Poznan University of Physical Education

TRENDS in SPORT SCIENCES

(formerly Studies in Physical Culture and Tourism)

quarterly • number 2 • volume 27 • year 2020

Editorial board address
Poznan University of Physical Education
ul. Królowej Jadwigi 27/39
61-871 Poznań, Poland
tel. +48 61 835 51 96; +48 61 835 50 68

ISSN 2299-9590

Publisher
Poznan University of Physical Education
ul. Królowej Jadwigi 27/39
61-871 Poznań, Poland
tel. +48 61 835 51 96
e-mail: gronek@awf.poznan.pl
e-mail: tss@awf.poznan.pl
www.tss.awf.poznan.pl

Printed by
ESUS Tomasz Przybylak
ul. Południowa 54
62-064 Plewiska, Poland

Indexed in
SCOPUS
EBSCO Publishing, Inc.
SPORTDiscus
Ulrich's International Periodical Directory
ICI Journals Master List
AGRO database

Index Copernicus (2017): 88.38 points
KBN/MNiSW (2019): 20 points

1. The distribution is realized by the Publisher.
2. The price of polish subscription for one year (1-4/2020) equals 120 PLN. Payments with specified period of subscription are accepted at the following account:
   Akademia Wychowania Fizycznego w Poznaniu, PKO BP Poznań nr 86 1020 4027 0000 1902 1271 4947
   Please indicite the address for correspondence.
3. The price of foreign subscription for one year (1-4/2020) equals 60 euro or equivalent in the other currency. Payments with specified period of subscription are accepted at the following account:
   Akademia Wychowania Fizycznego w Poznaniu, PKO BP Poznań nr 86 1020 4027 0000 1902 1271 4947
   Please indicite the address for correspondence.
4. We accept orders at any time, also for archival issues (unless the edition is sold out).

CONTENTS

ORIGINAL ARTICLE

TRENDS in
Sport Sciences
2020; 27(**2**): 49-55
ISSN 2299-9590
DOI: 10.23829/TSS.2020.27.2-1

Oral health in young elite swimmers

FILIPA CARDOSO[1,2], ANA SOFIA MONTEIRO[1,2], ALÉXIA FERNANDES[1,2], JOÃO PAULO VILAS-BOAS[1,2], JOÃO CARLOS PINHO[3], DAVID B. PYNE[4], RICARDO J. FERNANDES[1,2]

Abstract

Introduction. **Evidence of a lack in oral healthcare in sport has emerged since reports from Olympic Games indicated a higher risk for problems of the oral cavity. Oral diseases could affect well-being and the quality of life, with anecdotal reports that athletes are concerned about their oral conditions and potential impairment of performance.** Aim of Study. **Our purpose was to observe, through a clinical perspective, the orofacial development, dental relationships and oral health of young elite swimmers.** Material and Methods. **A cohort of 17 young elite swimmers were evaluated for skeletal and occlusion development or problems arising from gums and teeth.** Results. **Several conditions (e.g. pattern II, class III and crossbite) differed from the normal skeletal and dental development but most of the swimmers evaluated had a proper position of bone bases and teeth. Dental caries (n = 5) and gum-inflammatory states (n = 3) were also detected.** Conclusions. **Oral health status was not completely monitored in our group of elite swimmers. Strategies to prevent oral diseases and promote oral health within sport need to be developed. Good oral health practices should be a priority for athletes, clubs and sports federations.**

KEYWORDS: oral hygiene, occlusion, swimming, performance.

Received: 23 March 2020
Accepted: 20 April 2020

Corresponding author: ricfer@fade.up.pt

[1] *University of Porto, Faculty of Sport, Centre of Research, Education, Innovation and Intervention in Sport, CIFI2D, Porto, Portugal*

[2] *University of Porto, Porto Biomechanics Laboratory, LABIOMEP-UP, Porto, Portugal*

[3] *University of Porto, Faculty of Dental Medicine, Porto, Portugal*

[4] *University of Canberra, Research Institute for Sport and Exercise, Canberra, Australia*

Introduction

Protecting athletes health and wellbeing is an important consideration, given the high standards of performance required on elite sports competitions. Oral health is an important part of overall health and a key factor for wellbeing and quality of life [17]. Links between oral health and sports performance have been studied primarily through studies of the Olympic Games focusing on the higher risk of poor oral health conditions in elite athletes across a wide range of sports [12, 19]. Elite sport practitioners are being very concerned about their own oral conditions since oral health is an important part of overall health and well-being, and deficits could impair training and performance. Dietary patterns, high nutritional requirements, exercise-induced immunosuppression and a lack of oral health literacy, awareness and preventive support are possible risks to oral health [2, 5, 18].

Swimming is an individual and cyclic sport, where performance is dependent on several determinants including genetic, physiological, biomechanical, psychological and contextual [10]. Oral health has been consistently reported as poor across elite athletes from a range of sports, such as the presence of dental caries

(15-75%), dental erosion (36-85%), moderate-to-severe periodontitis (up to 15%) and pericoronitis (5-39%) [2, 18, 19]. Beyond pain, systemic inflammatory illness, eating and sleeping instabilities, oral diseases can impair self-confidence and social interaction [2, 12]. In the view of these well-recognised effects it is likely that oral-related conditions might affect sport performance determinants and, hence, good oral health should be promoted to maintain a good exercise and sporting performance.

Many athletes do not have dental monitoring and do not receive dental care (even those preparing to compete in the Olympic Games), suggesting a lack of prioritisation of oral health in sport [19]. Therefore, oral health promotion and prevention strategies should be integrated within sports medicine aiming to change oral health-related behaviours, including awareness of risks of oral diseases, regular dental assessment and level of knowledge and beliefs related to oral conditions. Despite poor oral conditions are reported across several sport practitioners, in contradiction to the common perception that athletes are completely healthy, the nexus between oral diseases and sports performance is not well understood and warrants further and detailed research. Nevertheless, and since studies about swimming and oral health are particularly scarce, is important to consider all the information available in a cohort of young elite promising athletes in order to avoid any potential hinder to their development.

Aim of Study

To quantify, through a clinical perspective, the orofacial development, dental relationships and oral health of young elite swimmers.

Material and Methods

A cohort of 17 young elite Portuguese swimmers (five males and 12 females, 10 front craw specialists with unilateral breathing pattern, five backstrokers and two butterflyers, 15.9 ± 1.1 years of age, 61 ± 6 kg of body mass, 171 ± 6 cm of height and ≥14 h/week of training) voluntarily participated in this study. The experiments were conducted during a training control session for those swimmers who reached qualifying standards to participate in World and European championships as part of long-term preparations to the Paris 2024 Olympic Games. All swimmers gave their informed consent after a detailed description of the study aims and the potential risks and benefits from their participation. All participants had the opportunity to withdraw from the investigation at any time. The study protocol was approved by the local Ethics Committee and conducted in compliance with the ethical standards of the Declaration of Helsinki.

Participants were evaluated by a dentist to guarantee a standardised examination of skeletal and dental occlusion-related development or problems arising from gums and teeth. The visual dental health inspection was performed for the purpose of making a gross assessment of the swimmers oral status. The process was limited to recognising abnormal conditions and encouraging the athletes to visit a dentist (preferably with additional training in sports dentistry) to provide an exactly diagnosis, planning and treatment. All procedures were minimally invasive, painless and designed to minimise its impact on training schedules, evaluation staff and swimmers performance tests. During data collection, all swimmers were instructed to control and maintain good oral behaviours. Swimmers were also warned of possible negative impacts on their performance resulting from oral health problems.

Facial pattern and asymmetry were evaluated through subjective facial analysis [22, 25] after an extraoral standardised photographic (Sony Cyber-Shot™ DSCHX300, Tokyo, Japan) protocol (frontal and right profile views) with the subjects standing, in an oriented natural head position, with teeth occluding on maximal intercuspal position and lips relaxed. Facial pattern analysis was performed on the profile view allowing for any sagittal skeletal discrepancies between maxilla and mandible. Facial pattern assessment followed this classification: (i) pattern I, when harmonious facial growth and relationships between upper and lower dental arches were presented; (ii) pattern II, when a convex profile was presented resulting from maxillary excess, mandibular deficiency or a combination of both; (iii) pattern III, when a flat or concave profile was presented resulting from maxillary deficiency, mandibular excess or a combination of both [22, 25]. Facial asymmetry was evaluated on the frontal view analysing the presence of visible laterognathism [25].

Without involving the use of dental instruments or specialised equipment, intraoral dental examination was cursorily conducted using gloves, tongue depressors and intraoral artificial lightening, to assess the occlusion relationships, dental and periodontal health. An intraoral photographic (Sony Cyber-Shot™ DSC-HX300, Tokyo, Japan) set were also taken (frontal, right and left-side views) with teeth occluding on maximal intercuspal position. Dental occlusion was assessed by the first molar relationships in agreement with Angle classification [1] and by intraoral observation of dental malocclusions features. Dental and periodontal health were evaluated to identify the presence of dental caries and gums-related states (e.g. supragingival plaque and visible gingivitis clinical signs), respectively. Healthy teeth were considered when free from plaque or decay, and healthy gums when free from redness and bleeding.

Without previous tooth brushing, swimmers oral status was generically and qualitatively evaluated using a three criteria scale (good, sufficient and poor) including both dental and periodontal conditions. Other situations as dental stains, missed teeth and orthodontic treatment (finished or unfinished) were also recorded through clinical intraoral inspection. The photographs were processed and filed by subject in a digital file (Microsoft® PowerPoint®, version 2010, Microsoft Corporation, Washington, USA) creating a single extraoral and intraoral visible screen for each swimmer. All frequencies were obtained using the Statistical Package for the Social Sciences (SPSS, version 25.0 for Windows).

Results

Swimmers skeletal and facial development, occlusion, dental and periodontal health, and oral status are presented in Table 1. In the extraoral analysis, most of the subjects presented a proper sagittal skeletal development (pattern I). In contrast, facial asymmetry was observed in the frontal view in most swimmers (11 out of 17) and particularly for front crawl specialists. Similar to skeletal development, a proper molar relationship (Angle class I) was also identified in 10 subjects. However, malocclusions were present in form of unilateral (Figure 1a) or bilateral crossbite and edge-to-edge bite. Good dental and periodontal health were observed, as the worst findings were present in five and three swimmers affected by dental caries and gingivitis (Figure 1b), respectively. Participants were generally classified with good oral hygiene (n = 11), being also identified sufficient (n = 4) and poor (n = 2) oral

Table 1. Description of the skeletal and facial development, occlusion relationships, dental and periodontal health and oral status for all swimmers observed (n = 17)

		Front crawlers (n = 10)		Backstrokers (n = 5)		Butterflyers (n = 2)	n = 17
		Male (n = 4)	Female (n = 6)	Male (n = 1)	Female (n = 4)	Female (n = 2)	Total
Skeletal pattern	Pattern I	3	4	1	3	2	13
	Pattern II	1	2	–	1	–	4
Facial asymmetry		4	4	1	–	2	11
Angle classification	Class I	3	3	–	2	2	10
	Class II	–	–	–	1	–	1
	Class III	1	3	1	1	–	6
Malocclusions	Crossbite	3	1	–	–	–	4
	Edge-to-edge bite	1	1	–	–	–	2
Dental caries		2	1	1	1	–	5
Periodontal health	Supragingival plaque	3	2	–	1	1	7
	Gingivitis	1	–	–	1	1	3
Oral status	Good	1	5	1	3	1	11
	Sufficient	2	1	–	–	1	4
	Poor	1	–	–	1	–	2
Other observations	Dental stains	1	–	–	1	–	2
	Missed teeth	–	–	1	–	–	1
	Past orthodontics	1	2	–	–	–	3
	Current orthodontics	1	–	–	2	–	3

conditions. Other conditions including extrinsic dental stains, missing teeth and current or past orthodontic treatment, were also reported.

a) b)

Figure 1. Example of a unilateral posterior crossbite, supragingival plaque and gingivitis (left and right panels, respectively) observed in our group of swimmers

Discussion

During childhood, occlusion development is exposed to many stimuli. Despite multifactorial aetiology, occlusion deviations from ideal aesthetic and functional conditions, so-called malocclusions, are largely dependent on environmental conditions such as a correct neuromuscular role, proper breathing and normal tongue position and function [20]. Malocclusions can occur anteroposteriorly, vertically and/or transversely in the form of skeletal and/or dental discrepancies. The oral cavity is positively affected by pressures exerted by surrounding oral tissues and muscles (e.g. tongue, lips and cheeks) during the growth phase and, since swimming includes orofacial rhythmic movements that are repeated many times, it can be important for a suitable skeletal and muscular growth, including the dental progress and the dentoalveolar arches tridimensional development [14, 26].

Swimming is recommended during childhood for water safety, learn-to-swim, recreation and enjoyment, as well as competitive sporting pursuits, all of which can promote full-body harmonic development. Specific effects of swimming in dentofacial morphology and orofacial muscle activity have been notated. Within the limits of different studies, swimmers appear to have more symmetrical and proper maxillary and dental relationships and less rate of malocclusions on different tridimensional planes (e.g. less cross and open bites), abnormal swallowing, oral breathing habits and incompetent lips than non-swimmers [26]. From our results, several conditions differed from the normal skeletal and dental development but most of the swimmers evaluated had a proper position of bone bases and teeth (pattern I and Angle class I, respectively).

When practiced from the earliest ages, swimming is a useful breathing exercise requiring entrained breathing methods [15, 26]. At a young age swimmers learn how to prioritise nasal breathing during expiration and oral breathing during inspirations, have frequent apnea periods and need to seal their lips avoiding swallowing water. It is well-known that any abnormal perioral muscular activity as well an incorrect tongue position can facilitate dentoalveolar changes. Only when there are balanced intraoral and extraoral muscle forces, i.e. the existence of a neutral zone, it is possible to establish the appropriate tooth eruption and dental arches growth [14, 26]. The inspiratory and expiratory cyclic movements, involving nose, mouth, tongue, lips and cheeks, when repeated correctly over extended bouts of swimming, should assist the correct development of the whole stomatognathic system [14, 26].

During swimming the pattern of breathing needs to be synchronised with body motion and swimmers must learn how to breathe in a way to ensure propulsive continuity and well-adjusted coordination [15, 23]. Postural and occlusal changes in swimmers possibly are linked with swimming technique, breathing pattern and the amount of training time and frequency [24, 26]. Since breathing habits can disturb swimming performance, an inadequate or irregular breathing process also could affect the orofacial development leading to specific malocclusions, postural unbalances, asymmetric muscle contractions and non-synchronised coordination [14, 16].

Asymmetric breathing habits increase asymmetric muscle activation and may influence the onset of crossbites [26]. While breaststrokers and butterflyers have been stated with less facial and occlusal discrepancies, the front crawl specialists have been increased in these asymmetries [14]. Our results seem to confirm the findings reported in the literature with the presence of crossbites being only observed in front crawl and reporting a higher frequency for male swimmers. The facial asymmetry was presented in backstrokers and butterflyers, however, in front crawl it was greater evident probably given the large number of these specialists breathing unilaterally in our group of swimmers.

Breath asymmetries presence in front crawl specialists should be a focus, however, it should also be paid close attention to the swimmers from techniques described as "more symmetrical", since freestyle swimming still also very present in their training schedules. Complementarily, to maintain the face above the water line (e.g. backstrokers) or breathing too late (e.g. butterflyers) might lead to head over-extension or flexion, respectively, and may encourage the jaw to adopt different anteroposterior positions. From our results, it is possible to observe skeletal and dental discrepancies (e.g. pattern II and Angle class II and III, respectively) in backstrokers despite without any rate of these problems in butterflyers. A low tongue position has also been adopted by competitive athletes, including swimmers as a functional movement to reduce the time required to breathe avoiding swallowing water. This position could explain different dental discrepancies and orthodontics needs and the large number of swimmers with several malocclusions, and undergoing or undergone orthodontic treatment [14]. From our results, orthodontics needs (past or current) were more presented in front crawl, which it seems to confirm higher asymmetries for these specialists rather than the other swimming techniques. However, at the time of our observation, two female backstrokers were also undergoing orthodontic treatment.

Elite swimmers are encouraged to train intensively and extensively to achieve their best performance. Athletes competing to the highest level can be subject to intense training loads and may have periodically experience transient immunosuppression leading to a decrease in host defenses. This pattern could have consequences on general health. Although the degree of immune suppression is dependent on the level of fitness, intensity and duration of exercise, it is possible that athletes have a higher potential infections risks as an increased incidence of upper respiratory tract infections [13, 21]. As a part of the first-line-of-host-defense against pathogens that invade the oral mucosal surface, salivary immunoglobulin A is one of the best indicators of mucosal immunity [7, 28]. Studies confirm a decrease in salivary immunoglobulin A levels of those who practice sports at a high-competitive level, especially elite swimmers [7, 8, 13].

Given that, salivary immunoglobulin A is a marker of oral mucosal defence and the prominent immunoglobulin in saliva. By preventing microbial adherence and neutralizing virulence enzymes and toxins, a decrease in salivary immunoglobulin A could facilitate a higher incidence of oral health problems, increasing susceptibility to gum and teeth-related diseases such as periodontal problems and caries development [7, 28]. Nevertheless, have been suggested lower values of active caries and a higher frequency of protective bacteria in competitive swimmers compared to non-competitive counterparts [7]. However, data should be interpreted carefully since tooth decay development is a multifactorial and dynamic disease dependent on many interacting factors such as microbial biofilm, host conditions, substrate and time [11]. Non-competitive swimmers might have poorer nutritional habits with a large intake of sugar, explaining a higher presence of cariogenic bacteria.

Nutritional (including sports drinks, supplements and a high carbohydrate intake) and physiological changes (as dehydration, local drying of the mouth and decreased salivary flow) are also major sport-related causes for oral problems, impairing the protective role of saliva against microbial activity and also a teeth remineralizing effect [6, 18]. Oral inflammatory and infectious diseases such as gingivitis and tooth decay lead to higher levels of pro-inflammatory cytokines in whole body, increasing the susceptibility to fatigue and muscle injuries and the tendency to reinjury in several sports [2, 18, 27]. From our results, gingivitis and dental caries were observed as well as supragingival plaque across different swimmers and, if these diseases were not managed, it can progress to a systemic inflammatory illness, could cause pain, inability to train or perform, high treatment need or even tooth loss [19, 29].

During day-to-day swimming activities, especially for who engage in elite competition and spend several hours in pool, the teeth are permanently in contact with large volumes of pool water. The repetitive and long-term exposure of the teeth surfaces could increase dental staining or even dental erosion [4, 9]. Even in properly maintained gas-chlorinated pools, dental stains develop from the interaction between saliva and chemicals used for pool water disinfection (when contact are >6 h/week) predominantly on the upper or lower incisors buccal or/and lingual surfaces [9]. In contrast, enamel erosion results from the pH uncontrolled monitoring as acidic swimming pool water [3, 4]. In the current study, two swimmers from different clubs presented dark-brown stains on the buccal surfaces of lower incisors. Although teeth stains often produce dental aesthetic changes with significant psychological and social effects, dental erosion is a painful and irreversible tooth wear condition. This can be minimised if swimmers are informed about the potential risks and if are supervised in regular dental attendance.

Our study requires acknowledgment of some limitations. First, the study was not conducted under a clinical environment or using dental tools. Therefore, our results need to be carefully interpreted given the likelihood that some diagnoses could be underestimated, overestimated or not fully diagnosed. However, the protocol adopted characterised by its simplicity with the added advantage that it required only minimal complexity, time and costs has become widespread, and is frequently employed to provide dental data. Secondly, the subjective analysis has some limitations and swimmers with past orthodontic treatment may have reduced the number of occlusion asymmetries. An objective evaluation requires a highly detailed extraoral and intraoral inspection, using specific dental equipment as well, if necessary, using x-ray sources, to establish a reliable diagnosis.

Conclusions

The results reported that oral conditions appear to be poorly monitored in our group of elite swimmers and highlight oral healthcare needs in elite sport. To determine how oral health is important, epidemiological studies, regular oral screening and prevention programs need to be implemented. Strategies to prevent oral diseases and promote oral health need to be developed and evaluated. These strategies should be a high priority for athletes, clubs and national federations. Clinicians and researchers should pay close attention to orofacial development, occlusion discrepancies and dental-related problems, integrated with a sports dentistry team, to prevent, treat and monitoring oral health-related changes in swimmers and other athletes.

Acknowledgments

The authors gratefully acknowledge the cooperation of the swimmers, coaches and support staff who participated in this study.

References

1. Angle EH. Classification of malocclusion. Dent Cosmos. 1899; 41(3): 248-264.
2. Ashley P, Di Iorio A, Cole E, Tanday A, Needleman I. Oral health of elite athletes and association with performance: a systematic review. Br J Sports Med. 2015; 49(1): 14-19.
3. Baghele ON, Majumdar IA, Thorat MS, Nawar R, Baghele MO, Makkad S. Prevalence of dental erosion among young competitive swimmers: a pilot study. Compend Contin Educ Dent. 2013; 34(2): 20-24.
4. Bretz WA, Carrilho MR. Salivary parameters of competitive swimmers at gas-chlorinated swimming-pools. J Sports Sci Med. 2013; 12(1): 207-208.
5. Bryant S, McLaughlin K, Morgaine K, Drummond B. Elite athletes and oral health. Int J Sports Med. 2011; 32(9): 720-724.
6. Dawes C, Pedersen AM, Villa A, Ekstrom J, Proctor GB, Vissink A, et al. The functions of human saliva: a review sponsored by the World Workshop on Oral Medicine VI. Arch Oral Biol. 2015; 60(6): 863-874.
7. Ercole S, Tieri M, Martinelli D, Tripodi D. The effect of swimming on oral health status: competitive versus non-competitive athletes. J Appl Oral Sci. 2016; 24: 107-113.
8. Ercole S, Tripodi D. The effect of swimming on oral ecological factors. J Biol Regul Homeost Agents. 2013; 27: 551-558.
9. Escartin JL, Arnedo A, Pinto V, Vela MJ. A study of dental staining among competitive swimmers. Community Dent Oral Epidemiol. 2000; 28(1): 10-17.
10. Fernandes R, Oliveira E, Colaço P. Bioenergetical training control as a useful tool to increase performance in cyclic sports. In: Fernandes R, Oliveira E, Colaço P. Sports Medicine and Training Tools. 2011. pp. 61-88.
11. Ferraro M, Vieira AR. Explaining gender differences in caries: a multifactorial approach to a multifactorial disease. Int J Dent. 2010; 2010(8): 649643.
12. Gallagher J, Ashley P, Petrie A, Needleman I. Oral health and performance impacts in elite and professional athletes. Community Dent Oral Epidemiol. 2018; 46(6): 563-568.
13. Gleeson M, McDonald WA, Pyne DB, Cripps AW, Francis JL, Fricker PA, et al. Salivary IgA levels and infection risk in elite swimmers. Med Sci Sports Exerc. 1999; 31(1): 67-73.
14. Grosso FD, Nannelli P, D'Ercole S, Tieri M, Martinelli D, Nicola MD, et al. Effects of swimming on stomatognathic system. Ann Sports Med Res. 2015; 2(9): 1052.
15. Leahy MG, Summers MN, Peters CM, Molgat-Seon Y, Geary CM, Sheel AW. The mechanics of breathing during swimming. Med Sci Sports Exerc. 2019; 51(7): 1467-1476.
16. Leroux E, Leroux S, Maton F, Ravalec X, Sorel O. Influence of dental occlusion on the athletic performance of young elite rowers: a pilot study. Clinics. 2018; 73: 453.
17. Locker D, Quinonez C. To what extent do oral disorders compromise the quality of life? Community Dent Oral Epidemiol. 2011; 39(1): 3-11.
18. Needleman I, Ashley P, Fine P, Haddad F, Loosemore M, de Medici A, et al. Oral health and elite sport performance. Br J Sports Med. 2015; 49(1): 3-6.
19. Needleman I, Ashley P, Petrie A, Fortune F, Turner W, Jones J, et al. Oral health and impact on performance of athletes participating in the London 2012 Olympic Games: a cross-sectional study. Br J Sports Med. 2013; 47(16): 1054-1058.
20. Proffit WR. On the aetiology of malocclusion. The Northcroft lecture, 1985 presented to the British Society for the Study of Orthodontics, Oxford, April 18, 1985. Br J Orthod. 1986; 13(1): 1-11.
21. Pyne DB, McDonald WA, Gleeson M, Flanagan A, Clancy RL, Fricker PA. Mucosal immunity, respiratory

illness, and competitive performance in elite swimmers. Med Sci Sports Exerc. 2001; 33(3): 348-353.
22. Reis SAB, Abrão J, Capelozza Filho L, Claro C. Subjective facial analysis. R Dental Press Ortodon Ortop Facial. 2006; 11: 159-172.
23. Seifert L, Chehensse A, Tourny-Chollet C, Lemaitre F, Chollet D. Effect of breathing pattern on arm coordination symmetry in front crawl. J Strength Cond Res. 2008; 22(5): 1670-1676.
24. Serra N, Carvalho DD, Fernandes R. The importance of agonistic, antagonist and synergistic muscles coordination on swimming dry land training. Trends Sport Sci. 2017; 3(24):101-104.
25. Siécola GS, Capelozza LF, Lorenzoni DC, Janson G, Henriques JFC. Subjective facial analysis and its correlation with dental relationships. Dental Press J Orthod. 2017; 22(2): 87-94.
26. Silvestrini-Biavati A, Capurro C, Ugolini A, Butti AC, Salvato A. Possible causal relationships between competitive swimming in growing age and three-dimensional dentoalveolar development. Prog Orthod. 2013; 14(1): 17.
27. Solleveld H, Goedhart A, Vanden Bossche L. Associations between poor oral health and reinjuries in male elite soccer players: a cross-sectional self-report study. Sports Sci Med Rehabil. 2015; 7: 11.
28. Thaweboon S, Jitmaitree S. Salivary secretory IgA, pH, flow rates, mutans streptococci and Candida in children with rampant caries. Southeast Asian J Trop Med Public Health. 2008; 39: 893-899.

ORIGINAL ARTICLE

TRENDS in
Sport Sciences
2020; 27(**2**): 57-62
ISSN 2299-9590
DOI: 10.23829/TSS.2020.27.2-2

The real determinants of power generation and maintenance during extreme strength endurance efforts: the 3-Minute Burpee Test

KRZYSZTOF BORYSŁAWSKI[1], ROBERT PODSTAWSKI[2], FERENC IHÁSZ[3], PIOTR ŻUREK[4]

Abstract
Introduction. **Anthropometric characteristics and physical activity (PA) levels are often considered as potential variables that can be significantly correlated with specific motor abilities.** Aim of Study. **The aim of this study was to evaluate the relationships between anthropometric characteristics and motor abilities with the use of a methodological approach that is rarely applied in physical culture sciences. The correlations between body mass, body height, BMI and PA levels vs sequential power decrease in successive minutes of the 3-Minute Burpee Test (3-MBT) were analyzed.** Material and Methods. **The study involved 359 full-time university students aged 19-22, including 163 male (20.4 ± 0.67 years) and 196 female (20.4 ± 0.65 years) participants. Anthropometric characteristics (body mass, height and BMI), PA level (MET units) were measured according to standardized guidelines before the test. The participants' strength endrance were evaluated with the use of the 3-MBT. The results were processed statistically by calculating third-order partial correlation coefficients.** Results. **Raw score correlation coefficients were statistically significant (p-values: 0.05-0.01), excluding body height which was not bound by significant correlations with the number of cycles completed by women in each minute of the 3-MBT and the number of cycles completed by men in the first minute of the 3-MBT. However, the third-order partial correlation analysis demonstrated that PA level was the only independent variable that was significantly correlated with the results scored in the entire 3-MBT and in successive minutes of the test. In both sexes, the lowest values were observed in the first minute, and they were considerably higher in the second minute of the test.** Conclusions. **In the group of the analyzed variables, only PA levels significantly influence the strength endurance of moderately physically active young women and men during the 3-MBT.**

KEYWORDS: strength endurance, extreme efforts, university students, 3-Minute Burpee Test.

Received: 21 April 2020
Accepted: 15 May 2020

Corresponding author: podstawskirobert@gmail.com

[1] Wrocław University of Life and Environmental Sciences, Department of Anthropology, Wrocław, Poland
[2] University of Warmia and Mazury in Olsztyn, Department of Tourism, Recreation and Ecology, Olsztyn, Poland
[3] Eötvös Lóránd University, Faculty of Psychology and Pedagogy, Institute of Sports Sciences, Szombathely, Hungary
[4] University of Physical Education, Department of Physical Education in Gorzow Wielkopolski, Gorzów Wielkopolski, Poland

Introduction

Previous research into the 3-Minute Burpee Test (3-MBT) demonstrated that the participants' somatotype significantly influences their performance, and that exercise effectiveness measured by the number of completed burpees (cycles) generally decreases during the 3-MBT with an increase in the values of anthropometric characteristics. Exercise performance is bound by the strongest negative correlations with body mass, followed by BMI, whereas no correlations or weak correlations were noted with body height [17, 19]. Research by Alberghini [3] conducted separate comparisons of anthropometric values in subjects performing a 100-yard dash, a broad jump the burpee test, and identified a series of common correlations in all three trials. However, the anthropometric values associated with

age, height and weight were most highly correlated with burpee performance [3].
Despite the growing popularity of burpees as an effective exercise in sports and functional training [4, 20], the relevant research is rather limited. The applicability of the burpee test has been recognized mainly in martial arts [9, 23] and high-intensity interval training [14]. However, very few researchers have investigated the sequential power decrease in successive minutes of the 3-MBT and its relationship with anthropometric characteristics. The correlations between the participants' performance during the 3-MBT and their physical activity (PA) levels have also been rarely studied [21]. Physical activity levels can be bound by significant and varied correlations with the number of cycles completed in successive minutes of whole-body aerobic resistance exercises such as the 3-MBT [4]. This study contributes new observations regarding a wider application of the 3-MBT as a relevant and reliable tool for measuring strength endurance in adults, in both individual and population assessments. A sequential analysis was performed to determine the relationships between the anthropometric characteristics of young men and women and the decrease in power in successive minutes of the 3-MBT.

Aim of Study

The aim of this study was to evaluate the relationships between the anthropometric characteristics (body mass, body height and BMI) and the PA levels of male and female university students and the number of cycles completed in successive minutes of the 3-MBT as an indirect indicator of the generated power.

Material and Methods

Participants

The study involved 359 full-time university students aged 19-22, including 163 men (mean age of 20.4 ± 0.67 years) and 196 women (mean age of 20.4 ± 0.65 years). To increase the reliability of the results, the measurements were conducted in Poland (101 men and 112 women) and Hungary (62 men and 84 women) during physical activity interventions, self-defense classes and obligatory physical education classes (90 minutes per week). During preparatory meetings held before the study, every participant performed the 3-MBT five times to ensure the reliability of measurements [18].

Procedures

The research was performed in observance of the Declaration of Helsinki and upon the prior consent of the Bioethical Committee and the authorities of the University of Warmia and Mazury in Olsztyn. Every participant signed a written consent form before the study.

Measurements

The International Physical Activity Questionnaire (IPAQ, Polish short version) was used to evaluate the participants' PA levels before the study using [12]. In the questionnaire, the students indicated the duration of exercise (minimum of 10 minute bouts) performed in the weeks preceding the study. The associated energy expenditure was calculated and expressed in Metabolic Equivalent of Task (MET) units based on the Compendium of Physical Activities coding scheme [1]. The students were divided into groups with low (L < 600 METs-min/week), moderate (M < 1500 METs-min/week) and high (H ≥ 1500 METs-min/week) PA levels. Only students with moderate PA levels were included in the study. The results of the IPAQ survey revealed two relatively homogeneous groups of students (female and male) characterized by moderate PA levels. The average PA levels of female and male subjects were calculated based on the respective METs.
Body mass and height were measured to the nearest 0.1 mm and 0.1 kg on a calibrated WB-150 medical scale with a stadiometer (ZPU Tryb Wag, Poland) according to standardized guidelines. The measured values were used to calculate the participants' BMI scores.
Strength endurance levels were evaluated based on the number of burpee cycles completed in 3 minutes [20].
Stage I. Begin in a standing position and move into a supported squat with both hands on the ground.
Stage II. From a supported squat, kick your feet back into a plank with arms extended.
Stage III. Return from the plank position to a supported squat.
Stage IV. Return to a standing position, extend your arms over the head and clap your hands.
The participants repeat the cycle as many times as possible in a given time limit (3 minutes). The number of cycles was measured separately in each minute of the 3-MBT, and the results were recorded in a log that was designed specifically for the study. After the trial, the values recorded in each minute of the test were summed up.
Comments: The exercise has to be performed correctly, and the entire cycle has to be completed in the indicated order. The participants have to maintain the plank position on extended arms without arching the back, but an exception can be made for individuals with low upper

body strength. The legs should be fully extended in the plank position. A cycle is not counted when individual stages are not correctly performed.

Statistical analysis

The results were processed statistically by calculating third-order partial correlation coefficients. A partial correlation is a correlation between a pair of variables that accounts for their relationship with another (third) variable (first-order partial correlation) or several (*n*) other variables (*n*-order partial correlation). This approach is applied to determine the whether variables A and B are still correlated when the relationships between the remaining variables are eliminated (which is equivalent to the assumption that the remaining variables have constant values).

Results

The raw score correlation coefficients between the number of completed cycles in successive minutes of the 3-MBT vs the analyzed anthropometric features (body mass, body height, BMI) and METs, calculated separately for men and women, are presented in Table 1. The evaluated correlations were statistically significant, excluding body height which was not bound by significant correlations with the number of cycles completed by women in each minute of the 3-MBT and the number of cycles completed by men in the first minute of the 3-MBT.

The noted values of correlation coefficients in the studied population could be influenced by the presence of strong correlations between the number of burpees completed in each minutes of the 3-MBT and the anthropometric features in both sexes, excluding body height which was not significantly correlated with BMI or MET (Table 2).

Table 1. Raw score correlation coefficients between the studied anthropometric features and the number of cycles in successive minutes of the 3-MBT

Time	Male (N = 163)					Female (N = 196)				
	NC	BM	BH	BMI	MET	NC	BM	BH	BMI	MET
1 min	21.95	**–0.344**	ns	**–0.387**	**0.707**	19.86	**–0.398**	ns	**–0.443**	**0.659**
2 min	17.93	**–0.451**	–0.180	**–0.455**	**0.827**	14.80	**–0.526**	ns	**–0.533**	**0.806**
3 min	15.14	**–0.454**	–0.175	**–0.461**	**0.816**	12.13	**–0.496**	ns	**–0.502**	**0.793**
Total	55.02	**–0.468**	–0.160	**–0.486**	**0.876**	46.72	**–0.551**	ns	**–0.569**	**0.849**

Note: NC – number of cycles, BM – body mass, BH – body height, BMI – body mass index, MET – number of METs indicating PA level. Regular font denotes p-values: 0.05-0.01; bold <0.001; ns – not significant

Table 2. Raw score correlation coefficients between the studied anthropometric features and METs in males and females

Female \ Male	BM	BH	BMI	MET
BM		**0.589**	**0.868**	**–0.398**
BH	**0.468**		ns	ns
BMI	**0.847**	ns		**–0.415**
MET	**–0.491**	ns	**–0.485**	

Note: BM – body mass, BH – body height, BMI – body mass index, MET – number of METs indicating PA level. Regular font denotes p-values: 0.05-0.01; bold <0.001; ns – not significant

If all of the analyzed variables are significantly correlated, the question that remains to be answered is which anthropometric features or METs actually influence the results of the 3-MBT. This problem can be solved by calculating third-order partial correlation coefficients between the studied anthropometric features and the number of completed burpees. Physical activity level

Table 3. Third-order partial correlation coefficients between the studied anthropometric features and the number of cycles in successive minutes of the 3-MBT

Time	Male (N = 163)				Female (N = 196)			
	BM	BH	BMI	MET	BM	BH	BMI	MET
1 min	ns	ns	ns	**0.649**	ns	ns	ns	**0.565**
2 min	ns	ns	ns	**0.782**	ns	ns	ns	**0.733**
3 min	ns	ns	ns	**0.768**	ns	ns	ns	**0.718**
Total	ns	ns	ns	**0.845**	ns	ns	ns	**0.791**

Note: BM – body mass, BH – body height, BMI – body mass index, MET – number of METs indicating PA level. Regular font denotes p-values: 0.05-0.01; bold <0.001; ns – not significant (expressed by METs) was the only independent variable that was significantly correlated with the results scored in both the entire 3-MBT and in successive minutes of the test (Table 3). In both sexes, the lowest values were observed in the first minute, and the values noted in the second minute were considerably higher (Table 3).

Discussion

This study relies on an original approach to interpreting the relationships between the results of the 3-MBT and variables such as the participants' anthropometric characteristics and PA levels. The main limitation of many studies investigating the correlations between anthropometric features and motor abilities is that all variables are linked, and the final result of a motor ability test is a product of numerous factors.

The investigated variables are strongly correlated, which prevents a reliable assessment of whether motor abilities are directly influenced by body height, body mass, BMI or the participants' PA levels. The relationships between anthropometric characteristics, PA levels and motor abilities are often difficult to determine in preschoolers and early elementary school students where the analyzed correlations are highly varied and not as obvious as in older subjects [15]. It should also be noted that the motor test applied in this study (3-MBT) is a hybrid exercise that evaluates both endurance and strength abilities. According to some authors, selected groups of motor abilities have a more complex character, where a single dominant ability cannot be identified [25]. Motor abilities and bodily movements have a highly complex structure; therefore, many tests do not measure specific motor abilities, but their combinations. Save for a few exceptions, most motor tests evaluate physical fitness levels rather than potential motor performance (aptitude and motor abilities) [24]. Therefore, exercises that promote strength and endurance are often referred to as strength endurance tests [10]. Regardless of the semantic content, the hybrid nature of motor tests complicates the interpretation of the results. The results of the published studies indicate that high body mass and high body fat percentage exert a negative effect on endurance [7, 27], whereas high body mass and body height are essential in strength sports [13, 16]. These correlations appear to be more varied in sports disciplines that rely on strength endurance. Low body fat percentage and large body size are an advantage in martial arts such as judo [11]. Professional gymnasts are characterized by low body height, very low body mass and relatively high lean body mass [26]. Relative strength plays an important role in strength endurance training, and this parameter is significantly influenced by body mass [2, 8]. In the current study, male and female students with lower body mass had to overcome lower resistance during the 3-MBT [17].

Most studies investigating the relationships between anthropometric characteristics and motor fitness (MF) involve competitive athletes in specific sports disciplines. These subjects participate in strenuous training programs, most of which are developed for teams and groups, in preparation for competitive events, and they are characterized by high and very similar PA levels. Even in individual training programs, the number of exercise hours is high enough to guarantee very high PA levels. In contrast, the university students evaluated in this study were characterized by moderate PA levels ranging from 600 to 1500 METs/week. The results scored by individuals whose PA levels were closer to the lower limit of the moderate activity category could deviate significantly from the results scored by participants whose PA levels were closer to the upper limit. Therefore, PA levels significantly influenced the results of the 3-MBT despite the fact that the analyzed anthropometric characteristics were also bound by significant straight-line relationships with the number of completed burpees. An in-depth statistical analysis revealed that unlike PA levels, anthropometric characteristics were not bound by significant correlations with strength endurance. The reasons for the above can be found in an analysis of the mutual interactions between PA levels and MF. A systematic review of the literature conducted by Wartburton et al. [28] revealed a clear dose-response relationship between PA and selected health indicators, including MF. However, PA and MF exert independent effects on health indicators [5, 29]. The existing research suggests that improvements in physical fitness (PF) are most conducive to minimizing selected health risks [22] and that PF exerts a greater influence on health indicators than PA [6]. The above findings suggest that low levels of PF are a risk factor that is directly associated with a sedentary lifestyle [29]. In the present study, the results of the in-depth statistical analysis indicate that the PA levels of male and female university students were the only factor that influenced the generation of power and its decline in successive minutes of the 3-MBT. This observation could suggest that the range of MET values for assessing PA levels in the IPAQ (600-1500 MET) is too broad.

Conclusions

In the group of the analyzed variables, including body mass, body height, BMI and PA level (METs), only the last factor exerted a significant influence on the strength endurance of moderately physically active male and female university students performing the 3-MBT.

Acknowledgments
The authors would like to thank all students who volunteered for the study.

Funding statement
The funding for this research received from the University of Warmia and Mazury in Olsztyn does not lead to any conflict of interest.

References

1. Ainsworth BE, Haskell WL, Herrmann SD, Meckes N, Bassett DR Jr, Tudor-Locke C, et al. Compendium of physical activities: a second update of codes and MET values. Med Sci Sport Exerc. 2011; 43(8): 1575-1581.
2. Alba DL, Wu L, Cawthon PM, Mulligan K, Lang T, Patel S, et al. Changes in lean mass, absolute and relative muscle strength, and physical performance after gastric bypass surgery. J Clin Endocrinol Metab. 2019; 104(3): 711-720.
3. Alberghini D. A correlation study of the Burpee Test, 100-yard run, and Classification Index 111. Doctoral Dissertation, Boston: Boston University; 1949.
4. Bingley S. The application of popular body-weight exercises in a combat sport population. Master's thesis, The University of Canberra, Canberra, Australia, Course Code: 295JA, 4 March 2019.
5. Boraczynski MT, Sozanski HA, Boraczynski TW. Effects of a 12-month complex proprioceptive-coordinative training program on soccer performance in prepubertal boys aged 10-11 years. J Strength Cond Res. 2019; 33(5): 1380-1393.
6. Busing K, West C. Determining the relationship between physical fitness, gender, and life satisfaction. SAGE Open, 2016, 1-5. DOI: 10.1177/2158244016669974.
7. Crecelius AR, Vanderburggh PM, Laubach LL, Lloyd L. Contributions of body fat and effort in the 5K run age and body weight handicap. J Strength Cond Res. 2008; 22(5): 1475-1480.
8. de Lira C, Vargas V, Silva W, Bachi A, Vancini R, Andrade M. Relative strength, but not absolute muscle strength, is higher in exercising compared to non-exercising older women. Sports (Basel). 2019; 7(1): 19. DOI: 10.3390/sports7010019.
9. de Moura FC, Machado A, Vieira LL, Sousa AE, Soares PM, Brito G, et al. Jiu-jitsu athletes' cardiovascular responses in an adapted burpee test. AJST. 2016; 7(1): 2208-2212.
10. Delagardele Ch, Feiereisen P, Autier F, Shita R, Krecke R, Beissel J. Strength/endurance training versus endurance training in congestive heart failure. Med Sci Sport Exer. 2002; 34(12): 1869-1872.
11. Franchini E, Huertas JR, Sterkowicz S, Carratalá V, Gutiérrez-García C, Escobar-Molina R. Anthropometric profile of elite Spanish Judoka: comparative analysis among ages. Arch Budo. 2011; 7(4): 239-245.
12. Lee PH, Macfarlane DJ, Lam TH, Stewart SM. Validity of the international physical activity questionnaire short form (IPAQ-SF): a systematic review. Int J Behav Nutr Phy. 2011; 8: 115. DOI: 10.1186/1479-5868-8-115.
13. Lovera M, Keogh JWL. Anthropometric profile of powerlifters: differences as a function of bodyweight class and competitive success. J Sports Med Phys Fitness. 2015; 55(5): 478-487.
14. Machado AF, Evangelista AL, Miranda JMQ, Teixeira CV, Rica RL, Lopes CR, et al. Description of training loads using whole-body exercise during high-intensity interval training. Clinics. 2018; 73: e516. DOI: http://doi.org/10.6061/clinics/2018/e516.
15. Milanese C, Bortolami O, Bertucco M, Verlato G, Zancanaro C. Anthropometry and motor fitness ich children aged 6-12 years. JHSE. 2010; 5(2): 265-279.
16. Ojanen T, Rauhala T, Häkkinen K. Strength and power profiles of the lower and upper extremities in master throwers at different ages. J Strength Cond Res. 2007; 21(1): 216-222.
17. Podstawski R, Kasietczuk B, Boraczyński T, Boraczyński M, Choszcz D. Relationship between BMI and endurance-strength abilities assessed by the 3-Minute Burpee Test. Int J Sport Sci. 2013; 3(1): 28-35.
18. Podstawski R, Markowski P, Choszcz D, Klimczak J, Romero Ramos O, Merino Marban R. Methodological aspect of evaluation of the reliability the 3-Minute Burpee Test. Arch Budo Sci Martial Arts Extreme Sport. 2016; 12: 137-144.
19. Podstawski R, Markowski P, Choszcz D, Żurek P. Correlations between anthropometric indicators, heart rate and endurance-strength abilities during high-intensity exercise of young women. Arch Budo Sci Martial Arts Extreme Sport. 2016; 12: 17-24.
20. Podstawski R, Markowski P., Clark CCT, Choszcz D, Ihász F, Stojiljković S, et al. International standards for the 3-Minute Burpee Test: high-intensity motor performance. J Hum Kinet. 2019; 69: 131-140.
21. Podstawski R, Żurek P, Clark CCT, Laukkanen JA, Markowski P, Gronek P. A multi-factorial assessment of the 3-Minute Burpee Test. JPES. 2019; 19(2): 1083-1091.
22. Rankinen T, Church TS, Rice T, Bouchard C, Blair SN. Cardiorespiratory fitness, BMI, and risk of hypertension:

the HYPGENE study. Med Sci Sport Exer. 2007; 39: 1687-1692.
23. Siska L, Brodani J. Use of burpees in combat sports conditioning training: a pilot study. IJSPE. 2017; 3(4): 1-6.
24. Szopa J. Structure of motor abilities: identification and measurements. Antropomotoryka, 1998; 18: 79-86 (in Polish).
25. Szopa W, Chwała T, Ruchlewicz T. Investigations on structure of "energetic" motor abilities and validity of their testing. Antropomotoryka, 1998; 17: 3-42 (in Polish).
26. Taboada-Iglesias Y, Vernetta Santana M, Gutiérrez-Sánchez Á. Anthropometric profile in different event categories of acrobatic gymnastics. J Hum Kinet. 2017; 57: 169-179.
27. Vanderburggh PM, Laubach LL, Lloyd L. Body mass bias in a competition of muscle strength and aerobic power. J Strength Cond Res. 2008; 22(2): 375-382.
28. Warburton DE, Charlesworth S, Ivey A, Nettlefold L, Bredin SDS. A systematic review of the evidence for Canada's physical activity guidelines for adults. Int J Behav Nutr Phys. 2010: 7: 39. Retrieved from: http://www.ijbnpa.org/content/7/1/39.
29. Williams PT. Physical fitness and activity as separate heart disease risk factors: a meta-analysis. Med Sci Sport Exer. 2001; 33: 754-761.

ORIGINAL ARTICLE

TRENDS in
Sport Sciences
2020; 27(**2**): 63-69
ISSN 2299-9590
DOI: 10.23829/TSS.2020.27.2-3

Physical activity rates of male and female students from selected European physical education universities

JANUSZ MACIASZEK[1], MARTA OŁPIŃSKA-LISCHKA[1], BARBARA POSPIESZNA[2], ELKE KNISEL[3], ŠÁRKA HONSOVÁ[4], ROY EPPING[5], MICHAŁ BRONIKOWSKI[6]

Abstract
Introduction. Physical education teachers should promote physical activity that is beneficial to health. It is assumed that physical education students as future physical education teachers will have a high level of physical activity. Aim of Study. The aim of this study was to compare the level of physical activity (PA) in physical education (PE) students from different countries (Czech Republic, Germany, the Netherlands, and Poland) using the unified questionnaire (an IPAQ-based questionnaire with questions adapted for this purpose). Material and Methods. The study included a random selection of female and male (f = 131, m = 214) university students majoring in physical education. To measure the PA rate, the International Physical Activity Questionnaire – Long Form (IPAQ-LF) was used. Differences between the groups were tested with ANOVA. Significance was denoted by $p < 0.05$. Results. Comparison of intense PA rates shows that the highest results were recorded for men and women studying in the Czech Republic, while the lowest ones were for students from Poland and Germany. Considering the results it was noted that male students have higher PA rates than women. Only female students from Germany had a higher result than their fellow male students from Germany. Analysis of differences in moderate PA undertaken by students showed the highest activity level for both women and men studying in the Netherlands. Conclusions. We observed that nearly all female participants, except for the students from Germany, had a lower level of intense PA than male participants. Identification of the reasons for differences in PA intensity between the sexes might help eliminate the barriers and increase the level of PA in all countries. We observed that social support may have indirectly predicted the PA of students.

KEYWORDS: physical activity, IPAQ, physical education, students, Europe.

Received: : 8 February 2020
Accepted: 15 April 2020

Corresponding author: jmaciaszek@awf.poznan.pl

[1] Poznan University of Physical Education, Department of Physical Activity and Health Promotion Science, Poznań, Poland
[2] Poznan University of Physical Education, Department of Athletics, Strength and Conditioning, Poznań, Poland
[3] Otto von Guericke University Magdeburg, Faculty of Humanities, Social Science and Education Institute III, Magdeburg, Germany
[4] Charles University, Faculty of Physical Education and Sport, Department of Kinanthropology and Humanities, Prague, Czech Republic
[5] Hanze University of Applied Sciences, Groningen, The Netherlands
[6] Poznan University of Physical Education, Department of Physical Activity Teaching, Poznań, Poland

Introduction

A sedentary lifestyle and lack of physical activity (PA) may contribute to overweight and obesity entailing a risk of such diseases as type 2 diabetes, knee, and hip joint disorders, renal failure, diathesis, and obstructive sleep dyspnea. At a later age, a lack of PA may lead to severe disability and premature death. Regular exercise alters brain structures and, thus, functional and cognitive performance in older adults observed especially in tests demanding a greater amount of executive functions [8]. Evidence and findings from other research [25] suggest that PA improves explicit memory and executive cognitive functions at the extreme ends of life span (elderly and children).

Regrettably, insufficient PA both in adults and youth is observed worldwide [1]. Research shows that PA declines with age from childhood to adulthood [26]. In addition to PA decreasing with age, the termination of education may additionally decrease PA because of the resulting change in social roles (occupation, marriage) [29]. Moreover, PA can decrease after graduation due to the discontinuation of access to free-of-charge activities or discounted conveniences and infrastructure [16].

Usually, children are highly active, while adulthood is the time when PA, unfortunately, decreases [7]. These findings apply also to students. Results by Bomirska [5] showed that one in five students (20%) majoring in physical education did not get involved in any PA during their studies, and following 19% of the students declared only occasional PA. Differences in terms of awareness, knowledge, quality of life, economic development level, and education system are probably the most significant determinants of the PA rate. The differences recorded in many studies to date, however, may arise from using different measurement methods or different questionnaires. The potential bias effect of the measurement method used for accessing PA on the results obtained has been noted by Kantanista and Osiński [13]. They stated that among Polish people (in the age category 19-64 years) a satisfactory level of PA was observed in from 9.2% of male subjects and 12.0% of female subjects to 77.6% of male and female subjects. They suggest that it might vary depending on the methods of PA measurement. Therefore, in this study, we used the same, unified questionnaire (an IPAQ-based questionnaire with questions adapted for this purpose).

Diverse levels of PA observed in various studies depend on cultural or economic conditions and commonly on the country where the study is conducted. A study from 2010 reported that the Netherlands was a country leading in terms of high PA compared to all other EU countries [24]. In 2018, six countries improved (Belgium, Luxembourg, Finland, Cyprus, Bulgaria, and Malta), and their citizens were more active than from the Netherlands, which held the seventh position in that rank [19]. Gavric [11] reported that of 15 EU countries surveyed in 2002, Dutch citizens were the most physically active ones (39.43 MET hours/week). The Germans seemed to be also very active with approximately 34 MET hours/week [21]. On the other hand of the European PA rates scale is for example Poland. Polish citizens are seen as one of the least active nations in Europe [18]. 60% of the Polish population society was not sufficiently involved in PA [21]. Unexpectedly, Czechs and Hungarians had much better results than Polish citizens – although these countries have a similar economic growth [12], which is deemed to be an important determinant of the PA rate and underwent a similar political and economical transformation in the recent years. A study by Sekot [22] showed that one-third of the adults in the Czech Republic were physically active at least once a week – men more frequently than women.

Therefore, to compare the situation in the nations with such diverse levels of PA we have undertaken a study, which aimed to assess PA with one unified method of measurement and identify differences between male and female students from the Czech Republic, Germany, the Netherlands, and Poland. Comparing the PA of this group of students may cause a need for change, perhaps a need to modify the programs of physical education teacher training in "young" or new member states.

Material and Methods

The study included a random selection of (n = 131) female and (n = 214) male university students majoring in physical education. 110 students (f = 41; m = 69) from the Czech Republic (age M = 20.7; SD = 0.73), 109 students (f = 49; m = 60) from Poland (age M = 20.8; SD = 1.29), 86 students (f = 27; m = 58) from Germany (age M = 20.8; SD = 2.00), and 40 students (f = 15; m = 25) from the Netherlands (age M = 21.1; SD = 1.82) participated in the study. Differences in the number of subjects in each group resulted from the varied number of students studying at each University in each country who could join the study.

Study design

The study of a cross-sectional design was performed on a selected population of students gaining similar qualifications in the profession of physical education teaching. Research considers differences between selected countries, the first members of United Europe, and countries that joined 45 years later. From the first group of 6 countries, two were selected (the Netherlands and Germany), and the other two countries were selected (Poland and the Czech Republic) from the second group (from 10 countries). This was a pilot study that aimed at proposing some modifications in students' activities to increase the competences of future physical education teachers in promoting physical activity. Descriptive nature of the study aimed at assessing and describing the current status of a variable (PA) in a particular segment of the population. To maintain the similar conditions of testing the study took place at the same time of the year (early September of 2017). All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted under the rules of the Helsinki Declaration. The study protocol was approved by the Local Bioethics Committee of Poznan Medical University (decision no. 908/16).

Measurement and procedure

To measure the PA rate, the International Physical Activity Questionnaire – Long Form (IPAQ-LF) was used. The purpose of the questionnaire is to estimate the level of PA in four domains: work, leisure, transportation, and household. The IPAQ-LF tool, prepared for international use, has acceptable measurement properties (Spearman's p = 0.8; criterion validity, assessed against accelerometer measures, median p = 0.30) as for self-reports [10].

Results were classified according to IPAQ's recommendations into three PA levels:

1. High:
   - 3 or more days of intense physical exercise at least 1500 MET minutes per week,
   - 7 or more days of any combination of exercises exceeding 3000 MET minutes per week.
2. Sufficient:
   - 3 or more days of intense physical exercise of least 20 minutes per day,
   - 5 or more days of moderate exercise or walking of at least 30 minutes per day,
   - 5 or more days of any combination of exercises exceeding 600 MET minutes per week.
3. Insufficient – persons without physical exercise or who do not meet the criteria for sufficient or high level.

According to IPAQ Research Committee's methodology, the level of PA determined as high is a health-promoting amount of PA [21]. Moderate PA means exercise with slightly heavier breathing (and a slightly faster heart rate at 50-70% of the maximum heart rate). Intense PA means heavy exercise requiring very heavy breathing (and a faster heart rate at 70-85% of the maximum heart rate). Every type of exercise was quantified in MET minutes per week – by multiplying the ratio assigned to this exercise (intense – 8 METs, moderate – 4 METs, walking – 3.3 METs) by the number of days of exercise per week and the average duration in minutes per day.

Questionnaires were completed in whole-class groups during a regular academic class, in quiet classroom conditions, and took approximately 30 minutes to complete. Students were informed about the anonymous and voluntary nature of their participation, that the study records would be kept confidential, and that their contributions would be unidentifiable in the final report.

Statistical analysis

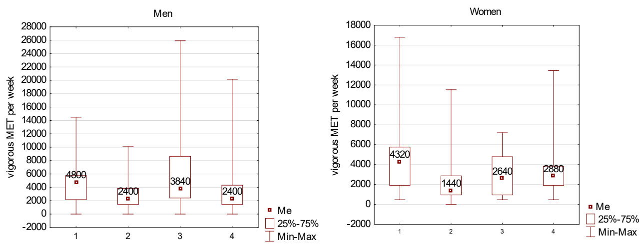
Differences between the groups were tested with ANOVA. Dunn's Test of Multiple Comparisons Using Rank Sums was used for all samples as the post-hoc test. Significance was denoted by $p < 0.05$. Statistical analysis was carried out using Statistica 10.0 software.

Results

Intense physical activity

Comparison of intense PA rates shows that the highest results were recorded for men (4800 MET min/week) and women (4320 MET min/week) studying in the Czech Republic, while the lowest ones were for students from Poland and Germany (2400 MET minutes/week) (Figure 1). Similar differences apply to female students where intense PA was lowest among female students from a Polish university and highest among female students from the Czech Republic (Figure 1).

Considering the results it was noted that male students have higher PA rates than women. Only female students from Germany had a higher result (2880 MET min/week) than their fellow male students from Germany (2400 MET min/week) (Figure 1).



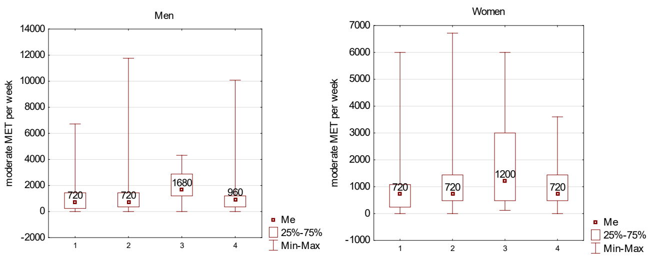
Note: 1 – the Czech Republic, 2 – Poland, 3 – the Netherlands, 4 – Germany. Men: H = 15.51879, p = 0.0014; CZE-POL $p < 0.05$; women: H = 14.69412, p = 0.0021; POL-CZE $p < 0.05$

Figure 1. Intense physical activity of students from the Czech Republic, the Netherlands, Germany, and Poland (MET min/week)

Furthermore, the number of days of intense PA performed by the students per week was analyzed. Intense PA was most frequently undertaken by male students from the Netherlands (6 days/week) and the Czech Republic (5 days/week). Of female students, intense PA was most frequently carried out by Czech students (5 days/week) and least frequently by female students from Poland (3 days/week).

Moderate physical activity

Analysis of differences in moderate PA undertaken by students showed the highest activity level for both women and men studying in the Netherlands (1680 and 1200 MET min/week, respectively). Male students from the German university scored 960 MET min/week. Polish male and female students were involved in moderate PA to a small extent (720 MET min/week). Scores of Polish students were much lower than those recorded in other countries. It was noted that Dutch students of both sexes were much more likely to carry out moderate PA than their fellow students from other universities (Figure 2).



Note: 1 – the Czech Republic, 2 – Poland, 3 – the Netherlands, 4 – Germany. Men: H = 17.24446, $p = 0.0006$; NED-CZE $p < 0.05$, NED-POL (U) $p < 0.05$, NED-POL (PE) $p < 0.05$, NED-GER $p < 0.05$; women: H = 3.037333, $p = 0.3859$

Figure 2. Differences in moderate physical activity between students from the Czech Republic, the Netherlands, Germany, and Poland (MET min/week)

Analysis of the number of days on which the students undertook moderate PA has shown that students from the Dutch university of both sexes were active most frequently (5 days/week). Other student groups performed moderate PA every 2-3 days.

Discussion

It is common knowledge that the level of education [27] and the place of study (or at least of longer residence) [4] affect the PA level and health behaviors. Seemingly, it should not apply to students – especially of physical education – as their activity should be rather high, and less sensitive to the cultural, social, or national factors. Students majoring in the same professional pathways should be gaining qualifications via comparable study programs, at least according to the Bologna Law of the European Higher Education Area.

Analysis of collected data has shown a very high level of intense PA among PE students from the Czech university. These results were confirmed by reports of other authors which show that, compared to other countries, adult Czechs usually have the highest level of PA. Comparative studies between students from the Czech Republic and China have also shown a high general PA of the Czech students [28]. Therefore, based on this study, Czech students seem to be some of the most active students from European countries. Sjöström et al. [23] suggest that citizens of such countries as the Czech Republic may be presenting a higher level of PA because of the infrastructure facilitating various forms of walking activities which may encourage more frequent PA in general. The importance of easy access to recreational and sports facilities has been emphasized in many studies before, and correctness of this supposition is confirmed by the equally high level of PA in Dutch people who had one of the highest scores in terms of moderate PA among our sample (1680 MET min/week). This is consistent with the Eurobarometer study [24] showing that Dutch students were one of the most active groups of all young adults studying in Europe. This may be due to few facts: good infrastructure (for example cycling, skating and sailing routes), higher rates of community and social engagement in active-lifestyle in general, higher economical status, increased health awareness.

PE students of the university from Poznań presented a lower level of PA. This result is surprising as a previous study by Baj-Korpak [2] has shown students of a Polish university as having high levels of PA, higher than the generally assumed level of 3000 MET min/week. These comparative studies on Polish students have shown that students majoring in physical education in other Polish cities (Biała Podlaska and Kraków) scored 1078 MET min/week at a moderate level and 2493.6 MET min/week at intense PA level. So, although students from different universities in Poland have similar studying program, when comparing activities performed by students majoring in PE in those different universities in terms of their spare time (e.g. PA) you need to take into account differences in study curricula and also a different level of awareness and needs, behavior patterns. The different curricula involve various forms of physical exercise to a certain extent, specifically in the context of recent curricular changes. Perhaps fewer obligatory physical exercise classes may be related to the lower spare-time PA. Therefore, the need for extra leisure-time PA as realized by the students may vary. Unfortunately, in our study, we did not analyze the correlation between study curricula and the part of physical exercise in the different study programs but it could be important.

Besides presenting a lower level of PA compared to other European countries Polish students' PA score was just sufficient (according to IPAQ). On the contrary, the Czech and the Dutch activity level was higher and above the recommended values. Bednarek et al. [3] compared the levels of PA of Polish and Turkish students and the Polish ones had a much higher PA level per day/week (women: 3720 MET min/week, men: 5045 MET min/week) than the Turkish ones (women: 1690 MET min/week, men: 2590 MET min/week). Another comparison of the PA of Polish and Turkish students has also shown the Polish ones to be much more physically active than the Turkish ones [15]. Zuzda et al. [30] noted that students of the Białystok University of Technology had a higher score (3706.90 MET min/week) than students in Portugal (2790.84 MET min/week). Concerned those three research the season of the year or climate might have been an important factor affecting the PA level. Perhaps the lower level of PA of students from Turkey and Portugal was due to the much warmer climate [6] and higher temperatures discouraging any leisure-time PA. This proposition was, however, rejected by Kijo [14] who noted that for 46.6% of students from Poland majoring in physical education the season of the year was irrelevant for the level of their PA and, according to their declarations, they were most active in the summer. Nevertheless, temperatures even in summer differ significantly between Turkey, Portugal, and Poland. Our study was, however, conducted in similar climate regions (Central European area) and at the same time of the year (early September) and still the results differ significantly. The above-mentioned determinants are probably of lesser importance. Many other factors like motivation, well-being, or environmental variables may substantially determine PA [17]. Facilities such as access to biking paths, swimming pools, or gyms are certainly (as has already been noted) very important factors encouraging the decision to undertake PA. This is confirmed by a high PA of the students from the Czech Republic and the Netherlands regardless of their sex. But as indicated by the results obtained by German students, good technical facilities may be an insufficient motivator. The level of PA of German PE students was, likewise, higher than that of their Polish peers but lower than Czech and Dutch PE students.

Men have usually presented a higher level of general and intense PA than women [22, 28]. In our study, we observed that nearly all female participants, except for the students from Germany, had a lower level of intense PA than male participants. Identification of the reasons for differences in PA intensity between the sexes might help eliminate the barriers and increase the level of PA in all countries. The results of Choi et al. [9] showed that a higher PA social support score was significantly associated with a higher PA participation rate. Concordant with our findings, other authors argue that social support might not directly impact PA. But social support may have indirectly predicted the PA of students. Thus, further studies are required to identify the direct and indirect PA determinants of students, specifically those concerning PE and health-related professions. However, other studies report that the PA environmental factors such as footpaths safe for walking and access to local facilities are significantly associated with PA level [20]. However, we observed lower PA among German students than from other countries (e.g. Czech Republic, Netherlands). Thus, further studies are necessary to clarify the relationship between the PA environment and PA levels. This study has several limitations. First, this study was cross-sectional in 4 universities, and participation was based on the voluntary base, which precludes analyses of some of PA determinants among the full range of the PE student sample. In addition, PA data were self-reported, meaning they may be over- or underestimated. Future studies should incorporate prospective designs. Therefore, future research that includes empirical measurements using objective methods is needed.

Conclusions

We observed that nearly all female participants, except for the students from Germany, had a lower level of intense PA than male participants. Identification of the reasons for differences in PA intensity between the sexes might help eliminate the barriers and increase the level of PA in all countries. We observed that social support may have indirectly predicted the PA of students.

References

1. Andersen LB, Mota J, Di Pietro L. Update on the global pandemic of physical inactivity. Lancet. 2016; 388(10051): 1255-1256. DOI: 10.1016/S0140-6736(16)30960-6.
2. Baj-Korpak J, Korpak F, Szepeluk A. Factors conditioning the motives and obstacles to physical activity of students of physical education. Soc Diss. 2016; 10(4): 60-72.
3. Bednarek J, Pomykała S, Bigosińska M. Physical activity of Polish and Turkish university students as assessed by IPAQ. CEJSSM. 2016; 16(4): 13-22. DOI: 10.18276/cej.2016.4-02.

4. Bergier J, Bergier B, Tsos A. Place of residence as a factor differentiating physical activity in the life style of Ukrainian students. Ann Agric Environ Med. 2016; 23(4): 549-552. DOI: 10.5604/12321966.1226844.
5. Bomirska L. Struktura aktywności sportowej w środowisku studenckim (Structure of sporting activity in the student environment). In: Drozdowski S, Dworak L, Wachowski E, editors. Wychowanie fizyczne i sport w badaniach sportowych (Physical education and sport in sports research). Poznań: AWF; 2000. pp. 331.
6. Bosdriesz J, Witvliet M, Visscher T. The influence of the macro-environment on physical activity: a multilevel analysis of 38 countries worldwide. Int J Behav Nutr Phys Act. 2012; 11(9): 1-10. DOI:10.1186/1479-5868-9-110.
7. Caspersen C, Pereira M, Curran K. Changes in physical activity patterns in the United States, by sex and cross-sectional age. Med Sci Sports Exerc. 2000; 32(9): 1601-1609. DOI: 10.1097/00005768-200009000-00013.
8. Cassilhas RC, Viana VA, Grassmann V, Santos RT, Santos RF, Tufik S, et al. The impact of resistance exercise on the cognitive function of the elderly. Med Sci Sports Exerc. 2007; 39(8): 1401-1407. DOI: 10.1249/mss.0b013e318060111f.
9. Choi JY, Chang AK, Choi EJ. Sex differences in social cognitive factors and physical activity in Korean college students. J Phys Ther Sci. 2015; 27(6): 1659-1664.
10. Craig CL, Marshall AL, Sjöström M, Bauman AE, Booth ML, Ainsworth BE, et al. International Physical Activity Questionnaire: 12-country reliability and validity. Med Sci Sports Exerc. 2003; 35(8): 1381-1395. DOI: 10.1249/01.MSS.0000078924.61453.FB.
11. Gavric Z, Culafic A, Markovic B. Correlation between phq-9 score and physical activity level, risk factors and non-communicable diseases in patients in family medicine clinic. Cent Eur J Med. 2011; 6(3): 372-377. DOI: 10.2478/s11536-011-0022-4.
12. Grabia T. Economic situation in the Visegrad Group countries: comparative analysis. Economy in Practice and Theory, 2014; 2: 35-48.
13. Kantanista A, Osiński W. Physical activity of Poles – Critical analysis of research 2010-2014. AAEM. 2014; 21(4): 839-843.
14. Kijo P. Aktywność fizyczna wśród studentów kierunków pedagogicznych łódzkich uczelni publicznych i niepublicznych (Physical activity of students of pedagogical faculties at public and private universities). In: Barabasz Z, Zadarko E, editors. Aktywność przez całe życie. Zdrowie i sprawność studentów pod kontrolą (Active throughout life. Health and fitness of students under control). Krosno: Państwowa Wyższa Szkoła Zawodowa w Krośnie; 2010. pp. 157-180.
15. Kotowski P, Ostrowska B. Aktywność fizyczna studentów kierunku fizjoterapia (Assessment of physical activity among physiotherapy students). Scientific Treatises of University School of Physical Education in Wrocław. 2017; 56(1): 26-35.
16. MacKenzie J, Brunet J, Boudreau J. Does proximity to physical activity infrastructures predict maintenance of organized and unorganized physical activities in youth? Prev Med Rep. 2015; 2(C): 777-782. DOI: 10.1016/j.pmedr.2015.09.005.
17. Mirzaei-Alavijeh M, Soroush A, Nasirzadeh M, Hatamzadeh N, Zinat-Motlagh F, Jalilian F, Mohammadi M, et al. Middle East. Socio-cognitive determinants of regular physical activity among college students. J Family Med. 2018; 16(2): 158-162. DOI: 10.5742/MEWFM.2018.93256.
18. Mrozik WJ, Stupnicki R. Ocena aktywności fizycznej studentów WSKFiT za pomocą kwestionariusza IPAQ (Physical activity of physical education external students as assessed by IPAQ questionnaire). WSKFT Scientific Letters. 2015; 10: 1-10.
19. New Eurobarometer on sport and physical activity. Special Eurobarometer 472 / Wave EB88.4 – TNS Opinion & Social, 2018.
20. Nies MA, Kershaw TC. Psychosocial and environmental influences on physical activity and health outcomes in sedentary women. J Nurs Scholarsh. 2002; 34(3): 243-249.
21. Piątkowska M. Age-related changes in physical activity patterns in Poland. Antropomotorics. 2012; 22(59): 17-29.
22. Sekot A. Sport and physical activities in the Czech Republic. Phys Cult Sport Stud Res. 2010; 48(1): 44-65. DOI: 10.2478/v10141-010-0006-0.
23. Sjöström M, Oja P, Hagströmer M. Health-enhancing physical activity across European Union countries: the Eurobarometer study. J Public Health. 2006; 14(5): 291-300. DOI: 10.1007/s10389-006-0031-y.
24. Sport and physical activity – special study Eurobarometer. Special Eurobarometer 334 / Wave 72.3 – TNS Opinion & Social, 2010.
25. Stillman CM, Watt JC, Grove GA Jr, Wollam ME, Uyar F, Mataro M, et al. Physical activity is associated with reduced implicit earning but enhanced relational memory and executive functioning in young adults. PLoS ONE, 2016; 11(9): e0162100. DOI: 10.1371/journal.pone.016210.
26. Varma VR, Dey D, Leroux A, Di J, Urbanek J, Xiao L, et al. Re-evaluating the effect of age on physical activity over the lifespan. Prev Med. 2017; 101: 102-108. DOI: 10.1016/j.ypmed.2017.05.030.
27. Vašíčková J, Frömel K, Nykodým J. Physical activity recommendation and its asscociation with demographic

variables in Czech University students. Acta Univ. Palacki Olomuc Gymn. 2008; 38(2): 75-84.
28. Zhao Y, Sigmund E, Sigmundová D. Comparison of physical activity between Olomouc and Bejing University students using an international physical activity questionnaire. Acta Univ Palacki Olomuc Gymn. 2007; 37(4): 107-114.
29. Zick CD, Smith KR, Brown BB. Physical activity during the transition from adolescence to adulthood. JPAH. 2007; 4(2): 125-137. DOI: 10.1123/jpah.4.2.125.
30. Zuzda G, Brás R, Pasek M. Physical fitness patterns, barriers and motivations among Portugal and Polish university students. University of Life Sciences, Lublin. 2015: 337-352.

ORIGINAL ARTICLE

TRENDS in
Sport Sciences
2020; 27(**2**): 71-85
ISSN 2299-9590
DOI: 10.23829/TSS.2020.27.2-4

Tactical training of elite athletes in Olympic combat sports: practice and experience

OLHA ZADOROZHNA, YURIY BRISKIN, MARYAN PITYN, ALINA PEREDERIY, NEONILA NERODA

Abstract
Introduction. The work studied specifics of tactical training in Olympic combat sports. According to the current researches, technical and tactical training is the basis of athletes' training, but in most papers and official documents, tactical training is not substantiated. Aim of Study. This study aimed to analyze the practical experience of tactical training performed by elite athletes in Olympic combat sports. Material and Methods. We have recruited 40 coaches. Their average experience was almost 15 years. Experts had to rank the components of tactical training such as directions, means, and methods of tactical training, control of tactical preparedness, components of tactical knowledge. Results. In some questions expert's opinions were similar, but in other questions, they were different inside groups and between them. Average and strong concordance ($p < 0.05$) was found in such groups of experts: fencing – about directions of tactical training (0.56); verbal, visual and practical methods (0.53; 0.63; 0.62 respectively); means and methods of control (0.53); wrestling – about directions and practical methods (0.74 and 0.59 respectively); boxing – only about practical methods (0.56); taekwondo – about directions (0.58); verbal, visual and practical methods (0.55; 0.64; 0.73 respectively); means and methods of control (0.64); karate – about verbal, visual and practical methods (0.62; 0.64; 0.70 respectively); means and methods of control (0.72); information blocks "Basics of Tactics in Sports" (0.55) and "Competition performance" (0.61). In judo, concordance was weak in all questions (0.41-0.45). Conclusions. The general algorithm of tactical training of elite athletes consists of six steps and is aimed to prepare for the main competition of the year (the Olympic Games or World Championship). The tasks are to choose an effective strategy; to develop the most effective tactical actions against the main rivals; to train to make correct decisions during the bout; to learn how to predict the opponent's actions.

KEYWORDS: knowledge, tactical skills, competition, preparedness, training.

Received: 2 November 2019
Accepted: 9 April 2020

Corresponding author: ozadorozhna@ukr.net

Lviv State University of Physical Culture named after Ivan Boberskyy, Department of Theory of Sports and Physical Culture, Lviv, Ukraine

Introduction

The specificity of competitive activity in combat sports dictates its requirements for the implementation of different aspects of athletes' training. The current trends in fencing, boxing, wrestling, judo, taekwondo, karate could be characterized by the intensification of competitive activity, changes in competition rules, improvement of various aspects of training of experienced athletes [2, 3, 4, 9, 10, 11]. Analysis of recent publications illustrates that during the last five-ten years scientific researches in combat sports were focused on issues of technical and tactical training, physical skills and their indicators, psychological aspects of training and formation of special knowledge [2, 3, 7, 12, 15, 18]. Moreover, a considerable number of researchers are convinced that the main reason for the low and unstable results of competition performances is the insufficient level of athletes' technical and tactical skills [17, 18, 25, 26]. According to this point of view, the main accent during the training process should be made on improving technical and tactical preparedness, while other components of athletes' skills are considered as an additional option [6, 14, 27, 28].

Analysis of scientific publications indicates that such an approach is actual for the majority of combat sports represented in the Olympic program. In most of the works, tactical training is presented mainly in combination with technical one [3, 6, 12] and the efforts are mainly directed to the development of innovative tools and methods of technical and tactical training [6, 13, 14, 17]. In this tandem, however, technical training is dominant both in the official documents (programs for the sports clubs, curriculums at physical education colleges) and in the scientific literature [1, 5, 6, 8, 28]. At the same time, the implementation of tactical training is, in our opinion, insufficiently substantiated and contradictory, what, in our opinion, may be a serious obstacle in preparations for the competitions at the highest level – World and European Championships, and the Olympic Games. Practice demonstrates that in the face of fierce competition at the international stage, athletes who are the most physically trained do not always win. The ability to make the right decision and implement it at the right moment in the fight is much more important. Because the competition rules, the specificity of movements, the structure of competitive and training activities, as well as the peculiarities of athletes' training in combat sports are similar, it is possible to use the general algorithm of tactical training in different types of combat sports. Therefore, this study aimed to analyze the practical experience in tactical training of elite athletes in fencing, boxing, wrestling, judo, taekwondo, and karate, and to create the organizational and methodological foundations for tactical training in combat sports.

Material and Methods

The first stage of our research was the theoretical analysis of literary sources and identification of the main problems of tactical training in combat sports represented in the Olympic program. Analysis of the sports club's programs, the curriculums of physical education colleges, scientific and methodological literature in combat sports [1, 5, 6, 8, 28], enabled to determine the most controversial aspects of tactical training of elite athletes. Those aspects were connected with the directions of tactical training, its methods, ways of tactical skills' control, theoretical tactical knowledge, and factors influencing the training strategy during competitions.

The next step of our research was to develop a questionnaire, which included all controversial questions (Appendix). The questionnaire included the following five sections: 1) Tactical training directions (5 components), 2) Factors that influence the training strategy for competitions (5 components), 3) Theoretical material within the tactical training (9 components in each of 3 questions: basics of tactics in sports, competition performance, theory and methodology of tactical training), 4) Methods and means of tactical training (6 components in 2 questions about verbal and visual methods, and 10 components in question about practical methods of tactical training), and 5) Control in tactical training (9 components).

The next step included an expert's assessment (February–August 2019). There were 6 expert groups recruited. The total number of 40 experts included 8 in fencing, 8 in wrestling (freestyle and Greco-Roman), 6 in amateur (Olympic) boxing, 6 in judo, 6 in taekwondo WTF, and 6 in karate WKF. The experts were well educated (ten among them held Ph.D. diplomas) and experienced 4 coaches of the national teams (three of Ukrainian national teams, one of USA national teams), 2 world category referees, and 8 athletes – national team's members. On average, experts had almost 15 years of experience in training Olympic combat sports athletes of different ages. The questionnaires were administered to the experts in two different ways. 25 questionnaires were administered in a paper form and filled under the supervision of the researcher. The other 15 questionnaires were distributed by e-mail. Each expert was asked to rank the components of tactical training in each section. The number of components in sections ranged from 5 to 10. Rank 1 was always considered the most significant. The highest rank indicated the least important component (eg. in section with 9 components, rank 9 was the least important). In most questions, experts could add their components and to rank them, but none of them did.

In order to confirm the accuracy of the answers, the concordance coefficient was determined in each group of experts (W). The statistical validity of the concordance coefficient was verified using the χ^2 criterion (Pearson's chi-squared test). According to Shiyan, Edinak, Petryshyn [24], the critical value of the concordance coefficient was defined as W = 0.5. Therefore, at $0.69 > W \geq 0.5$, the agreement of experts' opinions was evaluated as average, at $W \geq 0.7$ as high (strong), and at $W < 0.5$ as low (weak). To compare the answers in different expert groups we used the average rank (arithmetic mean of all ranks assigned to a particular position of tactical training provisions in every expert group).

Results

An analysis of the experts' answers indicated that in most combat sports similar components of tactical training were estimated as the most or the least significant. At the same time, within some questions, the degree of agreement of experts' opinions in different sports within one question could be average, strong, weak ($p < 0.05$) or unreliable ($p > 0.05$).

The priority of factors that influence the training strategy for competitions is presented in Table 1. Experts indicated that elite athletes should more emphasize: improvement of tactical thinking (average ranks: 1.50-2.67) in fencing, wrestling, and judo, and practical implementation of tactical preparedness (average ranks: 1.75-2.17) in boxing, taekwondo, and karate. The least significant in all expert groups, except for judo, was the study of the essence and basics of sports tactics (average ranks: 3.67-4.63). In judo, the least significant was the study of information necessary for the practical implementation of tactical preparedness (average rank: 3.50).

The priority of components that influence the training strategy for competitions is presented in Table 2. In all expert groups, except judo, priority was given to the functional preparedness and psychological status of the athletes or team (average ranks: 1.50-2.75). In wrestling, in addition to this factor, experts suggested to take into account the level of opponents' preparedness, and in judo – the level of technical and tactical skills of the athletes or team (average rank: 2.17). However, when selecting the least significant factor, the expert's opinions in different groups were different. In boxing, judo, and karate the least significant factor was the level of opponents' preparedness (average ranks: 3.67-4.17), in wrestling – the level of competitions and their formula (average rank: 3.50), in fencing and taekwondo – knowledge about the opponents' preparedness (average ranks: 4.00 and 4.17 respectively).

Table 1. Experts' opinions on the importance of the components of tactical training of elite athletes in Olympic combat sports ($n = 40$, $p < 0.05$)

No.	Components of tactical training	Average rank form groups of experts					
		1	2	3	4	5	6
1	The study of the essence and basics of sports tactics	4.38	4.63	3.67	2.83	4.25	4.08
2	The study of the basic elements, techniques, options of tactical actions	4.00	4.13	3.00	3.00	4.17	3.92
3	The study of information necessary for practical implementation of tactical preparedness (information about opponents, competition)	2.75	2.88	3.33	3.50	2.67	2.58
4	Practical implementation of tactical preparedness (the use of tactical actions during competition)	2.38	1.50	2.17	3.00	1.75	1.83
5	Improvement of tactical thinking (how to trick an opponent and make him make a mistake)	1.50	1.88	2.83	2.67	2.17	2.58
	Concordance coefficient	0.56	0.74	0.13*	0.04*	0.58	0.38*

Note: Groups of experts: 1 – fencing (n = 8); 2 – wrestling (n = 8); 3 – boxing (n = 6); 4 – judo (n = 6); 5 – taekwondo (n = 6); 6 – karate (n = 6)
* unreliable concordance coefficient ($p > 0.05$)

Table 2. Experts' opinions on the importance of components influencing the training strategy for competitions of elite athletes in Olympic combat sports ($n = 40$, $p < 0.05$)

No.	Components of tactical training	Average rank form groups of experts					
		1	2	3	4	5	6
1	The level of technical and tactical skills of athletes (teams)	2.63	2.88	2.50	2.17	2.50	3.08
2	Functional preparedness and psychological status of athletes (teams)	1.63	2.75	1.50	2.33	2.00	2.00
3	The level of competition and their formula	3.00	3.50	3.33	3.33	2.50	2.50
4	The level of opponents' preparedness	3.75	2.75	4.17	3.67	3.83	3.83
5	Knowledge about the opponents' preparedness	4.00	3.13	3.50	3.50	4.17	3.58
	Concordance coefficient	0.36	0.04*	0.42	0.19*	0.36*	0.23*

Note: Groups of experts: 1 – fencing (n = 8); 2 – wrestling (n = 8); 3 – boxing (n = 6); 4 – judo (n = 6); 5 – taekwondo (n = 6); 6 – karate (n = 6)
* unreliable concordance coefficient ($p > 0.05$)

The priority of components in information blocks “Basics of Tactics in Sports”, “Competition Performance”, “Theory and Methodology of Tactical Training” is presented in Tables 3-5. As shown in Table 3, the most attention should be devoted to the following topics: in fencing, judo and taekwondo – “The varieties and content of tactical techniques and actions” (average ranks: 2.81-3.83), in wrestling and karate – “Competition strategy and tactics” (average ranks: 2.87-3.50). At the same time, two components were estimated as equal in karate: “The

Table 3. Experts’ opinions on the importance of components in information block “Basics of Tactics in Sports” in Olympic combat sports ($n = 40$, $p < 0.05$)

No.	Components of tactical training	Average rank form groups of experts					
		1	2	3	4	5	6
1	“Te importance of tactics in sports”	7.19	6.50	8.67	6.17	9.00	8.67
2	“The interrelation of tactical skills with other parties of preparedness”	4.44	3.88	6.00	4.17	7.00	7.83
3	“The varieties and content of tactical techniques and actions”	2.81	4.38	5.67	3.83	3.50	3.67
4	“Competition strategy and tactics”	3.94	2.88	5.33	4.00	4.00	3.50
5	“Forms of tactics”	4.75	5.63	4.67	4.50	3.50	4.00
6	“Directions of tactical training”	7.31	7.00	3.33	4.83	4.00	6.17
7	“The interrelation of the athlete’s specialized feelings with tactics”	4.13	5.25	3.17	5.33	4.33	3.50
8	“Tactical plan, tactical scheme”	4.75	3.75	3.00	5.50	4.33	4.17
9	“Current trends in tactics of the chosen sport”	5.69	5.75	5.17	6.67	5.33	3.50
	Concordance coefficient	0.31	0.25	0.42	0.14*	0.46	0.55

Note: Groups of experts: 1 – fencing (n = 8); 2 – wrestling (n = 8); 3 – boxing (n = 6); 4 – judo (n = 6); 5 – taekwondo (n = 6); 6 – karate (n = 6)
* unreliable concordance coefficient ($p > 0.05$)

Table 4. Experts’ opinions on the importance of components in information block “Competition Performance” in Olympic combat sports ($n = 40$, $p < 0.05$)

No.	Components of tactical training	Average rank form groups of experts					
		1	2	3	4	5	6
1	“Competition rules”	6.06	4.38	6.67	2.00	3.67	5.33
2	“International competition system”	3.19	3.75	5.50	3.08	3.67	2.42
3	“National competition system”	4.19	3.50	5.50	3.50	4.67	4.83
4	“Duties of judges and refereeing of competitions”	4.69	5.75	4.67	5.00	6.67	4.50
5	“Organization of competitions”	5.31	5.75	4.33	5.58	7.67	7.00
6	“Competition terminology”	6.38	6.38	5.00	5.67	7.17	7.67
7	“Requirements for equipment and inventory”	6.25	8.13	4.50	6.67	5.33	7.83
8	“Participation of national and foreign athletes (teams) in competitions of different levels”	5.31	3.88	5.50	7.00	4.33	2.83
9	“Individual styles of competition performance”	3.63	3.50	3.33	2.00	1.83	2.58
	Concordance coefficient	0.18*	0.34	0.12*	0.41	0.49	0.61

Note: Groups of experts: 1 – fencing (n = 8); 2 – wrestling (n = 8); 3 – boxing (n = 6); 4 – judo (n = 6); 5 – taekwondo (n = 6); 6 – karate (n = 6)
* unreliable concordance coefficient ($p > 0.05$)

interrelation of the athlete's specialized feelings with tactics" and "Current trends in tactics of the chosen sport". At the same time, the following components were estimated as the least significant: in boxing, taekwondo, and karate – "The importance of tactics in sports" (average ranks: 8.67-9.00), in fencing and wrestling – "Directions of tactical training" (average ranks: 7.00-7.31), in judo – "Current trends in tactics of the chosen sport" (average rank: 6.67).

Judo experts chose the components "Competition rules" and "Individual styles of competitive activity" (average rank: 2.00; Table 4). In fencing and karate, the most significant was the "International competition system" (average ranks: 2.42-3.19), in wrestling – "National competition system" (average rank: 3.50), in taekwondo – "Individual styles of competition performance" (average rank: 1.83). Besides, experts' opinions were different when defining minor components. In wrestling, and karate the least significant was: "Requirements for equipment and inventory" (average ranks: 7.83-8.12), in fencing – "Competition terminology" (average rank: 6.37), in boxing – "Competition rules" (average rank: 6.67), in judo – "Participation of national and foreign athletes (teams) in competitions of different levels" (average rank: 7.00), in taekwondo – "Organization and holding competitions, competition regulations" (average rank: 7.67).

In wrestling, boxing, judo, and taekwondo the most important was the topic: "Individual training plan" (average rank: 2.17-3.33) and in fencing and karate – "Formation of a tactical plan and choice of a tactical scheme" (average ranks: 2.88 and 2.33 respectively), in judo – "Model characteristics of tactical skills of elite athletes" (average rank: 3.33; Table 5). At the same time, the least significant were such topics: in boxing and taekwondo – "Basics of tactical training in sports" (average ranks: 7.17 and 8.33 respectively), in fencing – "Control of tactical skills" (average rank: 6.75), in wrestling – "Planning of tactical training" (average rank: 6.00), in judo – "Forming a team, defining the functions of its members" (average rank: 6.67), in karate – "Methods and means of tactical training" (average rank: 7.50).

The priority of verbal, visual and practical methods of tactical training is represented in Tables 6-8. Among the verbal methods, the leaders in all expert groups except boxing were analysis and discussion (average ranks 1.83-2.12; Table 6). In boxing, preference was given for guidance and recommendations (average rank: 1.83). At the same time, the last place in the ranking in fencing, wrestling, judo, and taekwondo was a lecture (average ranks: 4.58-5.83), and in boxing and karate – a story (average ranks: 5.50 and 5.67 respectively).

As depicted in Table 7, experts from all groups agreed and preferred to use video (average ranks: 1.00-2.50). However, they did not agree on the least significant visual aids. In fencing and karate, the use of photographs

Table 5. Experts' opinions on the importance of components in information block "Theory and Methodology of Tactical Training" in Olympic combat sports (n = 40, p < 0.05)

No.	Components of tactical training	Average rank form groups of experts					
		1	2	3	4	5	6
1	"Basics of tactical training in sports"	4.25	5.88	7.17	4.67	8.33	7.00
2	"Individual training plan"	4.88	3.13	2.67	3.33	2.17	3.83
3	"Methods and means of tactical training"	6.63	4.13	5.83	4.67	3.67	7.50
4	"Control of tactical skills"	6.75	4.00	4.50	5.33	5.83	4.67
5	"Model characteristics of tactical skills of elite athletes"	4.75	3.38	5.50	3.33	5.50	4.17
6	"Periodization of tactical training"	5.38	6.50	4.00	5.67	4.67	3.83
7	"Planning of tactical training"	4.25	6.75	3.50	6.17	4.50	4.67
8	"Formation of a tactical plan and choice of a tactical scheme"	2.88	4.25	5.50	5.17	3.33	2.33
9	"Forming a team, defining the functions of its members"	5.25	7.00	6.33	6.67	7.00	7.00
	Concordance coefficient	0.19*	0.22*	0.28*	0.18*	0.48	0.42

Note: Groups of experts: 1 – fencing (n = 8); 2 – wrestling (n = 8); 3 – boxing (n = 6); 4 – judo (n = 6); 5 – taekwondo (n = 6); 6 – karate (n = 6)
* unreliable concordance coefficient (p > 0.05)

is considered inappropriate (average ranks were 5.25 and 5.00 respectively), in wrestling and taekwondo – graphs and diagrams (4.87 and 4.75 respectively) and in boxing – educational films (average rank: 4.33), in judo – tables (average rank: 4.42).

Among the practical methods, experts of all groups except boxing and judo preferred training with a partner (average ranks: 1.17-2.50; Table 8). Instead, in boxing and judo, they preferred to use training with an opponent (average ranks: 1.67 and 2.17 respectively). At the same time, learning tactical actions from other sports were recognized as the least important in all expert groups except wrestling and karate (average ranks: 7.83-9.50). In wrestling, experts recommended to use referee practice (average rank: 8.37), and in karate – conducting training sessions by athletes (average rank: 9.50).

The priority of means and methods of control in tactical training is presented in Table 9. In all expert groups, except fencing, participation in competitions was valued as the best way to evaluate the tactical skills (average ranks: 1.33-3.00). Besides, in boxing and karate analysis of competitive performance was considered equivalent. In turn, the following methods were recognized as unimportant: in fencing, wrestling and boxing – keeping and checking athletes' diaries (average ranks: 6.50-6.67), in taekwondo and karate – conducting training sessions by athletes (average ranks: 7.17 and 7.76 respectively), in judo – execution of intellectually-developing tasks (average rank: 6.83). In addition, fencing and boxing were not recommended to focus on the use of the refereeing of training and competitive bouts.

Table 6. Experts' opinions on the importance of verbal methods of tactical training of elite athletes in Olympic combat sports (n = 40, p < 0.05)

No.	Components of tactical training	Average rank form groups of experts					
		1	2	3	4	5	6
1	Story	4.25	3.75	5.50	3.83	3.33	5.67
2	Explanation	3.38	3.50	4.17	4.50	3.50	3.33
3	Lecture	5.75	5.38	3.67	4.58	5.83	4.83
4	Conversation	3.25	2.75	3.83	3.83	4.00	3.00
5	Analysis and discussion	1.88	2.13	2.33	2.00	1.83	2.00
6	Guidelines and recommendations	2.50	3.50	1.83	2.25	2.50	2.17
	Concordance coefficient	0.53	0.35	0.50	0.36*	0.55	0.62

Note: Groups of experts: 1 – fencing (n = 8); 2 – wrestling (n = 8); 3 – boxing (n = 6); 4 – judo (n = 6); 5 – taekwondo (n = 6); 6 – karate (n = 6)
* unreliable concordance coefficient (p > 0.05)

Table 7. Experts' opinions on the importance of visual methods of tactical training of elite athletes in Olympic combat sports (n = 40, p < 0.05)

No.	Components of tactical training	Average rank form groups of experts					
		1	2	3	4	5	6
1	Graphs and diagrams	3.31	4.88	3.83	3.83	4.75	3.33
2	Tables	4.06	4.13	3.50	4.42	4.58	2.67
3	Slides	4.50	3.13	3.67	3.83	4.75	4.50
4	Photos	5.25	3.75	3.17	4.17	3.50	5.00
5	Videos	1.19	1.63	2.50	1.50	1.67	1.00
6	Educational films	2.69	3.50	4.33	3.25	1.75	4.50
	Concordance coefficient	0.63	0.34	0.11*	0.32*	0.64	0.64

Groups of experts: 1 – fencing (n = 8); 2 – wrestling (n = 8); 3 – boxing (n = 6); 4 – judo (n = 6); 5 – taekwondo (n = 6); 6 – karate (n = 6)
* unreliable concordance coefficient (p > 0.05)

Table 8. Experts' opinions on the importance of practical methods of tactical training of elite athletes in Olympic combat sports ($n = 40$, $p < 0.05$)

No.	Components of tactical training	Average rank form groups of experts					
		1	2	3	4	5	6
1	Training with a partner	2.00	1.38	2.50	3.83	1.17	2.50
2	Training with an opponent	2.38	2.00	1.67	2.17	2.92	2.50
3	Training with an imaginary opponent	2.63	4.38	3.33	4.17	3.00	3.00
4	Training without a rival	4.63	5.63	4.83	5.67	4.00	6.33
5	Keeping and checking diaries	7.75	7.38	6.17	5.67	7.33	8.50
6	Referee practice	7.56	8.38	7.00	6.17	7.33	6.83
7	Use of technical devices	6.38	5.50	6.67	5.33	5.50	4.67
8	Conducting training sessions by athletes	6.88	7.50	7.67	7.67	8.17	9.50
9	Execution of intellectually-developing tasks (training games)	6.88	5.75	7.33	4.83	6.92	4.00
10	Learning tactical actions from other sports	7.94	7.13	7.83	9.50	8.67	7.17
	Concordance coefficient	0.62	0.59	0.56	0.45	0.73	0.70

Note: Groups of experts: 1 – fencing (n = 8); 2 – wrestling (n = 8); 3 – boxing (n = 6); 4 – judo (n = 6); 5 – taekwondo (n = 6); 6 – karate (n = 6)
* unreliable concordance coefficient ($p > 0.05$)

Table 9. Experts' opinions on the importance of means and methods of control in tactical training of elite athletes in Olympic combat sports ($n = 40$, $p < 0.05$)

No.	Components of tactical training	Average rank form groups of experts					
		1	2	3	4	5	6
1	Analysis of competitive performance	1.63	2.38	2.67	3.83	1.67	1.67
2	Participation in competitions	1.88	3.13	2.67	2.00	1.33	1.67
3	Control standards	4.50	5.63	4.83	3.50	4.00	3.33
4	Testing (topic-specific surveys)	5.25	6.25	5.67	5.67	5.58	5.50
5	Keeping and checking athletes' diaries	6.75	6.13	6.17	6.00	5.83	7.67
6	Conducting training sessions by athletes	6.00	5.00	5.50	5.50	7.17	7.67
7	Refereeing of training and competitive bouts	6.63	6.50	7.00	5.83	6.58	6.83
8	Execution of intellectually-developing tasks (training games)	6.38	5.25	7.67	7.33	6.00	5.00
9	Use of technical devices	6.00	5.00	2.83	5.33	6.83	5.67
	Concordance coefficient	0.53	0.27	0.48	0.34*	0.64	0.72

Note: Groups of experts: 1 – fencing (n = 8); 2 – wrestling (n = 8); 3 – boxing (n = 6); 4 – judo (n = 6); 5 – taekwondo (n = 6); 6 – karate (n = 6)
* unreliable concordance coefficient ($p > 0.05$)

Discussion

The analysis of scientific and methodological literature concerning tactical training in combat sports indicates that the main accent of athletes' training is put on the development of technical and tactical skills [5, 7, 9, 10]. At the same time, in official documents (programs for sports clubs and colleges) tactical training is not substantiated properly [8, 19, 20, 22].

According to Platonov [19], the traditional structure of tactical preparedness includes tactical knowledge (a set of ideas about the means, types, and forms of sports tactics), tactical skills (ability to guess the plans of the opponent, to predict the course of competition's development, to change their tactics), tactical skills (trained tactical actions) and their combinations, and tactical thinking (athlete's thinking aimed at solving tactical problems).

The formation of tactical skills and the use of the most effective tactical actions in combination with technical actions are the most discussed in scientific papers [4, 16, 20, 23, 25, 26, 27]. At the same time, most contradictory are questions about tactical knowledge, which is the basis for the development of tactical skills, and the amount of time spent on tactical practice in the training process.

The most fundamental research devoted to tactical skills in combat sports during the last 10 years was made by Ryzhkova [20]. The author also used expert assessment for the determination of the most essential components of tactical preparedness. However, it included only information connected with tactical decision-making (act immediately or wait, provoke a rival or make a real action). The main accent was put on tactical information about the technological components of the construction of fights: specialized positions and movements of the blade chosen before the fight, typical combat operations, the results of the analysis of the alleged varieties of enemy actions in the upcoming battle, distances selected before combat [20]. According to this information, Ryzhkova developed technologies for the formation and improvement of athletes' tactical skills at different stages of long-term training [20]. The effectiveness of such technologies was revealed in pedagogical experiments. In our opinion, this research is very useful for fencers, but it doesn't take into account the specifics of other combat sports.

The next research in fencing, also tested as a pedagogical experiment, was held by Kriventsova et al. [16]. It was dedicated to student's tactical training. The technology of students' skills development was similar to previous research. The author suggested to use various methods and their combinations according to the students' experience in fencing. Some of them practiced fencing before entering the university, some of them tried that kind of sport for the first time. According to the traditional approach there should be no difference between tactical training at the university level for those students who practiced fencing before and those who have never done it. The results of the experiment proved that the author's approach to student's tactical training was more effective than the traditional one. But again, those findings are effective only in fencing.

During the last 10-15 years the authors of papers related to tactical training in combat sports were most interested in: the activity of athletes in different conflict situations [25]; tactical training as a basis for modeling the motor actions of coaches and sportsmen [2, 3, 7, 11]; individualization of tactical training of experienced athletes and formation of special style [15]; formation and development of tactical knowledge, skills, and abilities in the system of long-term training [6, 20]; structure and content of technical and tactical actions of athletes of different age and qualification [13, 14, 26, 27, 29]; planning of technical and tactical improvement in the annual macrocycle [15]. Scientists also developed a great amount of technical devices to improve technical and tactical skills, eg.: "Spuderg simulator" by Savchin [22], computer program "Analysis and modeling of competitive activity of fencers" by Shevchuk [23], fighting simulator "Spartak" by Velychenko and Zherdzinsky [29], "A device for evaluating some of the special physical skills of the boxer" by Saenko et al. [21], "Tyshler's Simulator (TTD)" by Tyshler and Ryzhkova [27]. In our opinion, the disadvantage of those methods is that they could be used only for the improvement of the individual aspects of preparedness, and do not provide integral control over the technical, tactical, special physical, psychophysiological aspects of the preparedness of combat sports. Moreover, their use doesn't involve the acquisition of specific knowledge of sports theory by athletes and the fulfillment of tasks in the conditions of counteracting the opponent in real-time.

The data obtained according to expert's assessment allowed us to conclude that practical experience of tactical training in combat sports is different, that is why coaches use various approaches. The choice of the particular approach depends on the coach's experience, his or her affiliation to the traditional sports schools, which were formed in different countries and regions over the years. The comparison of average ranks in all expert groups allowed us to make conclusion that some approaches in different combat sports are similar. It concerns the choice of the most significant and the least significant components of tactical training.

According to expert's assessment in tactical training of elite athletes in Olympic combat sports priority should be given to the following components:

- among the directions of tactical training – the practical implementation of tactical preparedness (in boxing, taekwondo and karate) and the improvement of tactical thinking (in fencing, wrestling and judo);
- among the factors that influence the training strategy for competitions – the functional preparedness and psychological state of the athlete or team (except judo);

- in information block "Basics of Tactics in Sports" – topics: "The varieties and content of tactical techniques and actions" (in fencing, judo and taekwondo) and "Competition strategy and tactics" (in wrestling and karate);
- in information block "Competition performance" – topics: "International competition system" (in fencing and karate), "Individual styles of competition performance" (in boxing and taekwondo);
- in information block "Theory and Methodology of Tactical Training" – topics: "Individual training plan" (in wrestling, boxing, judo, taekwondo), "Formation of a tactical plan and choice of tactical scheme" (in fencing and karate);
- among verbal methods – analysis and discussion (except boxing);
- among visual methods – videos;
- among practical methods – training with a partner (in fencing, wrestling, taekwondo, and karate) and training with an opponent (in boxing, judo, and karate);
- among the means and methods of control – the analysis of participation in control competitions (in boxing, judo, taekwondo, and karate) and indicators of competition performance (in fencing, wrestling, boxing, and karate).

Analysis of the research results allowed us to form a generalized algorithm of tactical training which could be useful for elite athletes in Olympic combat sports: fencing, freestyle, and Greco-Roman wrestling, amateur (Olympic) boxing, judo, taekwondo WTF, karate WKF. Elite athletes, to keep or increase their position in the national and international rankings or to win a quota place for the next Olympic Games, take part in various competitions during the sports season. Therefore, their tactical training should aim at the practical implementation of tactical preparedness and the improvement of tactical thinking – the main accent should be given to 1) the development of the most effective tactical actions against the main rivals, 2) the ability to make a correct decision during the bout, and 3) to predict the opponent's actions. When preparing for the particular event or bout the choice of the tactics should always be based on the functional preparedness and psychological state of the athlete or team (in team events). The athletes should be familiarized with the most important theoretical topics as they are the basis for the improvement of the athlete's tactical knowledge and tactical thinking. The coach may also use analysis and discussion when choosing the most appropriate strategy for the competition. Usually, he supposes the strategy for the whole competition – to win all bouts in the preliminary stage with the maximum score or to win only the number of fights that will allow moving on to the next stage of the competition. Then the coach and the athlete may discuss which actions to use against different rivals and options if the chosen tactics would be ineffective. After discussion, they should use videos of the duels in which the athlete has already competed with these opponents and analyze them (to choose the most effective actions). The next step is to improve these actions in training with a partner when another sportsman or a coach creates easier conditions for using the chosen actions. Then the athlete attempts to use these actions with an opponent in sparring matches. All the attempts should be recorded on video. The athlete and the coach review the video and correct the mistakes. If there is an additional event (less important tournament) before the main competition, the athlete may try to use these actions in the match with new opponents. In the future, the coach concludes whether these actions can be used at the main competition (the Olympic Games or World Championship) with particular opponents.

In brief, the algorithm of tactical training for elite athletes in Olympic combat sports should aim to prepare for the main competition of the year (the Olympic Games or World Championship). The tasks should be to choose an effective strategy; to develop the most effective tactical actions against the main rivals; to train undertaking correct decisions during the bout; to learn how to predict the opponent's actions. The developed steps of tactical training are: 1) to analyze the functional preparedness and psychological state of the athlete or team before the event; 2) to learn more about the varieties and content of tactical techniques and actions, competition strategy and tactics, individual styles of competition performance, tactical plans and choice of tactical schemes; 3) to choose the most appropriate strategy for the competition and tactics for each bout with different opponents; 4) to determine the range of the most effective and reliable actions; 5) to improve these actions, using training with the partner and the opponent; 6) to analyze the quality of performance of these actions, to make eventual corrections.

In our opinion, this algorithm of tactical training may be useful for elite athletes in all Olympic combat sports. At the same time, it may be more detailed depending on the types and amount of competition during the season, the athletes' other important tasks, their functional and psychological state, and the preparedness of the main opponents.

Conclusions

1. Tactical training is one of the most important components of athletes' tactical preparedness in

modern Olympic combat sports. It is aimed to develop tactical knowledge and skills which are essential to defeating different opponents.
2. Despite that in modern Olympic combat sports, the coaches use various approaches, the general algorithm of tactical training of elite athletes could be used. It consists of six steps and is aimed to prepare for the main competition of the year (the Olympic Games or World Championship). The tasks are to choose an effective strategy; to develop the most effective tactical actions against the main rivals; to train to make a correct decision during the bout; to learn how to predict the opponent's actions.

Financial support
Financial support was provided by Lviv State University of Physical Culture named after Ivan Boberskyy.

References
1. Antonov SA, Ost'yanov VN, Komisarenko GI, Matvienko GG, Shevchuk YuV. Boxing: Teach. program for children's and youth sports schools, specialized children-youth schools of the Olympic reserve, schools of higher sporting skills. Kyiv; 2014 [in Ukrainian].
2. Bober T, Rutkowska-Kucharska A, Jaroszczuk S, Barabasz M, Woźnica W. Kinematic characterization of the lunge and the fleche in epee fencing: two case studies. Polish J Sport Tour. 2017; 23(4): 181-185.
3. Boroushak N, Eslami M, Kazemi M, Daneshmandy H, Johnson J. The dynamic response of the taekwondo roundhouse kick to head using computer simulation. Ido Mov Culture. J Martial Arts Anthrop. 2018; 18(2): 54-60. DOI: 10.14589/ido.18.2.8.
4. Briskin Yu, Zadorozhna O, Perederiy A, Pityn M, Sydorko O. Team composition in epee fencing which accounts for sportsmen's individual performance. JPES. 2018; 273: 1863-1870. DOI: 10.7752/jpes.2018.s4273.
5. Busol VA. Fencing: Teach. program for children's and youth sports schools, specialized children-youth schools of the Olympic reserve, schools of higher sporting skills and schools of the Olympic reserve. Kyiv; 2014 [in Ukrainian].
6. Bychkov Y. Coach in the fencing lesson. Moscow; 2006 [in Russian].
7. Chen TLW, Wong DWC, Wang Y, Ren S, Yan F, Zhang M. Biomechanics of fencing sport: a scoping review. PLOS ONE. 2017; 12(2): 21-27.
8. Guittet M, Palmai M. Long Term Athlete Development. Canadian Fencing Federation; 2010.
9. Harmenberg J. Epee 2.0: The Birth of New Fencing Paradigm. SKA SwordPlay Books; 2007.
10. Harmenberg J, Ceci R, Barvestad P, Hjerpe K, Nyström J. Comparison of different tests of fencing performance. Int J Sports Med. 1991; 12(6): 573-576. DOI: 10.1055/s-2007-1024736.
11. Ince ML. Professional development of coaches and teachers: trends and challenges. Sport Mont. 2013; XI (37-38-39): 3-9.
12. Johnson J. Enhancing Taekwondo Pedagogy through Multiple Intelligence Theory. Ido Mov Culture. J Martial Arts Anthrop. 2016; 16(3): 57-64. DOI: 10.14589/ido.16.3.7.
13. Johnson J. From technique to way: an investigation into taekwondo's pedagogical process. Ido Mov Culture. J Martial Arts Anthrop. 2017; 17(4): 3-13; DOI: 10.14589/ido.17.4.2.
14. Johnson J, Kang HJ. Hapkido research trends: a review. Ido Mov Culture. J Martial Arts Anthrop. 2018; 18(3): 42-50. DOI: 10.14589/ido.18.3.7.
15. Korobeynikov GV, Korobeynikova LG, Axyutin VV. The features of perception and processing of visual information in boxers with different style of match. Pedagog Psychol Med-Biol Probl Phys Train Sports. 2018; 7: 41-44.
16. Kriventsova I, Iermakov S, Bartik P, Nosko M, Cynarski WJ. Optimization of student-fencers' tactical training. Ido Mov Culture. J Martial Arts Anthrop. 2017; 17(3): 21-30. DOI: 10.14589/ido.17.3.3.
17. Lisitsyn VV. Technical and tactical training of highly qualified female boxers. Candidate Dissertation. Moscow: Russian State University of Physical Culture, Sports, Youth and Tourism; 2015 [in Russian].
18. Matveev L. The general theory of sport and its applications. St. Petersburg: Lan'; 2001 [in Russian].
19. Platonov VN. Sports training periodization. General theory and its practical application. Kiev: Olympic Literature. 2015; 315-400 [in Russian].
20. Ryzhkova LG. Vyibor takticheskoy modeli vedeniya boya v ekstremalnyih usloviyah sorevnovaniy u fehtovalschikov vyisshey kvalifikatsii (The choice of tactical model of bout in extreme conditions of competitions in fencing of elite athletes). Ekstrem. deyatelnost cheloveka. 2014; 2: 123-125 [in Russian].
21. Saenko OV, Ivanov VI, Stepanenko SV. Inventor, patent holder. A device for evaluating some of the special physical skills of the boxer. Patent Ukraine No 62607; 2011 Sep 12 [in Ukrainian].
22. Savchin M. Training of the boxer and its diagnostics. Kiev: Nora-print; 2003 [in Ukrainian].
23. Shevchuk E. Computer program "Analysis and modeling of competitive activity of fencers" as a means and method of preparing for competitions. Chernigiv. 2009; 69: 311-315 [in Ukrainian].

24. Shiyan BM, Edinak GA, Petryshyn YV. Scientific researches in physical education and sports: scientific manual (for faculty of Physical education and higher education institutions of the II-IV levels of accreditation). Kamianets-Podilskyi: Printing House Ruta; 2012; 35-40 [in Ukrainian].
25. Tabben M, Coquart J, Chaabene H, Franchini E, Ghoul N, Tourny C. Time-motion, tactical and technical analysis in top-level karatekas according to gender, match outcome and weight categories. J Sports Sci. 2014; 33: 1-9. DOI: 10.1080/02640414.2014.965192.
26. Tupeev YuV, Bojko VF. Analyzes of methodological approaches during technique studying in sports wrestling. Fizicheskoe vospitanie studentov: nauchnyj zhurnal. 2010; 3: 116-121 [in Russian].
27. Tyshler D, Ryzhkova L. Fencing. Technical and tactical and functional training Moscow: Academic project; 2010 [in Russian].
28. Tyshler D. Fencing. Moscow: Physical Culture and Sports; 1997 [in Russian].
29. Velychenko YV, Zherdzinsky IA. Inventor, patent holder. Fighting simulator “Spartak”. Patent Ukraine No 119649; 2017 Sep 27 [in Ukrainian].

Appendix

Dear expert!
We ask you to express your opinion regarding the tactical training of elite athletes in your kind of sport (Olympic combat sports).

Full name: ....; age: ....;
kind of sport: ....; qualification: ....;
coaching category: ....;
scientific degree: ....;
experience as a coach and/or teacher: ....;
place of work: ....

Section 1. TACTICAL TRAINING DIRECTIONS

Indicate the importance of the tactical training directions of elite athletes, ranging from 1 (most significant direction) to 5 (least significant direction).

No.	Directions of tactical training	Rank
1.	The study of the essence and basics of sports tactics	
2.	The study of the basic elements, techniques, options of tactical actions	
3.	The study of information necessary for practical implementation of tactical preparedness (information about opponents, competition)	
4.	Practical implementation of tactical preparedness (the use of tactical actions during competition)	
5.	Improvement of tactical thinking (how to trick an opponent and make him make a mistake)	

Section 2. FACTORS THAT INFLUENCE THE TRAINING STRATEGY FOR COMPETITIONS

Indicate the importance of factors that influence the training strategy for competitions, ranging from 1 (most significant direction) to 5 (least significant direction).

No.	Directions of tactical training	Rank
1.	The level of technical and tactical skills of athletes (teams)	
2.	Functional preparedness and psychological status of athletes (teams)	
3.	The level of competition and their formula	
4.	The level of opponents' preparedness	
5.	Knowledge about the opponents' preparedness	

Section 3. THEORETICAL MATERIAL WITHIN THE TACTICAL TRAINING

Indicate the importance of topics in the blocks of the tactical training at different stages of the long-term development, ranking them from 1 (the most important topic) to 10 (the least important topic).

Information block "Basics of Tactics in Sports"

No.	Topics	Rank
1.	"The importance of tactics in sports"	
2.	"The interrelation of tactical skills with other parties of preparedness"	
3.	"The varieties and content of tactical techniques and actions"	
4.	"Competition strategy and tactics"	
5.	"Forms of tactics"	
6.	"Directions of tactical training"	
7.	"The interrelation of the athlete's specialized feelings with tactics"	
8.	"Tactical plan, tactical scheme"	
9.	"Current trends in tactics of the chosen sport"	
	Your offer:	

Information block "Competition Performance"

No.	Topics	Rank
1.	"Competition rules"	
2.	"International competition system"	
3.	"National competition system"	
4.	"Duties of judges and refereeing of competitions"	
5.	"Organization of competitions"	
6.	"Competition terminology"	
7.	"Requirements for equipment and inventory"	
8.	"Participation of national and foreign athletes (teams) in competitions of different levels"	
9.	"Individual styles of competition performance"	
	Your offer:	

Information block "Theory and Methodology of Tactical Training"

No.	Topics	Rank
1.	"Basics of tactical training in sports"	
2.	"Individual training plan"	
3.	"Methods and means of tactical training"	
4.	"Control of tactical skills"	
5.	"Model characteristics of tactical skills of elite athletes"	

6.	"Periodization of tactical training"	
7.	"Planning of tactical training"	
8.	"Formation of a tactical plan and choice of a tactical scheme"	
9.	"Forming a team, defining the functions of its members"	
	Your offer:	

Section 4. METHODS AND MEANS OF TACTICAL TRAINING

Indicate the importance of verbal methods and means of tactical training, ranging from 1 (most significant direction) to 7 (least significant direction).

No.	Verbal methods and means of tactical training	Rank
1.	Story	
2.	Explanation	
3.	Lecture	
4.	Conversation	
5.	Analysis and discussion	
6.	Guidelines and recommendations	
	Your offer:	

Indicate the importance of visual methods and means of tactical training, ranging from 1 (most significant direction) to 7 (least significant direction).

No.	Visual methods and means of tactical training	Rank
1.	Graphs and diagrams	
2.	Tables	
3.	Slides	
4.	Photos	
5.	Videos	
6.	Educational films	
	Your offer:	

Indicate the importance of practical methods and means of tactical training, ranging from 1 (most significant direction) to 11 (least significant direction).

No.	Practical methods and means of tactical training	Rank
1.	Training with a partner	
2.	Training with an opponent	

3.	Training with an imaginary opponent	
4.	Training without a rival	
5.	Keeping and checking diaries	
6.	Referee practice	
7.	Use of technical devices	
8.	Conducting training sessions by athletes	
9.	Execution of intellectually-developing tasks (training games)	
10.	Learning tactical actions from other sports	
	Your offer:	

Section 5. CONTROL IN TACTICAL TRAINING

Indicate the importance of methods and means of control in tactical training, ranging from 1 (most significant direction) to 10 (least significant direction).

No.	Practical methods and means of tactical training	Rank
1.	Analysis of competitive performance	
2.	Participation in competitions	
3.	Control standards	
4.	Testing (topic-specific surveys)	
5.	Keeping and checking athletes' diaries	
6.	Conducting training sessions by athletes	
7.	Refereeing of training and competitive bouts	
8.	Execution of intellectually-developing tasks (training games)	
9.	Use of technical devices	
	Your offer:	

Date .... *Signature* ....

Thank you for your help!

ORIGINAL ARTICLE

TRENDS in
Sport Sciences
2020; 27(**2**): 87-92
ISSN 2299-9590
DOI: 10.23829/TSS.2020.27.2-5

Reliability of Functional Movement Screen and sexual differentiation in FMS scores and the cut-off point among amateur athletes

JAROSŁAW DOMARADZKI, DAWID KOŹLENIA

Abstract
Introduction. **Functional Movement Screen (FMS) is a tool used in injury prediction based on the quality of movement patterns. Crucial is to determine the cut-off point which indicates the injury risk increment. Most of the researches regard professional athletes.** Aim of Study. **The aim of this study was to determine the reliability of the FMS test, and sexual differentiation in the value of the FMS total score test and subtests. Furthermore, the study aimed to evaluate the values of injury risk cut-off point in the FMS test in young male and female individuals from the moderately-active population.** Material and Methods. **The study group consisted of 89 physically active individuals not involved in high-performance sport: 42 males aged 20.5 ± 1.10 years, and 47 females aged 20.0 ± 0.68 years. FMS, a questionnaire concerning the previous injury history of 12 months preceding the study were used. The interclass correlation coefficient (ICC) was used to evaluate the reliability of the FMS test and a receiver operating characteristic curve (ROC) for FMS cut-off scores was calculated.** Results. **The FMS test showed excellent agreement between two screenings. There were some differences in the quality of movement patterns between men and women in subtests. The values of injury risk cut-off scores were different between sexes, 14 points for males and 17 points for females.** Conclusions. **The FMS test is a highly reliable research tool. For the average population of physically active young male and female amateur athletes, the cut-off score values in the FMS test should be evaluated separately between sexes to determine injury risks.**

KEYWORDS: FMS test reliability, cut-off score, physical activity.

Received: 15 January 2020
Accepted: 17 March 2020

Corresponding author: dawid.kozlenia@awf.wroc.pl

University School of Physical Education in Wrocław, Faculty of Physical Education, Department of Biostructure, Wrocław, Poland

Introduction

Athletes involved in high-performance sport and the average population taking up various kinds of physical activity are exposed to the risk of injuries [18]. With the increasing number of people in society taking up regular physical exercise, the problem of injuries, related to physical activity, concerns not only the elite sport but becomes rather a common phenomenon [24]. Knowledge of factors conducive to the occurrence of injuries makes it possible to intervene appropriately early and to limit injury risk. The factors indicated as predisposing to injuries include functional disorders of the locomotor system resulting in incorrect movement patterns [8, 13]. Cook designed a test assessing fundamental movement patterns in terms of mobility, stability, and motor control within the locomotor system termed the Functional Movement Screen (FMS) [4, 5]. This test was developed for professional athletes and people involved in occupations requiring a high level of physical fitness. It is a tool that, by assessing movement patterns, allows for predicting an injury risk of an individual. The FMS test has been used for injury risk assessment among soccer players [4], rugby players [7], runners [3], or people in such occupations as military service [9] and firefighting [10]. The FMS was also utilized for the average population of physically active people. However, the number of such studies is small [16, 19]. However, the problem with injuries related to physical activity is also common for the average population [4]. Therefore, the diagnosis of injury risk is critical as a first step in the prevention of the average population of physically active people.

The use of the FMS for the evaluation of injury risks requires the determination of cut-off scores. The most widely applied and accepted cut-off score on the FMS point scale is the value of 14 points. This minimum value was obtained by Kiesel et al. [13] in a group of professional football players based on the data collected for injuries, the FMS test, and the use of the receiver operating characteristic curve (ROC) [10]. The results were confirmed by Garrison et al. [8]. However, there is a likelihood of a variation in the cut-off score that may cause some misinterpretation of the FMS score. In studies attempting to determine injury risk, the factors typical for a given group (e.g. sex) are not often taken into consideration. However, some sex differences in cut-off scores may occur [16]. Therefore, it is required to establish classifying values in the FMS test for the individual groups of participants. This is crucial for the accurate categorization of an injury risk level as the first step into injury prevention.

Regardless of the sports skill level, all physically active people are exposed to injury risks [15, 18, 24]. The FMS test is commonly used in high-performance sports [7, 11, 13] or representatives of professions requiring a high level of physical fitness [17, 22]. Because the FMS test is an inexpensive tool, it can be applied even in the average population, where no access to more advanced tools is available. Till now only a few studies have conducted the FMS test in the population of average physically active individuals in injury risk assessment [16, 19].

Aim of Study

The aim of this study was to determine the reliability of the FMS test, and sexual differentiation in the value of the test and subtests. Furthermore, the study aimed to evaluate the values of injury risk cut-off scores in the FMS test for young male and female individuals from the average physically active population.

Material and Methods

Participants

Data of 89 students of the University School of Physical Education in Wrocław (42 men and 47 women) was collected. Nonprobability sampling according to inclusion and exclusion criteria was used in the study. The following inclusion criteria were established: participant age (19-25 years), not having suffered an injury throughout the 6 weeks preceding the study and declared participation in regular sports activity without experiences in professional sport.

The survey questionnaire concerning the history of injuries: the participants filled in a short questionnaire containing questions concerning the number of injuries in 12 months preceding the study.

Measurements

Functional Movement Screen (FMS) is composed of 7 movement tasks (subtests) of which 5 tests are performed on the left and right body side. They allow for the assessment of the functional status of the locomotor system. The seven subtests are: (1) Deep Squat, (2) Hurdle Step, (3) In-Line Lunge, (4) Shoulder Mobility, (5) Active Straight Leg Raise, (6) Trunk Stability Push-Up, and (7) Rotary Stability. Additionally, there are three tests provoking pains: Impingement Clearing Test used with Shoulder Mobility, Press-Up Clearing Test used with Trunk Stability Push-Up and Posterior Rocking Clearing Test used with Rotary Stability. Each task is performed maximally 3 times and assessed on a scale of 0 to 3 points. The zero score means pain (reported by the participant), 1 point is the inability to perform movements correctly, 2 points is a movement performed with compensatory movements, and 3 points mean a movement performed correctly. Clear guidelines concerning the scores were developed for every single task [4, 5]. The maximum total result is 21 points. The FMS overall score includes the highest grade from each test. In the case of tasks performed on two sides, the lower grade is considered. The tests provoking pains are considered only in the case of a positive result. In this case, the score of 0 is given for the main trial. According to the literature, 14 points is the critical value, above which the injury risk is significantly growing [5, 6, 13].

Statistical analysis

The validation of the FMS test as a tool to predict the risk of injuries was carried out for physically active individuals on a sample coming from the Polish population. The reliability of the measurements conducted

by the researcher was assessed. From the research group, 20 individuals (10 males and 10 females), were randomly selected for repeated FMS test assessment 7 days later. The simple, non-refundable random draw was conducted. The sampling frame was a list of respondents in alphabetical order. The tools available in Statistica v13.0 were used. The ICC (interclass correlation coefficient) was adopted as a criterion of measurement reliability [20]. In this study, the ICC (2,1) model was used. This model is used when the same judge takes the measurement twice on the same test group [14]. Furthermore, the analysis of the FMS test reliability was complemented by comparisons between first and second FMS assessment scores. The following tests were carried out: dependent samples Student's t-test (for the total sum of points) and Wilcoxon test (single modules of FMS). The test was found reliable if the differences were statistically insignificant and the effect size was very low. The Cohen's d defined as a difference between means divided by the standard deviation for the sample was used to assess the effect size in the total number of points in the FMS test [3].
The Student's t-test for independent samples (total point score in the test) and the Mann–Whitney U test (individual modules) was employed to determine the sexual differentiation of morphological traits and the results of the FMS test.
The cut-off values indicating higher and lower injury risks were evaluated using the receiver operating characteristic (ROC) method, which is a tool for measuring the quality and correctness of a classifier. Based on the number of injuries (data collected by survey) a cut-off score was determined for the total FMS score. The curve allows for the determination of the optimal point of data division into two subgroups according to the adopted criterion [10].

Ethical clearance
The study was approved by the Research Ethics Committee of the University School of Physical Education in Wroclaw and was consistent with institutional ethical requirements for human experimentation under the Declaration of Helsinki (consent No. 16/2018). The participants were fully informed about the used procedures and the experimental risk.
The examinations and statistical calculations were conducted in May 2018 in the Biokinetics Research Laboratory of the University School of Physical Education, holding the Certificate of the Quality Management System (PN-EN ISO 9001:2009, the certificate registration No. PW-48606-10E). Statistical analyses were carried out using a computer suite of statistical programs (Statistica 13.0, Statsoft, Poland).

Results

Table 1 illustrates the profile of age and morphology of male and female study participants. As expected, men were taller and heavier than women.

Table 1. Descriptive statistics of age and morphological features of structure and BMI of men and women. Comparisons between men and women. Results of the t-Student test

Group	Men	Women	Statistics	
Variable	Mean ± SD	Mean ± SD	T	p
Age [years]	20.5 ± 1.10	20.0 ± 0.68	2.457	0.016
Height [cm]	182.2 ± 5.71	167.7 ± 6.40	11.167	<0.001
Body mass [kg]	79.0 ± 8.17	58.5 ± 7.78	12.097	<0.001
BMI [kg/m^2]	23.9 ± 1.98	20.8 ± 2.14	6.849	<0.001

SD – standard deviation

In Table 2 the FMS test reliability measurements. The interclass correlation coefficient (ICC) was used for reliability assessment. The calculations were performed both for the total tests' scores and single test modules. The excellent results (above 0.90 [14]) and were found for both total test replicability and the researcher's assessments (Table 3). The reliability of assessments in single modules was similar. The lowest reliability, but still at a good level (0.75-0.90 [14]) was obtained in rotary stability for the right side of the body. No statistical significance was found in the Student's t-test (FMS – Overall) and Mann–Whitney U test (individual FMS modules) ($p < 0.05$ see Table 3). Furthermore, the effect size computed for the FMS total score test was Cohen's d = 0.267. Cohen's range of 0.2 to 0.3 may mean a small magnitude of effect [3].
Table 3 summarizes the diversity of the FMS assessment in total score and all subtests scores between men and women. In the Active Straight Leg Raise test and Rotary Stability, in both subtests for the left and right limbs, women presented better movement quality. Furthermore, men had better results in the Trunk Stability Push-Up test than women. No statistically significant differences were found in other subtests and FMS total score.
The results provided the basis for another analysis, which consisted of considering cut-off score values in the FMS test indicating an increase in injury risk separately for men and women.

Table 2. Values of the interclass correlation coefficient (ICC (2,1)). Results of the t-Student test (FMS-Overall) and Wilcoxon test (FMS – single modules) comparison for the differences between means (the whole test) and medians (individual modules) $p < 0.05$

Variable	ICC	Level of agreement (Reliability)	(t-Student test and Wilcoxon test)
FMS – Overall	0.95	Excellent	Non-significant
Deep Squat	1.00	Excellent	Non-significant
Hurdle Step – left	0.92	Excellent	Non-significant
Hurdle Step – right	1.00	Excellent	Non-significant
In-Line Lunge – left	0.95	Excellent	Non-significant
In-Line Lunge – right	1.00	Excellent	Non-significant
Shoulder Mobility – left	1.00	Excellent	Non-significant
Shoulder Mobility – right	1.00	Excellent	Non-significant
Active Straight Leg Raise – left	1.00	Excellent	Non-significant
Active Straight Leg Raise – right	1.00	Excellent	Non-significant
Trunk Stability Push-Up	1.00	Excellent	Non-significant
Rotary Stability – left	1.00	Excellent	Non-significant
Rotary Stability – right	0.80	Substantial	Non-significant

Table 3. Characteristics and sexual diversity of the FMS test results. Comparison of Student's t-test for independent tests of FMS and U-Mann–Whitney global assessment for individual motor tasks

Variable	Men		Women		p
	Mean	SD	Mean	SD	
FMS – Overall	14.2	2.95	14.8	3.02	0.388
Deep Squat	2.1	0.80	1.9	0.69	0.205
Hurdle Step – left	1.9	0.69	2.2	0.68	0.056
Hurdle Step – right	2.0	0.67	2.2	0.64	0.182
In-Line Lunge – left	2.4	0.70	2.5	0.62	0.354
In-Line Lunge – right	2.0	0.84	2.2	0.75	0.286
Shoulder Mobility – left	2.3	0.81	2.4	0.99	0.457
Shoulder Mobility – right	2.4	0.81	2.7	0.71	0.074
Active Straight Leg Raise – left	2.2	0.65	2.6	0.57	**0.003**
Active Straight Leg Raise – right	2.2	0.67	2.6	0.48	**<0.001**
Trunk Stability Push-Up	2.5	0.64	1.8	0.82	**<0.001**
Rotary Stability – left	1.9	0.46	2.2	0.49	**0.004**
Rotary Stability – right	1.9	0.46	2.1	0.50	**0.011**

SD – standard deviation

Calculating the ROC curve allowed for the determination of the values of the cut-off scores for male and female participants in order to classify individuals as more exposed to injury risks in relation to the point value obtained in the FMS test. In the male group, the ROC value amounted to 14 points. In the case of the female group, this value was 17 points (Figure 1).

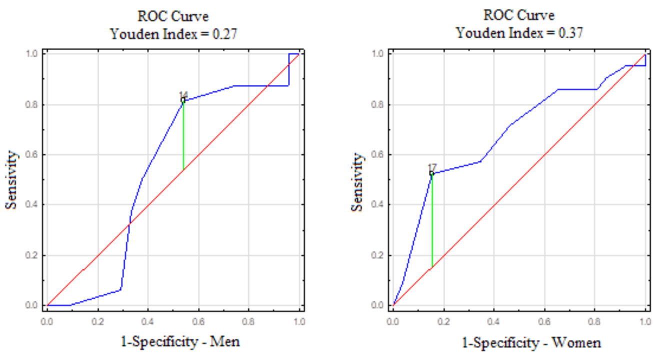


Figure 1. Receiver – operator characteristics (ROC) curve used to plot sensitivity vs 1-specificity for screening tests among men and women

Discussion

The FMS test is a highly reliable tool. Statistically significant differences were found in the scores of some FMS subtests between men and women, as well as in cut-off scores. Women performed better in Active Straight Leg Raises and Rotary Stability test, whereas men reached better scores in Trunk Stability Push-Up. The cut-off point of FMS total score was 14 points and for women 17 points. It could indicate differences in injury risk between sexes. For the average population of physically active young male and female amateur athletes, the cut-off score values in the FMS test should be evaluated separately between sexes to determine injury risks.

The first step of the analysis was to confirm the reliability of FMS screenings. This study demonstrated excellent reliability. Other researchers have also presented similar results concerning the high reliability of the test [9, 21, 23]. This result adds to the growing evidence for the high reliability of the FMS test. Numerous studies have shown that the FMS test is a valuable tool in predicting the prevalence of injuries in various groups of athletes [7, 8, 13] or firefighters [22], demonstrating correlations between the low result in the FMS test (below cut-off score) and injury risk [8, 13]. Based on the FMS score injury risk is determined according to the cut-off score. In literature this value is estimated on 14 points, however, some authors indicate slightly different values [8, 12].

The differences in movement patterns showed that women had better results in Active Straight Leg Raise and Rotary Stability, whereas men were better in Trunk Stability Push-Up, which points to males' stronger upper limbs and ability to stabilize the trunk in dynamic conditions. Similar observations were recorded by Schneiders et al. [19]. They found that the male group had better scores in Trunk Stability Push-Up, whereas women performed better in Active Straight Leg Raise. Chimera et. al. [2] observed that women performed better in Active Straight Leg Raise and Shoulder Mobility, whereas male participants had better scores in Trunk Stability Push-Up. However, mean FMS total scores did not vary between sexes [2, 19], whereas some differences in a subtest suggest that more attention is needed in the interpretation of the FMS total score. These findings were confirmed by Letafatkar et al. [16]. The differences in individual subtests can explain the phenomenon of motor differences between men and women. This is confirmed by a study by Kibler et al. [12] who confirmed that average male individuals demonstrate higher muscle strength than women, who, in turn, are more flexible than men.

The indicated statistically significant differences in individual subtests suggest that the cut-off point for the FMS score should be considered separately for male and female individuals. This study indicates, the cut-off value of 14 points for the male group. Similar findings were documented by Garrison et al. [8] and Kiesel et al. [13]. The results of this study showed this value should be higher (17 points) in the female group. The higher cut-off point values in the FMS test were also observed by Letafatkar et al. [16]. In their research, the value of the classifier (ROC) amounted to 17 points in the group of physically active university students. Furthermore, a higher value of ROC (15 points) was found in the study by Dorrel et al. [6]. However, these researchers analyzed female and male participants together. Chorba et al. [1] showed the ROC value of 14 points in the female group. Few previous studies have employed the FMS test to examine physically active young individuals not involved in high-performance training. This population is exposed to high injury risks, despite performing the physical activity at a lower level compared to professional athletes [15, 24]. It is suggested that the interpretation of the FMS score with co-existing factors may influence the prevalence of injury (e.g. sex, level of physical activity level, level of physical fitness, morphology, training experience, etc.). Further studies should focus on other co-existing factors of this kind. This will allow for the wider application of the FMS test and a more adequate interpretation of the FMS scores.

Conclusions

1. The FMS test is a reliable tool for the assessment of movement patterns. The assessment made by the same researcher with adequate competences ensures the perfect reliability of the results.
2. The statistically significant differences were found between men and women in individual subtests of the FMS. This suggests the necessity to compute injury classifiers separately for male and female athletes.
3. The differences in injury risk FMS cut-off scores between sexes are considerable. The assessment of injury risks based on the FMS test total score in the population of young physically active individuals not involved in high-performance sports should be made separately for men and women. This will allow for the accurate categorization of participants according to injury risk and implementation of adequate injury prevention programs.

The Functional Movement Screen is a simple and low-cost tool that is useful in the assessment of movement patterns. It indicates body function disorders which can potentially lead to injuries. The results of this study can be helpful in the interpretation and understanding of

FMS scores in the average physically active population with consideration for possible sex differences.

References

1. Chorba RS, Chorba DJ, Bouillon LE, Overmyer CA, Landis JA. Use of a functional movement screening tool to determine injury risk in female collegiate athletes. N Am J Sports Phys Ther. 2010; 5(2): 47-54.
2. Chimera NJ, Knoeller S, Cooper R, Nicholas K, Smith C, Warren M. Prediction of Functional Movement Screen™ performance from lower extremity range of motion and core tests. Int J Sports Phys Ther. 2017; (12)2: 173-181.
3. Cohen J. Statistical power analysis for the behavioral sciences. Revised ed. Academic Press; 1997.
4. Cook G, Burton L, Hoogenboom B. Pre-participation screening: the use of fundamental movements as an assessment of function – Part 1. N Am J Sports Phys Ther. 2006; 1(2): 62-72.
5. Cook G, Burton L, Hoogenboom B. Pre-participation screening: the use of fundamental movements as an assessment of function – Part 2. N Am J Sports Phys Ther. 2006; 1(3): 132-139.
6. Dorrel B, Long T, Shaffer S, Myer GD. The Functional Movement Screen as a predictor of injury in National Collegiate Athletic Association Division II athletes. J Athl Train. 2018; 53(1): 29-34.
7. Duke SR, Martin SE, Gaul CA. Preseason Functional Movement Screen predicts risk of time-loss injury in experienced male rugby union athletes. J Strength Cond Res. 2017; 31(10): 2740-2747.
8. Garrison M, Westrick R, Johnson MR, Benenson J. Association between the functional movement screen and injury development in college athletes. Int J Sports Phys Ther. 2015; 10(1): 21-28.
9. Gribble P, Brigle J, Pietrosimone B, Pfile K, Webster K. Intrarater reliability of the Functional Movement Screen™. J Strength Cond Res. 2013; (27)4: 978-981.
10. Harańczyk G. ROC curves, the rating of quality the classifier and the search for the optimal cut-off point. Statsoft Poland; 2010.
11. Hotta T, Nishiguchi S, Fukutani N, Tashiro Y, Adachi D, Morino S, et. al. Functional Movement Screen for predicting running injuries in 18- to 24-year-old competitive male runners. J Strength Cond Res. 2015; 29(10): 2808-2815.
12. Kibler WB, Chandler TJ, Uhl T, Maddux RE. A musculoskeletal approach to the preparticipation physical examination: preventing injury and improving performance. Am J Sports Med. 1989; 17(4): 525-531.
13. Kiesel K, Plisky PJ, Voight ML. Can serious injury in professional football be predicted by a Preseason Functional Movement Screen? N Am J Sports Phys Ther. 2007; 2(3): 147-158.
14. Koo TK, MY L. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. J Chiropr Med. 2016; 15(2): 155-163.
15. Krutsch W, Krutsch V, Hilber F, Pfeifer C, Baumann F. Weber J, et. al. 11.361 sports injuries in a 15-year survey of a Level I emergency trauma department reveal different severe injury types in the 6 most common team sports. Sportverletz Sportschaden. 2018; (32)2: 111-119.
16. Letafatkar A, Hadadnezhad M, Shojaedin S, Mohamadi E. Relationship between functional movement screening score and history of injury. Int J Sports Phys Ther. 2014; 9(1): 21-27.
17. Lisman P, O'connor FG, Deuster PA, Knapik JJ. Functional Movement Screen and aerobic fitness predict injuries in military training. Med Sci Sports Exerc. 2013; 45(4): 636-643.
18. Rechel JA, Yard EE, Comstock RD. An epidemiologic comparison of high school sports injuries sustained in practice and competition. J Athl Train. 2008; 43(2): 197-204.
19. Schneiders AG, Davidsson A, Horman E, Sullivan SJ. Functional Movement Screen normative values in a young, active population. Int J Sports Phys Ther. 2011; 6: 75-82.
20. Shrout PE, Fleiss JL. Intraclass correlations uses in assessing rater reliability. Psychol Bull. 1979; 86: 420-428.
21. Smith PD, Hanlon MP. Assessing the effectiveness of the Functional Movement Screen in predicting noncontact injury rates in soccer players. J Strength Cond Res. 2017; (31)12: 3327-3332.
22. Stanek JM, Dodd DJ, Kelly AR, Wolfe AM, Swenson RA. Active duty firefighters can improve Functional Movement Screen (FMS) scores following an 8-week individualized client workout program. Work. 2017; 56(2): 213-220.
23. Teyhen DS, Shaffer SW, Lorenson CL. The Functional Movement Screen: a reliability study. J Orthop Sports Phys Ther. 2012; 42(6): 530-540.
24. Złotkowska R, Skiba M, Mroczek A, Bilewicz-Wyrozumska T, Król K, Lar K, et. al. Negative effects of physical activity and sports training. Hyg Pub Health. 2015; 50(1): 41-46.

ORIGINAL ARTICLE

TRENDS in
Sport Sciences
2020; 27(**2**): 93-100
ISSN 2299-9590
DOI: 10.23829/TSS.2020.27.2-6

Monitoring the performance and technique consolidation in youth football players

GIOVANNI ESPOSITO, GAETANO RAIOLA

Abstract
Introduction. **The monitoring of the skills development data is especially important in youth soccer players. It should be important for the trainer in order to properly plan the training and achieve the highest possible adaptation of the individual athlete.** Aim of Study. **After an initial qualitative and quantitative testing phase, carried out in previous works, the aim of this study was to choose adequate tests to evaluate the overall performance in the young players.** Material and Methods. **After an initial review of the literature, the research team chose three types of tests with the technical components: T-drill Test (shooting), Loughborough Soccer Passing Test (passage), Hoff Test (conduction). The first two tests focus only on the agility component, while the third also evaluates resistance and agility. Tests were performed in 15 boys between 13 and 14 years of age practicing in an amateur football school.** Results. **The overall average time in the T-drill Test was 15"53 without corrections for scored goals and 14"79 with such corrections. The average time achieved in the LSP Test was 56"47 in the first attempt and 58"53 in the second attempt. Finally, in the Hoff Test, the boys covered an average distance of 1512.8 m.** Conclusions. **By comparing the results obtained from the sample with the reference data in the literature, it is possible to examine the performance and the level of basic skills. These tests can also be used to identify talent in youth groups.**

KEYWORDS: agility, Loughborough Soccer Passing Test, T-drill Test, Hoff Test.

Received: 30 November 2019
Accepted: 11 March 2020

Corresponding author: g.esposito198@studenti.unisa.it

University of Salerno, Department of Humanities, Philosophy and Education, Salerno, Italy

Introduction

The evolution of the football game in the last twenty years has been remarkable, especially concerning playing time and the transition. In football, there are two phases of play: the ball possession phase and the non-possession phase. Between two phases, a "third phase" or "transition" playing time is recognized. It is "the time frame for changing from an individual attitude to a collective attitude between the ball possession phase and the non-possession one" [1]. This change has led to several negative aspects, linked to the almost total disappearance of the football technique in football schools [14]. All this is worrying since, as stated by Castelo and Matos [7] "without a good command of the technique there can be no football". It is known that the lack of domination – and therefore of the familiarity in controlling the ball – inhibits both the technical-tactical growth and the acquisition of a player's tactical and decision-making skills, and therefore the formation of the personality [6, 38]. As soon as the coach tries to plan the training session, he must necessarily try to introduce both individual and collective exercises and situations, proceeding from simplified to complex, from simple to difficult, with the knowledge that the nature of the proposals must have technical, tactical, physical-athletic but above all mental objectives [28]. Looking at the importance of these components in the formation of the young football player, it is clear that the technique is a driving force and the priority element to train [5]. Each training session must include primary and secondary objectives. The primary objectives are essential of a technical nature (such fundamentals as a passage, conduction, shooting) but also strategic-tactics (such as the 1 vs 1 and two-three-player collaborations both in the possession and non-possession phases). The secondary objectives, on the other hand, are always in "manifestation regime", where both the coordinative and the organic-muscular components are present [11, 26, 43]. It must be considered that the football technique helps to improve coordination skills but, at the same time, coordination skills also help to improve the technique. The technique is a skill or a set of skills – it is a series of actions performed without conscious control, which allows the player to carry out the movements required by the sporting discipline practiced with great confidence and ease [17]. From a didactic point of view, the improvement of the player from a technical-tactical point of view (the development of his dexterity) cannot be separated from the position and attitude of the comrades, as well as from the location and behavior of opponents [37]. However, in analytical form, the technique of the movements with the ball, which is called "fundamental technique", is of crucial importance. Although the training is mainly oriented towards exercises, closely related to the game situations, it is a mistake not to work on the execution of different gestures, i.e. without the presence of the opponent, to improve the man-ball relationship, which is essential in managing the ball in the game situations. Therefore in the youth sector, it is necessary to train memory, perception, concentration skills and situation analysis [31]. Trainers need to recreate actions that are more likely to appear in the game but stimulate reasoning as a training factor. The player, once gained experience, will automatically know how to use it in the game [40].

Agility, acceleration, deceleration, change of direction, and sprint are all considered critical technical skills and main components of soccer training [13, 41]. Very often, these movements are performed in exercises that involve ball usage [2, 16, 41], with agility in kicking, anticipating the direction of the ball with the right timing being crucial issues for success [12, 39]. Football requires the execution of skills in a dynamic context. A player with good (technical) movement patterns, when not performing them at the right time (skill), becomes almost a "useless player" [33]. In order to investigate the greatest possible amount of factors that determine the performance, various approaches are used. In this case, attention has been paid to functional evaluation, which is the prerequisite for training control. It is a fundamental moment for every player, sportsman, team and an indispensable help for the coach even at the youth sector level. Using specific tests allows coaches to measure certain variables, such as a physical condition or technical-tactical performance [34], and later to improve the qualities of the young player, and help to define the purposes of the training program. In assessing the results of young peoples' tests, it must be remembered that some variables change during growth as a result of body changes, while others are the result of adaptive changes in physiological functions.

Several validated tests are currently in use to assess the players' performance and technical qualifications [3]. Among these, it is worth mentioning the Bosco test used to evaluate the elastic reactive component of the extensor force of the lower limbs [4], the Cooper test which is certainly the easiest endurance test [35], and the Léger test which allows determining the maximum speed [42]. Yet, based on literature evaluation T-drill Test (shooting), Loughborough Soccer Passing Test (passage), and Hoff Test (conduction) seems to be the most appropriate for football players. Therefore to this study aimed to evaluate the overall performance of 15 amateur players and to compare the results to reference values inherent to the youth elite categories [8, 9, 10].

Material and Methods

Fifteen U14 (age: 13 ± 0.3 yrs; height: 166.4 cm; body mass: 62.92 kg; training experience: 3 ± 0.3 yrs) participated in this study. All participants were free from musculoskeletal injuries, participated in ≥95% of training sessions per year, and were not early or late matures. Experimental procedures and potential risks, discomforts, and benefits were fully explained to all boys and parents/guardians prior to participation. Signed informative consent forms were provided by subjects' parents and/or legal guardians.

Three types of tests with technical components fundamental for football were used in this study: T-drill Test (shooting), Loughborough Soccer Passing Test (passage), and Hoff Test (conduction). The first two tests focus only on the agility component, while the third test covers resistance as well as agility. The tests were carried out individually on different days. Results were obtained after a 2-week familiarization with the test procedures.

T-drill Test

The T-drill Test is one of the most used tests in the world to measure agility: it measures the ability to accelerate, decelerate and change the direction in a short space. In this case, a variant of the classic Test T proposed by Kutlu et al. [22] was proposed, where kicking the ball instead of touching the cones was performed. The components of technique and ones related to decision-making as well as cognitive skills specific to kicking on goal were added to classic elements like speed, acceleration, and change of direction (Figure 1).

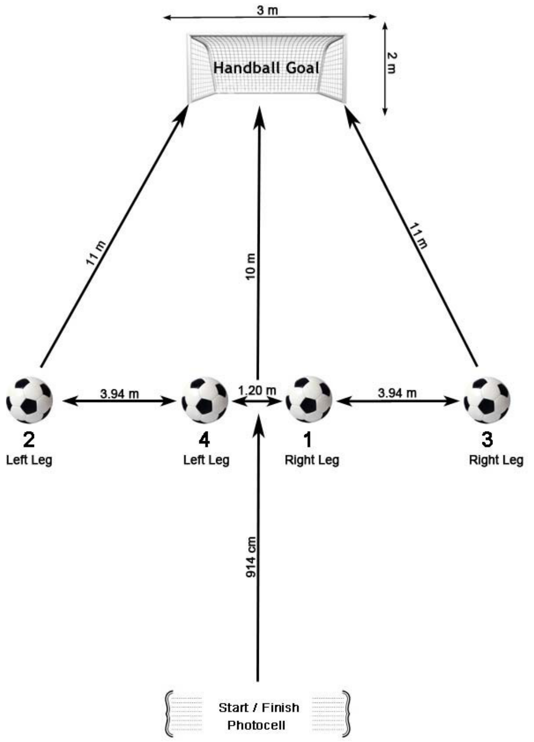


Figure 1. The T-drill Test scheme [22]

Figure 1 shows the path of the T-drill Test where initially the player is standing with his feet behind the starting line, and at a start signal, he runs accelerating forward to reach the line set at 9.14 m distance, kicks a ball with the right foot to 0.6 m on the right, trying to center the Handball Goal 10 m away. Immediately afterward, the player moves with side steps to the left, towards another ball at 5.14 m distance from the first one, and shoots with the left foot in Handball Goal, which is 11 m away. Then with lateral steps, he moves to the right reaching the third ball, placed at 9.08 m from the second. He also kicks it into the goal with his right foot and moves with side steps 5.14 m to the left and scores the fourth ball with the left foot. Finally, he runs backward covering the 9.14 m that separates him from the start/finish line. The precision of scoring is granted by subtracting the adequate part of one second from the total time of test performance:

- 1 sec, when all four balls end up in the net;
- 0.75 sec, when the player scores 3 goals;
- 0.50 sec, when the player scores two;
- 0.25 sec, when the player scores only one.

Loughborough Soccer Passing Test

The Loughborough Soccer Passing Test (LSPT) is a reliable and validated test, which evaluates aspects of football skills including passages, dribbling, control and decision making [24]. Tests' authors observed that elite male and female players achieved significantly better results than their non-elite counterparts, confirming the validity of the test criterion. Because the talent identification process takes place between the ages of 12 and 15 [44] and there are concerns if the LSPT is appropriate for teenage players, O'Regan et al. [29] used a modified version of the LSPT claiming that the original test conditions were not suitable for their players (aged 12 or over). In this study, however, for better comparison and performance monitoring between young and adult players, we have maintained the conditions from the original LSPT.

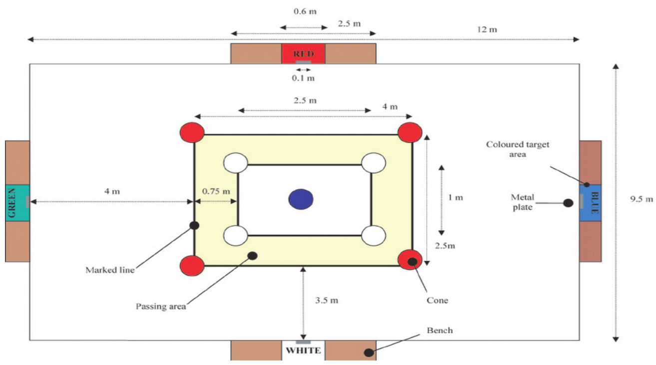


Figure 2. Loughborough Soccer Passing Test scheme [24]

Figure 2 shows the scheme of the Loughborough Soccer Passing Test. Initially, a rectangle of 12 m (long side) × 9.5 (short side) is drawn. Inside there are two other concentric rectangles, one of 4 × 2.5 m, the other of 2.5 m × 1 m, so that the smaller rectangle is surrounded by a 0.75 m wide corridor. The cones are placed at each corner of the central rectangles and additionally one in the center of the smaller rectangle. On the outermost perimeter, in the central area of each side, there is a rectangle, 2.5 m long and 30 cm high, with a 1 m long colored area in the middle. A target formed by a 30 cm wide metal plate is inside a target area with 60 cm × 30 cm sides. 16 passages must be made, of which 8 passages of 3.5 m, towards the long sides of the outer rectangle (red and white colors) and 8 passages of 4 m towards the short sides (blue and green colors) trying to hit the metal target. The test requires two operators, one controlling the time, the other indicating the target that the player must hit with the ball, calling a color with a predetermined sequence, but which is randomly defined so that the player can never know the succession of targets to hit. Passages must be made from the corridor between the two internal rectangles and the return ball, after having bounced off the colored rectangles, must return to the central one, towards the central cone, before being kicked against a new target called by the operator. The test begins with the player entering the corridor and ends after making the 16 passes in a maximum time of 43 sec. The performance is measured in seconds, with the following penalties/bonuses:

- 5 sec if the player does not hit the rectangle or hits the wrong rectangle;
- 3 sec if the player touches the ball with his hands;
- 3 sec if it does not hit the target area (69 × 30 cm);
- 2 sec if the ball is not kicked into the corridor;
- 2 sec if the ball hits one of the cones;
- 1 sec for every second more than the maximum time of 43 sec;
- bonus: 1 sec for each hitting of a metal target.

Players perform two test trials and the average result is calculated. Players' performance is measured through:

1. The total time taken to complete the 16 passages.
2. The time resulting from the calculation of penalties and bonuses.
3. The total time calculated from the difference between the two previous.

Hoff Test

The Hoff Test, proposed by Chamari et al. [9] is an extension of the endurance training exercise, introduced by Hoff. The test assesses agility as well as endurance. The path is traced on the playing field and is 51.5 m long on the side where the ten cones for the slalom and the three obstacles are placed, 55 m from the other and is 35 m wide (Figure 3). The player continuously covers a 290 m path with technical elements for 10 min in order to reach the maximum possible distance. It's possible to test up to 5 players simultaneously, starting them every 1 min.

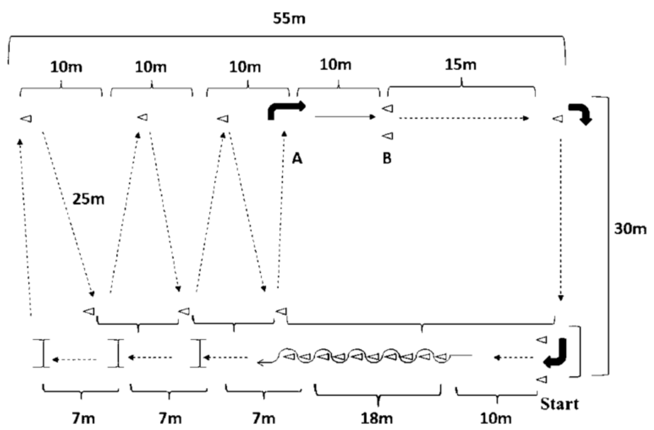


Figure 3. Hoff Test scheme [9]

As shown in Figure 3, in the beginning, the player must bring the ball from the starting point between 10-cone slalom arranged in a straight 12 m line (2 m every each cone). Then he continues to run and jumps above three 30-35 cm high obstacles, placed 7 m from each other. After the third obstacle, the player turns about 90° to the right and heads 30.5 m towards a cone, after which he starts another slalom, with 25.5 m distance between cones. After the seventh cone player turns in order to run 10 m backward, with the ball, in the right direction. Once he reaches a gate (made of two cones) he turns around and continues to run forward. After 15 m, he turns 90° right and runs the last 30 m to the starting gate.

Statistical analysis

Data obtained from the tests showed a normal distribution and were presented as average and standard deviation (SD). The analysis refers to the following variables: T-drill Test, to detect the ability to accelerate, decelerate and change the direction in a short space (sec), Loughborough Soccer Passing Test, to detect the passages, dribbling, control and decision making (sec) and Hoff Test, to detect agility and endurance (m). A paired sample t-test was conducted to combine the results obtained from the test and re-test. The t-test was selected as the analytical method to verify the presence or absence of a significant difference between two sets of data. The significant level has been set at $p < 0.05$. Statistical analyses were carried out with the software IBM SPSS Statistics 23.

Results

Table 1 shows the results of the T-drill Test. The significant difference ($p < 0.05$) was observed between the two data series.

Table 1. Results obtained in the T-drill Test

Players	Time taken without correction for goals scored	Time taken with correction for goals scored
Player 1	17.98	17.23
Player 2	16.05	15.05
Player 3	15.45	14.70
Player 4	13.83	12.83
Player 5	13.05	12.80

Player 6	15.23	14.48
Player 7	17.24	16.24
Player 8	15.88	14.88
Player 9	16.23	15.73
Player 10	15.49	14.99
Player 11	16.27	15.52
Player 12	13.37	12.62
Player 13	15.76	14.76
Player 14	16.34	16.09
Player 15	14.82	14.07
Average SD	15.53 ±1.34	14.79* ±1.32

* denotes significant correlation at $p < 0.05$

Table 2 shows the results obtained by the sample of Pontecagnano boys in the Loughborough Soccer Passing Test. There were no significant differences between the two series of the test in trial time, penalty time and global performance.

Table 2. Results obtained in the Loughborough Soccer Passing Test

Players	Trial 1	Penalty time 1	Global perfor-mance 1	Trial 2	Penalty time 2	Global perfor-mance 2
Player 1	45.24	6	51.24	49.46	12	61.46
Player 2	48.42	8	56.42	49.48	13	62.48
Player 3	46.96	9	55.96	47.32	9	56.32
Player 4	49.74	11	60.74	51.84	15	66.84
Player 5	49.93	7	56.93	48.21	10	58.21
Player 6	50.51	8	58.51	48.98	12	60.98
Player 7	48.96	14	62.96	49.83	8	57.83
Player 8	45.17	9	54.17	47.03	11	58.03
Player 9	46.70	7	53.70	46.24	5	51.24
Player 10	47.08	6	53.08	48.02	10	58.02
Player 11	49.60	12	61.60	47.23	8	55.23
Player 12	47.53	8	55.53	49.85	11	60.85
Player 13	48.62	7	55.62	48.15	10	58.15
Player 14	46.15	7	53.15	46.90	8	54.90
Player 15	49.55	8	57.55	49.45	8	57.45
Average SD	48.07 ±1.73	8.40 ±2.26	56.47 ±3.34	48.53 ±1.48	10 ±2.47	58.53 ±3.67

Finally, Table 3 shows the results obtained by each boy in 10 min of the Hoff Test. The average distance covered by the analyzed group during the test was 1512.8 m.

Table 3. Results obtained in the Hoff Test

Player	Distance covered (m)
Player 1	1499
Player 2	1512.5
Player 3	1509
Player 4	1532.5
Player 5	1612.5
Player 6	1484
Player 7	1402.5
Player 8	1617.5
Player 9	1417.5
Player 10	1537
Player 11	1484
Player 12	1509
Player 13	1512.5
Player 14	1564
Player 15	1499
Average SD	1512.8 ±58.44

Discussion

We believe that with these tests any coach, even at the amateur level, can draw very interesting information about the group he works with, as they allow a systemic evaluation of the psychomotor area, highlighting the skills, difficulties, and potential of the players close to ones performed in natural environmental situations [32]. In the first test, the ability of the players to perform rapidly repeated sprints with changes of direction and to shot on goal from a standstill position with accurate decision-making ability was assessed. In this case, the attention was not aimed at finding the error in performing the move or in the shot on goal, that is, on the performance model. The players were not forced to kick with the left or right foot or with a certain anatomical part of the foot; they were simply asked to try to execute shots on goal as quickly as possible through lateral displacements. In contrast to Italian teaching methodology, where there is a tendency to focus the player's attention on the correct acquisition of biomechanical elements of technic, English one focuses on achieving a certain goal by finding an individual solution [21, 25, 30, 36].

Overall, some reasonable run times were achieved during the tests but, in some cases, the inability or difficulty of young players to use the weak foot to shoot on goal clearly emerged. While in the research of Kutlu et al. [22] the average time obtained by his sample was 12"36 in the test without correction for the goals scored and 11"70 in the test with this correction, in this study the examined boys had an average total time of 15"53 in the test without correction for the goals scored and 14"79 in the trail with correction. No significant correlation between the two results is in line with other research findings [22]. Another study focusing on agility, conducted by Little and Williams [23] obtained a slightly faster total completion time compared to the current study. This may be because the participants in that study were soccer players from the first and second division English League.

The second test (LSPT) was aimed at assessing the ability of the players to perform repeated, as accurate as possible, passages in a "stressful"/time-limited situation. Their attention was focused not only at making the passages in the indicated area, but also at good space-time and decision-making capacity. In this test the element of time limitation was significant. The execution of passages in the non-time-limited test was about 12-13 out of 16, and dropped to about 6-7 correct passages when time limitation appeared. The LSPT can distinguish elite players with their counterparts by analyzing various aspects of soccer skill performance (gross motor performance with the time-only score and accuracy using penalty time) [24]. Because of the few studies that have used the LSPT in young players, it is difficult to compare our findings. Impellizzeri et al. used the LSPT with 26 junior soccer players to examine the effects of aerobic interval training on the decline in short-passing ability caused by a short bout of high-intensity intermittent activities [20]. Time scores ranged 44-49 sec and global performance was around 62-68 sec in the fatigued condition.

Finally, the third test (Hoff Test) analyzed the player's aerobic performance with technical exercises through a specific dribbling circuit. In the Hoff circuit, in addition to the physical parameters, specific good technical skills were needed to perform the test in a shorter time. It is clear that, since the maximum distance covered in 10 min of exercise is the dependent variable in this test, the motivational factor also influences the result of the test, hence the use of the ball, which is certainly a fundamental motivational point for performing this test. Previous studies [9, 18, 19] have concluded that players who covered more than 2100 m in the Hoff Test had a VO_2max >200 ml/kg^{0,75}/min, and those that ran <1900 m had <200 ml/kg^{0,75}/min, which was suggested as a minimum value for active soccer players. Therefore, these authors suggested that the goal of the Hoff Test for elite U-15 players should be to run >2100 m distance (about 7 laps of the track) in the 10-min test [35, 45]. In this study, amateur players obtained significantly lower results than indicated by mentioned elite players. As it was previously observed the recurrent execution of this test implies an effective improvement to the running economy and the maximum absorption of oxygen. Hoff et al. [19] suggested that this protocol could be used as a training method to improve VO_2max level, respecting many of the motor actions performed during the football game, which is very interesting for practical application. However, it is necessary to review this assumption in the future.

Conclusions

By comparing the results obtained from the sample with the reference data in the literature, it is possible to examine the performance and the level of basic skills. These tests can also be used to identify talent in youth groups.

References

1. Accame F. La didattica del giuoco del calcio. Tecnica e tattica secondo la scuola di Coverciano (The didactics of the game of football. Technique and tactics according to the school of Coverciano). Correre; 2010.
2. Abernethy B, Russell DG. Expert-novice difference in an applied selective attention task. J Sport Exerc Psychol. 1897; 9(4): 326-345.
3. Ali A. Measuring soccer skill performance: a review. Scand J Med. Sci Sports. 2011 Apr 21; 21(2): 170-183.
4. Alptekin A, Kilic O, Marvis M. The effect of an 8-week plyometric training program on sprint and jumping performance. Serb J Sports Sci. 2013; 7(2): 45-50.
5. Altavilla G, Riela L, Di Tore AP, Raiola G. The physical effort required from professional football players in different playing positions. J Phys Educ Sport. 2017; 17(3), 200: 2007-2012.
6. Battisti E. Giovanissimi e allievi. La metodologia di allenamento. Princìpi ed esercitazioni per formare il calciatore (Giovanissimi and Allievi. The training methodology. Principles and exercises to train the soccer player). Correre; 2018.
7. Castelo J, Matos LF. Il grande libro dell'allenamento calcistico (The great book of football training). Calzetti & Mariucci; 2019.

8. Chaalali A, Rouissi M, Chtara M, Owen A, Bragazzi NL, Moalla W, et al. Agility training in young elite soccer players: promising results compared to change of direction drills. Biol Sport. 2016; 33(4): 345.
9. Chamari K, Hachana Y, Kaouech F, Jeddi R, Moussa-Chamari I, Wisløff U. Endurance training and testing with the ball in young elite soccer players. Br J Sports Med. 2005; 39(1): 24-28.
10. Chamari K, Hachana Y, Ahmed YB, Galy O, Sghaier F, Chatard JC, et al. Field and laboratory testing in young elite soccer players. Br J Sports Med. 2004; 38(2): 191-196.
11. Di Guida G, Casella F. Didattica della finta e del dribbling. Nomenclatura e classificazione dei gesti tecnici (Didactics of feint and dribbling. Nomenclature and classification of technical gestures). Librati; 2008.
12. D'Isanto T, D'Elia F, Raiola G, Altavilla G. Assessment of sport performance: theoretical aspects and practical indications. Sport Mont. 2019; 17(1): 79-82.
13. Docherty D, Wenger HA, Neary P. Time-motion analysis related to the physiological demands of rugby. J Hum Mov Stud. 1988; 14(1): 269-277.
14. Esposito G, Ceruso R, Valentini M, D'Isanto T. The use of enabling tests to provide a qualitative measurement of the sport skill level of small soccer players. J Hum Sport Exerc. 2019; 14(3): 592-601.
15. Esposito G, Ceruso R, D'Isanto T. Evaluation of some quantitative aspects in the young soccer players training process during puberty. J Phys Educ Sport. 2019; 19(1): 1777-1783.
16. Farrow D, Young W, Bruce L. The development of a test of reactive agility for netball: a new methodology. J Sci Med Sport. 2005; 8(1): 40-48.
17. Ferrari F. Elementi di tattica calcistica. Organizzazione e proposte didattiche (Elements of football tactics. Organization and educational proposals). Vol. 2. Correre; 2019.
18. Helgerud J, Engen LC, Wisløff U, Hoff J. Aerobic endurance training improves soccer performance. Med Sci Sports Exerc. 2001; 33(11): 1925-1931.
19. Hoff J, Wisløff U, Engen LC, Kemi OJ, Helgerud J. Soccer specific aerobic endurance training. Br J Sports Med. 2002; 36(3): 218-221.
20. Impellizzeri FM, Rampinini E, Bishop D, Castagna C, Ferrari Bravo D, Tibaudi A, et al. Validity of a repeated sprint test for football. Int J Sports Med. 2008; 29(1): 899-905.
21. Kern A, Schwarzmann M, Wiedenegger A. Measuring the efficiency of English Premier League football: a two-stage data envelopment analysis approach. Sport Bus Manag Int J. 2012; 2(3): 177-195.
22. Kutlu M, Yapıcı H, Yoncalık O, Çelik S. Comparison of a new test for agility and skill in soccer with other agility tests. J Hum Kinet. 2012; 33(1): 143-150.
23. Little T, Williams AG. Specificity of acceleration, maximum speed, and agility in professional soccer players. J Strength Cond Res. 2005; 19(1): 76-78.
24. Le Moal E, Rué O, Ajmol A, Abderrahman AB, Hammami MA, Ounis OB, et al. Validation of the Loughborough Soccer Passing Test in young soccer players. J Strength Cond Res. 2014; 28(5): 1418-1426.
25. Lusted J. Playing games with race: understanding resistance to race equality initiatives in English local football governance. Soccer Soc. 2009; 10(6): 722-739.
26. Maiuri G. Un diverso modo di pensare calcio: L'approccio sistemico e la periodizzazione tattica (A different way of thinking about football: the systemic approach and tactical periodization). Youcanprint; 2014.
27. MacDougall JD, Wenger HA, Green HJ. Physiological testing of the high-performance athlete. 2nd ed. Campaign: Human Kinetics; 1991.
28. Molinas E, Argiolas I. Tecnica e didattica delle abilità motorie del gioco del calcio (Technique and didactics of the motor skills of the game of football). Roma, IT: Società Stampa Sportiva; 2002.
29. O'Regan S, Ali A, Wilson F. The influence of playing level on the skill performance of early pubescent Irish soccer players. J Sports Sci Med. 2006; 10(1): 188-189.
30. Potrac P, Lee N, O'Gorman J. Exploring the everyday realities of grass-roots football coaching: towards a relational perspective. Soccer Soc. 2016; 17(6): 910-925.
31. Raiola G, D'Elia F, Altavilla G. Physical activity and sports sciences between European Research Council and academic disciplines in Italy. J Hum Sport Exerc. 2018; 13(1): 283-295.
32. Raiola G. Motor learning and teaching method. J Phys Educ Sport. 2017; 17, 236: 2239-2243.
33. Reilly T, Gilbourne D. Science and football: a review of applied research in the football codes. J Sports Sci. 2003; 21(9): 693-705.
34. Roi GS. I test di valutazione funzionale nel calcio (Functional evaluation tests in football). Correre; 2014.
35. Rosch D, Hodgson R, Peterson L, Baumann TG, Junge A, Chomiak J, et al. Assessment and evaluation of football performance. Am J Sports Med. 2000; 28(1): 29-39.
36. Rossi M, Thrassou A, Vrontis D. Football performance and strategic choices in Italy and beyond. Int J Organ Anal. 2013; 21(4): 546-564.
37. Rosso G. L'apprendimento dei fondamentali individuali del gioco del calcio riferito a ragazzi in età compresa fra i dieci e i dodici anni (Learning the individual

fundamentals of the game of football refers to children between the ages of ten and twelve). Youcanprint; 2018.
38. Sannicandro I. Small-sided games. Vol. 2. Correre; 2019.
39. Scandroglio R. Come migliorare tecnica e tattica con il metodo dei movimenti fondamentali (How to improve technique and tactics with the fundamental movement method). Ares; 2010.
40. Sheppard JM, Young WB, Doyle TLA, Sheppard TA, Newton RU. An evaluation of a new test of reactive agility and its relationship to sprint speed and change of direction speed. J Sci Med Sport. 2006; 9(4): 342-349.
41. Sheppard JM, Young WB. Agility literature review: classifications, training and testing. J Sport Sci. 2006; 24(9): 919-932.
42. Spedicato M. Soccer in young ages: training program as a prevention tool for overload pathologies. In: Roi GS, Della Villa S, editors. Health, prevention and rehabilitation in soccer. Calzetti Mariucci Editori, Torgiano; 2007. pp. 113-118.
43. Wein H. Il calcio a misura dei ragazzi (Football for kids). Vol. 2. Mediterranee; 2011.
44. Williams AM, Reilly T. Talent identification and development in soccer. J Sports Sci. 2000; 18(9): 657-667.
45. Zagatto AM, Miyagi WE, Brisola GMP, Milioni F, Da Silva ASR, Santiago PR, et al. Correlation between Hoff test performance, body composition and aerobic and anaerobic fitness in professional soccer players. Sport Sci Health. 2015; 11(1): 73-79.

ORIGINAL ARTICLE

TRENDS in
Sport Sciences
2020; 27(**2**): 101-107
ISSN 2299-9590
DOI: 10.23829/TSS.2020.27.2-7

Algorithm of competitive program's correction in acrobatic rock and roll

LARYSA LUTSENKO[1], YULIYA LUTSENKO[2]

Abstract
Introduction. **Constantly increasing competition brings new challenges to athletes' training forcing them to master the world-class programs in a short time at a high-quality level and to demonstrate the stability and reliability of performance under competition conditions [4, 6, 13, 20]. Modern trends in acrobatic rock and roll are influenced by new rules and are associated with the increasing complexity of competitive programs, with finding new original elements and bringing technical skills of sports couples to virtuosity [7, 4, 14, 15]. The intensification of athletes' preparation, the development of their special physical qualities, and the improvement of their technical skills open up new potentials for elevating the success of competitive activity of qualified athletes in acrobatic rock and roll [16, 18, 19, 21].** Aim of Study. **The study aimed to establish the relationship between the preparedness of skilled athletes and competitive structural components of the main class contact style (MCCS) program in acrobatic rock and roll, to develop and experimentally prove the algorithm of competitive programs' correction of qualified MCCS athletes in acrobatic rock and roll.** Methods. **Pedagogical methods of testing and mathematical statistics were used. The experimental part was attended by 16 qualified athletes (8 sports couples, sports category MCCS aged 14 to 21 years – girls, boys).** Results. **The relationship between the preparedness of skilled athletes and competitive structural components of the main class contact style program in acrobatic rock and roll highlighted 6 factors on which the correction algorithm of competitive programs was developed.** Conclusions. **The process of mastering the technical elements was determined, the objective conditions for the modeling of complex new elements and combinations were created, the strategy of forming technical skills of sports couples in main class contact style was developed, and the algorithm of correction of competitive programs that display the content of each block with the degree of its significance and sequence of a competitive program was proposed.**

KEYWORDS: acrobatic rock and roll, main class contact style (MCCS), preparedness, competitive program, structural blocks, factor structure.

Received: 2 December 2019
Accepted: 23 April 2020

Corresponding author: l.s.lutsenkosport@gmail.com

[1] National Law University of Yaroslav Mudryi, Department of Physical Education, Kharkiv, Ukraine
[2] Kharkiv State Academy of Physical Culture, Kharkiv, Ukraine

Introduction

Constantly increasing competition in the international arena brings new challenges to athletes' training process. One of the priorities is to master the world-class programs and to demonstrate the stability and reliability of their performance in conditions of competition [2, 4, 17]. Acrobatic rock and roll is a sport in which there is an active search for optimal competition rules and, accordingly, methods of competitive activity in order to enhance the overall effectiveness of competitive programs and their spectacular's in general [3, 4, 25].
Modern trends in acrobatic rock and roll are associated with the increasing complexity of competitive programs, finding new original elements, and bringing technical skills of sports couples to virtuosity [4, 19, 26]. The mentioned tendencies are caused by the existing international rules of competitions in acrobatic rock and roll, which focus on the complexity of acrobatic elements and combinations that are performed by athletes, the technology of "basic step" performance,

as well as on increasing the number of dance figures included in the competitive program.

Thus, the need to intensify the training process, to improve the competition programs through the development of special physical qualities and improvement of technical skills is relevant to the chosen research topic and opens up new potentials for the increasing success of competitive activity of qualified main class contact style athletes in acrobatic rock-n-roll [12, 19, 21]. The works of authors [10, 13, 14, 20] revealed the features of the structure of competitive programs of qualified athletes, and this study focuses on the contradictions that exist in the assessment of acrobatic elements used in competitive programs of skilled athletes. It is also important to analyze the competitive activity of leading sports couples of the present time.

Based on the analysis of literature, survey data of qualified judges and coaches in acrobatic rock and roll, the most important directions of improvement of competitive programs in acrobatic rock and roll were highlighted [1, 8, 19]. It was found that the list of objective factors of structural elements' complexity groups in acrobatic rock and roll is a prerequisite for the development of an algorithm for constructing competitive programs, and it is necessary to consider the value of technical elements and preparedness of sports couple in order to execute them correctly and efficiently. The purpose of this study was to develop and experimentally prove the algorithm of competitive programs' correction of qualified MCCS athletes in acrobatic rock and roll. The objective of the study was to establish the relationship between the preparedness of qualified athletes and structural components of the competitive MCCS program in acrobatic rock and roll.

Material and Methods

To achieve the objectives, the following research methods were used: the pedagogical testing method and mathematical statistics. The study was conducted during the year 2019 based on acrobatic rock and roll sports clubs in Ukraine, including Kyiv city ("FARRK", "School of Filimonovs LIA") and Kharkiv city ("Grand", "Rapid"). The experimental part was attended by 16 qualified athletes (8 couples, sports category MCCS aged 14 to 21 years – girls and boys). Testing and evaluation of qualified main class contact style athletes were carried out using conventional and developed methods [11, 18, 22, 23]. The selection of tests was carried out based on the dominant motor mode of competitive exercise analysis and the specificity of acrobatic rock and roll, age characteristics of the tested athletes and the requirements of modern rules of competition, as well as on data of previously conducted researches in complex coordination sports (sports gymnastics, acrobatics, sports aerobics, figure skating, etc.). Given this, we have selected, developed, and used control exercises (15 tests). They are all justified and meet the requirements of the theory test standardization [4, 15].

The structural components of the competitive programs were determined by analyzing video materials of different level competitions and the electronic results scored by the independent experts in this sport [4]. Particular attention was paid to the parameters of the competitive program, its construction, means, and design's methods, taking into account the age characteristics and qualifications of athletes. In our experiment, first, we developed a block structure for the competitive program (6 blocks consisting of 2 content modules) and assigned 5 independent experts to score the performance of them (0 to 10 points).

The data obtained were statistically analyzed using the SPSS, XLSTAT programs [5, 12, 24]. Factor analysis was used as a data reduction method and as a classification method. This analysis helped to reduce the number of variables (data reduction), determine the structure of relationships between variables, and to reveal the structure of the competition program.

Results

A detailed study of qualified MCCS athletes' capabilities and values (points scored) of technical elements in the competitive program indicated a special relationship between levels of physical and technical preparedness of athletes, and performance quality (points scored) of structural components (blocks) and competitive programs' parameters. In total, factor analysis analyzed 10 indicators of special physical preparedness, 7 parameters of technical preparedness, 6 parameters of structural blocks, and 4 scoring components of competitive programs. To analyze the factor loadings, reliable correlation coefficients were used, each indicator with individual factors at $p < 0.05$. After applying mathematical processing to all research data of complex testing (27 testing tasks), there were 6 main factors, and their contribution to the general variance was 87.5% (Table 1).

Table 1 illustrates the relationship between athletes' preparedness and competitive structural components of MCCS program in acrobatic rock and roll, and the load factor, which was the base for the identification of blocks' load sequence in the competitive program.

Table 1. Factors that determine the competitive program of qualified main class contact style athletes in acrobatic rock and roll (n = 16; $p < 0.05$)

No.	Tests	Factors					
		1	2	3	4	5	6
	Scoring parameters of the competitive program						
T1	Elements of acrobatics, acrobatic combinations (points scored)	0.94*	0.92*	0.63#	0.38	0.41	0.35
T2	"Basic Step" (points scored)	0.44	0.76#	0.37	0.64#	0.39	0.72#
T3	Dancing figures (points scored)	0.58	0.29	0.43	0.31	0.22	0.33
T4	Choreography (points scored)	0.42	0.31	0.66#	0.27	0.45	0.51
	Special physical preparedness (solo, in a couple)						
T5	Two "Basic Steps" holding medical ball with both hands, position "Staff" throw and catch the ball for 30 seconds (number of times)	0.77#	0.84*	0.50	0.40	0.41	0.38
T6	Facing gymnastic wall to hold partner (woman) who is standing on the shoulders (seconds)	0.49	0.43	0.82*	0.40	0.77#	0.44
T7	Jump up, holding a partner sitting on the shoulders (number of times)	0.55	0.51	0.41	0.67#	0.43	0.63#
T8	Combination: back roll into a handstand, Kurbet, turn jump 360°, 540°, 720° (points)	0.71#	0.47	0.67#	0.73#	0.41	0.52
T9	Handstand near wall on the elevated surface with the run (tucked, picked, straight) (points)	0.49	0.51	0.38	0.75#	0.52	0.78#
T10	Hight jump for 30 seconds (number of times)	0.72#	0.84*	0.50	0.61#	0.57	0.52
T11	Facing partner, woman rolls back on the floor (both hands in contact), exits directly to the ice position into straight hands of the partner (number of times)	0.91*	0.48	0.52	0.63#	0.58	0.67#
T12	Two changes of places with basic step (R, L), spin (woman's solo) (points)	0.41	0.45	0.32	0.51	0.33	0.48
T13	Two front rolls in couple, roll to the left twice, roll to the right twice, two back rolls (hand (s) in contact) (points)	0.48	0.51	0.97*	0.62#	0.58	0.43
T14	Competitive program execution 2 times without rest (%)	0.28	0.37	0.79#	0.60#	0.88*	0.66#
	Technical preparedness						
T15	Basic step, change places (R turn), change places (L turn), acrobatic element of Group 1 (somersault element with rotation forward), basic step (points)	0.43	0.96*	0.57	0.64#	0.51	0.72#
T16	Basic step, change places (R turn), change places (L turn), acrobatic element of Group 2 (somersault element with rotation backwards), basic step (points)	0.98*	0.43	0.47	0.62#	0.54	0.48
T17	Basic step, change places R, change places L, acrobatic element of Group 3 (dive), basic step (points)	0.55	0.48	0.32	0.67#	0.59	0.78#
T18	Basic step, change places R, change places L, acrobatic element of Group 4 (rotation and its variations), basic step (points)	0.55	0.61#	0.97*	0.43	0.38	0.41
T19	Basic step, change places R, change places L, combination of acrobatic elements – Group 5 (main class contact style), basic step (points)	0.55	0.91*	0.87*	0.48	0.51	0.43
T20	Basic step, change places R, change places L, acrobatic element of Group 6 (other acrobatic elements), basic step (points)	0.52	0.42	0.38	0.66#	0.78#	0.62#
T21	Dance series (points)	0.77#	0.52	0.84*	0.42	0.48	0.57
	Structural blocks of the competitive program						
T22	I Block of competitive program (points)	0.53	0.94*	0.72#	0.51	0.63#	0.52
T23	II Block of competitive program (points)	0.51	0.47	0.52	0.61#	0.49	0.67#
T24	III Block of competitive program (points)	0.97*	0.64#	0.71#	0.55	0.68#	0.44

T25	IV Block of competitive program (points)	0.55	0.60#	0.59	0.79#	0.53	0.67#
T26	V Block of competitive program (points)	0.65#	0.55	0.88*	0.66#	0.52	0.49
T27	VI Block competitive program (points)	0.57	0.44	0.59	0.61#	0.69#	0.59
	Contribution to variance (%)	**21.14**	**18.38**	**15.22**	**13.04**	**10.75**	**8.82**

Note: T1-T27 – test task; # medium correlations; * high correlations

The share of the first factor, which is the III Block of the competitive program, has 21.14% of the total variance of the sample. It is characterized by a high load factor performance in tests: technical preparedness (TP) No. 15, No. 19; special physical preparedness (SPP) No. 10; scoring parameters of the competitive program (SPCP), test No. 1.

The second factor loads I Block of the competitive program and is characterized by high factor load of test results: TP No. 16, No. 21 and No. 19; SPP No. 11; SPCP, test No. 1 and is 18.38% of the total variance of the sample.

V Block of the competitive program determines the third factor, which is 15.22%. The most significant load factor for the third factor is characterized by the results of the TP tests No. 14, No. 18, No. 19, No. 21; SPP tests No. 6 and No. 8, and SPCP tests No. 1 and No. 4.

The fourth factor highlights IV Block, which is 13.04%. This factor is characterized by high load factor tests result of TP No. 17 and No. 20; SPP No. 7-9; parameters of SPCP test No. 2.

The fifth factor which is 10.75% of the total sample variance is VI Block. The most significant load factor is in the following parameters: TP No. 14 and No. 20; SPP No. 6; SPCP tests No. 3, No. 4.

The sixth factor is II Block, manifested as 8.82%, the parameters that give its characteristics: TP No. 15, No. 17, No. 20; SPP No. 9, No. 11; SPCP test No. 2; 12.65% are unidentified factors.

The factor structure of the preparedness of qualified athletes, model characteristics, and performance skills were analyzed. Based on the results of the factor structure of the competitive program, algorithm of correction of competitive program of main class contact style couples was compiled (Figure 1).

Based on the results of the research, the process of mastering elements' techniques was put in order, objective conditions for modeling of complex new

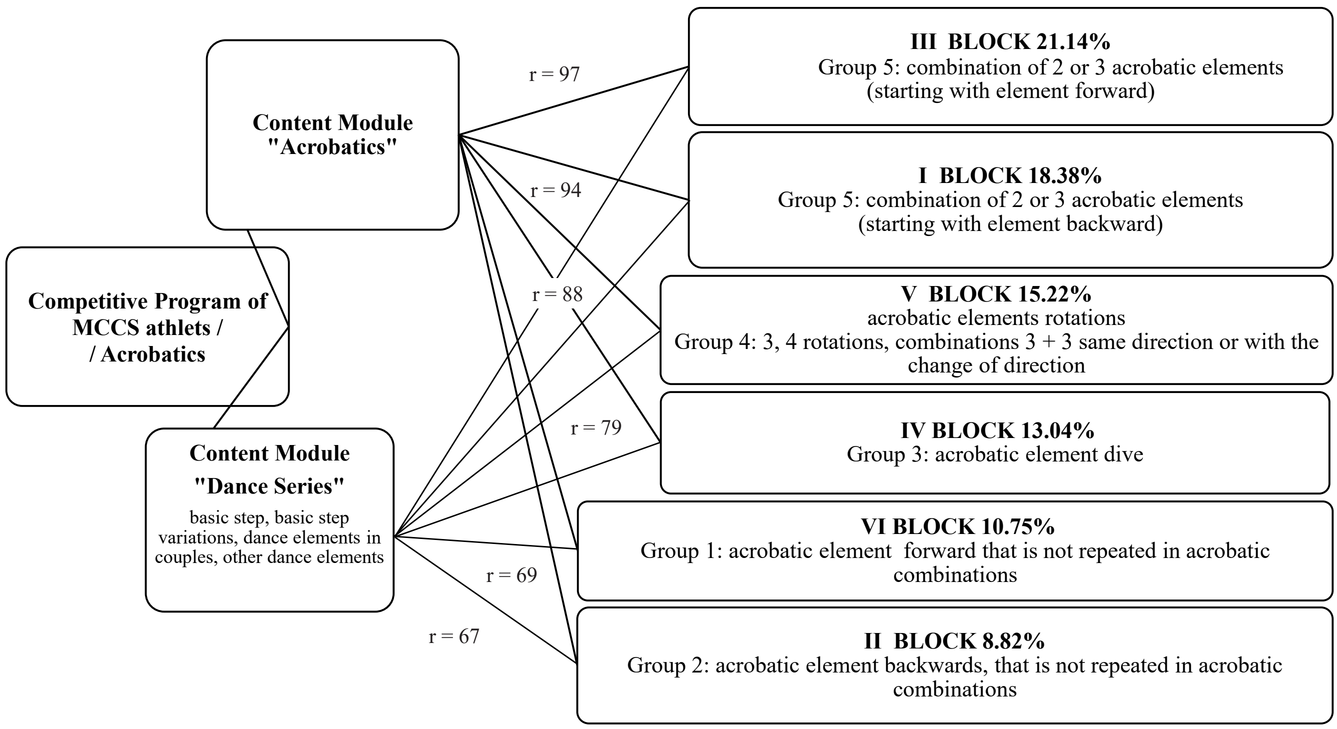


Figure 1. Algorithm of competitive program's correction in acrobatic rock and roll, MCCS

elements and combinations were created, and a strategy of forming technical mastery for main class contact style sports couples was created.

Discussion

Currently, there is insufficient scientific research in the field of an individual approach to the training process in acrobatic rock and roll and this study is the first in terms of developing an algorithm for the correction of competitive programs in acrobatic rock and roll. There are only a few theoretical, methodological and organizational foundations for combining the level of preparedness of a sports couple and an individual approach to the training process of acrobatic rock and roll athletes [13, 14], which is confirmed by our research. At the same time, some authors are engaged in research and development of different parameters of athletes' training [11, 20, 23] and they do not consider the process of improving competitive programs in terms of analyzing the special physical and technical preparedness of qualified athletes.

In our work, the process of constructing competitive programs is based on the results of the factor structure of the preparedness of each athlete and couple together. Therefore, the creation of an algorithm for the correction of competitive programs in acrobatic rock and roll is a new task, developed for the first time. Our study makes it possible to use the individual characteristics of athletes to create effective competitive programs and successful competitive activity. The research uses the methodology of preparing athletes for competitive activities in gymnastics and dance sports [6, 8, 10, 17]. From this point of view, the system for improving competitive programs in acrobatic rock and roll is an extension and addition to the results of other studies.

Training of athletes in acrobatic rock and roll is a complex and multilayered process. Finding the optimal balance between the difficulty of acrobatics and the quality of dance is one of the most difficult tasks. To date, among the huge variety of complex-coordination, gymnastic, and dance sports, special attention is paid to acrobatic rock and roll, as it is the improvement of physical qualities, motor skills, and achievement of sports results. It is a complex and emotional sport in which athletes perform the complex exercise to music, connected without undue pauses logically and dynamically, and perform them with confidence and energy. The specific content of the competitive programs, manner of performance, and exercise style significantly complicate the motor activity of athletes in this sport. This study consisted of a conceptual approach to the preparation of competitive sports program of main class contact style couples in acrobatic rock and rolls that is based on algorithms of acrobatic elements' complexity and combinations, dance series (blocks, elements of competitive program), and factors that are driven by the characteristics of special physical and technical preparedness of the athletes. Research-based algorithms of competitive programs with the technical values of acrobatic rock and roll elements based on the complexity factors enabled the implementation of the principle of perspective-predictive approach in training qualified athletes. This offered a positive progress trajectory of acrobatic rock and roll based on stimulation of natural complexity growth of competition programs and objectification of evaluation of sports achievements of qualified athletes in acrobatic rock and roll.

Conclusions

The algorithm has been developed for the correction of competitive programs of qualified athletes in acrobatic rock and roll, taking into account the level of their special physical and technical preparedness. Factor analysis was used in this approach. The algorithm contains all stages of the standard multivariate analysis procedure. The factor analysis revealed six factors based on the six blocks of the competitive program. The general and individual factor structure of the athletes' comprehensive preparedness was determined.

It is recommended that the content of competitive programs was analyzed to correct and improve selected blocks and content of modules ("Acrobatics", "Dance Series"), which consist of acrobatic elements, acrobatic combinations, and dance series. The algorithm of correction of competitive programs that displays the contents of each block, with the degrees of its significance and its sequence in a competitive program performance is suggested.

Thus, for mastering a high-quality world-class program and to achieve a high athletic performance level, main class contact style competitive program should be divided into 6 blocks and refer to the following algorithm: I Block of the competitive program is a combination of 2 or 3 acrobatic elements (Group 5, starting with element backwards) – 18.83%; II Block is an acrobatic element backwards that is not repeated in the performed combinations (Group 2, backwards) – 8.82%; III Block is a combination of 2 or 3 acrobatic elements (Group 5, starting with element forward) – 21.14%; IV Block is an acrobatic element dive (Group 3, front or back) – 13.04%; V Block is an acrobatic element rotation (Group 4) – 15.22%; and VI Block is acrobatic element forward that is not repeated in the combinations (Group 1, forward) – 10.75%. Implementation of the algorithm can significantly improve the performance of competitive main class contact style. Further research is expected to construct a model of the training process in acrobatic rock and roll of main class contact style athletes.

Acknowledgements
This research was carried out according to the Consolidated plan of scientific research work in the field of physical culture and sports for the period of 2016-2020 on the theme "Psycho-sensory regulation of motor activity of athletes in situational sports" (No. 0116U008943).

References

1. Bankosz Z, Pawlaczyk K, Lewandowski M. Reproduction accuracy of the range of movement range and pressure force in athletes. Trends Sport Sci. 2016; 2(23): 95-103.
2. Boloban V, Litvinenko Y, Niznikowski T. Evaluation of the kinematic structure of indicators key elements of sports equipment exercise by postural orientation movements. Physical Education of Students. 2014; 18(6): 9-6. DOI: 10.15561/20755279.2014.0606.
3. Boloban VN. Koordinatcionnaya trenirovka sportsmenov s ispolzovaniyem pryjkovyh uprajneniy na battue (Coordination training of the athletes using jumping exercises on trampoline). Science in Olympic Sports. 2016; (4): 85-94 (in Russian).
4. Competition rules of acrobatic rock and roll (WRRC). Retrieved from: https://wrrc.dance/rules/rock-n-roll-rules/.
5. Denysova LV, Khmelnytskaia YV, Kharchenko LA. Izmerenyia i metody matematycheskoi statystyky v fyzycheskom vospytanyy i sport (Measurements and methods of mathematical statistics in physical education and sports). Olimpiyskaya literatura, Kyiv. 2008; 127 (in Russian).
6. Floría P, Gómez-Landero LA, Harrison AJ. Centre of pressure correlates with pyramid performance in acrobatic gymnastics. Sport Biomech. 2015; 14(4): 424-434. DOI: 10.1080/14763141.2015.1084032.
7. Haering D, Huchez A, Barbier F, Holvoe P, Begon M. Identification of the contribution of contact and aerial biomechanical parameters in acrobatic performance. PLoS ONE. 2017; 12(4): 1-16. DOI: 10.1371/journal.pone.0172083.
8. Hiley MJ, Schmid N, Yeadon MR. How do technique and coordination change during learning of a whole-body task: application to the upstart in gymnastics. J Sports Sci. 2019; 37(20): 2374-2380. DOI: 10.1080/02640414.2019.1634413.
9. Ivashchenko O, Cieślicka M, Nosko M, Shcherbyk D. Movement coordination: peculiarities of strength effort assessment in girls aged 11-13. Teorìâ Ta Metodika Fìzičnogo Vihovannâ. 2018; 18(4): 175-179. DOI:10.17309/tmfv.2018.4.03.
10. Kovalenko YO. Strukturnyye elementy postroyeniya sorevnovatelnyh kompozitciy individualnyh I grupovyh uprajneniy v khudojestvennoy gimnastike (Structural elements of competitive team and solo compositions' constructing in rhythmic gymnastics). Fizicheskoye vospitaniye studentov. 2016; 1: 12-20 (in Russian).
11. Kozina ZhL, Cieslicka M, Prusik K, Muszkieta R, Sobko IN, Ryepko OA, Bazilyuk TA, Polishchuk SB, Osiptsov AV, Korol SA. Algorithm of athletes' fitness structure individual features' determination with the help of multidimensional analysis (on example of basketball). Physical Education of Students. 2017; 21(5): 225-238. DOI: 10.15561/20755279.2017.0505.
12. Lopatiev A, Ivashenko O, Khudolii O, Pjanylo Y, Chernenko S, Yermakova T. Systemic approach and mathematical modeling in physical education and sports. JPES. 2017; 17(1): 146-155. DOI: 10.7752/jpes.2017.s1023.
13. Lutsenko L, Kyzim P. Some contradictions in contemporary assessment acrobatic elements used in the compositions of the category «B-Class» in acrobatic rock'n'roll. Slobozhanskyi herald of science and sport. 2015; 2(46): 97-100. DOI: 10.15391/snsv.2015-2.021.
14. Lutsenko YM. Struktura ta zmist zmagalnyh program, kvalifikovanyh sportcmeniv v akrobatychnomu rock and rolli (Structure and content of the qualified athletes' competitive programs in acrobatic rock and roll). Slobozhanskyy scientific and sports Gazette. Kharkiv, HDAFK. 2017; 5(61): 75-79. DOI: 10.15391/snsv.2017-5.013 (in Ukrainian).
15. Lutsenko YM. Yakist vykonannya strukturnyh komponentiv zmagalnyh program kvalikfikovanyh sportsmeniv, yak factor, scho vyznachaye sportyvnyi rezultat v akrobatychnomu rock and rolli (Execution quality of structural components of qualified athletes' competition programs' as factor that defines sportive result in acrobatic rock and roll). Slobozhanskyy scientific and sports Gazette. Kharkiv, 2018; 2(65), 41-44. DOI: 10.15391/snsv.2018-2.008.
16. Nishioka GAC, Dantas PMS, Filho JF. Dermatoglyphics, somatotopic profile and basic physical qualities results of modern dancers of Deborah Colker Movement Center. Fitness Performance J. 2007; 6(5): 331-337. DOI: 10.3900/fpj.6.5.331.

17. Omelyanchik-Zurkalova OA. Modelnoye postroyeniye kompozitciy na volnyh uprajneniyah s uchetom horeograficheskoy podgotovlennosti gimnastok (Model building of compositions in free exercises with consideration of gymnasts' choreography preparedness). Nauka v olimpiyskom sporte (Science in Olympic Sports). 2015; (1): 63-67 (in Russian).
18. Ozolin NG. Nastolnaya kniga trenera (Trainer's desktop handbook). Nauka pobezhdat, Moscow. 2006; 863 (in Russian).
19. Platonov VN. Sistema podgotovki sportsmenov v olimpiyskom sporte. Obshchaya teoriya i ee prakticheskie polozheniya (The system of athletes' training in Olympic sports. The general theory and its practical provisions). Olympic Literature, Kyiv. 2004; 808 (in Russian).
20. Podrigalo L, Artemieva H, Rovnaya O, Panshyna A, Ruban L, Merkulova T, Galashko M, Chernukha O. Analysis of the physical development and somatotype of girls and females involved into dancing and gymnastic sports. Physical Education of Students. 2019; 23(2): 75-81. DOI: 10.15561/20755279.2019.0204.
21. Preatoni E, Hamill J, Harrison AJ, Hayes K, Van Emmerik R, Wilson C, Rodano R. Movement variability and skills monitoring in sports. Sports Biomech. 2013; 12(2): 69-92. DOI: 10.1080/14763141.2012.738700.
22. Sergienko LP. Kompleksne testuvannya rukhovikh zdibnostey lyudini: navchalniy posibnik (Comprehensive testing of motor abilities, educational textbook). Mykolayiv. 2001; 360 (in Ukrainian).
23. Shepelenko TV, Kozina ZhL, Cieslicka M, Prusik K, Muszkieta R, Sobko IN, Ryepko OA, Bazilyuk TA, Polishchuk SB, Osiptsov AV, Kostiukevych VM. Factorial structure of aerobics athletes' fitness. Pedagog, Psychol, Med-Biol Probl Phys Train Sports. 2017; 21(6): 291-300. DOI:10.15561/18189172.2017.0606.
24. Shestakov MP. Statistika. Obrabotka sportivnykh dannykh na kompyutere: uchebnoye posobie dlya studentov vysshyh uchebnyh zavedeniy fizicheskoy kultury (Statistics. Processing of sports' data on computer: textbook tool for students. Proc. institutions of physical culture). Moscow; 2002, 278 (in Russian).
25. Shinkaruk O, Topol A. Kompleksnaya otsenka podgotovlennosti kvalifitsirovannykh sportsmenok v khudozhestvennoy gimnastike (Complex evaluation of preparedness of female gymnasts in rhythmic gymnastics). Nauka v olimpiyskom sporte. 2017; 3: 17-26 (in Russian).
26. Su H, Chang NJ, Wu WL, Guo LY, Chu IH. Acute effects of foam rolling, static stretching, and dynamic stretching during warm-ups on muscular flexibility and strength in young adults. J Sport Rehab. 2016; 26(6): 469-477. DOI: 10.1123/jsr.2016-0102.

INSTRUCTIONS FOR AUTHORS

Authors are encouraged to submit high quality, original manuscripts (that have not appeared, nor are under consideration in other journals) electronically via Editorial System at https://www.editorialsystem.com/tss/

ORGANIZATION OF THE MANUSCRIPT

The instructions for authors are based on the ICMJE *Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly Work in Medical Journals* (up-dated December 2016) published by the International Committee of Medical Journals Editors, available at http://www.icmje.org.
All submitted manuscripts should adhere to TSS Editorial Policy available at http://tss.awf.poznan.pl/

Article content

The size of original and review articles should not exceed 20 pages, including references, tables, figures, and abstract (standard page – 1800 characters). No more than 30 references (in review articles 45) should be provided.
Short reports and short reviews should be up to 10 pages long. Maximum 3 tables, 3 figures, and 3 photographs can be enclosed. No more than 15 references (in review articles 30) should be provided.

General information

- Only full papers are reviewed; abstracts are not considered for review.
- Papers are published only in English.
- Manuscripts should be sent to TSS in a Word file.
- 1.5 line spacing and Times New Roman 12 points should be used throughout.
- All margins should be 2.5 cm and the text should be justified.
- Pages should be numbered.
- Automatic word hyphenation should be turned off.
- Type only one space following the end of a sentence.
- Manuscripts should follow a standard division into paragraphs.
- Highlighted parts of the text should be in bold print.
- Do not use italics in the titles of section and subsections.

Text structure

The text of the manuscript should be divided into the following sections (a different arrangement and style of papers may be applied only to invited review articles):

Introduction: should be comprehensible to the reader, give a clear statement of the article and provide relevant context to support the basis for the paper and the significance of the work; please do not exhaustively review the literature. All abbreviations used in the text should be explained at their first use.

Aim of Study: clear, as short as possible.

Material and Methods: is to explain in detail all the applied investigation methods mentioned in Results. The names of statistical methods and computer software used in the study should be given.

Results: the results of biochemical assays and other measurements should be given in SI units. Length, height, weight, and volume measurements should be reported in metric units (meter, kilogram, liter) or their decimal multiples. Temperatures should be expressed in degrees Celsius. Enclose a maximum of 3 tables, 3 figures, and 3 photographs to illustrate your data. All tables, figures, and photographs must be referred to in the text of the manuscript.

Discussion: please emphasize the new and important aspects of the research and conclusions derived from the study.

Conclusions: clear and only on the discussed research.

References: should be listed in alphabetical order. The number of cited references should not exceed 30 (in review articles 45). References should be provided in Vancouver style – it uses numbers within the text, placed in square brackets [e.g. 17] that refer to numbered entries in the reference list. Only published papers should be included. The reference format should be consistent with ICMJE recommendations (https://www.nlm.nih.gov/bsd/uniform_requirements.html).
Provide the Digital Object Identifier (DOI) if one has been assigned.
Abbreviation of the journal name should be used according to the list of journals indexed in Index Medicus.

Journal citation

A citation of a journal article should include authors' names and initials without periods, the title of the paper, abbreviation of the journal name, year of publication, volume number, and page numbers (first and last page of the article).

1. Up to six authors: Halpern SD, Ubel PA, Caplan AL. Solid-organ transplantation in HIV-infected patients. N Engl J Med. 2002 Jul 25;347(4):284-287.
2. More than six authors – list the first six authors followed by et al.: Rose ME, Huerbin MB, Melick J, Marion DW, Palmer AM, Schiding JK, et al. Regulation of interstitial excitatory amino acid concentrations after cortical contusion injury. Brain Res. 2002;935(1-2):40-46.
3. Article published electronically ahead of the print version: Yu WM, Hawley TS, Hawley RG, Qu CK. Immortalization of yolk sac-derived precursor cells. Blood. 2002 Nov 15;100(10):3828-3831. Epub 2002 Jul 5.

Book citation

References to books should include surname(s) of the author(s) with first name initials (list the first six authors followed by et al.), title, number of an edition (not required for the first edition), city and name of the Publishing House and year of publication.

1. Gardiner PF. Advanced neuromuscular exercise physiology. Champaign: Human Kinetics; 2011.

Book chapter

References to book chapters should include surname(s) of the author(s) of the chapter with first name initials without periods (list the first six authors followed by et al.), chapter title, and after indicating In: surname(s) of the author(s)/editor(s) with first name initials, the title of the book, number of edition (not required for the first edition), city and name of the Publishing House and year of publication followed by page numbers of the chapter, e.g.

1. Renson R. Sport Historiography in Belgium. Status and Perspectives. In: Renson R, Lämmer M, Riordan J, editors. Practising Sport History. Sankt Augustin: Akademia Verlag Richarz; 1987. pp. 1-18.

All titles and institutional names in languages other than English (including Greek, Polish, German, French, etc.) should be provided with their English equivalents, e.g.:

1. Drees L. Der Ursprung der Olympischen Spiele (Origins of the Olympic Games). Schorndorf: Karl Hofmann; 1974.

Punctuation used in references must strictly follow the above examples.

References to Internet publications are allowed (with complete web page addresses), only if no corresponding data is available in print literature.

Citations

When cited in the text, only the respective number of references should be used. No other system of references will be accepted.

Tables

Each table should be on a separate A4 sheet, with a brief descriptive title at the top using the full word Table. All abbreviations should be explained in a footnote to the table where they appear. The tables should be numbered using Arabic numerals (1, 2, 3, 4, etc.).

Figures

Figures should be sent on separate A4 sheets as well as on separate files. Legends for the figures should be explained in full and appear on a separate page. All abbreviations should be explained in footnotes.

All photographs, graphs, diagrams should be referred to as figures and should be numbered consecutively in the text using Arabic numerals (1, 2, 3, etc.).

Figures should be accompanied by data from which they were made. The Editor has the right to create figures based on the enclosed data.

Figures and legends to figures should be provided in a single text file.

Abbreviations and symbols

Use only standard abbreviations and symbols. The expansion of an abbreviation should precede its first use

Table 1. Descriptive statistics and comparative analysis of maximal oxygen uptake (VO_2max in $ml/kg \cdot min^{-1}$) between genotypes of the I/D *UCP2* gene polymorphism

UCP2	DD					ID					II				
Sex	*N*	$\bar{x}$	*SD*	*Min*	*Max*	*N*	$\bar{x}$	*SD*	*Min*	*Max*	*N*	$\bar{x}$	*SD*	*Min*	*Max*
F	42	45.65	*6.14*	32.30	59.00	36	45.66	*7.18*	30.60	59.80	7	45.07	*7.60*	35.00	54.80
M	72	54.01[a]	*6.20*	40.30	79.00	70	55.60	*7.32*	42.30	76.80	12	59.07[a]	*9.04*	49.70	74.90

in the text and be repeated in the legend under a figure or a table in which the abbreviation is used.
Papers that do not adhere to these guidelines will be returned to the author for corrections and improvements.

SUBMISSION
Manuscripts must be submitted in English to TRENDS in Sport Sciences Editorial Office via Editorial System at: https://www.editorialsystem.com/tss/
All files should be labeled with the Author's name, the first three words of the manuscript title and file name. The text, tables, figures, and photographs should be placed in separate files. For the text, we recommend using Word for Windows. Figures, graphs, and diagrams may be drawn using widely available software. The recommended formats include *.PNG, *.GIF, *.TIF, *.JPG, *.XLS. Titles and contents of tables and figures should be given in English.