pearson parametric correlations (r) were calculated between the anthropometric indicators and the value of the performances in the muscle strength tests. The confidence interval was set at 95% ($p < 0.05$) [39, 40, 41, 42, 43].

Results

Table 2 summarizes the information resulting from the multivariate test, tables 3 and 4 the univariate test results for the lower and upper body. Tables 5 and 6 identify the significance of the differences between the averages of the resulting pairs (by BMI levels), and tables 7 and 8 summarize the value of the correlation coefficients between the anthropometric indicators and the set of applied tests.

The global effect of the independent variable BMI levels on the performances in the strength tests for the tested students (Multivariate Tests) is presented in table 2. The value F is associated with a statistically significant threshold ($p < 0.05$), an aspect also reinforced by the η^2_p value (expression of size effect), which indicates that 20.4% of the variance in the applied tests is generated/explained by the variable BMI levels.

The influence of the independent variable on the explosive force evaluation tests in the lower limbs is summarized in table 3. It is observed that significant thresholds of F ($P<0.05$) are obtained only in tests based on horizontal jumps (Standing Long Jump, 3-Hop Test and The multiple 5 bounds test). However, ^2_p values indicate that an average effect size for The multiple 5 bounds test (where 8.4% of the performance variance is explained by the BMI levels variable), in the other two cases low and medium effect size values were obtained. For vertical jumps, repeated jumps and the 10m sprint, all thresholds obtained are insignificant ($P>0.05$), and the η^2_p values indicate weak and null effect sizes, so in these tests no significant influence of BMI levels on muscle strength is found of the lower body.

The results of the analysis of variance for upper body explosive strength are summarized in Table 4. Significant thresholds for F values ($P<0.05$) are identified for all tests involving throwing heavy objects (the 3 variants of throwing the medicine ball and Shot put – track and field). In these cases, strong and medium η^2_p values are also obtained (for example, for Shot put 14.2% of the variance of the results is determined by the influence of BMI

Table 2. The results of the Multivariate Tests (MANOVA[a])

Gender	Effect	λ	F	Hypothesis df	Error df	Sig.	η^2_p	Observed Power
Male	BMI levels	0.634	2.595[b]	26.000	264.000	0.000	0.204	1.000

a. Design: BMI levels; b. Exact statistic;

λ-Wilk's lambda; F-Fisher test; df-degrees of freedom; Sig.-level of probability; η^2_p-partial eta squared

Table 3. Univariate test results (ANOVA) – The effect of variable BMI levels on the performances in lower body strength tests

Dependent Variable	Sum of Squares	Mean Square	F (2, 144)	Sig.	Partial Eta Squared	Observed Power
Vertical Jump Test/VJT	37.703	18.851	0.496	0.610	0.007	0.130
Standing Long Jump Test/SLJ	2442.195	1221.097	3.914	0.022	0.052	0.698
3-Hop Test	23044.884	11522.442	3.245	0.042	0.043	0.610
The multiple 5 bounds test/MB5	124330.803	62165.402	6.609	0.002	0.084	0.907
30s lateral double leg hop test	257.277	128.638	2.247	0.109	0.030	0.452
Speed Test 10m	0.053	0.026	2.488	0.087	0.033	0.493
30s Continuous vertical jumps	21.623	10.811	0.935	0.395	0.013	0.210

Table 4. Univariate test results (ANOVA) – The effect of variable BMI levels on the performances in upper body strength tests

Dependent Variable	Sum of Squares	Mean Square	F (2, 144)	Sig.	Partial Eta Squared	Observed Power
Overhand ball throw (OBT)	69.922	34.961	0.686	0.505	0.009	0.164
Shot put -track and field	243239.472	121619.736	11.873	0.000	0.142	0.994
Overhead Medicine Ball Throw-forward 3kg	396630.905	198315.452	7.541	0.001	0.095	0.941
Overhead Medicine Ball Throw-backward 3kg	443911.827	221955.913	6.970	0.001	0.088	0.922
Medicine ball chest throw 3kg	140055.364	70027.682	6.132	0.003	0.078	0.883
30s Plyometric Push-Ups/clap push ups	113.179	56.590	1.122	0.329	0.015	0.244

levels). Non-significant thresholds of F (P>0.05) are registered only for Overhand Ball Throw and 30s Plyometric Push-Ups, where the size effect values are also weak or null, so in these cases performances are not decisively influenced by BMI levels.

The differences between the average scores at the level of the BMI pairs, for the explosive force of the lower body, are shown in table 5. They capture the superior scores of the underweights in almost all tests (except for 30s Continuous vertical jumps, where the normal-weights have the best average), and the overweight group has the worst results in all tests, among all tested groups. However, few significant differences (P<0.05) are reported and these are between the underweight and overweight groups for the 3 horizontal jump tests. Even if the normal weight group has higher values than the overweight group in all tests, we identified only one significant difference between these 2 groups (for The multiple 5 bounds test). The average values of the normal weight group are close to those of the underweight group, with only insignificant differences being reported (P>0.05). We found that regular physical activity reduces the gaps and mitigates the variations in explosive strength performances between the compared groups, in 4 of the 7 tests evaluated.

The average values and the differences between them at the level of the 3 pairs for the explosive strength of the upper body are shown in table 6. We find a major change, in the sense that the overweight group has the superiority in these tests, followed by that of the normal weight group, and the worst results belong to those in the underweight group. The differences are statistically significant (P<0.05) for the Shot put test and the medicine ball throwing variants, both between the overweight and underweight groups, and between the overweight and normal weight groups. This situation can be explained by the composition of the group of overweight athletes, involved in rugby, handball, fitness/bodybuilding and combat sports, where the level of muscle mass development and the demands of the upper body are obvious. Only insignificant differences (P>0.05) are reported between the underweight and normal weight groups, even though normal weight has better average scores in all tests. No significant differences were recorded between the groups for the overhand ball throw and 30s Plyometric Push-Ups, so the superiority of the average performances for normal weight and overweight is not statistically confirmed.

Associations between anthropometric indicators and lower body explosive strength values are shown in Table 7. Body mass and BMI levels are negatively associated with most leg strength test performances, except Speed test 10m. Height shows weak and significant positive associations (P<0.05) with vertical and horizontal jumps, but also negative associations with repeated jumps and Speed test 10m. Most of the weak but significant (P<0.05) negative associations with the tests are observed at the BMI level, so increasing BMI and body mass indices are correlated with decreased muscle power in all jumps, but weakly, positively and significantly correlated with short distance sprint. This aspect that must take into account the fact that, in the sprint, the increase in the result actually highlights a weaker performance, so a negative influence of BMI and body mass can also be discussed.

The associations between the anthropometric indicators and the explosive strength tests of the upper body (Table 8) are materialized in weak and medium correlation coefficients, but statistically significant (P<0.05) at the Shot put level and the 3 medicine ball throwing tests. We can state that the tall students and with increased values of muscle mass and BMI index have better values in tests of throwing heavy objects. The aspect is not confirmed for throws with light objects and for plyometric push-ups, where all correlation coefficients obtained are statistically insignificant (P>0.05).

Discussion

Other similar research also identifies differences between lower and upper body explosive strength

Table 5. Synthesis of average values and differences obtained between the 3 BMI categories for lower body explosive strength (underweight=15, normal weight=107, overweight=25)

Test	Group	Mean	Std. deviation	Std. error	a-b	Sig.[b]	a-c	Sig.[b]	b-c	Sig.[b]
Vertical Jump Test/ VJT	a. underweight	44.066	6.250	1.592	0.751	1.000	1.867	1.000	1.116	1.000
	b. normal weight	43.315	6.154	0.596						
	c. overweight	42.200	6.159	1.233						
Standing Long Jump Test/SLJ	a. underweight	234.667	13.854	4.561	8.732	0.225	15.987*	0.019	7.255	0.200
	b. normal weight	225.934	18.231	1.708						
	c. overweight	218.680	17.087	3.533						
3-Hop Test	a. underweight	720.533	47.112	15.387	26.571	0.324	49.053*	0.038	22.483	0.275
	b. normal weight	693.962	60.608	5.761						
	c. overweight	671.480	61.550	11.918						
The multiple 5 bounds test/ MB5	a. underweight	1176.400	110.702	25.042	45.690	0.269	108.400*	0.002	62.710*	0.013
	b. normal weight	1130.710	98.208	9.376						
	c. overweight	1068.000	81.798	19.397						
30s lateral double leg hop test	a. underweight	32.800	5.857	1.954	0.529	1.000	3.960	0.334	3.431	0.129
	b. normal weight	32.271	7.587	0.732						
	c. overweight	28.840	8.320	1.513						
Speed Test 10m	a. underweight	1.874	0.099	0.027	-0.011	1.000	-0.059	0.244	-0.048	0.108
	b. normal weight	1.885	0.099	0.010						
	c. overweight	1.933	0.119	0.021						
30s Continuous vertical jumps	a. underweight	20.866	3.758	0.878	-0.358	1.000	0.667	1.000	1.024	0.531
	b. normal weight	21.224	3.320	0.329						
	c. overweight	20.200	3.523	0.680						

*The mean difference is significant at the .05 level. [b]Adjustment for multiple comparisons: Bonferroni.

values, most of which are in agreement with the results obtained in our study.

Excess body mass induces negative effects on lower body muscle strength tests, an aspect signalled by the analysis of young Greek basketball players. In the U18 group, average countermovement/CMJ performances of 40 cm for those of normal weight and 37.3 cm for overweight ones are obtained. For the SLJ test a performance of 248 cm for those of normal weight and 229 cm for overweight ones is reported. Even though in the Speed Test 10m both groups have equal values (1.91s), for the U15 and U12 groups, weaker results are obtained for the overweight [44]. Other research reports a decline in fitness levels for university students [4, 6, 18, 45]. The results are in accordance with those obtained by us, where the underweight and normal-weight have superior values compared to the overweight in horizontal jumps.

Jump values are higher for athletic Indian university students (23.86 years) compared to those not engaged in regular physical activity (22.16 years). At VJT, athletes get 49.13cm, compared to 42.41cm for non-athletes. The values of the explosive force of the lower limbs are positively correlated with the ectomorph and mesomorph constitutional types, low body mass and the percentage of muscle tissue, respectively negatively correlated with the endomorph type, weight and body fat percentage [46]. A longitudinal study of university students in Taiwan (20–24 years) identified stronger negative associations between BMI and standing long jump (SLJ) strength for men compared to women. Average values of 201.87 cm for men and 149.66 cm for women are obtained for the participants [47]. Significant differences between Indian male university student athletes and non-athletes are highlighted for VJT (49.13cm vs 42.41cm). Performances for explosive leg strength are positively associated with mesomorph and ectomorph somatic type, lean body

Table 6. Synthesis of average values and differences obtained between the 3 BMI categories for upper body explosive strength (underweight=15, normal weight=107, overweight=25)

Test	Group	Mean	Std. deviation	Std. error	a-b	Sig.[b]	a-c	Sig.[b]	b-c	Sig.[b]
Overhand ball throw	a. underweight	39.226	7.437	1.844						
	b. normal weight	41.302	6.481	0.690	-2.076	0.881	-2.619	0.790	-0.544	1.000
	c. overweight	41.846	9.389	1.428						
Shot put -track and field	a. underweight	581.733	81.223	26.132						
	b. normal weight	646.186	93.152	9.784	-64.454	0.067	-151.867*	0.000	-87.413*	0.000
	c. overweight	733.600	138.871	20.242						
Overhead Medicine Ball Throw-forward	a. underweight	822.667	196.292	41.871						
	b. normal weight	879.570	147.866	15.677	-56.903	0.615	-180.533*	0.003	-123.630*	0.002
	c. overweight	1003.200	196.822	32.433						
Overhead Medicine Ball Throw-backward	a. underweight	1090.933	189.227	46.075						
	b. normal weight	1164.570	169.714	17.251	-73.637	0.410	-198.587*	0.003	-124.950*	0.006
	c. overweight	1289.520	207.270	35.690						
Medicine ball chest throw	a. underweight	764.533	114.092	27.592						
	b. normal weight	820.495	106.723	10.331	-55.962	0.179	-118.107*	0.003	-62.145*	0.029
	c. overweight	882.640	103.058	21.373						
30s Plyometric Push-Ups/ clap push ups	a. underweight	13.733	5.509	1.834						
	b. normal weight	16.607	7.086	0.687	-2.874	0.433	-2.987	0.600	-0.113	1.000
	c. overweight	16.720	7.950	1.421						

*The mean difference is significant at the .05 level. [b]Adjustment for multiple comparisons: Bonferroni.

Table 7. The value of the Pearson correlation coefficients between anthropometric indicators and lower body explosive strength tests

Variable		Vertical Jump Test	Standing Long Jump	3-Hop Test	The multiple 5 bounds test	30s lateral double leg hop test	30s Continuous vertical jumps	Speed Test 10m
Weight	r (value)	-0.004	-0.141	-0.123	-0.138	-0.306**	-0.173*	0.181*
	Sig.	0.959	0.089	0.137	0.095	0.000	0.036	0.028
Height	r (value)	0.212*	0.156	0.199*	0.354**	-0.196*	-0.084	0.136
	Sig.	0.010	0.058	0.015	0.000	0.017	0.312	0.101
BMI	r (value)	-0.118	-0.250**	-0.253**	-0.333**	-0.247**	-0.146	0.269**
	Sig.	0.154	0.002	0.002	0.000	0.003	0.078	0.001

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

mass and % skeletal muscle mass, and negative associations are reported with endomorph somatic type, % body fat, weight and body surface area [46]. Our research supports these findings, identifying negative associations between BMI values and all types of jumping tests.

For the sedentary Indian university students in Calcutta (21-25 years old), average vertical jump test/CMJ values of 47 cm for men and very poor values of 22.05 cm for women are obtained. The high percentage of adipose tissue is a factor that limits the value of performances in this test [48]. We have identified a statistically significant superiority of the underweights over the overweight ones, for all variants of horizontal jumps. Weight loss (by ketogenic diet) for Korean Taekwondo practitioners

Table 8. The value of Pearson correlation coefficients between anthropometric indicators and upper body explosive strength tests

Variable		Overhead ball throw	Shot put	Overhead Medicine Ball Throw-forward	Overhead Medicine Ball Throw-backward	Medicine ball chest throw	30s Plyometric Push-Ups
Weight	r (value)	0.101	0.508**	0.483**	0.450**	0.459**	0.067
	Sig.	0.226	0.000	0.000	0.000	0.000	0.423
Height	r (value)	0.141	0.330**	0.381**	0.311**	0.380**	-0.024
	Sig.	0.088	0.000	0.000	0.000	0.000	0.773
BMI	r (value)	0.035	0.401**	0.355**	0.342**	0.322**	0.082
	Sig.	0.670	0.000	0.000	0.000	0.000	0.326

** Correlation is significant at the 0.01 level (2-tailed)

shows beneficial effects related to increased aerobic capacity and fatigue resistance. For the SLJ/Standing broad jump, however, a slight decrease in performance is noted, from 229.6cm to 227.55cm, a similar situation being also reported for the sprint test [49]. These results are above the average values obtained by our normal weight and overweight groups, but our underweight group achieves a higher average value (234.667cm).

Elevated body fat values negatively influence performance in all short-distance sprint and explosive strength tests for young Qatari handball players (16.55 years) selected from all playing positions. At the CMJ, the normal-weight achieve 32.61cm and the obese 31.15cm, and at the 3 kg medicine ball chest throw/MBCT the normal-weight have a result of 840cm vs 769cm for the obese [50]. The results of our overweight group do not confirm these findings for the medicine ball throws (where they perform better) and they do confirm for the vertical jump (where the average values are poorer). Values in explosive strength and agility tests (T-test, 10m sprint, VJT) for Qatari handball players are much better for those with a low percentage of adipose tissue. However, the medicine ball overhead throw-forwards test is the only one in which the average value of the overweight is higher than that of the normal weight [51]. For Polish university students (20 years old), negative associations are reported between BMI values and increased body mass with almost all muscle strength tests. However, positive correlations are identified for medicine ball throw variants, men achieve a maximum score of 1283cm for Medicine ball forward throw, 1745cm for Medicine ball backward throw and 278cm for SLJ [52]. The higher values of the overweight for the medicine ball throwing tests are also confirmed by our study, with significant differences compared to the normal and underweight students.

Studies on young football/soccer players (U16, U17 and U-19) highlight the superiority of those who play more minutes in matches, compared to those with fewer playing minutes, in terms of aerobic fitness. However, no significant differences and correlations are reported at the level of anaerobic power (vertical and horizontal jumps) or for Body fat between the two studied categories. For the U19 group, 740cm are obtained in the triple hop test and 40cm in the CMJ, the fitness level being better with advancing age [53]. The triple hop test performance is superior to all the average values obtained by our groups, a possible explanation being the exclusive presence of performance athletes, within our subgroups there are also students who are not constantly involved in performance sports. Body height and vertical jumps are important aspects for the performance of volleyball players (elite level) whose lower body explosive strength test values differ according to the position on the court. The top results for CMJ are obtained by opposite hitters and outside hitters/receivers (57.4 cm), and the best CMJ (with arm swing) values are also reported for the same positions (70.67 cm), according to [54]. Our study identifies positive associations between body height and vertical jump performance, except for 30-second repeated jumps (vertical and horizontal), where the associations are negative.

The comparison of CMJ test values between Brazilian judoka athletes (20.5 years) and Brazilian jiu-jitsu (BJJ) athletes, identifies higher but statistically insignificant scores for judoka (46.56 cm vs. 45.33 cm). For the advanced level groups, the performances are higher and relatively balanced (48.44 cm vs. 48.41 cm). For both disciplines, higher values of experienced athletes are found, compared to beginners/novices, so experience and physical accumulations have a role in the manifestation of explosive strength [55]. Investigation of young track and field sprinters (18 years) indicated strong associations between short-distance sprint/acceleration test performance with vertical jump explosive strength and body height [56].

The use of Trampoline Exercise (20 weeks x 4 sessions per week) for Iranian adolescents has effects on increasing calf girth, but also on optimizing the anaerobic power of the lower limbs, with very good values for VJT (71cm) and SLJ (218cm), according to [57]. Our values for VJT are weaker, but at the SLJ level only the overweight group has a similar performance, and the underweight and normal weight groups have higher average scores. The efficiency of plyometrics in optimizing the explosive strength of the lower limbs is demonstrated on Algerian university students, majoring in Physical Education and Sports (19 years old). They obtain SLJ values of 241cm, compared to 228cm for those who followed a traditional strength development program, the performances being optimized in the triple jump/athletic test and in the short-distance sprint [58]. In this case we note that all 3 of our groups have lower values at SLJ, compared to the value of those who exclusively used plyometrics in training.

Arm muscles are important in serving in tennis, and using push up variations generates increases in muscle strength for Indonesian university student athletes, with final values of 16.38 push-ups [59]. Our overweight and normal weight groups have similar average results, and the underweight group has a poorer score of just 13,733 push-ups.

For male recreational athletes (22.6 years old) involved in team sport games (soccer, basketball, rugby, baseball) values of 1.76s are obtained in the 10m acceleration test. Short-distance sprint values are significantly correlated with unilateral vertical and horizontal jump performance [60]. For US male collegiate student athletes (21.1 years), the following leg muscle strength values are obtained: VJT (51.72cm), SLJ (240.44cm), 10 Yard Sprint (1.72s). Negative associations are identified between SLJ performance and short distance sprint times [61]. All of these studies show leg muscle strength values superior to our students. A comparative analysis of the effectiveness of plyometrics vs electrostimulation for predominantly male Indian badminton players (where agility and vertical jumps are specific demands) identifies better short-distance sprint progress with the plyometric variant. For lower limb explosive strength both methods are efficient, but electrostimulation generated better average results than plyometrics at VJT (55.93cm vs 48.26cm) and at SLJ (237.53cm vs 226.46cm) [62]. In this case also, our groups obtained poorer results than those previously presented. Various sports (soccer and judo) require skills related to strength, speed and motor coordination, with an effect on competition performance. The use of speed-jumping training (various horizontal and vertical jumps) for these sports (Polish teenagers) leads to increases in explosive strength at the level of the legs. The results are better for soccer players: in SLJ 227.2cm vs 225.4cm, and at 3-Hop Test 700.8cm vs 680.4cm [63]. In this case, our underweight group has better average scores on both tests, the normal weight group has similar values, and the overweight group has lower average values.

Conclusions

Univariate tests results indicate F values associated with significant thresholds at the level of the lower body ($P<0.05$) for tests based on horizontal jumps (Standing Long Jump, 3-Hop Test and The multiple 5 bounds test). Similar significant values are obtained at the upper body level for Shot put and medicine ball throws (Overhead Medicine Ball Throw-forward, Overhead Medicine Ball Throw-backward and Medicine ball chest throw). Group comparison according to BMI levels indicates the superiority of underweight and normal weight over overweight in all tests of lower body explosive strength. The situation is reversed for the upper body explosive strength tests, where the overweight has the best average values, followed by the normal weight, and the worst results are found for the underweight group. The only tests at the level of the upper body where the differences between the groups are statistically insignificant ($P>0.05$) are the Overhand ball throw and 30s Plyometric Push-Ups.

The correlations (r / Pearson values) between the anthropometric indicators and the results of the applied set of tests indicate positive associations between body height and vertical and horizontal jumps, except for repeated ones (lateral and vertical 30s). With the exception of the 10m speed test, body mass and BMI only show negative associations with jump-based tests, so increases in these indicators negatively influence performance in all types of jumps. The correlations recorded at the level of the upper body show average positive and, in most cases, significant values ($P<0.05$) of r for most tests, so increases in body mass, BMI and body height are associated with an improvement in results in all throwing tests.

The results of our study must be viewed with caution, the main limitation of the research being the numerical imbalance between the groups, with a low percentage representation of the underweight and overweight groups. Studies on larger and balanced samples are needed from this point of view. We believe that investigations based on the analysis of body composition would bring additional information related to the amount of active muscle mass, especially for the overweight group, and would provide scientific arguments related to their superiority in tests of explosive strength based on throws.

Acknowledgement

The authors thank the group of students who participated in this study.

Conflict of interest

No potential conflict of interest that is of any relevance to this study was reported by the authors.

References

1. Badau D, Badau A. Optimizing Reaction Time in Relation to Manual and Foot Laterality in Children Using the Fitlight Technological Systems. *Sensors*, 2022;22(22):8785. https://doi.org/10.3390/s22228785
2. Pion J, Segers V, Fransen J, Debuyck G, Deprez D, Haerens L, et al. Generic anthropometric and performance characteristics among elite adolescent boys in nine different sports. *European Journal of Sport Science*, 2015;15(5):357–66. https://doi.org/10.1080/17461391.2014.944875
3. Tomkinson GR, Kaster T, Dooley FL, Fitzgerald JS, Annandale M, Ferrar K, et al. Temporal Trends in the Standing Broad Jump Performance of 10,940,801 Children and Adolescents Between 1960 and 2017. *Sports Med*. 2021;51(3):531–48. https://doi.org/10.1007/s40279-020-01394-6
4. Saha S. Morphological Characteristics and Explosive Power of Athlete and Non-Athlete. *Archives of Exercise in Health & Disease*, 2015;5(1/2):354– 8. https://doi.org/10.5628/aehd.v5i1-2.174
5. Fort-Vanmeerhaeghe A, Bishop C, Buscà B, Aguilera-Castells J, Vicens-Bordas J, Gonzalo-Skok O. Inter-limb asymmetries are associated with decrements in physical performance in youth elite team sports athletes. *PLOS ONE*, 2020;15(3):e0229440. https://doi.org/10.1371/journal.pone.0229440
6. Ángyán L, Téczely T, Karsai I, PetÅfi Á. Comparative analysis of the effects of physical exercise. *Acta Physiologica Hungarica*, 2005;92(1):19–26. https://doi.org/10.1556/aphysiol.92.2005.1.3
7. Aiyegbusi A, Fapojuwo O, Ayodele A. Vertical Jump Performances in Recreational Basketball Players in Lagos, Nigeria: The role of Physical characteristics and Anthropometric Parameters of the Lower Limbs. *Journal of the Romanian Sports Medicine Society*, 2016;13(1):7.
8. Lopes VP, Cossio-Bolaños M, Gómez-Campos3 R, de Arruda M, Hespanhol JE, Rodrigues LP. Linear and nonlinear relationships between body mass index and physical fitness in Brazilian children and adolescents. *American Journal of Human Biology*, 2017;29(6):e23035. https://doi.org/10.1002/ajhb.23035
9. Arum sari DW, Ahmadi HUA, Jordan T, Puruhito B, Basyar E, Indraswari DA. Correlation between Body Mass Index, Muscle Mass, and Muscle Explosive Power in First-Year Medical Students of Diponegoro University. *Diponegoro Medical Journal (Jurnal Kedokteran Diponegoro)*, 2021;10(6): 433–437. https://doi.org/10.14710/dmj.v10i6.31687
10. Zanini D, Kuipers A, Somensi IV, Pasqualotto JF, Quevedo J de G, Teo JC, et al. Relationship between body composition and physical capacities in junior soccer players. *Revista Brasileira de Cineantropometria & Desempenho Humano*, 2020;22: e60769. https://doi.org/10.1590/1980-0037.2020v22e60769
11. Nikolaidis PT, Ingebrigtsen J. Physical and Physiological Characteristics of Elite Male Handball Players from Teams with a Different Ranking. *J Hum Kinet*. 2013;38:115–24. https://doi.org/10.2478/hukin-2013-0051 PMID: 24235989
12. Marques V, Coswig V, Viana R, Leal A, Alves F, Alves A, et al. Physical Fitness and Anthropometric Measures of Young Brazilian Judo and Wrestling Athletes and Its Relations to Cardiorespiratory Fitness. *Sports*, 2019;7(2):38. https://doi.org/10.3390/sports7020038
13. Harabagiu N, Pârvu C. The Statistical Analysis of the Game Actions of the Middle-Blocker Based on the Application of the "Data Volley" Software. *Revista Romaneasca pentru Educatie Multidimensionala*, 2022;14(1Sup1):101–10. https://doi.org/10.18662/rrem/14.1Sup1/539
14. Vizitiu E, Constantinescu M. Chapter 27 - Impact of physical activities on overweight people during the COVID-19 pandemic. In: Balas VE, Geman O, editors. *Biomedical Engineering Applications for People with Disabilities and the Elderly in the COVID-19 Pandemic and Beyond*. Academic Press; 2022. P. 313–24. https://doi.org/10.1016/B978-0-323-85174-9.00020-0
15. Vizitiu E, Constantinescu M. Comparative study on the importance of physical activity on body composition in adults. *Balneo and PRM Research Journal*, 2022;13(4):530– 530. https://doi.org/10.12680/balneo.2022.530
16. Voinea N-L, Rață G, Puni A-R, Șufaru C, Ciocan VC. service efficiency index analysis for romanian men's volleyball teams in division A1, 2019-2020 season. In: *Book of Proceedings of the 11th International Congress of Education, Health and Human Movement*. Bucharest: Discobolul Publishing House; 2021 P. 142–53. https://doi.org/10.51267/icehhm2021bp13
17. Landolsi M, Labiadh L, Zarrouk F, Maaref K, Ghannouchi S, Tabka Z, et al. Kinematic analysis of the shot-put: A method of assessing the mechanical work of the hand action force. *European Journal of Sport Science*, 2018;18(9):1208–16. https://doi.org/10.1080/17461391.2018.1478449
18. Muazu Musa R, Abdul Majeed APP, Taha Z, Abdullah MR, Husin Musawi Maliki AB, Azura Kosni N. The application of Artificial Neural Network and k-Nearest Neighbour classification models in the scouting of high-performance archers from a selected fitness and motor skill performance parameters. *Science & Sports*, 2019;34(4):e241–9. https://doi.org/10.1016/j.scispo.2019.02.006
19. Pacholek M. The Effects of Various Stimuli on Motivation and Physical Fitness of Physically Active and Non-Active Students. *Annals of Applied Sport Science*, 2021;9(4):0–0. https://doi.org/10.52547/aassjournal.954
20. Bozic PR, Berjan Bacvarevic B. Force-Velocity Profiles of Elite Athletes Tested on a Cycle Ergometer. *Monten J Sports Sci Med*. 2018;7(1). https://doi.org/10.26773/mjssm.180308
21. Daniela M, Catalina L, Ilie O, Paula M, Daniel-Andrei I, Ioana B. Effects of Exercise Training on the Autonomic Nervous System with a Focus on Anti-Inflammatory and Antioxidants Effects. *Antioxidants*. 2022;11(2):350. https://doi.

org/10.3390/antiox11020350
22. Matei D, Buculei I, Luca C, Corciova C-P, Andritoi D, Fuior R, et al. Impact of Non-Pharmacological Interventions on the Mechanisms of Atherosclerosis. *International Journal of Molecular Sciences*, 2022;23(16):9097. https://doi.org/10.3390/ijms23169097
23. Onu I, Iordan DA, Codreanu CM, Matei Daniela, Galaction Anca-Irina. Anti-inflammatory effects of exercise training. A systematic review. Munteanu C (ed.) *Balneo and PRM Research Journal*, 2021;12(4): 418–425. https://doi.org/10.12680/balneo.2021.473
24. Cooper CN, Dabbs NC, Davis J, Sauls NM. Effects of Lower-Body Muscular Fatigue on Vertical Jump and Balance Performance. *The Journal of Strength & Conditioning Research*, 2020;34(10):2903–10. https://doi.org/10.1519/JSC.0000000000002882
25. Leister I, Mattiassich G, Kindermann H, Ortmaier R, Barthofer J, Vasvary I, et al. Reference values for fatigued versus non-fatigued limb symmetry index measured by a newly designed single-leg hop test battery in healthy subjects: a pilot study. *Sport Sci Health*. 2018;14(1):105–13. https://doi.org/10.1007/s11332-017-0410-5
26. Sevene TG, DeBeliso M, Carson C, Berning JM, Harris C, Adams KJ. Continuous weighted jumping: effects on vertical jump height. *European Journal of Physical Education and Sport Science*, 2017;3(9):12. https://doi.org/10.46827/ejpe.v0i0.982
27. Weldon A, Duncan MJ, Turner A, LaPlaca D, Sampaio J, Christie CJ. Practices of Strength and Conditioning Coaches: A Snapshot From Different Sports, Countries, and Expertise Levels. *Journal of Strength and Conditioning Research*, 2022;36(5):1335–44. https://doi.org/10.1519/JSC.0000000000003773
28. Amin A, Ramadi R, Agust K. Medicine ball exercise effect to arm and shoulder muscles power on shot put class x male students majoring in computer network engineering at smk nurul falah pekanbaru. *Jom Fkip Unri*. 2016;3(2):12.
29. Kikuchi N, Nakazato K. Low-load bench press and push-up induce similar muscle hypertrophy and strength gain. *Journal of Exercise Science & Fitness*, 2017;15(1):37–42. https://doi.org/10.1016/j.jesf.2017.06.003
30. Sandu AS. *Etica si deontologie profesionala* [Professional ethics and deontology]. Iasi: Lumen; 2012. (In Romanian).
31. World Medical Association Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects. *JAMA*. 2013;310(20):2191. https://doi.org/10.1001/jama.2013.281053
32. Čular D, Ivančev V, Zagatto AM, Milić M, Beslija T, Sellami M, et al. Validity and Reliability of the 30-s Continuous Jump for Anaerobic Power and Capacity Assessment in Combat Sport. *Frontiers in Physiology*, 2018;9: 543. https://doi.org/10.3389/fphys.2018.00543
33. de Salles PG da CM, Vasconcellos FV do A, de Salles GF da CM, Fonseca RT, Dantas EHM. Validity and Reproducibility of the Sargent Jump Test in the Assessment of Explosive Strength in Soccer Players. *J Hum Kinet*. 2012;33:115–21. https://doi.org/10.2478/v10078-012-0050-4
34. Decleve P, Van Cant J, De Buck E, Van Doren J, Verkouille J, Cools AM. The Self-Assessment Corner for Shoulder Strength: Reliability, Validity, and Correlations With Upper Extremity Physical Performance Tests. *Journal of Athletic Training*, 2020;55(4):350–8. https://doi.org/10.4085/1062-6050-471-18
35. Dobos K, Tóth Pj. Within-session reliability and validity of overhand ball throw test to evaluate power ability in junior tennis players. *Studia Universitatis Babes-Bolyai, Educatio Artis Gymnasticae*, 2021;66(3):21–32. https://doi.org/10.24193/subbeag.66(3).22
36. Hackett DA, Davies TB, Ibel D, Cobley S, Sanders R. Predictive ability of the medicine ball chest throw and vertical jump tests for determining muscular strength and power in adolescents. *Measurement in Physical Education and Exercise Science*, 2018;22(1):79–87. https://doi.org/10.1080/1091367X.2017.1385462
37. Hogarth L, Deakin G, Sinclair W. Are plyometric push-ups a reliable power assessment tool? *Journal of Australian Strength and Conditioning*, 2013;21:67–9.
38. Tomčić J, Šarabon N, Marković G. Factorial Structure of Trunk Motor Qualities and Their Association with Explosive Movement Performance in Young Footballers. *Sports*, 2021;9(5):67. https://doi.org/10.3390/sports9050067
39. Armstrong RA. When to use the Bonferroni correction. *Ophthalmic and Physiological Optics*, 2014;34(5):502–8. https://doi.org/10.1111/opo.12131
40. Murariu G, Munteanu D. *Lucrări practice de identificare, modelare şi simulare a proceselor fizice* [Practical works of identification, modeling and simulation of physical processes]. Galati: Galați: University Press; 2018. (In Romanian).
41. Opariuc DC. *Statistica aplicata in stiintele socio-umane. Analiza asocierilor şi a diferenţelor statistice* [Applied statistics in the social and human sciences. Analysis of associations and statistical differences]. Sibiu: Arhip Art; 2011. (In Romanian).
42. Sarma KVS, Vardhan RV, editors. *Multivariate Statistics Made Simple: A Practical Approach*. 1st Edition. Boca Raton: Chapman and Hall/CRC; 2018. https://doi.org/10.1201/9780429465185
43. Sedgwick P. Pearson's correlation coefficient. *BMJ*. 2012;345:e4483. https://doi.org/10.1136/bmj.e4483
44. Nikolaidis PT, Asadi A, Santos EJAM, Calleja-González J, Padulo J, Chtourou H, et al. Relationship of body mass status with running and jumping performances in young basketball players. *Muscles Ligaments Tendons J*. 2015;5(3):187–94. https://doi.org/10.11138/mltj/2015.5.3.187
45. Ding C, Jiang Y. The Relationship between Body Mass Index and Physical Fitness among Chinese University Students: Results of a Longitudinal Study. *Healthcare*, 2020;8(4): 570. https://doi.org/10.3390/

healthcare8040570
46. Sukanta S. Somatotype, body composition and explosive power of athlete and non athlete. *Lase Journal of Sport Science*, 2014;5(1):28–37. https://doi.org/10.1515/ljss-2016-0023
47. Kung Y-T, Chang C-M, Hwang F-M, Chi S-C. The Association between Body Mass Index and Physical Fitness of Normal Weight/Overweight/Obese University Students. International *Journal of Environmental Research and Public Health*, 2020;17(15):5391. https://doi.org/10.3390/ijerph17155391
48. Dalui R, Roy AS, Kalinski M, Bandyopadhyay A. Relationship of vertical jump test with anthropomethric parameters and body composition in university students – a gender variation. *Central European Journal of Sport Sciences and Medicine*, 2014;5(1):83–90.
49. Rhyu H, Cho S-Y. The effect of weight loss by ketogenic diet on the body composition, performance-related physical fitness factors and cytokines of Taekwondo athletes. *J Exerc Rehabil.* 2014;10(5):326–31. https://doi.org/10.12965/jer.140160
50. Hermassi S, Bragazzi NL, Majed L. Body Fat Is a Predictor of Physical Fitness in Obese Adolescent Handball Athletes. International *Journal of Environmental Research and Public Health*, 2020;17(22):8428. https://doi.org/10.3390/ijerph17228428
51. Hermassi S, van den Tillaar R, Bragazzi NL, Schwesig R. The Associations Between Physical Performance and Anthropometric Characteristics in Obese and Non-obese Schoolchild Handball Players. *Frontiers in Physiology*, 2021;11: 580991. https://doi.org/10.3389/fphys.2020.580991.
52. Podstawski R, Markowski P, Clark CCT. Sex-mediated differences and correlations between the anthropometric characteristics and motor abilities of university students. *JPES.* 2020;2020(01):86–96. https://doi.org/10.7752/jpes.2020.01011
53. Silva AF, Clemente FM, Leão C, Oliveira R, Badicu G, Nobari H, et al. Physical Fitness Variations between Those Playing More and Those Playing Less Time in the Matches: A Case-Control Study in Youth Soccer Players. *Children*. 2022;9(11):1786. https://doi.org/10.3390/children9111786
54. Junior NKM. Vertical jump of the elite male volleyball players in relation the game position: a systematic review. *Revista Observatorio del Deporte*, 2015;10–27.
55. Lima Kons R, da Silva Athayde MS, da Silva Junior JN, da Silva Tavares W, Detanico D. Vertical jump performance in judo and Brazilian jiu-jitsu athletes: an approach with different training levels. *Ido Movement for Culture Journal of Martial Arts Anthropology*, 2017;17(4):25–31. https://doi.org/10.14589/ido.17.4.5
56. Ntoumas I, Nounos G, Ioannidis P, Voutselas V. Acceleration and Maximum Running Phases in 60-m Sprint and Vertical Jump Performance. *Proceedings*. 2019;25(1):21. https://doi.org/10.3390/proceedings2019025021
57. Aalizadeh B, Mohammadzadeh H, Khazani A, Dadras A. Effect of a Trampoline Exercise on the Anthropometric Measures and Motor Performance of Adolescent Students. *Int J Prev Med*. 2016;7:91. https://doi.org/10.4103/2008-7802.186225
58. Bensikaddour H, Benzidane H, Touati AB, Mokrani D. The effect of using plyometric exercises to improve some physical abilities and performance in the triple jump (hop, step, jump). *The Swedish Journal of Scientific Research,* 2015;2(11):9.
59. Harjanto MD, Jariono G. Method of Strengthening Arm Muscles Against the Ability of the Tennis Flat Service Stroke (Experimental Study in Students of Muhammadiyah University of Surakarta). *International Journal of Educational Research & Social Sciences*, 2021;2(4):743–50. https://doi.org/10.51601/ijersc.v2i4.142
60. Lockie RG, Callaghan SJ, Berry SP, Cooke ERA, Jordan CA, Luczo TM, et al. Relationship Between Unilateral Jumping Ability and Asymmetry on Multidirectional Speed in Team-Sport Athletes. *The Journal of Strength & Conditioning Research*, 2014;28(12):3557–66. https://doi.org/10.1519/JSC.0000000000000588
61. Davis K, Rossi S, Langdon J, McMillan J. The Relationship Between Jumping and Sprinting Performance in Collegiate Ultimate Athletes. *Journal of Coaching Education*, 2012;5(2):24–37. https://doi.org/10.1123/jce.5.2.24
62. Panda M, Rizvi MR, Sharma A, Sethi P, Ahmad I, Kumari S. Effect of electromyostimulation and plyometrics training on sports-specific parameters in badminton players. *Sports Medicine and Health Science*, 2022;4(4): 280–286. https://doi.org/10.1016/j.smhs.2022.08.002
63. Mackala K, Witkowski K, Vodičar J, Šimenko J, Stodółka J. Acute effects of speed-jumping intervention training on selected motor ability determinants: Judo vs. soccer. *Archives of Budo*, 2019;15:311–20.

Information about the authors:

George D. Mocanu; https://orcid.org/0000-0002-3534-5055; george.mocanu@ugal.ro; Faculty of Physical Education and Sport, "Dunarea de Jos" University of Galati; Galati, Romania.

Gabriel Murariu; (Corresponding Author); https://orcid.org/0000-0002-7107-2007; gabriel.murariu@ugal.ro; Faculty of Sciences and Environment, "Dunarea de Jos" University of Galati; Galati, Romania.

Vladimir Potop; https://orcid.org/0000-0001-8571-2469; vladimir_potop@yahoo.com; University of Pitesti; State University of Physical Education and Sport; Pitesti, Romania; Chisinau, Republic of Moldova.

Cite this article as:

Mocanu GD, Murariu G, Potop V. Differences in explosive strength values for students of the faculty of physical education and sports (male) according to body mass index levels. *Pedagogy of Physical Culture and Sports,* 2023;27(1):71–83.
https://doi.org/10.15561/26649837.2023.0109

Received: 02.12.2022
Accepted: 28.01.2023; Published: 28.02.2023

ORIGINAL ARTICLE

Cognitive functions and special working capacity in elite boxers

Georgiy Korobeynikov[1,2ABCDE], Lesia Korobeinikova[1,2ABCDE], Markus Raab[2,3CDE], Mario Baić[4BCD], Olga Borysova[1BCE], Ivanna Korobeinikova[2,5BCD], Gou Shengpeng[1ABD], Irene Khmelnitska[1CD]

[1]*National University of Ukraine on Physical Education and Sport, Ukraine*
[2]*German Sport University Cologne, Institute of Psychology, Germany*
[3]*School of Applied Sciences London South Bank University, Great Britain*
[4]*University of Zagreb, Faculty at Faculty of Kinesiology, Zagreb, Croatia*
[5]*Institute of Psychology of the National Academy of Educational Sciences of Ukraine, Ukraine*

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

Abstract

Background and Study Aim In the basis of the boxer's power qualities is the ability to perceive and process external information. Therefore, in order to ensure the proper training of qualified boxers, there is a need to monitor the functional state of the boxer's organism. The relationship between cognitive functions and special working capacity of elite boxers were studied.

Material and Methods The level of special working capacity was studied by the test of punching a boxer for 8 s at maximum speed. Cognitive functions (verbal and nonverbal intelligence, and word memory) were studied using the "Multipsychometer-05" (European-Asian Association of Polygraphologists, Kazakhstan) hardware-software. 26 elite boxers, aged 18-24, were tested.

Results The research results showed that groups of boxers with different levels of special working capacity differ in terms of accuracy and efficiency when performing a cognitive task with verbal stimuli. The high level of special working capacity of elite boxers is provided by the manifestation of verbal intelligence. Besides, the special working capacity is related with activation of mental functions of attention, speed of visual perception, operational and logical thinking. At the same time, significantly higher values of decision latency in this group of boxers indicate a slowdown in the processing of nonverbal information in boxers with a high level of special working capacity to work. It can be noted that the special working capacity of boxers has a direct relationship with quality and inverse relationship with the speed of information processing. The speed of memorizing verbal information is better in boxers with a high level of special working capacity. This fact indicates the importance of the verbal factor for the assimilation of special information in the training of boxers. The best values of accuracy and efficiency indicate the relationship of special working capacity in skilled boxers with the quality and volume of memorized verbal information.

Conclusions The special working capacity of elite boxers has a direct relationship with quality and inverse relationship with the speed of information processing. The elite boxers with a high level of special working capacity have a better speed of verbal information memorizing.

Keywords: cognitive functions, boxers, special capacity, verbal, nonverbal, intelligence

Introduction

Modern boxing is characterized by an increase in the intensity of fights and the rate of change of the situation in the ring. Many researchers focus on the speed and strength properties of boxers as necessary factors of efficiency in competitive conditions [1, 2, 3]. However, the basis of the boxer's power qualities is the ability to perceive and process external information [4, 5].

Therefore, in order to ensure the proper training of qualified boxers, there is a need to monitor the functional state of the boxer's organism. After all, the high intensity of the fight requires boxers to maximize the mobilization of psycho-emotional and functional resources. It is known that the functional state of the athlete's body reflects an integrated set of characteristics of the athlete, which are responsible for the effectiveness of training and competitive activities [6, 7]. Among the factors of the functional state of the qualified wrestler's organism, the psychophysiological characteristics are most important [8, 9]. In turn, cognitive functions are components of the athlete's psychophysiological state [10, 11]. Based on this, it is advisable to use the evaluation of the state of cognitive functions to assess the ability of boxers to the training and competitive process.

Analysis of the structure of competitive activity in single combats indicates an important aspect of mental activity aimed at the perception of information and prompt decision-making during the fight [12, 13]. Current research on integrated control in single combats shows that most of the work concerns certain characteristics of athlete's

doi:10.15561/26649837.2023.0110

functional state in different conditions of training and competitive activities [14, 15, 16]. However, many studies do not have a comprehensive approach to assessing the relationship between athlete's cognitive function and special working capacity. From the point of view of the peculiarities of a boxing match, it is important to synchronize between the perception and processing of external information with the motor realization. For effective perception of information, its analysis and decision-making on the appropriate response to the actions of the opponent, it is necessary to activate cognitive functions such as memory and intelligence of the boxer.

Verbal intelligence is associated with the perception of verbal information, primarily from the coach - the second, which allows the athlete to adjust their actions in accordance with appropriate strategies. Non-verbal intelligence is related to the athlete's ability to perceive external factors related to the opponent's actions and to respond quickly to situations that arise in a duel. The memory function is characterized by memorizing and retrieving information from the long-term motor response to counteract the actions of the opponent. In sum, there is a need to study the relationship between the manifestation of cognitive functions and the special working capacity of elite boxers.

The research purpose is to study the relationship between cognitive functions and special working capacity of elite boxers.

Material and Methods

Participants

26 elite boxers, members of the Kyiv city team, aged 18-24, were tested. All athletes agreed to conduct scientific tests and use the research results for scientific purposes, in accordance with the recommendations of the Ethics Committees on biomedical research.

Research Design

Special working capacity

The chronodynamometer "Spuderg" of Savchyn's design was used to assess the athlete's special working capacity [17]. The level of special working capacity was studied by the test of the boxer's blows for 8 s at maximum speed.

Cognitive functions

Cognitive functions were studied using the "Multipsychometer-05" (European-Asian Association of Polygraphologists, Kazakhstan) hardware-software. The following methods have been assessed: verbal, nonverbal intelligence and word memory. The assessment of verbal intelligence was carried out on the "Establishing patterns" test. This test is designed to study the features of the thinking process (activity, intelligence) and random access memory (RAM). The peculiarity of testing is to define in one word out of five, presented in coded form. The athlete is asked to perform 25 tasks in 6 minutes. According to the test results, the following indicators are determined: productivity; speed; precision; efficiency. Nonverbal intelligence was determined by the "Comparison of numbers" test. The task of the "Comparison of numbers" test is to assess the peculiarities of the mobilization of human cognitive resources. The procedure involved a consistent comparison of numbers by size. One by one, numbers from 2 to 9 were displayed in the center of the display. The task was to compare the current number with the previous one. The length of the test is 128 signals; the duration of execution is from 1.5 to 4 minutes, at auto tempo. According to the test results, the following indicators were determined: efficiency, reaction latency, accuracy and stability. The "Memory for words" test was designed to assess the amount and stability of short-term memory for verbal stimuli. The subject had to memorize a set of 30 different words for 1 minute. At the end of the time, numbered combinations of 5 words appeared on the screen. The participant needs to recognize the word that was presented for memorization, and indicate it by pressing the appropriate key. In each proposed combination of words it could be only one word that was memorized. The technique took 4 minutes. Based on the test results, the following indicators were determined: productivity, speed, accuracy and efficiency.

Statistical analysis

Statistical processing of the obtained results was performed using the "Statistica 12" software. Since the analyzed indicators were non normal distributed, the Wilcoxon rank sum test was used to determine the statistically significant difference between the samples. To present the data distribution, an interquartile range was used, indicating the first quartile (25% percentile) and the third quartile (75%).

Results

According to the results of special working capacity, all boxers were divided into two conventional groups. The first group had a high level of working capacity (from 200 conventional units and above), the second group had a low level of special working capacity (below 200 conventional units). The first group included 12 athletes, the second – 14 athletes.

The Table 1 presents the average values of the "Establishing patterns" cognitive test for solving verbal tasks in qualified boxers with different levels of special working capacity. When performing the "Establishing patterns" test, the functions, perception of external information, operational and logical thinking, as well as concentration, are activated. The higher values of the accuracy index that were identified in terms of performing a verbal test in boxers with a high level of special working capacity indicated the ability to perceive and process information, as well as concentration (Table 1).

The research results showed that groups of boxers with different levels of special working capacity differ in terms of accuracy and efficiency when performing a cognitive task with verbal stimuli. The presence of significant better values of efficiency in boxers with a high level of special working capacity indicated the manifestation of logical and operational thinking in terms of performing a verbal test. Thus, a high level of special working capacity in elite boxers that is indicated by the manifestation of verbal intelligence with the activation of mental functions of attention, speed of visual perception, operational and logical thinking.

Table 2 presents the average values of the "Comparison of numbers" cognitive test in solving nonverbal problems in elite boxers with different levels of special working capacity. The analysis showed the presence of significant differences between groups of boxers with different levels of special working capacity in terms of efficiency, solution latency and stability. The presence of significantly higher values of efficiency in boxers with a high level of special working capacity indicates a better quality of processing of nonverbal information.

At the same time, significantly higher values of solution latency in this group of boxers indicate a slowdown in the speed of nonverbal information processing in boxers with a high level of special working capacity (Table 2). It can be noted that the special working capacity of boxers has a direct relationship with quality and inverse relationship with the speed of information processing.

Significantly higher values of stability in boxers with a high level of working capacity indicate a weakening of mental stress in boxers of this group (Table 2). At the same time, the decrease in

Table 1. The average values of the "Establishing patterns" cognitive test in elite boxers with different levels of special working capacity (median, lower and upper quartiles)

Parameter	High level of working capacity (n = 12)	Low level of working capacity (n = 14)
Productivity, conventional units	19.00	20.00
	17.00; 21.00	16.50; 21.00
Speed, conventional units	4.65	4.26
	3.66; 5.17	3.41; 5.39
Accuracy, conventional units	0.85	0.72*
	0.72; 0.91	0.66; 0.83
Efficiency, conventional units	60.00	43.60*
	46.80; 70.91	36.97; 51.60

Legenda: * - the difference is statistically significant comparing the two groups of boxers of high and low working capacity (p =.05)

Table 2. The average values of the "Comparison of numbers" cognitive test in elite boxers with different levels of special working capacity (median, lower and upper quartiles)

Parameter	High level of working capacity (n = 12)	Low level of working capacity (n = 14)
Efficiency, conventional units	1097.70	944.27*
	891.61; 1357.40	844.91; 1037.60
Solution latency, ms	1080.60	904.13*
	877.68; 1283.20	808.34; 983.96
Accuracy, conventional units	0.97	0.95
	0.93; 0.98	0.94; 0.96
Stability, %	36.03	26.59*
	32.47; 40.76	21.59; 31.06*

Legenda: * - the difference is statistically significant comparing the two groups of boxers of high and low working capacity (p =.05)

Table 3. The average values of the "Word memory" cognitive test in elite boxers with different levels of special working capacity (median, lower and upper quartiles)

Parameter	High level of working capacity (n = 12)	Low level of working capacity (n = 14)
Productivity, conventional units	24.00 17.00; 27.00	21.50 15.50; 24.50
Speed, conventional units	10.34 8.05; 12.96	8.62* 7.56; 10.60
Accuracy, conventional units	0.80 0.56; 0.90	0.71* 0.61; 0.80
Efficiency, conventional units	60.00 25.97; 78.75	46.59* 26.43; 62.98

Legenda: * - the difference is statistically significant comparing the two groups of boxers of high and low working capacity (p =.05)

the rate of stability in boxers with a slowdown in special working capacity indicates the presence of mental stress against the background of accelerated processing of information.

The Table 3 presents the average values of the "Word memory" cognitive test in elite boxers with different levels of special working capacity. The analysis showed significantly higher values of speed, accuracy and efficiency in qualified boxers with a high level of special working capacity. The speed of verbal information memorizing is better in boxers with a high level of special working capacity. This fact indicates the importance of the verbal factor for the assimilation of special information in the training of boxers. The best values of accuracy and efficiency indicate the relationship of special working capacity in skilled boxers with the quality and volume of memorized verbal information.

Discussion

The development of boxing at the present stage is characterized by changes in the rules of competition aimed at increasing the intensity and spectacle of competitive fighting [18, 19]. The changes taking place in boxing are aimed, firstly, at increasing the safety from athlete's injury, and, secondly, at bringing the boxing scheme closer to the result that is clear to the audience.

In addition, major changes in competition rules are associated with encouraging boxer activity and increasing the intensity of competitive combat [20]. In this regard, there is a need to restructure the training program for qualified boxers, taking into account the modern requirements of competitive activities.

Therefore, in order to ensure the proper training of qualified boxers, it is necessary to monitor the functional state of the body. After all, the high intensity of the fight requires boxers to maximize the mobilization of psycho-emotional and functional resources [21]. It is known that the functional state of the athlete's body reflects an integrated set of characteristics, which are responsible for the effectiveness of training and competitive activities [22, 23]. One of the components of the functional state of the body of qualified athletes is psychophysiological functions [24, 25]. Based on this, it is advisable to use the assessment of psychophysiological functions for the needs of current control for qualified boxers. However, among the components of psychophysiological functions, cognitive characteristics occupy a leading link [26, 27]. After all, due to the cognitive characteristics of the athlete, it is possible to perceive and process adequately the external information for successful activation [28, 29].

The structure of competitive activity in boxing includes elements of neurodynamic, psychomotor and cognitive characteristics [30, 31]. Analysis of modern research on the study of integrated control in single combats shows that most of the work is devoted to the study of certain characteristics of the functional state of athletes in different conditions of training and competitive activities [32]. However, among many studies there is no comprehensive approach to assessing the functional and psychophysiological condition of qualified athletes. In our research, we examined the relationship of special working capacity with cognitive functions in elite boxers.

It has been established that non-verbal intelligence is important for boxers with a reduced level of special working capacity in the training process. Obviously, non-verbal information related to visual perception allows elite boxers to compensate for the decrease in the level of special working capacity. Boxers with a high level of special working capacity have the best values of logical and operational thinking in terms of performing a verbal test. It was found that a high level of special working capacity in elite boxers is provided by the manifestation of verbal intelligence with the activation of the functions of attention, speed of visual perception, operational and logical thinking.

The quality of non-verbal information processing is better in boxers with a high level of special working capacity. However, this affects the speed of perception of non-verbal information, which is better for boxers with a reduced level of special working capacity. It can be noted that the special working capacity of elite boxers has a direct relationship with quality and inverse relationship with the speed of information processing. The speed of verbal information memorizing is better in boxers with a high level of special working capacity. This result indicates the importance of verbal intelligence for the assimilation of special information in the training of elite boxers.

Conclusions

In conclusion high level of special working capacity of elite boxers is provided by activation of verbal intelligence, logical and operational thinking. In addition, the special working capacity of elite boxers has a direct relationship with quality and inverse relationship with the speed of information processing. Finally, elite boxers with a high level of special working capacity have a better speed of verbal information memorizing.

Acknowledgement

Many thanks from the authors to the coaches and athletes for their help in conducting the study.

Conflict of interest

There is no potential conflict of interest between co-authors.

References

1. Cepulenas A, Bruzas V, Mockus P, Subacius V. Impact of physical training mesocycle on athletic and specific fitness of elite boxers. *Archives of Budo*, 2011;7(1): 33–39.
2. Bu X. Experimental Study on the Effect of Speed Strength Training on the Special Strikes of Chinese Female Boxers. *Journal of Environmental and Public Health*, 2022;2022: 5912231. https://doi.org/10.1155/2022/5912231
3. Wu Q. Boxing speed and muscle scientific training. *Revista Brasileira De Medicina Do Esporte*, 2022;28(2): 82–84. https://doi.org/10.1590/1517-8692202228022021_0428
4. Deochand N, Costello MS, Fuqua RW. Real-Time Contingent Feedback to Enhance Punching Performance. *Psychological Record*, 2020;70(1): 33–45. https://doi.org/10.1007/s40732-019-00357-2
5. Halperin I, Chapman DW, Thompson KG, Abbiss C. False-performance feedback does not affect punching forces and pacing of elite boxers. *Journal of Sports Sciences*, 2019;37(1): 59–66. https://doi.org/10.1080/02640414.2018.1482526
6. Broeker L, Brüning J, Fandakova Y, Khosravani N, Kiesel A, Kubik V, et al. Individual differences fill the uncharted intersections between cognitive structure, flexibility, and plasticity in multitasking. *Psychological Review*, 2022; 129(6): 1486–1494. https://doi.org/10.1037/rev0000376
7. Seidel-Marzi O, Ragert P. Neurodiagnostics in Sports: Investigating the Athlete's Brain to Augment Performance and Sport-Specific Skills. *Frontiers in Human Neuroscience*, 2020;14: 133. https://doi.org/10.3389/fnhum.2020.00133
8. Cirino C, Gobatto CA, Pinto AS, Torres RS, Hartz CS, Azevedo PHSM, et al. Complex network model indicates a positive effect of inspiratory muscles pre-activation on performance parameters in a judo match. *Scientific Reports*, 2021;11(1): 11148. https://doi.org/10.1038/s41598-021-90394-1
9. Korobeinikova L, Korobeynikov G, Cynarski WJ, Borysova O, Kovalchuk V, Matveev S, et al. Tactical styles of fighting and functional asymmetry of the brain among elite wrestlers. *Ido Movement for Culture. Journal of Martial Arts Anthropology*, 2020;20(4):24–30. https://doi.org/10.14589/ido.20.4.4
10. Musculus L, Raab M. A Developmental Perspective on Motor-Cognitive Interactions and Performance in Sports. *Psychology of Sport and Exercise*, 2022;61:102202. https://doi.org/10.1016/j.psychsport.2022.102202
11. Panten J, Loffing F, Baker J, Schorer J. Extending Research on Deception in Sport–Combining Perception and Kinematic Approaches. *Frontiers in Psychology*, 2019;10:2650. https://doi.org/10.3389/fpsyg.2019.02650
12. Drozdovski AK. The connection between typological complexes of properties of the nervous system, temperaments, and personality types in the professions and sports. *Open Access Journal of Sports Medicine,* 2015;6:161–172. https://doi.org/10.2147/OAJSM.S75612
13. Finlay MJ, Page RM, Greig M, Bridge CA. The prevalence of pre-conditioning and recovery strategies in senior elite and non-elite amateur boxing. *The Physician and Sportsmedicine*, 2022;50(4):323–31. https://doi.org/10.1080/00913847.2021.1931525
14. Kalén A, Bisagno E, Musculus L, Raab M, Pérez-Ferreirós A, Williams AM, et al. The role of domain-specific and domain-general cognitive functions and skills in sports performance: A meta-analysis. *Psychological Bulletin,* 2021;147(12):1290–1308. https://doi.org/10.1037/bul0000355
15. Chernozub A, Danylchenko S, Imas Y, Kochina M, Ieremenko N, Korobeynikov G, et al. Peculiarities of correcting load parameters in power training of mixed martial arts athletes. *Journal of Physical Education and Sport*, 2019;19:481–488. https://doi.

org/10.7752/jpes.2019.s2070
16. Korobeynikov G, Bulatova M, Zhirnov O, Cynarski WJ, Wasik J, Korobeinikova L, et al. Links between postural stability and neurodynamic characteristics in kickboxers. *Ido Movement for Cultutre. Journal of Martial Arts Anthropology*, 2021;21(1): 1–5. https://doi.org/10.14589/ido.21.1.1
17. Klychko V, Savchyn M. A system of tests for evaluating special fitness of highly skilled boxers. *Science in Olympic Sport*, 2019;3:138–144.
18. Bianco M, Loosemore M, Daniele G, Palmieri V, Faina M, Zeppilli P. Amateur boxing in the last 59 years. Impact of rules changes on the type of verdicts recorded and implications on boxers' health. *British Journal of Sports Medicine*, 2013;47(7): 452–457. https://doi.org/10.1136/bjsports-2012-091771
19. Dilmurodov SS. Competitive activities of qualified boxers in connection with peculiarities of battle tactics. *Berlin Studies Transnational Journal of Science and Humanities*, 2021;1:617–529. https://doi.org/10.5281/zenodo.5810753
20. Seifert T, Bernick C, Jordan B, Alessi A, Davidson J, Cantu R, et al. Determining brain fitness to fight: Has the time come?. *The Physician and Sportsmedicine*, 2015;43(4):395–402. https://doi.org/10.1080/00913847.2015.1081551
21. Slimani M, Miarka B, Teixeira RPA, Znazen H, Tod D, Nikolaidis PT, et al. Effect of acute boxing training session on cognitive function and psychological states. *Medicina Dello Sport*, 2022;75(3): 404–412. https://doi.org/10.23736/S0025-7826.22.04166-7
22. Korobeynikov G, Potop V, Korobeynikova L, Kolumbet A, Khmelnitska I, Shtanagey D, et al. Research of the hand motion dynamic characteristics of the women boxers with different types of functional asymmetry. *Journal of Physical Education and Sport*, 2019;19:2185–2191. https://doi.org/10.7752/jpes.2019.s6328
23. Schinke RJ, Battochio RC, Dube TV, Lidor R, Tenenbaum G, Lane AM. Adaptation Processes Affecting Performance in Elite Sport. *Journal of Clinical Sport Psychology*, 2012;6(2): 180–195. https://doi.org/10.1123/jcsp.6.2.180
24. Battaglini MP, Pessoa Filho DM, Calais SL, Miyazaki MCOS, Neiva CM, Espada MC, et al. Analysis of Progressive Muscle Relaxation on Psychophysiological Variables in Basketball Athletes. *International Journal of Environmental Research and Public Health*, 2022;19(24): 17065. https://doi.org/10.3390/ijerph192417065
25. Edwards AM, Polman RC. Pacing and awareness: brain regulation of physical activity. Sports Medicine. 2013;43(11):1057-64. https://doi.org/10.1007/s40279-013-0091-4
26. Huaguang G. Complex dynamics of the nervous system for information processing and abnormal functions. *Chinese Journal of Theoretical and Applied Mechanics*, 2017;49(2):410–20. https://doi.org/10.6052/0459-1879-16-315
27. Yongtawee A, Park J, Kim Y, Woo M. Athletes have different dominant cognitive functions depending on type of sport. *International Journal of Sport and Exercise Psychology*, 2022;20(1):1–5. https://doi.org/10.1080/1612197X.2021.1956570
28. Russo G, Ottoboni G. The perceptual–Cognitive skills of combat sports athletes: A systematic review. *Psychology of Sport and Exercise*, 2019;44:60–78. https://doi.org/10.1016/j.psychsport.2019.05.004
29. Harwood-Gross A, Lambez B, Feldman R, Zagoory-Sharon O, Rassovsky Y. The Effect of Martial Arts Training on Cognitive and Psychological Functions in At-Risk Youths. *Front Pediatr*. 2021;9:707047. https://doi.org/10.3389/fped.2021.707047
30. Johnstone A, Marí-Beffa P. The effects of martial arts training on attentional networks in typical adults. *Frontiers in Psychology*, 2018;9:1-9. https://doi.org/10.3389/fpsyg.2018.00080
31. Ashker SE. Technical and tactical aspects that differentiate winning and losing performances in boxing. *International Journal of Performance Analysis in Sport*, 2011;11(2):356–64. https://doi.org/10.1080/24748668.2011.11868555
32. Obmiński Z, Mroczkowska H, Kownacka I, Stabno J. Personality traits and eye-hand coordination in less-and more succesful young male boxers. *Journal of Combat Sports and Martial Arts*, 2011;2(2):83–89.

Information about the authors:

Georgiy Korobeynikov; (Corresponding Author); https://orcid.org/0000-0002-1097-4787; k.george.65.w@gmail.com; National University of Ukraine on Physical Education and Sport (Kyiv, Ukraine); Institute of Psychology, German Sport University Cologne, (Cologne, Germany).

Lesia Korobeinikova; https://orcid.org/0000-0001-8648-316X; korlesia.66@gmail.com; National University of Ukraine on Physical Education and Sport (Kyiv, Ukraine); Institute of Psychology, German Sport University Cologne (Cologne, Germany).

Markus Raab; https://orcid.org/0000-0001-6546-1666; Raab@dshs-koeln.de; Institute of Psychology, German Sport University Cologne (Cologne, Germany); School of Applied Sciences London South Bank University (London, Great Britain).

Mario Baić; https://orcid.org/0000-0003-0581-0590; mario.baic@kif.unizg.hr; Faculty at Faculty of Kinesiology, University of Zagreb; Zagreb, Croatia.

Olga Borysova; https://orcid.org/0000-0002-2311-1921; borisova-nupesu@ukr.net; National University of Ukraine on Physical Education and Sport; Kyiv, Ukraine.

Ivanna Korobeinikova; https://orcid.org/0000-0001-6231-8012; ivakorobeinikova@gmail.com; Institute of Psychology, German Sport University Cologne (Cologne, Germany); Institute of Psychology, National Academy of Educational Sciences of Ukraine (Kyiv, Ukraine).

Gou Shengpeng; https://orcid.org/0000-0003-1456-9962; guoshengpeng1118@126.com; National University of Ukraine on Physical Education and Sport; Kyiv, Ukraine.

Irene Khmelnitska; https://orcid.org/0000-0003-0141-3301; khmeln.irene@gmail.com; National University of Ukraine on Physical Education and Sport; Kyiv, Ukraine.

Cite this article as:

Korobeynikov G, Korobeinikova L, Raab M, Baić M, Borysova O, Korobeinikova I, Shengpeng G, Khmelnitska I. Cognitive functions and special working capacity in elite boxers. *Pedagogy of Physical Culture and Sports,* 2023;27(1):84–90.
https://doi.org/10.15561/26649837.2023.0110

Received: 02.12.2022
Accepted: 28.01.2023; Published: 28.02.2023

CONTACT INFORMATION
box 11135, Kharkiv-68, 61068, Ukraine
phone. 38-099-430-69-22
http://www.sportpedagogy.org.ua
e-mail: sportart@gmail.com

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

SCIENTIFIC EDITION (journal)
Pedagogy of Physical Culture and Sports, 2023;27(1)

Editorial to the publisher department:
certificate DK No 7472; 07.10.2021
----
designer - Sergii Iermakov
editing - Tetiana Yermakova
administrator of sites - Sergii Iermakov
designer cover - Alyna Bogoslavets
———————————————————————
passed for printing 28.02.2023
Format A4.
Publisher: Sergii Iermakov (Individual Entrepreneurs)
License: DK No 7472 from 01.10.2021
Publisher Address: Polevaya, 8/111, Kharkiv, 61068, Ukraine
e-mail: sportart@gmail.com