T&PPC

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Theory & Practice of Physical Culture

Athletic training | Sport psychology | Academic physical education | Sport physiology

EDITORIAL

Key issues of the modern sports science for discussion

Scientific and theoretical journal "Theory and Practice of Physical Culture" – the territory of the development of promising areas of sports science

The "TPPC" magazine is a leading publication covering the problems of physical culture and sports, scientific and theoretical aspects, the latest developments and achievements.

Based on the analysis of works, scientific and practical conferences and congresses, the problems of articles from leading journals, as well as current challenges and global trends in the development of sports, it is possible to formulate the most promising directions for the development of sports science, which should be covered on the pages of "TPPC" in the near future:

• In the system of scientific-methodological and medical-biological support for the training of qualified athletes, to update publications related to improving the methodology and practice of preparing athletes for international competitions and the Olympic Games.

• In the system of professional training of physical education personnel, to intensify the publication of the results of scientific research aimed at introducing modern achievements of sports practice and scientific and methodological developments into the system of specialized physical education. Special attention of scientists dealing with the problems of vocational education should be paid to research on distance learning forms of students. To date, the effectiveness of the remote format raises many questions, creates a number of problems that require immediate solutions. In this regard, on the pages of "TPPC", a discussion of specialists is unfolding related to the justification of the effectiveness of the remote format of physical education training.

• In the system of youth sports, first of all, scientists should pay attention to the problem of sports selection, methods of long-term training, preservation of the contingent of young athletes, their health and upbringing. This direction is becoming a key vector for attracting author teams to publish the results of scientific research in the field of youth sports.

• In the field of international cooperation, the editorial board continues its glorious traditions, filling its content with the results of research by foreign colleagues. Close cooperation with scientists from Poland, Greece, the Czech Republic and neighboring countries allowed us to bring to Russian sports science the experience of research in the field of kinesiology, biomechanics, psychology.

To determine the promising directions of the authors' publication activity, a historical analysis of the development of a particular vector of scientific research and the contribution of the journal to the overall content of sports science is always relevant.

Publications on the problems of sports science in the journal "TPPC" largely reflect the nature of scientific information updated by various challenges of society, which is further transformed into the content of new scientific papers, textbooks on the theory and methodology of various sports, and also defines promising areas of research in sports science and practice.

We invite scientists to publish articles that are aimed at finding new approaches in the development of sports science.

Editor-in-Chief,
Honored Worker of Physical Culture of the Russian Federation, Ph.D., Professor L.I. Lubysheva

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Theory and Practice of Physical Culture

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Women's freestyle wrestling in global sports movement: progress analysis

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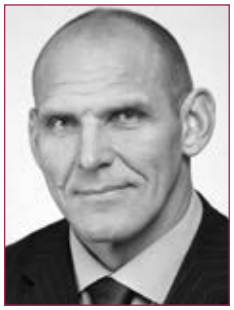

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Abstract

Objective of the study was to analyze modern women's freestyle wrestling progress trends in the context of the global sports movement history based on the statistics of the Women's World Wrestling Championships.

Results and conclusion. The Women's World Wrestling Championships statistics analysis for the whole Women's World Wrestling Championships period (31 events on the whole) shows only six nations leading in the team standings, with 24 events won by Japan women's freestyle wrestling team (77.4% of the total); followed by Russia and China (2 won events); and the USA, Norway and Azerbaijan (1 event each). The analysis demonstrates, on the one hand, the colossal superiority of the Japan women's freestyle wrestling team and, on the other hand, a very tough competition of the other leading nations.

Having summarized and analyzed the women's freestyle wrestling progress data in the context of the global sports movement, we would emphasize that the constantly growing competitiveness of the Women's World Wrestling Championship with the fast growths in numbers of individual elite competitors and competing national teams are the key factors indicative of the rapidly increasing popularity of the modern women's freestyle wrestling sport that is clearly on a fast progress path nowadays.

Keywords: *dynamics, female freestyle wrestler, characteristics, trend, indicator, competing nation, stage, sports movement, development.*

Background. It was back in the late 1980s that the relatively limited group of freestyle wrestling specialists and enthusiasts initiated international women's freestyle wrestling competitions [5]. The initiative has made a fast success due to multiple circumstances and factors of influence dominated by [2, 3]: (1) enthusiasm of the growing feminist organizations striving to empower women in every social domain including traditional men's sports; (2) great progress made by that time in the women's judo at the top-ranking international events including the World Cups and European Championships; and (3) fairly high popularity of the wrestling sport disciplines in many countries including France, Norway, Japan, Belgium, Denmark, Sweden, etc.

These developments and movements facilitated intensive growth of the women's freestyle wrestling thereafter, with the World Women's Wrestling Championships run since 1987, although most of the global sports community had been skeptical about this innovation since the competitive freestyle wrestling was widely considered a men-only sport [1]. The first Women's freestyle wrestling Championship in Norway still made success despite skepticism, indifference and even resistance, with 48 individual women's freestyle wrestling competitors from eight countries [4].

Objective of the study was to analyze modern women's freestyle wrestling progress trends in the context of the global sports movement history based on the statistics of the Women's World Wrestling Championships.

Results and discussion. The Women's World Wrestling Championships statistics analysis (see Table 1 hereunder) for the whole Women's World Wrestling Championships period (31 events on the whole) shows only six nations leading in the team standings, with 24 events won by Japan women's freestyle wres-

Tab1e 1. *Team standings in the Women's World Wrestling Championships*

Rank	Nation	Gold	Rank	Nation	Silver	Bronze	Total
1	Japan	24	1	Japan	7		31
2-3	Russia	2	2	Russia	7	4	13
2-3	China	2	3	USA	1	11	13
4-6	USA	1	4	China	4	1	7
4-6	Norway	1	5	Canada	2	3	5
4-6	Azerbaijan	1	6	France	1	4	5
			7	Norway	3		4
			8	Taiwan		3	3
			9-10	Kazakhstan	1	1	2
			9-10	Mongolia	1	1	2
			11	Ukraine		2	2
			12	Azerbaijan			1
			13-16	Belarus	1		1
			13-16	Hungary	1		1
			13-16	Venezuela	1		1
			13-16	Sweden	1		1
			17	Bulgaria		1	1

tling team (77.4% of the total); followed by Russia and China (2 won events); and the USA, Norway and Azerbaijan (1 event each). The analysis demonstrates, on the one hand, the colossal superiority of the Japan women's freestyle wrestling team and, on the other hand, a very tough competition of the other leading nations.

As far as the total gold, silver and bronze medal stocks are concerned, the Japan leadership is undeniable as the nation has never been lower than second on the team scoreboard in every championship with its 31 medals in total. Going second is Russia with its 13 wins (two gold, seven silver and four bronze medals) followed by the USA with also 13 medals albeit only one gold, one silver and 11 bronze ones. They are followed by China with its seven wins (two gold, two silver and three bronze medals) and Canada and France with five medals each. Ranked in the top-ten is Norway that four times was among the top-three world strongest teams (one gold and three silver medals), followed by Taiwan that was three times among the top-three teams; Kazakhstan and Mongolia, with two medals each (one silver and one bronze medal). The other nations listed in the Table were only once among the top-three teams, namely: Azerbaijan (one gold), Belarus, Hungary, Venezuela, Sweden (one silver each), and Bulgaria (one bronze medal). Given on Figure 1 hereunder is the historical statistics of the nations competing in the Women's World Wrestling Championship.

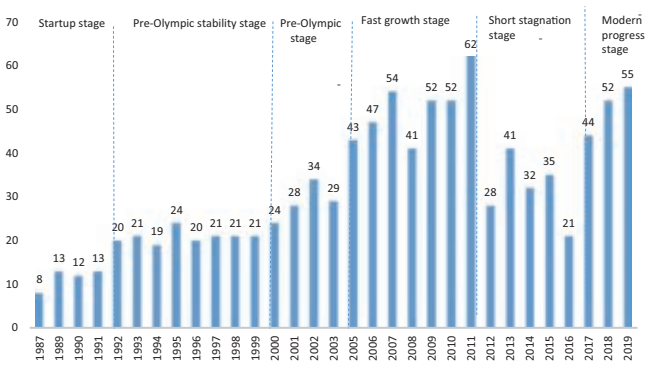

Figure 1. *Historical statistics of nations competing in the Women's World Wrestling Championship*

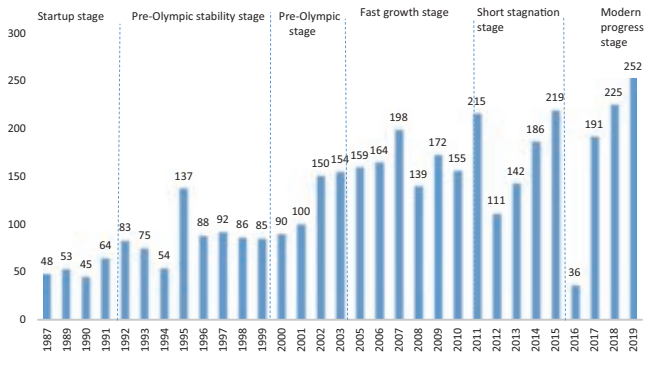

Figure 2. *Historical statistics of the individual competitors to the Women's World Wrestling Championship*

The women's freestyle wrestling progress may be classified into a few stages by the numbers of competing nations. Thus in 1987 through 1991 the numbers varied within the range of 8 to 13 competing nations (11.5±1.2 on average), and we would therefore call this period a Startup stage. It was followed (in 1992 through 1999) by a relatively long and stable Pre-Olympic stability stage with 19 to 24 national teams (23.5±0.6 on average) competing in the Women's World Wrestling Championship. Then the women's freestyle wrestling sport was listed in the 2004 Olympic Games program to open up the short albeit rather specific Pre-Olympic stage (2000 through 2003) with the numbers of national teams growing to 24 to 34 (28.8±2.4 on average).

Since the XXVIII (2004) Olympics mandated the women's freestyle wrestling discipline and it was since then ever listed in the Olympic Games programs, the Women's World Wrestling Championship statistics reported fast growth in the numbers of competing nations (in the period of 2005 to 2011) to as many as 41 to 62 (50.2±2.9 on average), and we would call this period a Fast growth stage. This peak was naturally followed by a notable drop in 2012 through 2016 when 21 to 41 (31.4±3.8 on average) national teams competed in the championships – and we would call it a Short stagnation stage. Lately, in 2017 till now, the Women's World Wrestling Championship statistics have reported a modest growth to 44 to 55 (50.3±3.7 on average) competing nations, and we would call this period a Modern progress stage.

The above variations and stages closely correlate with the flow statistics of individual qualifiers for the Women's World Wrestling Championship for the periods. Figure 2 hereunder demonstrates a high correlation of the numbers of individual competitors with the numbers of team competitors (r = 0.92).

The above data show only 48 to 64 Women's World Wrestling Championship competitors (52.5±3.9 on average) at the Startup stage; followed by growth to 54 to 137 competitors (87.0±10.3 on average) at the Pre-Olympic stability stage; and 90 to 154 competitors (123±15.5 on average) at the Pre-Olympic stage. Then goes a peak with 139 to 215 athletes (171.7±10.6 on average) competing at the Fast growth stage; followed by a fall to 36 to 219 competitors (131.6±35.1 on average) at the Short stagnation stage; and the latest increase to 191 to 252 athletes (222.7±20.9 on average) at the Modern progress stage.

Conclusion. Having summarized and analyzed the women's freestyle wrestling progress data in the context of the global sports movement, we would emphasize that the constantly growing competitiveness of the Women's World Wrestling Championship with the fast growth in numbers of individual elite competitors and competing national teams are the key factors indicative of the rapidly increasing popularity of the modern women's freestyle wrestling sport that is clearly on a fast progress path nowadays.

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Individual competitive styles in martial arts: theoretical grounds for synergized training

UDC 796.011.3

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Abstract

Objective of the study was to provide a theoretical basis for the individual competitive style improvement options in the modern elite martial arts.

Results and conclusion. In the context of study-specific goals, we would provisionally classify the individual competitive style elements into the following two groups: Group A including the individual competitive style elements always contributing to the competitive progress; and Group B including the potentially negative individual competitive style elements that may hamper competitive progress and cause failures in finals of the top-ranking events. It should be emphasized that this grouping is rather provisional since the same individual competitive style element may alternatively fall in either of the above groups depending on the actual fight situation.

Generally the higher is the individual class/ skill level, the better are the competitive-progress-specific qualities and test rates including the feel of distance, striking instinct, timing, pacing etc. – manifested in specific actions and combinations of the timely and effective technical and tactical actions. In our studies of the martial arts-specific individual competitive style, we give a special priority to the individual psychomotor profiles to differentiate and predict every competitive timing and spacing skill element, rate the technical and tactical actions timing, sequencing and tempo-rhythmic patterning under pressure from the opponent in every specific competitive fight situation in the modern elite martial arts.

Well-tested, analyzed and synergized individual competitive style elements in the modern martial arts elite help better design and manage the individual martial arts elite training systems so as to effectively control the individual fitness in every aspect in the context of the absolute and conditional genetic markers and psychological aspects – and outline new competitive progress opportunities for professional success.

Keywords: *martial arts, individualized approach, integration of individual competitive style components, psychomotor profiles, elite sport skills.*

Background. Individual competitive style in modern elite martial arts – viewed as the dynamic personal competitive progress system geared to excel the genetically predetermined individual athletic qualities and resources – has always been of special interest for the elite sports theory and practice.

Objective of the study was to provide a theoretical basis for the individual competitive style improvement options in the modern elite martial arts.

Results and discussion. Many studies have found, among other things, that the individual competitive progress in the context of the individual competitive styles is rather sport-specific, with the individual qualities, resources and gifts analyzable [1] as the synergized subjective traits critical for success [3]. It has also been found that an individual competitive style may be interpreted as the relatively standard/ stable action system (predetermined by a few typological characteristics) that largely secures competitive progresses in a specific martial arts discipline.

It is the congenital qualities of the individual nervous system that are known to shape up the individual competitive style with a special role of the most beneficial/ key abilities critical for competitive progress –

that are both genotype-specific and trainable by multi-annual focused individualized excellence systems. It should be mentioned that the genotype-specific nervous system qualities manifest themselves in a wide range of unpredictable and stressful situations typical for the modern elite martial arts.

The individual competitive style may be characterized by its specific imprint on the psychomotor profiles in elite martial arts. Thus our studies have found significant differences in the simple/ complex sensory-motor response rates, attention control and other classes of responses in the athletes grouped by the individual fight control preferences/ tactics [2, 4, 5, 6, 7]. The individual competitive style groupings on higher levels may, as we believe, help generalize the variability of a few genetic markers to rate the individual sensory/ functional asymmetries with their contributions to movement coordination, responsiveness, discriminative sensitivity (to effectively control, e.g., striking speed and power), tactical thinking qualities versus fatigue, motor memory, attention controls, etc.

Collectively the above individual competitive style components are commonly referred to by many traditional martial-arts-specific terms including the 'feel of distance, striking instinct, feel of opponent, timing, grappling instinct', etc. competitive progress in the modern martial arts is known to largely depend on the above feels and instincts classifiable into motor, energy, sensory, mental and other components.

The *motor component* is critical for an individual ability to control fight in a high-pace manner by the most successful technical and tactical actions and their combinations, with effective variations in pressure, striking pace and power, defenses, footwork, movement coordination patterns etc. – so as to use every tool in the individual skill set for success.

The *energy component* closely associated with the motor component mostly refers to the technical and tactical actions accuracy with fatigue, the counteraction speed, pace and timing under pressure from the opponent, and the decision-making capacity in attacks, counterattacks and defenses.

The *sensory component* we would consider in the context of the individual discriminatory sensitivity critical for the long-, middle- and close-distance striking power and pace control; tempo-rhythmic patterns of attacks and defenses, and the varying controlled-speed and power striking combinations for success. The individual competitive progress is known to heavily depend on the individual timing and pacing skills and the abilities to make timely adjustments for success in every fight and competitive progress in general.

As for the *mental component* we would consider it with a special attention to the individual moral and volitional qualities mobilized under pressure in the context of tactical thinking, attention control, motor memory and motor experience helpful in every bout when the situation requires special efforts to 'turn the tide' and win.

In the context of study-specific goals, we would provisionally classify the individual competitive style elements into the following two groups: Group A including the individual competitive style elements always contributing to the competitive progress; and Group B including the potentially negative individual competitive style elements that may hamper competitive progress and cause failures in finals of the top-ranking events. It should be emphasized that this grouping is rather provisional since the same individual competitive style element may alternatively fall in either of the above groups depending on the actual fight situation.

Generally the higher is the individual class/ skill level, the better are the competitive-progress-specific qualities and test rates including the feel of distance, striking instinct, timing, pacing etc. – manifested in specific actions and combinations of the timely and effective technical and tactical actions. In our studies of the martial arts-specific individual competitive style, we give a special priority to the individual psychomotor profiles to differentiate and predict every competitive timing and spacing skill element, rate the technical and tactical actions timing, sequencing and tempo-rhythmic patterning under pressure from the opponent in every specific competitive fight situation in the modern elite martial arts.

Conclusion. Well-tested, analyzed and synergized individual competitive style elements in the modern martial arts elite help better design and manage the individual martial arts elite training systems so as to effectively control the individual fitness in every aspect in the context of the absolute and conditional genetic markers and psychological aspects – and outline new competitive progress opportunities for professional success.

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Individual ‘qualities’ in physical education theory: problems, present situation and potential solutions

UDC 796.01

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Abstract

Objective of the study was to offer practical approaches to the meanings and interpretations of individual physical qualities in the context of physical education service.

Results and conclusion. Historical evolution of the notion of “quality” in the physical education theory and practice may be classified into a few stages, with special contributions from the Leningrad and Moscow physical education institutes. It was traditional for the first national studies of the qualities formed by target physical education service to refer to them as psychophysical qualities. It was in 1940 that the Leningrad-based Lesgaft institute of physical education published a practical physical education manual for academic establishments where K.Kh. Grantyn offered a definition of psychophysical qualities developed by specific physical exercises. He interpreted psychophysical qualities as quantitative measures of activity of every bodily system and basically grouped them into psychomotor and moral-volitional ones. The K.Kh. Grantyn classification ranked strength, speed, endurance and dexterity with the psychomotor qualities; and attention control, determination, courage, perseverance, stress-tolerance, endurance and some others with the moral-volitional ones.

After the WWII, the meanings of psychophysical qualities were comprehensively analyzed in the A.D. Novikov monograph "Physical education: issues of the subject, principles, tools, methods and physical practicing forms" [10] where he supported K.Kh. Grantyn in considering psychophysical qualities in the context of functions of the relevant bodily organs and systems. In the 1950-1960ies, the term psychophysical qualities was gradually replaced with motor skills and then physical qualities.

Based on the analysis, we would consider the notion of ‘psychophysical qualities’ as the primary and broadest concept of modern general physical education theory since it adequately covers the subject area of individual physical and mental/ spiritual progress and resource building. A systematic approach implies the individual qualities in the physical education context being considered within the vertical and horizontal ‘multi-storey’ hierarchical structure. In the material domain, physical qualities may be viewed as dictated by activities of the relevant bodily organs and systems.

Keywords: *physical education theory, physical qualities, physical abilities.*

Background. The key mission of every physical education specialist is to facilitate progress in many aspects, particularly in the sport-specific individual qualities. Modern physical education viewed as a specific social domain requires the individual physical and mental/ spiritual resource being mobilized for the multilateral development purposes [1, 6].

Historically, the physical education theory as a science and academic discipline has prioritized different interpretations of qualities and their manifestations in motor activity as defined by a few relevant terms including ‘physical qualities’, ‘motor skills’, ‘psychomotor qualities’, ‘psychophysical qualities’, ‘bodily motor skills’, etc. Modern educational and scientific publications often use physical qualities and motor skills in the same contexts and meanings without sound theoretical grounds and thereby often make the definitions and the relevant phenomena rather vague and uncertain. Despite the ongoing discussion of qualities and their meanings and interpretations in the theoretical and practical publications including those in the Theory and Practice

of Physical Culture journal [4, 5], many issues still remain rather debatable and underexplored.

Objective of the study was to offer practical approaches to the meanings and interpretations of individual physical qualities in the context of physical education service.

Results and discussion. Historical evolution of the notion of "quality" in the physical education theory and practice may be classified into a few stages, with special contributions from the Leningrad and Moscow physical education institutes. It was traditional for the first national studies of the qualities formed by target physical education service to refer to them as psychophysical qualities. It was in 1940 that the Leningrad-based Lesgaft institute of physical education published a practical physical education manual for the academic establishments where K.Kh. Grantyn offered a definition of psychophysical qualities developed by specific physical exercises. He interpreted psychophysical qualities as quantitative measures of activity of every bodily system and basically grouped them into the psychomotor and moral-volitional ones. The K.Kh. Grantyn classification ranked strength, speed, endurance and dexterity with the psychomotor qualities; and attention control, determination, courage, perseverance, stress-tolerance, endurance and some others with the moral-volitional ones [2].

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Later on, the theoretical, practical and educational publications increasingly favored the term 'physical/ motor abilities' as a substitute for physical qualities. We believe that the term physical qualities that have been dominant in the national physical education theory for many years actually fails to fully reflect the subject physical education theory area as was specified in the academic physical education curricula back in 1979. It is natural to question at this juncture whether the physical/ motor qualities may be considered the basic notion of modern general physical education theory. It appears unlikely for us. Analysis of the subject physical education area on the whole and its every element in particular shows that they are essentially geared rather to cultivate specific physical aspects by physical means than only develop the individual physical domain.

Considering the physical education system as a whole with its multiple interrelated elements, we naturally give a special priority to physical exercises as an important factor in developing an integral and multifaceted personality having high physical and mental resources, as was many times emphasized by P.F. Lesgaft [11].

This idea was further advanced by G.G. Natalov [8] who recommended to consider the exercise law in the following two dimensions: (1) "work builds an organ" (as provided by Lamarck); and (2) it is only via exercises that an individual movement structure is build up to fully develop the individual physical qualities and abilities (as provided by D. Diderot, N.A. Bernstein). The author argues that the physical education subject-object relationship is developed in the biological, psychological and social domains/ levels. In the biological domain of the exercise law (that is the relationship between the body and movement), the exercises are mostly focused on specific physical aspects/ qualities including strength, speed, endurance, agility, flexibility and elasticity of the bodily parts. In the higher (psychological and social) domains, the exercise law implies the key mental (sensory, intellectual), social (moral, volitional) and other relevant qualities being developed.

V.B. Korenberg [4] came up with a somewhat different approach to the physical qualities qualification issues to offer a concept of motor-functional qualities that classifies them into: (1) somatic (flexibility, strength, body length, body weight); (2) somatomotor (absolute and relative strength, speed,

working capacity); (3) psychosomatomotor (reactivity, coordination, motor stability); and (4) psychomotor (courage, resourcefulness, decisiveness, efficiency, willpower, etc.) ones.

Foreign researchers offer a different classification of qualities [13] based on a set of physical activity rating criteria indicative of the human interaction with the environment, such as the body-environment relationship; connections of the acting individual with the object of actions; and connections of the acting individual with the society. The resultant system of controlled motor acts is based on the classification of qualities into information-orienting, motivating-guiding, and energy-conditioned.

We believe that the concept of physical qualities viewed as elementary aspects within the hierarchy of individual motor activities may be considered the most promising for the subject matter analyzed herein since it assumes the individual social structure being developed on a multilevel staged basis [8, 15]. Thus B.A. Nikityuk [9] offered, based on findings of V.S. Merli and B.A. Vyatkin, the following levels of the human nature knowledge building structure with individual traits and qualities: socio-psychological (social/ team status, interpersonal relationships, teamwork); personal (motivations, individual priorities and values); psychological (perceptions, intelligence, willpower); psychodynamic (temperament); physiological and biomechanical (nervous system qualities, physique, etc.).

Therefore, we would recommend that an individual physical qualities system in the context of physical education forms should be interpreted as a hierarchy of psychophysical activity aspects and elements specific for the sport discipline, adaptive physical education, etc.

Conclusion. Based on the analysis, we would consider the notion of 'psychophysical qualities' as the primary and broadest concept of modern general physical education theory since it adequately covers the subject area of individual physical and mental/ spiritual progress and resource building. A systematic approach implies the individual qualities in the physical education context being considered within the vertical and horizontal 'multi-storey' hierarchical structure. In the material domain, physical qualities may be viewed as dictated by activities of the relevant bodily organs and systems.

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Athletic biomechanical system trajectory modeling experiment using body mass and length

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Abstract

Objective of the study was to offer and substantiate by computation experiments basics of the athletic biomechanical system trajectory modeling using the mass-inertial characteristics and elementary kinematics of the body parts.

Methods of the study. We used for the purposes of the study system-structuring analysis and movement design mathematical/ simulation/ modeling tools to model the biomechanical system kinematics in the computation experiment.

Computation experiment was designed to model the athlete's musculoskeletal system movements using a biomechanical system movement synthesizing mathematical toolkit. The athlete's musculoskeletal system movement model may be described as the limited kinematic diagram of the connected bodily elements with cylindrical joints that models a biomechanical system plane rotation process around a contact/ support point

Results and conclusion. The biomechanical system trajectory modeling experiment showed that when the biomechanical system rotates around a contact point, provided the programmed control and startup conditions are the same, then:

- Growths/ falls in masses of the model elements cause no effect on the biomechanical system trajectory;
- Elementary angular velocity angular velocity is directly correlated with the length of element i.e. the higher is the element's length the higher is the angular velocity and vice versa.

Keywords: *biomechanical system trajectory, sport exercise, mass-inertial characteristics, athlete's body elements.*

Background. Modern physical education theory and practice gives room for the belief that individual anthropometric characteristics are correlated with the sport techniques albeit it is seldom if ever substantiated by sound theoretical provisions [1, 2]. We know only in a few study reports making attempts to find and explain correlations between an athletic biomechanical system trajectory and body mass/ length [4, 5]. Presently these and other associating issues are still relevant and of special interest for the sport practice and, hence, there is a need for a theoretical understanding of the phenomena with due biomechanical arguments for one or another athletic technical performance concept [6].

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Methods of the study. We used for the purposes of the study system-structuring analysis and movement design mathematical/ simulation/ modeling tools to model the biomechanical system kinematics in the computation experiment.

Results and discussion. Computation experiment was designed to model the athlete's musculoskeletal system movements using a biomechanical system movement synthesizing mathematical toolkit.

The athlete's musculoskeletal system movement model may be described as the limited kinematic diagram of the connected bodily elements with cylindrical joints that models a biomechanical system plane rotation process around a contact/ support point: see Figure 1.

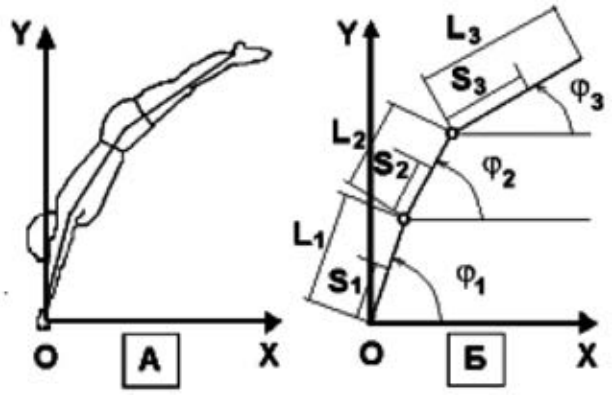


Figure 1. *Three-element musculoskeletal system movement kinematics*

Let us use the following notations for the model: N - number of elements in the model; i - alphabetic index of every element; (i = 1, 2, ..., N); L_i – length of the i-th element; S_i – distance from the contact point (rotation axis) of the i-th element versus the mass center; φ_i - i-th element inclination angle to the Ox axis (generalized coordinates); $\dot{\varphi}_i$ - generalized speed of the i-th element (i = 1,..., N); and $\ddot{\varphi}_i$ - generalized acceleration of the i-th element (i = 1,..., N).

The biomechanical system movement approximating mathematical model with programmed control at the kinematic level that we developed [3] using the Lagrange formal toolkit, is the following:

Table 1. *Programmed/ controlled kinematics (U1, U2) of the model joints*

t	Programmed control					
	Function		Speed		Acceleration	
	U_1	U_2	$\dot{U}_1$	$\dot{U}_2$	$\ddot{U}_1$	$\ddot{U}_2$
0,00	0,00	0,00	0,00	0,00	0,00	0,00
0,06	6,41	6,51	1,87	2,41	0,29	17,11
0,12	12,88	16,55	1,74	2,51	-6,85	-21,99
0,18	17,97	22,80	1,13	1,48	-12,53	-9,56
0,24	20,63	26,88	0,49	0,76	7,99	-14,83
0,30	21,67	28,04	0,18	0,05	-2,25	-8,94
0,36	22,23	27,20	0,29	-0.63	3,96	-14,36
0,42	23,26	23,42	0,01	-1,51	13,99	-16,06
0,48	21,55	16,03	-0,94	-3,73	-18,65	-48,72
0,54	15,65	0,80	-3,13	-2,33	-47,27	69,96
0,60	0,00	0,00	0,00	0,00	0,00	0,00

$$\ddot{\varphi}_i = \frac{M_1 - \sum_{i=1}^{N}\left[Y_i \cos\varphi_i + \sum_{k=2}^{N} A_{ik} \sum_{z=2}^{k} \ddot{u}_z \cos(\varphi_k - \varphi_i) - \sum_{j=1}^{N} A_{ij}\dot{\varphi}_j^2 \sin(\varphi_k - \varphi_i)\right]}{\sum_{i=1}^{N}\sum_{j=1}^{N} A_{ij}\cos(\varphi_k - \varphi_i)}. \quad (1)$$

Whereas: M_1 - frictional moment; Y_i - generalzed force of the i-th element (i = 1,..., N); and A_{ij} - dynamic coefficients of the model elements (i = 1,..., N; j = 1,..., N).

Dynamic coefficients A_{ij}, Y_i of the model elements were computed using the algorithms described in the prior study [3]. Model (1) has no analytical solution, and that is why we used the Runge-Kutta numerical method with the fourth-order accuracy in our computation experiments. We computed the generalized coordinates of every model element and derivatives in time at every integration step using the following algorithm:

$$u_i = \varphi_{i+1} - \varphi_i \qquad \dot{u}_i = \dot{\varphi}_{i+1} - \dot{\varphi}_i \qquad \ddot{u}_i = \ddot{\varphi}_{i+1} - \ddot{\varphi}_i \quad (2)$$

The computation experiment modeled the second half of a full backward swing on a gymnastics bar. The computation experiment conditions were formulated as follows:

Timing (temporal movement characteristics):

Startup: t_0 = 0 s; final: t_{10} = 0,6 s; integration step h = 0,06 s. (3)

Startup conditions of the movement:

$$\begin{cases} \varphi_1 = 270^0, & \varphi_2 = 270^0, & \varphi_3 = 270^0; \\ \dot{\varphi}_1 = 6 рад/с, & \dot{\varphi}_2 = 6 рад/с, & \dot{\varphi}_3 = 6 рад/с. \end{cases} \text{(radiant/s)} \quad (4)$$

Programmed control of the biomechanical system is given in Table 1.

Computation experiment designs with variations in the model kinematics and elementary mass-inertial characteristics:

Computation experiment-1 implied unvaried model elements:

(L_1=L_2=L_3=0,6 м; S_1=S_2=S_3=0,3 м) and varied elementary mass-inertial characteristics as follow:

Option I: m_1= m_2= m_3= 25,0 кг; Jc_1= Jc_2=Jc_3=0,750 кг·м^2;

Option II:– m_1= m_2= m_3= 12,5 кг; Jc_1= Jc_2=Jc_3=0,375 кг·м^2; (5)

Option III:m_1= m_2= m_3= 50,0 кг; Jc_1= Jc_2=Jc_3=1,500 кг·м^2.

Computation experiment-2 Computation experiment -1 implied unvaried elementary mass-inertial characteristics:

(m_1= m_2= m_3= 25,0 кг; Jc_1= Jc_2 =Jc_3=0,750 кг·м^2 and varied kinematics:

Option IY: m_1= m_2= m_3= 25,0 кг; Jc_1= Jc_2 =Jc_3=0,750 кг·м^2;

Option Y m_1= m_2= m_3= 12,5 кг; Jc_1= Jc_2 =Jc_3=0,375 кг·м^2; (6)

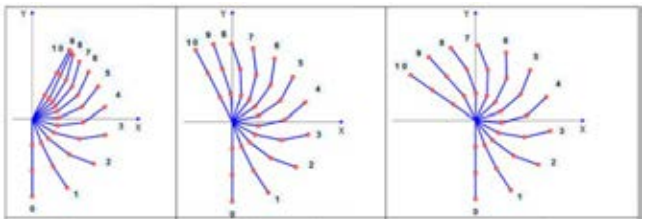
Option YI m_1= m_2= m_3= 50,0 кг; Jc_1= Jc_2 =Jc_3=1,500 кг·м^2.

Given hereunder are the modeled synthesized biomechanical system trajectories. Table 2 gives the biomechanical system movement trajectory model produced by Computation experiment-1.

The above computation experiment-2 product shows that when the programmed control is the same, masses of the elements cause no effect on the biomechanical system trajectory (Table 2). Figure 2 hereunder gives the biomechanical system movement trajectory model produced by computation experiment-2.

Table 2. *Biomechanical system trajectory model produced by computation experiment-1*

t	Three-element biomechanical system trajectory			Generalized coordinates		
	Option 1	Option 2	Option 3	φ_1	φ_2	φ_3
0,00				270,00	270,00	270,00
0,06				290,44	296,85	303,36
0,12				310,38	323,26	339,81
0,18				330,81	348,78	371,58
0,24				351,69	372,32	399,20
0,30				372,35	394,02	422,06
0,36				392,04	414,27	441,47
0,42				410,83	434,09	457,51
0,48				430,48	452,03	468,06
0,54				452,53	468,18	468,98
0,60				477,01	477,01	477,01



Option 4 Option 5 Option 6

Figure 2. *Biomechanical system movement trajectory model produced by computation experiment-2 with varied elementary mass-inertial characteristics*

The computation experiment-2 product shows (Figure 2) that, when the programmed control and the startup movement conditions are the same whilst length of the elements grows, the elementary angular velocity and rotation angle grow as well; and vice versa, when the element gets shorter, the elementary AC and rotation angle fall respectively.

Conclusion. The biomechanical system trajectory modeling experiment showed that when the biomechanical system rotates around a contact point, provided the programmed control and startup conditions are the same, then:

- Growths/ falls in masses of the model elements cause no effect on the biomechanical system trajectory;
- Elementary angular velocity angular velocity is directly correlated with the length of element i.e. the higher is the element's length the higher is the angular velocity and vice versa.

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Benefits of smart yachting technologies for russian yachting reserve training service

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Abstract

Objective of the study was to analyze benefits of the modern smart yachting technologies for the national yachting sport reserve technical and tactical skills training service.

Methods and structure of the study. In 2019-2021, our research team from the Sports, Health Technologies and Socio-Economic Issues Research Institute in Lesgaft National State University of Physical Education, Sport and Health completed the 'Research innovations to improve the sailing sport reserve technical and tactical skills training service Improvement' Project on the relevant state order. The Project included an experiment to pilot and test benefits of the 'SailData' smart yachting technologies (Italy) and Fast Skipper smart yachting technologies (Russia, St. Petersburg). We sampled for the study the 14-18 year-old sport reserve yachters (n=48) sailing two-person 420/ 470 dinghy and Swan 50 yachts. The smart yachting technologies were operated in the 'crew and coach' setting, with the sensors on the sailing craft designed to read, on a real-time basis, the key data for communication and control. The coaches used tablets with Android-based special software to track and analyze the sailing process.

Conclusion. The studies completed under the Research Innovations to Improve the Sailing sport reserve technical and tactical skills Training Service Improvement' Project gave us the grounds to recommend the following sport reserve training service improvement actions:

– Apply the modern smart yachting technologies for the sailing craft location, control and training service excellence purposes;
– Train the yachters on a systematic and purposeful basis to improve their competitive yachting tactics in regattas; and
– Improve the special physical training service to make the yachters perfectly fit for the sport-specific technical and tactical actions.

Furthermore, we recommended the following yachting sport reserve training service improvement options:
– Special mental training to improve the volitional control, emotional balancing and attention control skills;
– Special conflict-management training to improve the teamwork;
– Competitive mindset formation skills training with a special attention to the potential psychological barriers;
– Efficient interpersonal communication/ cooperation skills training; and
– Special mental training to counter the opponents' psychological tricks and manipulations.

Keywords: *sailing, sport reserve, technical and tactical skills, smart yachting technologies, psychological support service.*

Background. Analysis of the modern studies of the yachting elite training systems [4] highlighted a few problems and drawbacks in the technical and tactical skills training and excellence service. The national coaches and yachters still use a very limited digital toolkit for the technical and tactical skills analysis dominated by the traditional video records using smart phones without specialized software. Modern smart yachting technologies are seldom if ever used for the location and tracking purposes by the Russian yachting sport elite. Furthermore, most of the sport reserve yachters are tested with very superficial knowledge, skills and experience in the modern smart yachting tactics. The situation is further complicated by the fact that the sport reserve physical fitness tests show poor fitness vertically in every key physical quality including endurance, movement coordination, speed, etc. that need to be trained by special individualized exercises.

Objective of the study was to analyze benefits of the modern smart yachting technologies for the na-

tional yachting sport reserve technical and tactical skills training service.

Methods and structure of the study. In 2019-2021, our research team from the Sports, Health Technologies and Socio-Economic Issues Research Institute in Lesgaft National State University of Physical Education, Sport and Health completed the 'Research innovations to improve the sailing sport reserve technical and tactical skills training service Improvement' Project on the relevant state order. The Project included an experiment to pilot and test benefits of the 'SailData' smart yachting technologies (Italy) and Fast Skipper smart yachting technologies (Russia, St. Petersburg). We sampled for the study the 14-18 year-old sport reserve yachters (n=48) sailing two-person 420/ 470 dinghy and Swan 50 yachts. The smart yachting technologies were operated in the 'crew and coach' setting, with the sensors on the sailing craft designed to read, on a real-time basis, the key data for communication and control. The coaches used tablets with Android-based special software to track and analyze the sailing process. The smart yachting technologies produced the following test data:

– Tack speed in knots;

– True wind direction versus the bottom in degrees;

– True wind speed versus the bottom in knots;

– Lead/ lag in meters versus the race winner;

– Lead/ lag in meters after the buoy versus the race winner;

– Lead/ lag in meters in the tacking speed versus the race winner.

It should be emphasized that the above detailed logs may be produced only by the smart yachting technologies equipped with the appropriate sensors to rate the spatial locations and control of the mainsheet guards, boom guards, uncoiling/ steering belts, etc.

Results and discussion. The smart yachting technologies piloting experiment showed benefits of the technologies for the following purposes: tracking movement of the sailing craft in every point with preset intervals; and defragmenting the trajectory into specific spans to rate quality of maneuvers and vessel control with the movement speeds fixed by the relevant sensors. Analyses of the yacht control logs make it possible to find technical and tactical errors made by every yachter in the race and analyze them on an objective basis. We have analyzed details of the smart yachting technologies piloting experiment in a few prior study reports [1-3]. The study on the whole proved benefits of the modern smart yachting technologies for the vessel location and control analyses in the yachting sport reserve training and technical and tactical skills excellence systems. The immediate and detailed analyses of the sailing process logs generated by such systems give grounds for the coaches to fairly rate the individual technical and tactical skills in the training process to make timely necessary adjustments to the training service.

Conclusion. The studies completed under the Research Innovations to Improve the Sailing sport reserve technical and tactical skills Training Service Improvement' Project gave us the grounds to recommend the following sport reserve training service improvement actions:

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– Special conflict-management training to improve the teamwork;

– Competitive mindset formation skills training with a special attention to the potential psychological barriers;

м Efficient interpersonal communication/ cooperation skills training; and

– Special mental training to counter the opponents' psychological tricks and manipulations.

The above recommendations were detailed in the following publications: (1) 'Technical and tactical actions excellence in the yachting sport reserve: Practical Guidelines'; and (2) 'Improving the psychological support service in the yachting sport reserve training systems: Practical Guidelines'.

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Training predictor variables of faster marathon time in elite-amateur female marathon runners

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Abstract

Objective of the study was to collect a profile of elite-amateur female runners, who are able to run sub-3-hour marathon (S3HM) including their anthropometrical parameters, training regimes, and best non-marathon race performance and to detect predictor variables of faster marathon time.

Methods and structure. Twenty-one Russian female runners (mean weight 52.67 ± 3.88 kg, height 1.66 ± 0.059 m, body mass index (BMI) 19.16 ± 1.29, and years of training experience before their first S3HM 3.95 ± 3.8 years who had completed a S3HM answered a questionnaire. All runners had a main professional occupation other than sports. We gathered information on their anthropometric variables, diet and training regimes. One-third of the runners were vegan or vegetarian. S3HM time was positively correlated with 1-km time in runners with BMI ≤ 19.06 and in subjects running ≥ 344.5 km per month. S3HM time also correlated positively with the half-marathon best time, the sum of 1-, 5-, 10-km, and half-marathon best time and BMI in athletes running > 9 h per week. Running a S3HM requires a long preparation training period, long running distances, and is accompanied by weight loss. Predictor variables associated with faster marathon time become evident only upon accomplishing certain training times and distances.

Results and conclusions. Female marathon runners are able to run S3HM if they have no previous experience. Generally, it requires long training rounds (weekly 10.81 ± 4.28 h), lengthy running distances (weekly ~80 ± 39 km), and is accompanied by weight loss. Vegetarian diet is not a contraindication to run a S3HM. Predictor variables associated with faster marathon time become evident only upon accomplishing certain training times and running distances. S3HM time correlated positively with 1-km time in runners with BMI ≤ 19.06 and in athletes running ≥ 344.5 km per month. S3HM time also correlated positively with the half-marathon best time, the sum of 1, 5-, and 10-km times, and BMI in subjects running > 9 h per week.

Keywords: *female runners, marathon, race predictors*

Introduction. Long-distance running, including marathon running (42.195 km), enjoys growing popularity among recreational runners around the world. In 2016, around 5000 marathons were held worldwide, attracting more than 1.8 million participants (Association of Road Racing Statisticians. Marathon Lists, n.d.).

Women did not participate in marathons up until the 1970s. However, several female runners took part in some races unofficially. The first woman to run a marathon was Kathrine Switzer in 1967 in Boston. The Amateur Athletic Union officially allowed women to participate in the marathon in 1971 [2]. On September 19, 1971, Beth Bonner became the first winner of the women's division of the New York City Marathon at 19 years old; her race time was 2:55:22 (Boston Athletic Association, n.d.). The women's marathon Olympic debut was at the 1984 Summer Olympics in Los-Angeles. Joan Benoit Samuelson became the champion with a finish time of 2:24.52 (International Association of Athletics Federations, n.d.). The current marathon world record for women is held by Brigid Kosgei with a finish time of 2:14:04, which was set at the 2019 Chicago marathon (Bank of America Chicago Marathon, n.d.).

However, despite the growing popularity of marathon running, the number of female runners to complete a sub-3-hour marathon (S3HM) remains low. For instance, 21,295 female runners participated in the

Table 1. Anthropometric parameters of the runners (normal distribution, Shapiro-Wilk Test).

	Min	Mean ± SD	Max
Height (m)	1.55	1.66 ± 0.06	1.8
Weight before marathon training start, kg	37.0	54.55 ± 6.24	65.0
Weight at marathon, kg	46.0	52.67 ± 3.88	62.0
Weight loss, kg	0	3.08 ± 2.29	9.0
BMI	17.1	19.16 ± 1.29	21.23
Age at marathon, years	22.75	32.11 ± 4.86	41.42

2019 Chicago marathon, of which only 1% (n = 206) finished in under 3 h(Bank of America Chicago Marathon, n.d.). The particularly hard training requirements might explain such a moderate proportion for the S3HM (Esteve-Lanao et al., 2017).Heritability might also play an important role in running performance (de Moor et al., 2007).

There have been multiple attempts to determine the predictors of the marathon finish time (McKelvie et al., 1985)(Dotan et al., 1983)(Legaz Arrese et al., 2005), and several studies were conducted on top-class runners (Billat et al., 2001)(Karp, 2007). Several studies demonstrated an association between anthropometric and training variables and running performance. However, these studies were done on low-performance runners and did not specifically examine marathon races (Knechtle et al., 2015)(Sch tz et al., 2019)(Knechtle et al., 2014)(Barandun et al., 2012) (Knechtle, Knechtle, Barandun, & Rosemann, 2011) (Schmid et al., 2012)(Knechtle, Knechtle, Barandun, Rosemann, et al., 2011). Several studies on predictors of success at a marathon have been published (Bale et al., 1985)(Gordon et al., 2017)(Doherty et al., 2020). However, we could not identify studies demonstrating anthropometric and training parameters analysis in elite-amateur female marathon runners who finished an S3HM and had a main professional occupation other than sports. Therefore, studying predictor variables of S3HM performance might be of great practical interest for predicting marathon finish time and planning of training regimen. This study aimed to collect a profile of elite-amateur female runners, who are able to run sub-3-hour marathon (S3HM) including their anthropometrical parameters, training regimes, and best non-marathon race performance and to detect predictor variables of faster marathon time.

Table 2. Best non-marathon race time, during training to the first S3HM

	Mean ± SD, hours
1 K best time	0:03:29 ± 0:00:18
5 K best time	0:19:10 ± 0:00:58
10 K best time	0:39:37 ± 0:01:46
Half-marathon best time	1:26:16 ± 0:03:33
Marathon best time	2:48:46 ± 0:11:44

Methods. All procedures in this study were conducted following the ethical standards of the Sechenov University and National Research Committee and with the 1964 Helsinki Declaration and its later amendments. All study participants signed an informed consent form. The study was conducted during January–February 2020, utilizing a survey, which was mailed to study participants.

Participants. The study group comprised 21 female runners, who finished an S3HM in the 2018–2019 seasons. 23 potential participants were initially contacted for the research, 21 (91%) of them decided to complete the questionnaire. 17 (81%) filled the full questionnaire while 4 (19%) partially filled them. All study participants live and train in Russia, have no medical contraindications to sports, and have medical certificates for marathon running.

Inclusion criteria were as follows: (i) signed informed consent for study participation; (ii) age ≥ 18 years; (iii) finishing in at least one S3HM to the time point of research; (iv) main professional occupation other than sports to the time point of the first S3HM; (v) no activity in professional endurance sports under the age of 18 years.

Exclusion criteria were as follows: (i) refusal to participate in the study; (ii) age ≤ 18 years; (iii) running as a main professional occupation for at least 1 year during lifetime; and (iv) professional endurance sports activity under the age of 18 years. All runners had their primary professional occupation other than sports. They did not engage in endurance sports as adolescents. They were not trained by a professional coach. Instead, they had mentors who supervised them online and met only 1-2 times per year.

Methods. We assessed height, weight, age, training experience, and best race times of 1-, 5-, 10-km, half-marathon and marathon distances.

Design and procedures. Runners completed a questionnaire on their anthropometric and performance variables.

Statistical analysis. The Shapiro-Wilk test was used for testing the normality of data. Spearman's rank correlation coefficient was used for the assessment of the relationships between S3HM time and height, weight, BMI, 1, 5, 10-km, and half-marathon best time, monthly running distance (km), weekly training time (h). The Mann-Whitney U test was used for comparing the results of groups of runners. Kruskal–Wallis one-way analysis of variance was used for comparing S3HM time in runners with different diets.

Statistical analysis was performed using R Statistical Software (version 3.3.3; R Foundation for Statistical Computing, Vienna, Austria) and SPSS v23.0 (IBM Corp., USA). Statistical significance was defined at P-value < 0.05.

Results. The anthropometric parameters of the runners are presented in Table 1. The average time of the first S3HM was 2:52:06 ± 0:07:16 min. The average weekly training time was 10.81 ± 4.28 h, and the monthly training distance was 317.8 ± 154.3 km (~80 ± 39 km per week). The best non-marathon race time is presented in Table 2. Training experience before the first S3HM was not normally distributed (Me; Min-Max; interquartile range, years: 2.50; 0.5–18.0; 3.5).

Most (95%, n = 20) of the runners were trained by coaches. Most (67%) of the runners (n = 14) finished the first S3HM in autumn, 19% (n = 4) and 14% (n = 3) in winter and summer, respectively. The average weight loss during preparation rounds to the first S3HM was 3.01 ± 2.29 kg. At present, the participating runners continue training to achieve their next personal records. The average number of accomplished S3HM is 3.524 ± 3.76. One runner is pregnant and ceased training rounds. One-third (n = 7) of the runners were vegan or vegetarian. Eight (38%) of the runners had at least one significant injury that interrupted their training. S3HM time did not correlate with training experience before the S3HM, monthly running distance, weekly training time, 1-, 5-, 10-km, half-marathon best time, and the sum of the non-marathon races best time, as well as with weight, BMI, height, and alimentary habits.

Runners were then grouped according to the median values of the studied variables. The Mann-Whitney U test was used to compare the groups, and the correlation analysis was repeated. The median weight was 53 kg. The ≤ 53 kg weight group of runners and the > 53 kg group of runners did not differ significantly in any of the analyzed variables. There was no significant correlation between BMI and S3HM time. The median height was 1.65 m. The group of runners with a height of ≤ 1.65 m did not differ from the group of runners with height > 1.65 m. There was no significant correlation between height and the S3HM time in both groups.

The median BMI was 19.06 kg/m2. The group of runners with BMI ≤ 19.06 did not differ from the runners with BMI > 19.06. The 1-km time in runners with BMI ≤ 19.06 correlated significantly with S3HM time (p = 0.003, cor = 0.96). The median monthly running distance was 344.5 km. The group of runners with monthly running distance < 344.5 km did not differ from the group with monthly distance ≥ 344.5 km. Best 1-km time correlated positively with S3HM time in athletes running ≥ 344.5 km per month (p = 0.021, cor = 0.79) (Fig. 1).

The median weekly training time was 9 h. The group of runners training ≤ 9 h per week differed from the runners training > 9 h per week in 5-km (p = 0.016), 10-km (p = 0.021), and half-marathon (p = 0.013) best times and the sum of 1-, 5-, 10-km, and half-marathon best times (p = 0.029). In the group training > 9 h per week S3HM time correlated positively with half-marathon best time (p = 0.003, cor = 0.86), the sum of 1-, 5-, 10-km, and half-marathon best time (p = 0.015, cor = 0.9), and BMI (p = 0.028, cor = 0.72) (Fig. 2-4).

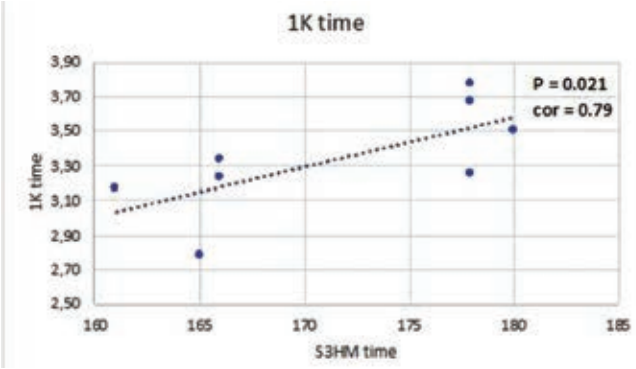

Figure 1. *Correlation between S3HM and 1K best time in athletes running ≥ 344.5 km per month.*

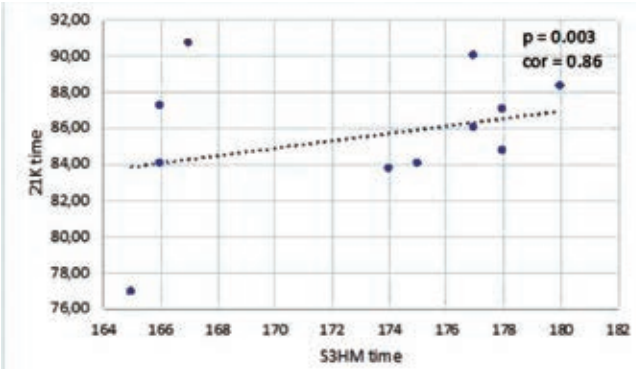

Figure 2. *Correlation between S3HM and 21K best time in athletes running > 9 hours.*

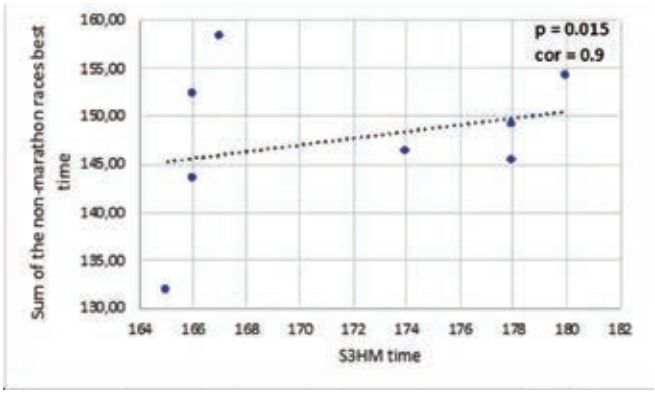

Figure 3. *Correlation between S3HM and the sum of the non-marathon races best time in athletes running > 9 hours.*

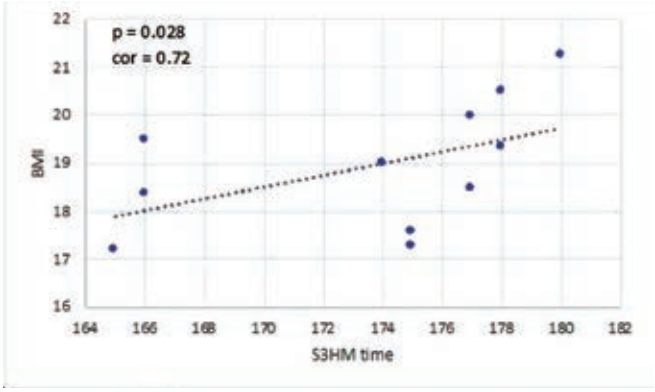

Figure 4. *Correlations of BMI and S3HM in athletes running > 9 hours.*

Discussion. The current study allowed us to collect a profile of female runners, including their anthropometrical parameters, training regimes, and best non-marathon race performance. S3HM time correlated positively with 1-km time in runners with BMI ≤ 19.06 and in athletes running ≥ 344.5 km per month. S3HM time also correlated positively with the half-marathon best time, the sum of 1, 5-, and 10-km times, and BMI in subjects running > 9 h per week. The main difference from other studies is that runners had their primary professional occupation other than sports. They did not engage in endurance sports as adolescents. They were not trained by a professional coach. Instead, they had mentors who supervised them online and met only 1-2 times per year. To our knowledge, this is the first study in elite-amateur runners with fast marathon time, who had a main professional occupation other than sports, which demonstrated an association between several training variables and marathon performance.

Bale et al. demonstrated the association between training mileage and running performance (Bale et al., 1985). This study was done on elite professional runners with marathon best times of 2 h 55 min or less, between 2 h 55 min and 3 h 8 min, and 3 h 18 min to 3 h 30 min. Interestingly, the runners in our study were older (32.11 ± 4.86 vs. 29.4 ± 7.6 years), weighted less (52.9 ± 4.8 vs 54.7 ± 5.6 kg), than the runners studied by Bale et.al., but had a comparable height (1.66 ± 0.06 vs 1.66 ± 0.04 m). The mean weekly distance covered by runners with a best marathon time ≤ 2 h 55 min was 106 ± 34 km, compared with ~80 ± 39 km in our study. Bale et al. concluded that the number of training sessions per week and the number of years of training were the best predictors of competitive performance at both 10 mile and marathon distances. We did not find a correlation between training h and S3HM time, as well as between training experience before the first S3HM and S3HM time. The main difference from our study is that the study by Bale et al. was done on elite professional runners (national and international distance runners and members of British Marathon Squad) (Bale et al., 1985). In contrast, our study was done on runners with a main professional occupation other than sports.

Gordon et al. considered training frequency, distance per session, and overall training experience to compare recreational runners within various marathon time groups (Gordon et al., 2017). These authors showed that training frequency and distance per session were significantly greater for the 2 h 30 min–3 h group compared to the 3 h 30 min–4 h and >4 h 30 min runner group. However, the 2 h 30 min to 3 h group in this study consisted almost exclusively of male athletes (one female and ten males). The mean weekly distance covered by these runners was 91.7 ± 31.6 km, which is higher than in our study. Therefore, faster marathon time cannot be reliably predicted in this setting (Gordon et al., 2017) .

Doherty et al. discovered a negative statistical association between the number of weekly runs, maximum running distance completed in a single week, number of runs ≥ 32 km completed in the pre-marathon training block, and the marathon finish time (Doherty et al., 2020). Even though these data were obtained in a meta-analysis, the dataset represented an over-bias towards male marathoners, which was noted as a limitation of the study by the authors themselves (Doherty et al., 2020).

Schmid et al. found that a low calf circumference and a high running speed in training are associated with a fast marathon race time in female recreational runners (Schmid et al., 2012). However, the mean weekly distance covered by runners in this study was

34.6 ± 12.0 km, which is much lower than in our study. There was no single runner who finished the marathon faster than 3 h. Thus, the running performance of participants in this study was lower than in ours. The runners in our study were younger (32.11 ± 4.86 vs. 47.1 ± 8.7 years), weighted less (52.9 ± 4.8 vs 59.1 ± 6.3 kg), than the runners studied by Schmid et.al., but had a similar height (1.66 ± 0.06 vs 1.66 ± 0.06 m).

The vegetarian diet is gaining popularity in sports. Wilson et al. found that 9% of recent marathon finishers adhere to vegan/vegetarian/pescatarian diet (Wilson, 2016). Nebl et al. states that a well-planned vegan diet, including supplements, can meet the athlete's requirements of vitamin B12, vitamin D and iron (Nebl et al., 2019), while Wirnitzer et al. found that vegetarian diet is associated with a good health status and is an equal alternative to an omnivorous diet for endurance runners (Wirnitzer et al., 2018). These data are supported by our study, where one-third of female runners were vegan/vegetarian. Thus, vegetarian diet is not a contraindication to run a S3HM.

This study showed that preparation training to run a S3HM is a serious challenge for female athletes without previous running experience. There are certain predictor variables, associated with faster marathon time. Disadvantages of our study are the relatively small sample group and the absence of such a variable as the skinfold or calf circumference measurement. However, the studied group might represent nearly all of the female S3HM finishers currently living in Russia. Further research should focus on a more thorough analysis of this group of runners and the impact of training regimens on their health and quality of life.

Conclusions. To conclude, female marathon runners are able to run S3HM if they have no previous experience. Generally, it requires long training rounds (weekly 10.81 ± 4.28 h), lengthy running distances (weekly ~80 ± 39 km), and is accompanied by weight-loss. Vegetarian diet is not a contraindication to run a S3HM. Predictor variables associated with faster marathon time become evident only upon accomplishing certain training times and running distances. S3HM time correlated positively with 1-km time in runners with BMI ≤ 19.06 and in athletes running ≥ 344.5 km per month. S3HM time also correlated positively with the half-marathon best time, the sum of 1, 5-, and 10-km times, and BMI in subjects running > 9 h per week.

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Hypoxic strength training model: benefits for football elite training systems

UDC 796.015+612.74

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Abstract

Objective of the study was to test and analyze benefits of hypoxic strength training method in KAATSU format for football elite.

Methods and structure of the study. We sampled for the hypoxic strength training model testing experiment elite football players (n=18) aged 19 years on average and split them up into Reference and Experimental Groups (RG, EG). Both groups made the following exercises to train strength endurance and lower limb strength: (1) back squats to failure; (2) seated leg extensions on a training machine; and (3) double knee to chest to failure. The EG training was designed in a KAATSU format; and the RG training was traditional KAATSU-free; with both groups trained for 40 days.

The group strength endurance progress was tested on the anterior thigh muscles by squats with 40% maximal weight to failure. We also tested the maximal isometric strength of the distal end of the shin by a bench seated test using a training machine, with the thigh-shin angle kept at 90 degrees.

Results and Conclusion. The study data and analysis showed significant benefits of the KAATSU-formatted hypoxic strength training for the anterior thigh muscle maximal isometric strength in the elite footballers, although the maximal strength growth was tested to stall in the training period followed by a significant skeletal muscles maximal strength growth three weeks upon completion of the KAATSU training. It should be mentioned that the energy resource was tested to restore and grow faster versus the startup level in the KAATSU training model than the skeletal muscles strength endurance.

Keywords: *hypoxic strength training, KAATSU training, skeletal muscle local ischemia.*

Background. For the last few decades, the sports research community has been interested in the hypoxic strength training methods that are known to trigger controlled local ischemia in the skeletal muscles with the relatively fast strength [7] and endurance building effects [5], and with special benefits for the skeletal muscle hypertrophy [2, 6, 8]. Modern hypoxic strength training methods apply blood pressure cuffs fixed on legs and hands to control the local blood circulation by the cuff being deflated and inflated [9, 12].

Objective of the study was to test and analyze benefits of hypoxic strength training method in KAATSU format for football elite.

Methods and structure of the study. We sampled for the hypoxic strength training model testing experiment elite football players (n=18) aged 19 years on average and split them up into Reference and Experimental Groups (RG, EG). Both of the groups made the following exercises to train strength endurance and lower limb strength: (1) back squats to failure; (2) seated leg extensions on a training machine; and (3) double knee to chest to failure. The EG training was designed in a KAATSU format; and the RG training was traditional KAATSU-free; with both groups trained for 40 days.

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thigh-shin angle kept at 90 degrees. The maximal isometric strength was tested by a digital DOR-3-2i dynamometer (Russia-made) within 0.2-2 kN range with an accuracy of 0.5 N. The test data were processed by Statgraphics Centurion XVI Version 16.2.04 software toolkit.

Results and discussion. The tests found the KAATSU-formatted EG training being significantly more beneficial for the anterior thigh muscles strength. In 26 days, the EG result in the weighted squats test was significantly ($p < 0.05$) higher than in the RG: 38±3 versus 25±3 reps, respectively: see Figure 1.

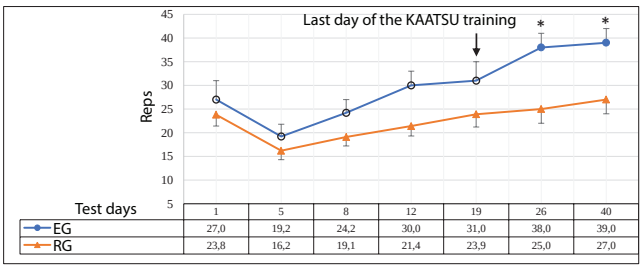

Figure 1. *Group progress in the anterior thigh muscle strength rating weighted (40% maximal) squats tests, averaged reps to failure (A. Golubev, A. Samsonova, L. Tsipin, 2020)*

The group progress in the lower-limb skeletal muscle strength tests in the hypoxic strength training was less expressed. The intergroup difference in the pre-experimental lower-limb skeletal muscle strength test was found insignificant ($p > 0.05$); and the KAATSU-training in the EG made no significant progress. Thus the Day 19 test found the lower limb maximal isometric strength in both groups virtually the same: 560±50N versus 560±80N (see Figure 2). Later on, for three weeks till completion of the experiment (Day 40), the anterior thigh muscle maximal strength in the EG was

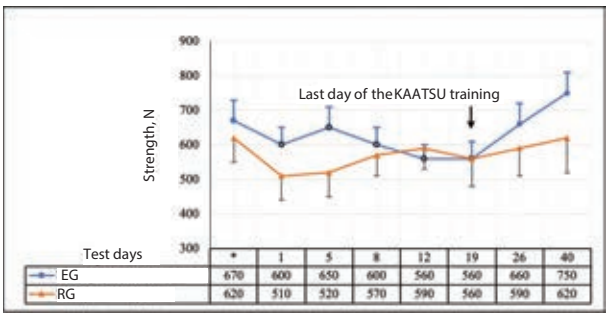

Figure 2. *Group progress in the anterior thigh muscle maximal isometric strength test (averaged data), with the EG showing significant progress in Day 40 versus Day 19 tests*

tested to grow to reach 750±60N and mark a significant ($p < 0.01$) 34% growth versus Day 19, whilst the RG showed virtually no progress in the anterior thigh muscle (quadriceps femoris muscle) maximal isometric strength for the period.

We would highlight the following four mechanisms of strength building by the hypoxic strength training model. (1) The hypoxic strength training helps increase the skeletal muscles strength endurance due to accumulation of energy-generation substances in the muscle tissues with improvements in the capillary circulation. (2) The muscle hypoxia activates production of reactive oxygen [3, 10] and hydrogen [1] to make some damage to the muscle tissue membranes and organelles and spur up division of satellite cells with growths of myonuclei as a result [3]. The growing myonuclei increase the protein synthesis and, hence, the skeletal muscles strength. (3) The hypoxic strength training activates type II muscle tissues [10] to further contribute to the skeletal muscles strength growth – as verified by drops in creatine phosphate levels in 93% of the fast muscle tissues after a hypoxic strength training [11]. And (4) the muscle hypoxia triggers growth of a few hormones in the blood including norepinephrine, adrenaline and growth hormone, to step up the anabolic level and stimulate protein synthesis thereby contributing to the skeletal muscles strength growth as well [3, 4, 10].

It should be emphasized, however, that our data showed the KAATSU training being of so much damage to the lower-limb skeletal muscle that the strength growth is effectively stalled during such a training. The lower-limb skeletal muscle strength was tested to grow only three weeks upon completion of the hypoxic strength training course. We believe that the stalled progress in the skeletal muscle strength in the KAATSU training period may be due to the too short rest breaks in the strength trainings. We found the rest breaks of at least four days between the KAATSU workouts being beneficial for the muscle rehabilitation in composition and structure. Therefore, we would recommend the strength training with the local muscle ischemia being run once a week at most.

Conclusion. The study data and analysis showed significant benefits of the KAATSU-formatted hypoxic strength training for the anterior thigh muscle maximal isometric strength in the elite footballers, although the maximal strength growth was tested to stall in the training period followed by a significant skeletal

muscles maximal strength growth three weeks upon completion of the KAATSU training. It should be mentioned that the energy resource was tested to restore and grow faster versus the startup level in the KAATSU training model than the skeletal muscles strength endurance.

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Elite running sport: injury risks versus footwork techniques analysis

UDC 796.012

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Abstract

Objective of the study was to analyze the key running footwork options versus the running efficiency and running related injuries exposure in the sport elite.

Research methods and structure. We tested the running footwork techniques of the cross-country running elite and found the running related injuries incidence rate in the forefoot strike groups being 2.6 times lower than in the rearfoot strike ones. We also found the group diagnosed with a chronic exercise syndrome reporting meaningful pain relief within one year after making transition to the forefoot strike technique.

We used a strike index as the key criterion in the running footwork tests and analyses. The strike index is a characteristic of the ground contact point location in percent to the full length of the sole – applicable to classify the running footwork into at least the rearfoot strike and forefoot strike techniques. It was found that the running footwork normally changes at submaximal running speed. We used a cluster analysis to group the sample into the (1) forefoot-strike-only group that never resorts to a different ground contact technique; (2) rearfoot strike-only group; and (3) transitional group that normally uses rearfoot strike making the foot flatter at higher speeds. We also found that the strike index tends to significantly sag with the running speed growth

Results and conclusion. It is commonly believed that the most efficient running technique requires the movements being kept economic due to the 'vertical stiffness' model of the lower-limb muscle work to attain a high strike index; with the running kinematics and kinetics also dependent on the running footwear. Thus the too soft shoes with cushioning soles may be detrimental to the lower-limb stiffness, in contrast to the thin-sole ones. The study shows, however, that we have good reasons to believe that the forefoot strike technique is generally less traumatic for the lower limbs than the rearfoot strike. It should also be emphasized that some special types of footwear may distort the running kinetics and kinematics and thereby increase the risks of running related injuries.

Keywords: *running, running footwork, running related injuries, running footwear.*

Background. Popularity of jogging and running has been on the rise for the last few decades. The sport research community has demonstrated a growing interest in causes and effects of the running related injuries albeit the efforts to reduce the running related injuries incidence rates have been mostly unsuccessful as yet [16]. Most analysts tend to believe that the running related injuries exposure is directly correlated with the running footwork i.e. foot striking/ ground contact technique [6, 12].

Objective of the study was to analyze the key running footwork options versus the running efficiency and running related injuries exposure in the sport elite.

Results and discussion.

Running footwork versus running related injuries correlation analysis

We tested the running footwork techniques of the cross-country running elite and found the running related injuries incidence rate in the forefoot strike

groups being 2.6 times lower than in the rearfoot strike ones [13]. We also found the group diagnosed with a chronic exercise syndrome reporting meaningful pain relief within one year after making transition to the forefoot strike technique [7].

We used a strike index as the key criterion in the running footwork tests and analyses. The strike index is a characteristic of the ground contact point location in percent to the full length of the sole – applicable to classify the running footwork into at least the rearfoot strike and forefoot strike techniques [12]. It was found that the running footwork normally changes at sub-maximal running speeds [15]. We used a cluster analysis to group the sample into the (1) forefoot-strike-only group that never resorts to a different ground contact technique; (2) rearfoot strike-only group; and (3) transitional group that normally uses rearfoot strike making the foot flatter at higher speeds [8]. We also found that the strike index tends to significantly sag with the running speed growth [15, 16].

Our study confirmed benefits of the foot/ lower-limb muscles being kept stiff (commonly referred to as the 'vertical stiffness' requirement). Of special interest was our finding that the vertical stiffness should be directly correlated with the ground contact time rather than the stride frequency despite the latter is favored by the running sport communities. It was also found that soft shock-absorbing running shoes may be detrimental to the vertical stiffness – as opposed to the light firm-soled shoes that tend to facilitate the stiff footwork, reduce the ground contact time and, hence, improve efficiency of the running stride biomechanics [9, 10].

Running efficiency is an important success factor heavily dependent on the individual running biomechanics, with the rearfoot strike commonly believed more efficient although the causes and effects of the running footwork options are still being analyzed and discussed [11, 14].

Practical running footwork analysis

Despite the experimental data that shows benefits of the anterolateral ground contact for stride stiffness and shorter ground contact time, the sport community still favors the external foot contact in addition to the above most efficient option. Practical analyses showed the ground contact in the straight sprints dominated by angular foot placements, with the toe mostly turned outward. The ground contact with the outer part of the foot is followed by a full front-foot contact with or without heal contact, depending to the actual individual speed-strength fitness – with a full plantar part contact in some cases. The analysts believe that such techniques help mitigate the strike at the beginning and develop a good support for push off by the end of the movement sequence [3].

It should be mentioned that the commercial running communities and coaching athletes promote the concept of any technique being efficient enough conditional on the body mass center being kept as close to the bent knee as possible to guarantee, as they argue, softer ground contact with no loss for the speed and low risk of injuries to ligaments and joints [1]. An ideal running footwork technique in this concept should secure fast and soft ground contact by the front foot [2].

Running footwear in the running related injuries context

Practical studies demonstrate benefits of the soft light shoes for the running efficiency in addition to the other common running efficiency factors including: shorter vertical body mass center oscillation amplitudes; sharper knee angle in the swing phase; shorter range with faster angular flexion/ extension speed of the plantar muscles at the toe push-off moment; short arm swing amplitudes; lower ground response peaks; faster shoulder rotation speeds in the transverse plane; longer angular excursion of the hips and shoulders around the polar axis in the transverse plane; accumulated elastic energy inputting efficiency, etc. The above aspects should be considered in the context of the individual anthropometrics including the preferable middle body length in the men's sprint and slightly above the middle body length in the women's sprint; high body mass index with ectomorphic or ectomesomorphic physique; low fat mass; lower-limb mass centers in the thighs; narrow pelvis and smaller-size feet; etc. [4].

Modern running shoes are designed with high cushioning and sole rest technology to secure the foot is comfortably fixed to avoid potential injuries and/or adjustments to the habitual movement patterns; albeit the sport statistics still report no reductions in the injury rates. Retrospective injury statistics of 1982-2006 when the special running footwear has been common show 79% of the sport elite reporting lower limb injuries and disorders including patellofemoral pain, iliotibial tract syndrome, plantar fasciitis, and Achilles tendonitis [5]. Some analysts

argue that the running footwear should be specialized for the professional and amateur sports, with a high sensitivity to the foot anthropometrics. Such individual footwear will help reduce the running related injuries, offset faults in the running footwork and safety practices and, hence, contribute to the competitive progress.

Conclusion. It is commonly believed that the most efficient running technique requires the movements being kept economic due to the 'vertical stiffness' model of the lower-limb muscle work to attain a high strike index; with the running kinematics and kinetics also dependent on the running footwear. Thus the too soft shoes with cushioning soles may be detrimental to the lower-limb stiffness, in contrast to the thin-sole ones. The study shows, however, that we have good reasons to believe that the forefoot strike technique is generally less traumatic for the lower limbs than the rearfoot strike. It should also be emphasized that some special types of footwear may distort the running kinetics and kinematics and thereby increase the risks of running related injuries.

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Pre-season physical fitness model for junior middle-distance runners at excellence training stage

UDC 796.42

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Abstract

Objective of the study was to develop and test benefits of a new pre-season physical fitness model for junior middle-distance runners at the excellence stage as complementary to the regular training service.

Methods and structure of the study. The pre-season physical fitness model testing experiment was run in November 2019 through April 2020 at "Leader" Children and Youth Olympic Reserve Sport School (CYORSS) in Seversk city (Tomsk Oblast). We sampled the young skilled middle-distance runners (n=24) and split them up into Experimental and Reference Groups (EG, RG) of 12 people each. The group progresses were tested by the pre- versus post-experimental physical fitness tests and verified by the actual competitive accomplishments of the sample for the period.

Results and conclusion. The EG training model included nine weekly microcycles including one preconditioning plus eight basic pre-season microcycles. The unspecific/ specific/ speed endurance and explosive strength in the EG was trained by the standard-continuous and alternating-continuous practices, interval runs, competitive conditioning method and static-dynamic training exercises [4]. We used the following special training tools in the above training formats: 30-60min moderate-intensity evenly-paced long runs to keep up the unspecific endurance and post-training rehabilitation capacity; high-intensity runs and fartlek to enhance the aerobic/ anaerobic capacities with the heart rate varying within 130-180 beats/ min; 100-800m uphill runs for the leg muscle strength, both in the evenly-paced and interval run formats; soft-surface (sand/ snow) runs to strengthen the leg muscles and ligaments; jumping workouts; pace-stepping/ rhythmic runs for speed training; short (100m at most) weighted runs with a cart to strengthen the leg muscles and train explosive strength and speed endurance; strength practices with weights for strength endurance; and a range of rehabilitation services including sauna and swimming pool

Keywords: *track and field athletics, training process, physical training structure, physical fitness, competitive performance.*

Background. Competitive accomplishments in the modern middle-distance running sport are secured by excellent physical fitness, high unspecific endurance, speed qualities, and speed/ specific endurance [1, 2]. Pre-season training service for elite middle-distance runners traditionally gives a special priority to these physical qualities [3]. Trainings in Western Siberia with the frosty weather staying for almost half a year are traditionally dominated by outdoor workouts, with a professional coaching service and athlete's determination and enthusiasm always required for competitive progresses and successes. Indoor/ gym trainings are relatively seldom and always prudently combined with the outdoor ones. These and other factors were taken into account in our study of the pre-season physical fitness model for the skilled junior middle-distance runners.

Objective of the study was to develop and test benefits of a new pre-season physical fitness model for junior middle-distance runners in excellence stage as complementary to the regular training process.

Methods and structure of the study. The pre-season physical fitness model testing experiment was run in November 2019 through April 2020 at "Leader" Children and Youth Olympic Reserve Sport School (CYORSS) in Seversk (Tomsk Oblast). We sampled the young skilled middle-distance runners (n=24) and split them up into Experimental and Reference Groups (EG, RG) of 12 people each. The group progresses were tested by the pre- versus post-experimental

Table 1. *Pre- versus post-experimental group physical fitness test data,* $\overline{X} \pm \sigma$

Test	Pre-experimental		Post-experimental	
	RG	EG	RG	EG
Cooper test, m	3020±83,66	3120±130,38	3400±100,00	3860±114,02*
Weighted shuttle sprint, s	14,34±0,19	14,28±0,22	14,14±0,13	13,82±0,22*
Five-step long jump, cm	1359±28,82	1372±34,50	1389±20,40	1430±19,52*
60m sprint, s	7,4±0,16	7,44±0,24	7,38±0,13	7,4±0,20

*Note: * significant (p≤0.05) intergroup difference*

physical fitness tests and verified by the actual competitive accomplishments of the sample for the period.

Results and discussion. The EG training model included nine weekly microcycles including one preconditioning plus eight basic pre-season microcycles. The unspecific/ specific/ speed endurance and explosive strength in the EG was trained by the standard-continuous and alternating-continuous practices, interval runs, competitive conditioning method and static-dynamic training exercises [4]. We used the following special training tools in the above training formats: 30-60min moderate-intensity evenly-paced long runs to keep up the unspecific endurance and post-training rehabilitation capacity; high-intensity runs and fartlek to enhance the aerobic/ anaerobic capacities with the heart rate varying within 130-180 beats/ min; 100-800m uphill runs for the leg muscle strength, both in the evenly-paced and interval run formats; soft-surface (sand/ snow) runs to strengthen the leg muscles and ligaments; jumping workouts; pace-stepping/ rhythmic runs for speed training; short (100m at most) weighted runs with a cart to strengthen the leg muscles and train explosive strength and speed endurance; strength practices with weights for strength endurance; and a range of rehabilitation services including sauna and swimming pool [5].

The above group test data show significant (p≤0.05) intergroup differences in the unspecific endurance, speed endurance and explosive strength tests. It should be mentioned that the 60m sprint test found insignificant intergroup differences that means that the EG training service should be complemented by special speed training tools.

Table 2. *Competitive accomplishments of the EG and RG in the 800m events for the experimental period,* $\overline{X} \pm \sigma$

800 m event	RG average, min	EG average, min
№ 1	1.58,09±0.02,21	1.57,72±0.02,45
№ 2	1.57,73±0.01,91	1.56,14±0.02,28*
№ 3	1.55,98±0.02,74**	1.54,05±0.01,87*,***

*Note: *significant intergroup difference (p≤0.05); ** significant intra-RG difference (p≤0.05); *** significant intra-EG difference (p≤0.05)*

As demonstrated by Table 2, the EG made an impressive competitive progress due to significant (p≤0.05) improvements in the pre-season physical fitness – versus the RG that also made some competitive progress for the period albeit significantly lower that the EG.

Conclusion. The new pre-season physical fitness model for the junior middle-distance runners at the excellence training stage tested as complementary to the regular training service and including nine weekly (preconditioning plus eight basic) microcycles was found beneficial for the pre-season physical fitness as verified by the group physical fitness progress test data and the actual competitive progress for the period in the 800m events.

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Role of ampd1, col1a1, and col5a1 genes polymorphism studies in selection in figure skating

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Abstract

Objective of the study was to conduct a comparative analysis of the frequency of polymorphic alleles (SNP) of the *AMPD1* (rs17602729), *COL1A1* (rs1800012), and *COL5A1* (rs12722) genes in successful figure skaters and children, who had not previously trained or taken part in sports competitions and were still selected for sports sections.

Methods and structure of the study. The experiment was run using the materials collected during the implementation of the project of ANO "Stan Chempionom" at Lesgaft National State University of Physical Education, Sport and Health, St. Petersburg. 13 figure skaters of different levels of sports qualification were genotyped in terms of the above-mentioned three polymorphisms: 6 Masters of Sport, 2 Candidate Masters of Sport, 4 I Class athletes, and 1 III Class athlete. The Control Group (CG) was made of 130 children still being selected for sports sections, who had been subjected to the DNA tests under the project of ANO "Stan Chempionom".

It should be immediately noted that due to the small number of representatives of the elite sport, the authors did not differentiate between the figure skating disciplines, nor were the groups of participants differentiated by gender. The subjects' age (group of athletes and CG subjects jointly) ranged from 6 to 24 years.

The biological material for DNA testing was collected by scraping the epithelial cells of the oral cavity using special sterile disposable probes. Each subject was asked to rub the buccal cavity with the tip of the probe for 10-15 seconds. DNA isolation from buccal epithelial cells was made using the modified STAB method.

Results and conclusions. The findings show that in the sport like figure skating, the following ancestral alleles predominate in the genotypes in athletes who regularly train and successfully increase their sports skill and qualification level: C of the *AMPD1* gene (rs17602729), G of the *COL1A1* gene (rs1800012), C of the *COL5A1* gene (rs12722). This fact suggests that the results obtained in the group of top-class athletes are not random and are supported by the physiological expression of the nature of the above-mentioned genes.

Consequently, the findings indicate association of the *AMPD1* (rs17602729), *COL1A1* (rs1800012), and *COL5A1* (rs12722) gene polymorphisms with successful trainings of athletes in figure skating sections. The assumption that the sample results are conditioned by the similarity in athletes' physiology is interesting, and the authors plan to continue this study by increasing the sample of top-class athletes (HMS and WCMS).

Keywords: *figure skating, sports selection, genes, polymorphisms (SNP), allele, PCR, DNA, sports, predisposition, AMPD1, COL1A1, COL5A1.*

Background. Determining the performance of a future athlete at a young age is a difficult task, and the peak of loading falls on the top sports mastery stage, which coincides with the period of puberty (all hereditary physiological features of a young athlete come into sharp focus in adolescence) [1, 3, 5]. Among the many important physiological indicators of an athlete's success, the authors chose such inherited traits as the ability to recover between trainings and the presence or absence of a predisposition to increased traumatism. In top-class sports, the following gene polymorphisms were studied to determine these traits: *AMPD1* gene (rs17602729), *COL1A1* gene (rs1800012), and *COL5A1* gene (rs12722):

- The *AMPD1* gene encodes adenosine monophosphate deaminase 1, a skeletal muscle protein, which is important for energy metabolism [4, 8, 9]. The rs17602729 polymorphism (C>T) is a replacement for cytosine (C) by thymine (T) at position 34 (C34T) of the *AMPD1* gene. As a result of this substitution, the codon representing the amino acid glutamine is replaced by the stop codon, which results in the synthesis of a shortened protein without catalytic activity [9].
- The *COL1A1* gene encodes the pro-alpha 1 chain of type I collagen, which is an important structural component of connective tissue [4]. The studied polymorphism rs1800012 is the replacement of guanine (G) by thymine (T) in the regulatory region of the *COL1A1* gene at position 1245 (G1245T). As a result of this nucleotide replacement, the gene transcription character is altered and the normal relation of collagen chains in the structure of collagen fibers is disturbed. The presence of allele T in the genotype (rs1800012 of the *COL1A1* gene) is associated with a decrease in the mineral density of the bones, higher chance of development of osteoporosis and bone fractures, as well as with ligament sprain due to active trainings [8].
- The *COL5A1* gene encoding the alpha 1 chain of type V collagen is also an important structural component of connective tissue [4]. The rs12722 polymorphism is associated with a predisposition to the development of chronic Achilles tendinosis, as well as with the increased frequency of cruciate ligament ruptures [10]. This polymorphism is the result of substitution in the sequence of nucleotides: cytosine (C) by thymine (T), at position 267 of the non-coding region 3'-UTR of the *COL5A1* gene (C267T), which results in changes in the mRNA stability of *COL5A1* within normal physiological oscillations and does not disrupt the formation of collagen fibrils [11].

Objective of the study was to conduct a comparative analysis of the frequency of polymorphic alleles (SNP) of the *AMPD1* (rs17602729), *COL1A1* (rs1800012), and *COL5A1* (rs12722) genes in successful figure skaters and children, who had not previously trained or taken part in sports competitions and were still selected for sports sections.

Methods and structure of the study. The experiment was run using the materials collected during the implementation of the project of ANO "Stan Chempionom" at Lesgaft National State University of Physical Education, Sport and Health, St. Petersburg. 13 figure skaters of different levels of sports qualification were genotyped in terms of the above-mentioned three polymorphisms: 6 Masters of Sport, 2 Candidate Masters of Sport, 4 I Class athletes, and 1 III Class athlete. The Control Group (CG) was made of 130 children still being selected for sports sections, who had been subjected to the DNA tests under the project of ANO "Stan Chempionom".

It should be immediately noted that due to the small number of representatives of the high-profile sport, the authors did not differentiate between the figure skating disciplines, nor were the groups of participants differentiated by gender. The subjects' age (group of athletes and CG subjects jointly) ranged from 6 to 24 years.

The biological material for DNA testing was collected by scraping the epithelial cells of the oral cavity using special sterile disposable probes. Each subject was asked to rub the buccal cavity with the tip of the probe for 10-15 seconds. DNA isolation from buccal epithelial cells was made using the modified STAB method [6]. The AMPD1 (rs17602729), COL1A1 (rs1800012), and COL5A1 (rs12722) genes polymorphisms (SNP - Single Nucleotide Polymorphisms) were detected by the method of real-time allele-specific polymerase chain reactions (PCR-RT). All reactions were detected

Table 1. *Genotype test results of figure skaters and children selected for sports section*

Genes, polymorphisms, genotypes		Study groups				
		Figure skaters (n=13)				CG (n=130)
		MS (n=6)	CMS (n=2)	Class I (n=4)	Class III (n=1)	
AMPD1 (rs17602729)	CC	6	1	3	1	39
	CT	---	1	1	---	64
	TT	---	---	---	---	27
COL1A1 (rs1800012)	GG	6	2	4	1	54
	GT	---	---	---	---	41
	TT	---	---	---	---	35
COL5A1 (rs12722)	CC	6	2	4	---	42
	CT	---	---	---	1	51
	TT	---	---	---	---	37

Table 2. *Compositional data on distribution of genotypes and alleles in two study groups*

Gene, polymorphism	Genotypes and alleles	CG (n=130)	*Figure skaters* (n=13)	Significance value (p) by Fisher criterion*
AMPD1, rs17602729, C > T	CC	39	11	p (CC vs CT+TT) **0.000179**
	CT +TT	91	2	
	C allele	142 (54.6%)	24 (92.3%)	**0.000103**
	T allele	118 (45.4%)	2 (7.7%)	
COL1A1 rs1800012, G > T	GG	54	13	p (GG vs GT+TT) **0.000026**
	GT + TT	76	---	
	G allele	149 (57.3%)	26 (100%)	**0.000001**
	T allele	111 (42.7%)	---	
COL5A1 rs12722, C > T	CC	42	12	p (CC vs CT+TT) **0.000033**
	CT + TT	88	1	
	C allele	135 (51.9%)	25 (96.2%)	**0.000003**
	T allele	125 (48.1%)	1 (3.8%)	

* *The values p<0.05, indicating statistically significant differences in the allele and genotype frequencies between the figure skaters and CG children, are highlighted in bold.*

using the BioRad CFX-96 device; the primers were designed during work. Nucleotide sequences within amplified DNA fragments were tested by the direct Sanger sequencing on the automatic capillary sequencer ABI PRISM 3130XL. When analyzing the results obtained in the laboratory studies, the frequency of the alleles and genotypes under study was evaluated. The statistical significance of differences between the study groups was determined using Fisher's Exact Test (p<0.05).

Results and discussion. The genotype test results demonstrated by the two groups showed no genotypes that were homozygous for mutant alleles in the group of figure skaters: TT of the *AMPD1* gene (rs17602729), TT of the *COL1A1* gene (rs1800012), TT of the *COL5A1* gene (rs12722); heterozygous genotypes of these genes were under-represented, and for the *COL1A1* gene (rs1800012) were absent at all. In CG, the proportion of such genotypes ranged from 20.7% to 28.5% (Table 1).

The Fisher F-criterion (Table 2) was used to identify and correctly understand the genetic differences in the study groups. In the figure skaters, the following ancestral alleles of the genes under study predominated: the frequency of allele C of the *AMPD1* gene (rs17602729) was 54.6%, of allele G of the *COL1A1* gene (rs1800012) - 100%, and of allele C of the *COL5A1* gene (rs12722) - 96.2%. The ratios of the genotype frequencies, homozygous by the ancestral alleles, to the heterozygotes and homozygotes by the polymorphic gene alleles: *AMPD1* (CC vs CT+TT), *COL1A1* (GG vs GT+TT), and *COL5A1* (CC vs CT+TT), found in the figure skaters, differed statistically significantly between the figure skaters and CG children (Table 2).

Conclusions. The findings show that in the sport like figure skating, the following ancestral alleles predominate in the genotypes in athletes who regularly train and successfully increase their sports skill and qualification level: C of the *AMPD1* gene (rs17602729), G of the *COL1A1* gene (rs1800012), C of the *COL5A1* gene (rs12722). This fact suggests that the results obtained in the group of top-class athletes are not random and are supported by the physiological expression of the nature of the above-mentioned genes.

Consequently, the findings indicate association of the *AMPD1* (rs17602729), *COL1A1* (rs1800012), and *COL5A1* (rs12722) genes polymorphisms with successful trainings of athletes in figure skating sections. The assumption that the sample results are conditioned by the similarity in athletes' physiology is interesting, and the authors plan to continue this study by increasing the sample of top-class athletes (HMS and WCMS).

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Bioelectrical activity of leg muscles while balancing on slippery surface in academic winter football

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Abstract

Objective of the study was to study the bioelectrical activity of the leg muscles of academic winter footballers while balancing on a slippery surface.

Methods and structure of the study. Sampled for the study were the 21-25 year-old (3rd-4th years of study) male students specializing in winter football (n=20). All subjects were asked to perform two attempts per exercise: "half-squat jump" with landing on the unstable platform Reebok Core Board RSP-21160. During the second attempt, the slide board GYMSTICK Power Slider 61131-PRO was attached to the 17 cm high platform. The slide board was 4.5 cm high. During the first attempt, the unstable platform was raised 21.5 cm high.

During the exercise, the bioelectrical activity of the following take-off leg muscles was recorded: calf muscle/ gastrocnemius (lateral and medial heads), rectus femoris, adductor longus. The bioelectric muscle activity was registered using a multifunctional computer complex "Neuro-MVP-4" (Neurosoft, Russia). The electrodes with the diameter of the electrically conductive surface of 1 cm2 and electrode spacing of 20 mm were used. The grounding electrode was placed on the opposite limb. The maximum and average bioelectrical activity amplitudes (μV), as well as the average frequency of bioelectric activity (Hz) were recorded. The statistical processing of the data obtained was carried out using the STATISTICA 10.0 software package.

Results and conclusions. The findings helped determine the main regularities in the lower limb muscle work organization of winter footballers while balancing on an unstable slippery surface.

All totaled, the results obtained suggest that it is the rectus femoris and calf muscles that are actively involved in the maintenance of equilibrium when jumping on a slippery surface, but the nature of their work changes significantly - the activity of the motor units is desynchronized, while the number of motor units involved grows. In contrast, the activity of the adductor longus in these conditions is decreased. According to the findings complex coordination skills when playing on a slippery surface are associated with the development of specific movement patterns. Special training programs are required to build the balancing skills and movement coordination of winter footballers.

Keywords: *students, winter football, electromyography, muscles, movement coordination, body balancing skills.*

Background. Most of the research aimed to increase the efficiency of play activity in football is focused on the metabolic needs; much less attention is paid to the peculiarities of the neuromuscular activity [5]. At the same time, movement coordination plays a major role in football [4]. Many authors insist on the importance of analysis of intermuscular coordination in developing football training methods [2, 6]. The significance of evaluation of the footballers' leg muscle performance according to their specialization [8] and load intensity [1, 7] is also shown.

In recent years, winter football has grown in popularity in the Siberian region, especially among students. This sport discipline demands higher standards of movement coordination and body balancing skills, as football is played on a slippery surface [3].

Objective of the study was to study the bioelectrical activity of the leg muscles of academic winter footballers while balancing on a slippery surface.

Methods and structure of the study. Sampled for the study were the 21-25 year-old (3rd-4th years

of study) male students specializing in winter football (n=20).

All subjects were asked to perform two attempts per exercise: "half-squat jump" with landing on the unstable platform Reebok Core Board RSP-21160. During the second attempt, the slide board GYMSTICK Power Slider 61131-PRO was attached to the platform. The height of the platform was 17 cm and that of the slide board - 4.5 cm. During the first attempt, the unstable platform was raised 21.5 cm high.

During the exercise, the bioelectrical activity of the following take-off leg muscles was recorded: calf muscle/ gastrocnemius (lateral and medial heads), rectus femoris, adductor longus. The bioelectrical muscle activity was registered using a multifunctional computer complex "Neuro-MVP-4" (made by Neurosoft Research and Production Company, Ivanovo, Russia). The electrodes with the diameter of the electrically conductive surface of 1 cm^2 and electrode spacing of 20 mm were used. The grounding electrode was placed on the opposite limb. The maximum and average bioelectrical activity amplitudes (μV), as well as the average frequency of bioelectrical activity (Hz) were recorded.

The statistical processing of the data obtained was carried out using the STATISTICA 10.0 software package. The significance level in testing the hypothesis that two samples belonged to the same general population was estimated using the Kruskal-Wallis ANOVA test. The data is presented as Xavg±SE.

The study was approved by the local ethics committee of the Biological Institute of Tomsk State University (Protocol No. 33 of 02 December 2019).

Results and discussion. The bioelectrical muscle activity rates are given in the table. The maximum EMG amplitude of the adductor longus when jumping on the slippery surface was half that of the rates obtained on the traditional surface. A similar trend was observed for the average EMG amplitude, which dropped by a factor of three when jumping on the slippery surface. There was also a 20% decrease in the frequency of the bioelectrical activity of the specified muscle. Thus, it can be concluded that the rate of contraction of the adductor longus is much lower when jumping on an unstable slippery surface than when jumping on a traditional one.

The maximum EMG amplitude of the rectus femoris when jumping on the slippery surface was 20% higher than on the traditional surface. At the same time, the average EMG amplitude when jumping on the slippery surface decreased by more than half. This decrease was accompanied by almost a twofold increase in the frequency of the bioelectrical activity of the specified muscle.

The maximum amplitude of the gastrocnemius contraction when jumping on the slippery surface was statistically significantly higher than on the traditional surface (more than twice for the medial head and by 30% for the lateral head). At the same time, the average EMG amplitude when jumping on the slippery surface decreased (by 60% for the median head and by 80% for the lateral head). As with the rectus femoris, this decrease was accompanied by the increase in the frequency of the bioelectrical activity of the specified muscle (65% for both heads).

Conclusions. The findings helped determine the main regularities in the organization of the lower limb muscle work of winter footballers while balancing on an unstable slippery surface.

All totaled, the results obtained suggest that it is the rectus femoris and calf muscles that are actively involved in the maintenance of equilibrium when jumping on a slippery surface, but the nature of their work changes significantly - the activity of the motor units is desynchronized, while the number of motor units involved grows (as evidenced by the increase in the maximum amplitude). In contrast, the activity of the adductor longus in these conditions is decreased.

The data obtained indicate that complex coordination skills when playing on a slippery surface are as-

Table 1. *Bioelectrical muscle activity rates during exercise (Xm±SE)*

EMG rates	Maximum bioelectrical activity amplitude, μV		Average bioelectrical activity amplitude, μV		Average frequency of *BA*, Hz	
	Exercise on traditional surface	Exercise on slippery surface	Exercise on traditional surface	Exercise on slippery surface	Exercise on *TS*	Exercise on *SS*
Adductor longus of thigh	9024.3±91.9	4460.5±109.5 *p <0.001*	1530.5±36.9	472.8±21.7 *p <0.001*	65.2±4.5	42.7±3.1 *p <0.05*
Rectus femoris	10430.9±294.3	12408.5±273.3 *p <0.05*	1795.5±28.1	772.3±25.9 *p <0.05*	46.7±8.0	75.3±7.1 *p <0.05*
Medial gastrocnemius	5682.4±42.9	13082.5±78.1 *p <0.001*	1880.6±24.7	1257.5±24.7 *p <0.05*	36.7±3.2	59.9±4.1 *p <0.05*
Lateral gastrocnemius	6887.4±258.3	9692.7±125.6 *p <0.05*	1975.2±23.9	1098.3±29.0 *p <0.05*	37.9±2.0	55.2±2.4 *p <0.05*

Significance of intergroup differences: p – between the exercise performance rates on traditional and slippery surface.

sociated with the development of specific movement patterns. Special training programs are required to develop the balancing skills and movement coordination of winter footballers.

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Effect of muscle tension type on lower limb blood flow and dynamics of lung volume rates when mastering punching technique in boxing

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Abstract

Objective of the study was to assess the influence of various types of muscle tension on lower limb blood flow and external respiration rates of skilled boxers when they perform punches.

Methods and structure of the study. Two equivalent groups were involved in the study: Experimental and Control one, consisting of 15 19-23 year-old boxers of the first category each.

The athletes were subjected to a loading test: a series of maximum-force straight blows on a boxing bag to be performed within one round (3 min) at 5-sec rest intervals between the series.

The following research methods were applied:

– *Rheography*. The rheographic complex "RHEO-SPECTRUM" was used to register the regional blood flow rates in the extensor muscles of both thighs and right shoulder before and after the loading test. The following indicators were recorded: rheographic index, amplitude-frequency indicator, Vmax, Vavg, dicrotic index, diastolic index;

– *Spirography*. The "Valenta" Computerized Test System was used to determine the subjects' respiratory rates. The spirographic study was conducted before and after the loading test. Vital capacity and tidal volume were measured. The multifunctional spirometer "MAC-1" was used to determine the expiratory (ERV) and inspiratory (IRV) reserve volumes. The sports medicine formulas were applied to calculate the ratio of tidal volume to vital capacity (TV%), expiratory reserve volume to vital capacity (ERV%), and inspiratory reserve volume to vital capacity (IRV%).

The data obtained were processed using the Statistica 10.0 software package. The significance of differences was assessed using the non-parametric Mann-Whitney test.

Results and conclusions. The findings showed that the straight blow performance by means of the ballistic muscle tension type using the sports outfit that limits the traumatic impact on the hands contributes to the more adequate functioning of the external respiration system and regional blood flow. The improvement of the speed-strength capabilities of the muscles involved in the single punch movement using the standard sports outfit does not contribute to the optimal recovery and motor training of skilled boxers.

Keywords: *lung volume rates, regional blood flow in muscles, sports training, muscle tension type.*

Background. The boxing punching technique biomechanics and the choice of sports outfit determine whether a straight blow is performed using a ballistic or non-ballistic type of muscle tension. The use of the sports outfit that limits the traumatic impact on the hands (boxing gloves) facilitates the performance of a straight blow by means of the ballistic type of muscle tension, and the use of the standard sports outfit (bag gloves) – by the non-ballistic type [4, 6].

It is assumed that muscle tension type has a qualitative impact on the external respiration system and regional blood flow in the lower limbs [3, 4, 7].

Objective of the study was to assess the influence of various types of muscle tension on lower limb blood flow and external respiration rates of skilled boxers when they perform punches.

Methods and structure of the study. Two equivalent groups were involved in the study: Experimental (EG) and Control (CG), consisting of 15 19-23 year-old boxers of the first category each.

The athletes were subjected to a loading test: a series of maximum-force straight blows on a boxing bag to be performed within one round (3 min) at 5-sec rest intervals between the series.

The following research methods were applied:

– *Rheography* [3]. The rheographic complex "RHEO-SPECTRUM" was used to register the regional blood flow rates in the extensor muscles of both thighs and right shoulder before and after the loading test. The following indicators were recorded: rheographic index, amplitude-frequency indicator, V_{max}, V_{avg}, dicrotic index, diastolic index;

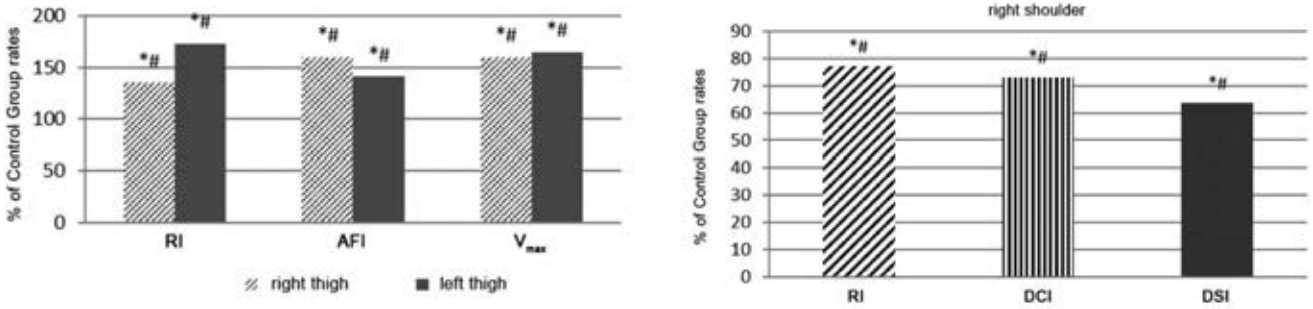
– *Spirography* [1, 2]. The "Valenta" Computerized Test System was used to determine the subjects' respiratory rates. The spirographic study was conducted before and after the loading test. Vital capacity and tidal volume were measured. The multifunctional spirometer "MAC-1" was used to determine the expiratory (ERV) and inspiratory (IRV) reserve volumes. The sports medicine formulas were applied to calculate the ratio of tidal volume to vital capacity (TV%), expiratory reserve volume to vital capacity (ERV%), and inspiratory reserve volume to vital capacity (IRV%) [2].

The data obtained were processed using the Statistica 10.0 software package. The significance of differences was assessed using the non-parametric Mann-Whitney test.

Results of the study. Given in Fig. 1 are the blood flow rates in the thigh and right shoulder of the boxers of the first category. The post-load rheographic index values in the EG exceeded those in the CG by 35% and increased relative to the resting values by 69% ($p<0.05$). The amplitude-frequency indicator values obtained in the EG after the punches performance were higher by 60% than in the CG and exceeded the resting values by 85% ($p<0.05$). In the CG, this indicator increased relative to the resting ones by 21% ($p<0.05$). The post-load V_{max} rates in the EG exceeded those in the CG by 60% ($p<0.05$).

After the load testing, the rheographic index values in the left thigh in the EG were higher by 73% ($p<0.05$) than in the CG. In the EG, these values increased relative to the resting ones by 107%. The post-load amplitude-frequency indicator values in the EG were higher by 41% than in the CG. These results exceeded the resting values by 66% ($p<0.05$). The amplitude-frequency indicator values in the CG increased by 20% after the loading test ($p<0.05$). In the EG, the post-load V_{max} rates were higher by 64% than in the CG, exceeding the resting values by 90% ($p<0.05$). Throughout the testing, there were no statistically significant differences in the V_{avg} rates dicrotic index and diastolic index between the boxers of the first category. At the same time, dicrotic index in the EG after the loading test increased relative to the resting values by 23% ($p<0.05$).

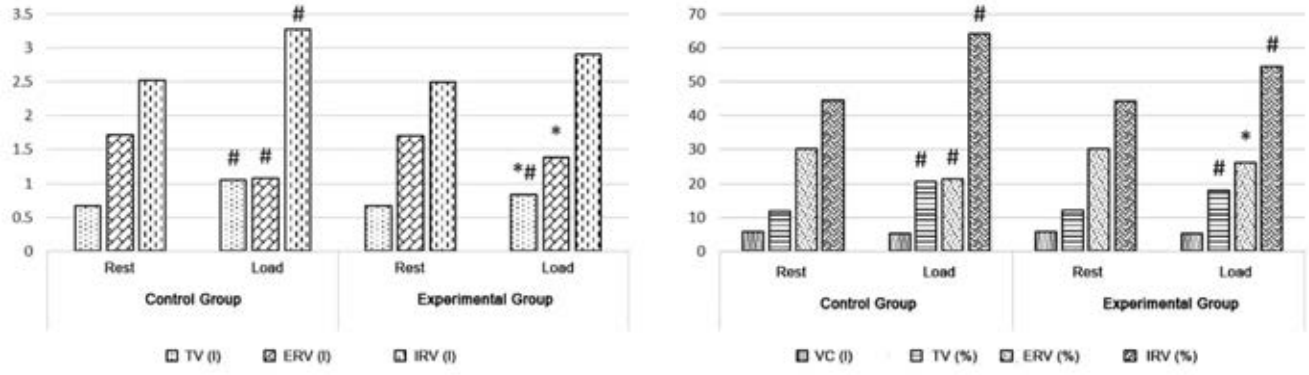
The post-load rheographic index values in the right shoulder were higher by 23% in the EG than in the CG ($p<0.05$). In the EG, the rheographic index values after the load testing were 4.6 times higher than at rest, and in the CG - 5.8 times higher ($p<0.05$). The post-load amplitude-frequency indicator values in both groups increased relative to the resting values by 87% and 113%, respectively ($p<0.05$). The V_{max} rates in the EG after the loading test were 7 times higher than in the quiescent state, while in the CG - 7.6 times higher ($p<0.05$). The V_{avg} rates after the loading test were 6.3 times higher than in the quiescent state for the EG and 6.4 times higher for the CG ($p<0.05$). The post-load CG results exceeded the resting values by 43% ($p<0.05$). The post-load dicrotic index rates in the EG were lower by 27% than in the CG ($p<0.05$). In the EG, the results obtained after the motor task were higher by 33% than at rest, and by 80% than in the CG ($p<0.05$). The post-load diastolic index rates in the EG were lower by 64% than the CG ($p<0.05$). At the same time, the prevalence of the post-load values over the resting ones amounted to 22% in the EG and to 94% in the CG ($p<0.05$).



* – significance of differences between EG and CG, $p<0.05$;

\# – significance of the loading test data relative to the resting level, $p<0.05$.

Fig. 1. *Blood flow rates in the upper and lower limbs in boxers of the first category*



* – significance of differences between EG and CG, p<0.05;

\# – significance of the loading test data relative to the resting level, p<0.05.

Fig. 2. *Spirographic test data in the boxers of the first category*

The vital capacity values in the boxers did not differ statistically significantly before and after the loading test. The tidal volume rates after one round were lower by 21% in the EG than in the CG and by 23% in the EG (p<0.05). In the CG, the test results increased by 56% relative to the baseline level (p<0.05). The post-load expiratory reserve volume values in the EG were higher by 29% (p<0.05) than in the CG (Fig. 2). In the CG, this indicator fell below the baseline level by 37% (p<0.05). There were no statistically significant inter-group differences in the inspiratory reserve volume values. However, in the CG, this value increased by 30% after the loading test (p<0.05, Fig. 2). After the test, the TV% ratio increased by 50% in the EG and by 76% in the CG. The post-load ERV% ratio was found to be higher by 22% in the EG than in the CG. Also in the CG, the resting values were higher by 30% than the post-load ones (p<0.05). The post-load IRV% values in the EG were higher by 23% than at rest, and in the CG – by 45% (p<0.05).

Therefore, the data obtained indicate that it is more economical to perform physical loads by means of the ballistic type of muscle tension, which contributes to the more adequate functioning of the respiratory muscles during athletes' recovery after motor activity. This contributed to the reduction of the functional tension of the external respiration system and regional blood flow.

Conclusions. The findings showed that the straight blow performance by means of the ballistic muscle tension type using the sports outfit that limits the traumatic impact on the hands contributes to the more adequate functioning of the external respiration system and regional blood flow. The improvement of the speed-strength capabilities of the muscles involved in the single punch movement using the standard sports outfit does not contribute to the optimal recovery and motor training of skilled boxers.

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Prevalence of low back pain among physically active study subjects

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Abstract

While the effect of a low level of physical activity on the low back pain prevalence is becoming clear, the possible effect of a high level of physical activity in individuals with the low back pain has received less attention to date.

Objective of the study was to characterize the low back pain (within the last year) taking into account the level of physical activity (moderate and high level).

Methods and structure. This study included 94 subjects (62 with low back pain and 32 healthy persons). The subjects were divided into two subgroups, i.e. students with a moderate level of physical activity (MPA) and students with a high level of physical activity (HPA). An original questionnaire was used to assess the low back pain prevalence.

Results and conclusion. This research revealed that the low back pain affected a considerable group of subjects. The subjects with high level of physical activity declared low back pain more often than their peers with the low back pain. Guidelines for the management of the low back pain recommend to stay active and continue with usual activities. Athletes, coaches, physicians, and physiotherapists should be sensitized to the low back pain problem in athletes and seek to integrate prevention programs in daily training.

Keywords: *low back pain, physical activity, physically active subjects, moderate level of physical activity, high level of physical activity.*

Background. Studies revealed that physical activity is significant for preventing and treating back pain (BP), and the increase in the level of physical activity has become an important part of recommendations in the management of BP [1]. Physical activity exerts an impact on bone modelling, helps to prevent reducing muscular strength, and decreasing postural stability [2,3]. This applies to all people, especially individuals with low back pain (LBP). On the other hand, there is evidence that a high level of physical activity is hazardous on the lower back [4]. While the effect of a low level of physical activity on the LBP prevalence is becoming clear, the possible effect of a high level of physical activity in individuals with LBP has received less attention to date.

Objective of the study was to characterize LBP (within the last year) taking into account the level of physical activity (a moderate and a high level).

Research methods and structure.

Study subjects

This study enrolled 3rd-year students of a Bachelor course in Physical Education. Sixty-two persons with a history of LBP (mean height: 183.1 cm; mean body mass: 81.4 kg), and 32 healthy persons without LBP (mean height: 179.9 cm; mean body mass: 79.3 kg) were qualified for the study. Healthy persons had no history of LBP within the last year. Students with such spinal diseases which may cause BP as Scheuermann's disease, spondylolysis, spondylolisthesis, rheumatic diseases, tumours, sarcomas, etc., were excluded from the study. The subjects were divided into two subgroups, i.e. (a) students with a moderate level of physical activity (MPA) and (b) students with a high level of physical activity (HPA). The inclusion criteria

Table 1 *The prevalence of LBP taking into account the level of physical activity*

		All n=94	MPA n=46	HPA n=48	*p* value
LBP	n (%)	62 (66.0)	27 (58.7)	35 (72.9)	0.15
Healthy	n (%)	32 (34.0)	19 (41.3)	13 (27.1)	

LBP – low back pain; MPA – moderate level of physical activity; HPA – high level of physical activity. Statistical significance was set at p<0.05.

in the MPA group were as follows: a) attending physical education classes included in the curriculum within three years of studying (each student attends 798 h of sports classes); b) undergoing no sports training at the time of the research or in the past (within the last year); c) taking up leisure-time physical activity no more than once per week and no longer than 60 min. The inclusion criteria in the HPA group were as follows: a) attending physical education classes included in the curriculum; b) training a minimum of 90 min per day – 5 times per week, c) training experience – a minimum of 3 years. The HPA group included individuals who trained one of the following team sports: handball or volleyball.

All the subjects gave their written informed consent. The study was conducted in accordance with the Declaration of Helsinki, and the research was accepted by the Senate Scientific Research Ethics Commission (1/2019).

Questionnaire

A questionnaire was used to assess the LBP prevalence [5]. The first page of the questionnaire included an explanation of the study aim and instructions. The personal information section consisted of questions about age, body mass, and height. The first section of the questionnaire included questions regarding:

a) training (sport) – sports discipline, number of training days per week, number of training hours per day;

b) experiencing LBP within the last year (12 months). LBP was assessed using the following question: „Have you experienced low back pain for the last year (12 months)?". The answer options were: „no", „yes". "Yes" was considered to denote the presence of LBP. Individuals who responded negatively to this question were asked not to answer the remaining questions.

Individuals who declared that they had experienced LBP in the period of the last year answered the question in the second part. The second part of the questionnaire included a question regarding the frequency of LBP, the situation in which LBP occurred or increased, and difficulties in everyday life caused by LBP.

Statistical analysis

The collected material was analysed with the use of Statistica 13.3 calculation software. The qualitative parameters were described using basic measurements of descriptive statistics for qualitative variables, i.e. percentage. Chi square test was used to identify significant differences in the percentage of LBP and healthy subjects at different levels of physical activity, and to compare the frequency of LBP taking into account the level of physical activity.

Results and discussion.

Prevalence and frequency of LBP

Out of 94 study subjects, 62 (66.0%) declared having experienced LBP within the last 12 months. LBP is more common among the subjects with a high level of physical activity (HPA) than among their peers with a moderate level of physical activity (MPA) (72.9% vs. 58.7%, respectively). However, this difference was not significant (p=0.15) (Table 1).

The largest group is constituted by respondents who experienced pain rarely, i.e. 1–2 times per year (46.7%). While analysing the frequency of LBP with regard to the level of physical activity, it was noted that the subjects with HPA declared rare pain (1-2 times per year) often than the subjects with MPA (48.4% vs. 44.4%, respectively). Frequent and constant pain (more than 1-2 times per month) was also declared often by students with HPA (34.3% vs. 25.9%, for HPA and MPA, respectively). The difference was not statistically significant (p=0.48) (Table 2).

Circumstances in which LBP occurred or increased and difficulties in everyday life caused by LBP

The most common circumstances in which LBP occurred or increased included standing (41.9) and sit-

Table 2 *The frequency of LBP taking into account the level of physical activity*

Frequency of occurrence of BP	%	All n=62	MPA n=27	HPA n=35	*p* value
Very rare LBP (1-2/year)	n (%)	29 (46.7)	12 (44.4)	17 (48.6)	0.48
LBP a few times a year (3-6/year)	n (%)	14 (22.6)	8 (29.6)	6 (17.1)	
Frequent or constant LBP (more than 1-2 months)	n (%)	19 (30.7)	7 (25.9)	12 (34.3)	

LBP – low back pain; MPA – moderate level of physical activity; HPA – high level of physical activity. Statistical significance was set at p<0.05.

Table 3. *Circumstances in which LBP occurred or increased and difficulties in everyday life caused by LBP*

Circumstances in which LBP occurs or increases*	%	All n=62	MPA n=27	HPA n=35
Sitting	n (%)	23 (37.1)	11 (40.7)	12 (34.3)
Standing	n (%)	26 (41.9)	11 (40.7)	15 (42.9)
Lying	n (%)	15 (24.2)	6 (22.2)	9 (25.7)
Lifting heavy objects	n (%)	18 (29.0)	7 (25.9)	11 (31.4)
Performing household chores (cleaning, cooking, getting dressed)	n (%)	7 (11.3)	3 (11.1)	4 (11.4)
Physical effort	n (%)	21 (25.9)	7 (25.9)	14 (40.0)
The influence of LBP on the undertaken PA				
No influence	n (%)	34 (66.7)	11 (55.0)	23 (65.7)
I limited the amount of PA when the pain is very intensive	n (%)	13 (25.5)	7 (35.0)	6 (17.1)
I gave up PA because of pain	n (%)	4 (7.8)	2 (10.0)	2 (5.7)
A higher intensity of LBP during physical exercises				
No	n (%)	35 (56.5)	20 (74.1)	15 (42.9)
Yes	n (%)	27 (43.5)	7 (25.9)	20 (57.1)
Difficulties in everyday life caused by LBP*				
Sitting	n (%)	38 (61.3)	15 (55.5)	23 (65.7)
Standing	n (%)	32 (51.6)	9 (33.3)	23 (65.7)
Lifting objects	n (%)	19 (30.6)	8 (29.6)	11 (31.4)
Performing household chores (cleaning, cooking, getting dressed)	n (%)	10 (16.1)	3 (11.1)	7 (20.0)
Learning and concentration	n (%)	15 (25.01	8 (29.6)	7 (20.0)
Sleeping	n (%)	16 (25.8)	6 (22.2)	10 (28.6)
Walking	n (%)	8 (12.9)	4 (14.8)	4 (11.4)

* The numbers do not add to 100% since the respondents were allowed to choose more than one answer.

LBP – low back pain; PA – physical activity; MPA – moderate level of physical activity; HPA – high level of physical activity.

ting (37.1). While analysing the circumstances taking into account the level of physical activity, it was noted that in such circumstances as standing (42.9), physical effort (40.0), and lifting heavy objects (31.4) LBP occurred and increased in the subjects with HPA more often than in the subjects with MPA (Table 3).

Difficulties in everyday life associated with LBP were also analyzed. Over 20% of the respondents limited their physical activity, while 7.9% had to give up physical activity altogether due to LBP. The subjects with MPA often limited their physical activity and had to give up because of pain than the subjects with HPA. In 43.5% of the subjects, LBP intensified during physical activity, often among the subjects with HPA. Over 60% of the subjects reported that LBP made it difficult for them to sit for prolonged periods, while prolonged standing was difficult for nearly 50% (Table 3).

The incidence of LBP in athletes has been examined in other studies [6,7]. Studies revealed that similar to the general population, the prevalence of LBP among athletes is high (between 10% to 67%) and LBP seems to be a problem in some sports. LBP occurred more often in sports and competitions which require substantial (especially axial) spinal loads, require a flexed position of the back, and frequent back twisting movements [6]. However, we need to be very cautious before blaming a high level of physical activity – or one particular form of exercise - for the onset or deterioration of LBP. While a high level of physical activity has been associated with an increased risk of self-reported LBP, a moderate level of physical activity protects persons with LBP from returning and chronic pain [4].

Conclusions. This research revealed that LBP affected a considerable group of subjects. The subjects with HPA declared LBP more often than their peers with MPA. Guidelines for the management of LBP recommend remaining active. While 'keep active' might seem an odd recommendation for athletes with LBP, inactivity for an athlete with LBP can increase their chance of getting injured, which ultimately results in further inactivity and potentially more pain. Emphasizing physical activity as a means to treating LBP remains an appropriate message. Additionally, athletes, coaches, physicians, and physiotherapists should be

sensitized to LBP problem in athletes and seek to integrate prevention programs in daily training.

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Bone mineral density in professional female volleyball players and dietary factors

UDC 796.012.6: 613.72

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Abstract

An excessive volume and intensity of physical effort which takes place during sports training, and many years of playing career are not protected against the development of osteoporosis.

Objective of the study was to assess the current bone mineral density in female professional volleyball players and the intake of selected dietary components, compared with women not practising sport.

Research methods and structure. The study included 40 female students from the University of Physical Education in Biala Podlaska. Bone mineral density (BMD) was determined in the humerus and in the whole skeleton using Dual Energy X-ray Absorptiometry (DEXA) method. The study was carried out using the HORIZON Ci device (USA). Using this device basic an-thropometric indicators were measured: body weight (kg), body height (cm), Body Mass Index in kg/m2 and fat tissue content in %. Nutritional assessment was made on the basis of three diet-related interviews, each of which focused on a period of 24 hours (two working days and one day off). Most portions that were consumed were verified with the use of "Products and meals photo album" prepared by the National Food and Nutrition Institute in Warsaw. The amounts of proteins, calcium, phosphorus, magnesium and vitamin D in daily food rations were calculated with "Dieta.5.0" software (NFNI). The obtained results were compared with the nutritional norms [7] taking into account age, gender and physical activity. The norm at the level of esti-mated average requirement (EAR) was applied for all the analysed nutrients except vitamin D (according to nutritional recommendations, the norm at the level of adequate intake (AI) was used).

Results and conclusions. The presented study provides evidence for positive effect of physical activity on bone tissue metabolism in junior female professional volleyball players. It is recom-mended to constantly monitor bone parameters of junior female athletes in the period of reaching their peak bone mass is advisable in terms of prevention of osteoporosis as female athletes are at increased risk of this disease. Such a monitoring should be multifaceted, taking into account the nutrition model and hormonal diagnosis.

Keywords: *female volleyball players, BMD, dietary factors.*

Introduction. Osteoporosis has been considered by the WHO as a civilisation disease, and defined as an 'epidemic of the 21st century'. It is a systemic skeletal disease characterized by the loss of bone mass and its disrupted architecture. It has a latent course and its clinical symptoms are most often manifested in the form of increased bone fragility and an increased risk of fractures [1, 2]. Many scientific studies demonstrate a number of osteoporosis risk factors, including those modifiable, which are associated with life style [3, 4]. Physical effort is one of its elements. Regular physical activity with a training load undertaken in childhood and during the period of adolescence improves the metabolic profile, decreases the risk of obesity, improves the functioning of the cardiovascular system, and prevents the development of diabetes [5, 6]. In addition, it exerts an effect on bone mineral density. However, females who are highly active physically are not protected against the occurrence of cardiovascular diseases, or disorders of bone tissue metabolism, compared to those who undertake moderate exercises. This situation is due to an exces-

sive volume and intensity of physical effort which takes place during sports training, and many years of playing career.

Objective of the study was to assess the current mineral bone density (the whole skeleton, the right and left humerus) in players professionally training volleyball, and consumption of the selected dietary components, compared to women who do not practice sports.

Research methods and structure. The study included 20 female students from the University of Physical Education who professionally trained volleyball, aged 19-21. The training period in the examined female athletes was 7.71±3.85. The players trained 5 days a week, on average (5.36±0.48), and their weekly training load was 9.57±3.08 hours. The control group were women who were not highly active physically (students of cosmetology from the University in Bia a Podlaska). The women were informed of the objectives and methodology also how the survey was conducted. The participation was voluntary and the participants could withdraw from the experiment at any time. All procedures were approved by the Ethics Committee for Scientific Research at Jozef Pilsudski University of Physical Education in Warsaw. Bone mineral density (BMD) was determined in the humerus and in the whole skeleton using Dual Energy X-ray Absorptiometry (DEXA) method. The study was carried out using the HORIZON Ci device (USA). Using this device basic anthropometric indicators were measured: body weight (kg), body height (cm), Body Mass Index in kg/m2 and fat tissue content in %. Nutritional assessment was made on the basis of three diet-related interviews, each of which focused on a period of 24 hours (two working days and one day off). Most portions that were consumed were verified with the use of "Products and meals photo album" prepared by the National Food and Nutrition Institute in Warsaw. The amounts of proteins, calcium, phosphorus, magnesium and vitamin D in daily food rations were calculated with "Dieta.5.0" software (NFNI). The obtained results were compared with the nutritional norms [7] taking into account age, gender and physical activity. The norm at the level of estimated average requirement (EAR) was applied for all the analysed nutrients except vitamin D (according to nutritional recommendations, the norm at the level of adequate intake (AI) was used). The presented work includes initial results of research realised within the scientific project titled "Assessment of bone parameters in women practising different sports", which was approved by the Ethics Committee for Scientific Research at Jozef Pilsudski University of Physical Education in Warsaw. Statistical analysis was performed with the use of one-way ANOVA, where the level of significance was set at $p < 0.05$.

Results. Table 1 presents anthropometric characteristics of the examined females. It was found that the mean body weight was considerably higher in volleyball players (66.17 kg), compared to the non-training group (62.5 kg) – by 5.9 %. However, an opposite relationship was noted taking into account the BMI. The examined females from both groups were characterized by age-appropriate amount of body fat, with its higher percentage observed in non-training women.

Considering the measurement of bone mineral density (BMD w g/cm2) in the right and left humerus (Tab. 2) it was confirmed that the mean values were higher in the group of volleyball players, especially on the right side (athletes 0.817g/cm2, control group 0.784 g/cm2; difference + 4.03%, $p < 0,05$). The same relationships were observed in the case of whole-skeleton BMD, where the mean value of bone density in volleyball players was 1.184 g/cm2, whereas in non-training women – 1.147 g/cm2 (difference +8.87% for the benefit of the players, $p < 0,05$). It was found that higher values of the whole-skeleton

Table 1. *Somatic characteristics of female athletes and controls*

Study group	Body weight (kg)	Body height (cm)	Body Mass Index (kg/m²)	Fat tissue (%)
Volleyball players	66,17±10,26	176,33±5,35	21,26±2,90	32,35±5,67
Control group	62,50±3,54	167,1±6,30	22,33±2,57	33,07±2,42

Table 2. *Bone mineral density (BMD) in female volleyball players and controls*.

Study group	BMD (g/m²)			BMD of the whole skeleton with regard to referential values for age groups (%)
	Right humerus	Left humerus	whole skeleton	
Volleyball players	0,817±0,007	0,787±0,018	1,184±0,081	105,5±2,12
Control group	0,784±0,049	0,749±0,036	1.079±0.168	102,3±4,93

Table 3. Selected *nutrients in daily food rations* of *female athletes and controls*

Study group	Protein (g)	Calcium (mg)	Phosphorus (mg)	Ca: P	Magnesium (mg)	Vitamin D (ug)
Volleyball players	62,39±19,69 (115,1%)*	750,51±556,79 (83,2%)*	1039,07 ± 405,65 (179,2%)*	1:1,4	209,03±89,55 (82%)*	1,59±1,27 (31,8%)*
Control group	56,97±31,33 (109,9%)*	604,43±286,87 (75,6%)*	916,00±458,94 (157,9%)*	1:1,5	199,56±92,00 (78,3%)*	0,94±2,79 (18,9%)*

* mean percentage of realisation of the norm at the level of estimated average requirement (EAR) and level of adequate intake (AI) for the group are given in brackets.

mineral bone density, expressed in percentage of the mean referential value for age, were obtained by players, compared to non-training women – 105.5% and 102.3%, respectively (difference +3.03%).

The consumption of proteins was higher in the group of volleyball players (62.39 g) than in the control group (56.97 g). The mean supply of calcium was from 750.51 mg/daily (83% of the EAR) in the players, up to 604.43 mg/daily (approximately 76% of the AI) in women from the control group. The analysis of the phosphorus consumed with the diet revealed its supply exceeded the EAR standard (athletes 179% and control group 158%). In all examined women the dietary calcium to phosphorus ratio was abnormal, and differed to a greater extent from the preferred value in the control group (1:1,5). The study of the amount of magnesium consumed with the diet it revealed the diet of professional volleyball players supplied a greater amount of this microelement, compared to that of young women not practicing sports professionally. Nevertheless, in both groups the percentage of the EAR for the intake of this macroelement ranged from the value 78 (control group) to 82 (players). It was noted that the consumption of vitamin D was insufficient in both groups of women. In the players its supply was on the level of 32.4% of the AI (1.59 ug), while in the control group – 18.9% of the AI (0.94). Table 3 demonstrate the results.

Discussion. Physical activity properly adjusted from the aspect of its form and intensity, pursued with the maintenance of dietary recommendations, prevents the loss of BMD and in this way reduces the risk of bone fractures. Various types of physical exercises exert a different effect on the bone remodelling [8]. Sports involving impact loading, including gymnastics, volleyball, basketball, and aerobic show a much higher osteogenic effect than sports which do not require such loading, e.g. cycling, rowing and swimming. Many of these scientific reports concern female players who have ended their sports career. The presented study provides evidence for positive effect of physical activity on bone tissue metabolism in the junior female professional volleyball players. It was found that in the female athletes who professionally practice this sport discipline aged 19-21, the bone characteristics were higher in both humerus bones, and in the whole skeleton. The results obtained are in accordance with a study by Valente-dos-Santos et al. [9] conducted among volleyball players aged 14-17 from Portuguese clubs. The researchers observed that the whole-skeleton mineral density in the junior volleyball players was 1.184 g/cm2 , and was significantly higher compared to females practising swimming, within the range of 5.5%.

Diet is one of the most important factors modifying the mineralization of the bone tissue. A great role in the osteoporosis prevention is ascribed to an appropriate content of calcium and vitamin D in the diet. The conducted studies indicted that daily food rations of both volleyball players and young women from the control group did not supply the recommended amount of calcium and vitamin D, compliant with nutritional standards. Calcium deficiency in combination with the vitamin D deficiency, with the disturbed process of intestinal absorption results in an increased resorption of bone tissue. Farrokhyar [10] assessed the vitamin D deficiency scale analyzing the 25(OH)D blood levels; its deficiency was observed in as many as 56% of sports persons, and it was conditioned by the geographic location. It is also important for the proper bone mineralization to maintain calcium-phosphate homeostasis; therefore, the ratio between these elements in food should be 1:1. In our study this homeostasis was disturbed. Magnesium plays an important role in many basic processes within the cell, muscle contractility, in mineral homeostasis of the body and skeleton. It may affect the formation of hydroxyapatite crystals and result in an increase in the mineral bone density. The abnormalities observed in the diet of young females need to be corrected.

Conclusions. It is recommended to constantly monitor bone parameters of the junior female ath-

letes in the period of reaching their peak bone mass is advisable in terms of prevention of osteoporosis as female athletes are at increased risk of this disease. Such a monitoring should be multifaceted, taking into account the nutrition model and hormonal diagnosis.

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Automated biochemical methods to assess muscle and myocardial damage in athletes

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Abstract

Objective of the study was to determine the effects of training loads on the blood level of muscle damage biomarkers, including cardiac biomarkers, in qualified male biathletes.

Methods and structure of the study. Subject to the study were 10 males aged 18-23 years (MS and CMS), height - 176.5±2.1 cm, body mass - 69.4±1.8 kg (Experimental Group (EG)). The Control Group was made of 10 male handball players aged 18-21 years and having the same sports skill level. The study was carried out at Kavgolovo Training Center and Medical Center of P.F. Lesgaft National State University of Physical Education, Sport and Health in two stages: preparatory (October-November 2018) and competitive (January-February 2019) periods of the one-year training cycle. The EG subjects were asked to ski using a freestyle technique for 120 minutes at a steady pace, with a heart rate of 140-160 bpm. The blood samples were taken from the vein on an empty stomach before and after training using the vacuum tubes with gel. The body response to physical loads was studied during the delayed recovery period, for which blood was collected 12-14 hours after training. The tests were conducted using the automatic analyzers Architect SR and Abbott (USA) reagents and control materials. The following biochemical indicators of the blood serum were assessed: total creatine phosphokinase (CK) activity, amount of cardiac isoform of creatine phosphokinase (CK-MB) by mass, levels of highly-sensitive troponin I (Tn), testosterone, creatinine, urea nitrogen, total cholesterol. The blood tests took less than 40 minutes.

Results and conclusion. The biochemical control using the high-tech methods for determining the blood levels of cardiac Tn, CK, urea nitrogen, and other laboratory blood readings helps coaches to determine the effects of training loads on the body of athletes in a timely and objective manner, adjust the training process, estimate the body's adaptation to training loads, and detect cardiac and muscle disorders.

Keywords: *biathlon, adaptation, heart, muscles, troponin I, creatine kinase.*

Background. Modern sports impose specific requirements on the functional training of athletes. Changes in the body primarily affect the metabolites, which number regulated by enzymes [1, 4]. Most of the remaining proteins are located in the cells, and the release of these molecules (biomarkers) into the bloodstream indicates increased permeability of the cell membranes and/or cell death. Automated biochemical and immunochemical tests are gradually becoming part of the practical work of coaches and doctors in sports medicine, which, in turn, makes it possible to evaluate metabolic changes in the body of athletes and timely adjust the training process [1, 2].

Objective of the study was to determine the effects of training loads on the blood level of muscle damage biomarkers, including cardiac biomarkers, in qualified male biathletes.

Methods and structure of the study. Subject to the study were 10 males aged 18-23 years (MS and CMS), height - 176.5±2.1 cm, body mass - 69.4±1.8 kg (Experimental Group (EG)). The Control Group was made of 10 male handball players aged 18-21

years and having the same sports skill level. The study was carried out at Kavgolovo Training Center and Medical Center of P.F. Lesgaft National State University of Physical Education, Sport and Health in two stages: preparatory (October-November 2018) and competitive (January-February 2019) periods of the one-year training cycle. The EG subjects were asked to ski using a freestyle technique for 120 minutes at a steady pace, with a heart rate of 140-160 bpm. The blood samples were taken from the vein on an empty stomach before and after training using the vacuum tubes with gel. The body response to physical loads was studied during the delayed recovery period, for which blood was collected 12-14 hours after training. The tests were conducted using the automatic analyzers Architect SR and Abbott (USA) reagents and control materials. The following biochemical indicators of the blood serum were assessed: total creatine phosphokinase (CK) activity, amount of cardiac isoform of creatine phosphokinase (CK-MB) by mass, levels of highly-sensitive troponin I (Tn), testosterone, creatinine, urea nitrogen, total cholesterol. The blood tests took less than 40 minutes.

Results and discussion. At the first stage of the study, we assessed the athletes' health status before the start of the competitive period after the day of rest; no athlete was found to be in the state of overtraining.

The educational experiment was designed to assess the degree of biomarker changes induced by the standardized training loads that lasted at least 90 minutes. During training, the average and maximum HR, duration (min) and distance (km) were recorded. The athletes themselves assessed their state of health after training using a 7-point scale (from 1 - very bad to 7 - excellent). The results obtained helped define model characteristics of training loads in the training process of biathletes. At the first stage, the training session lasted 114.0±3.8 min, the distance was 22.7±0.7 km, the average HR was 139.5±2.6 bpm, the maximum HR - 167.1±2.9 bpm. The pulsometry indicators indicated the aerobic nature of training loads. The subjective assessment of well-being showed that all athletes felt well.

The timing of blood collection after training is very important for the correct interpretation of the test results. Thus, patients are found to have an elevated Tn level within 12 hours after the onset of myocardial infarction, and the highest Tn level - within 12-14 hours. The biomarker level is then normalized within 7 days [2, 5]. The Tn blood level in the EG athletes was 15.1±5.9 ng/l. In two athletes, the troponin I level exceeded the limits of the normal range at the normal CK-MB level. It is believed that significant cardiac cell death occurs when the Tn level rises more than tenfold in relation to the upper limit of normal [5]. The CK-MB level in the athletes was 3.8±0.4 ng/ml and did not exceed the upper norm. The total CK activity in most biathletes, as before training, exceeded the normal values for healthy persons and was 284.6±42.3 u/l.

In assessing the biathletes' myocardial contractile response to training loads, cardiac Tn showed

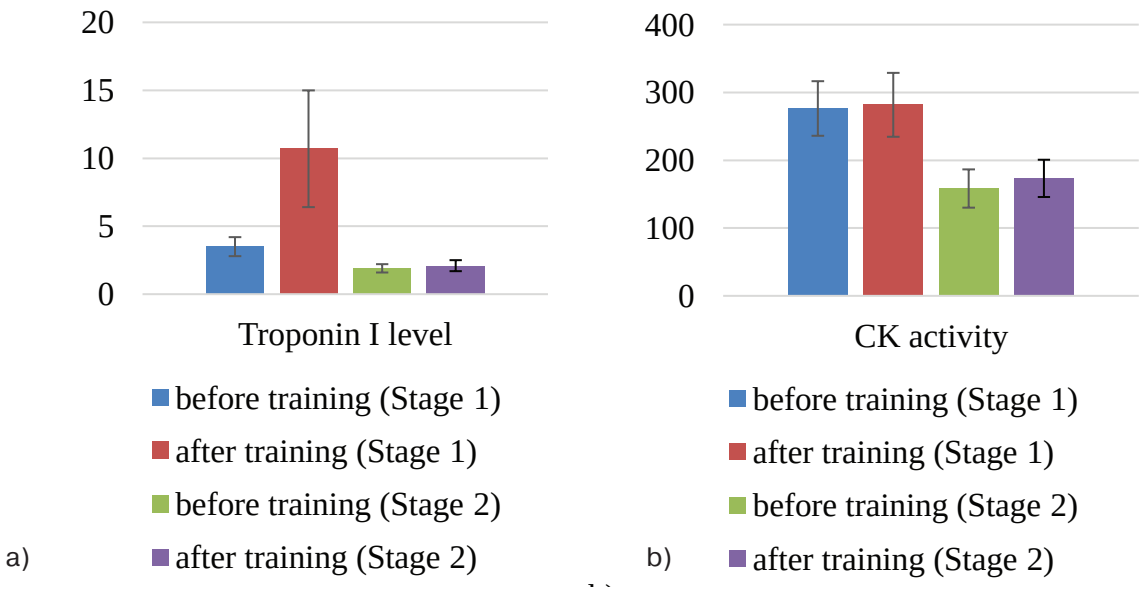

Fig. 1. *Level of laboratory markers of myocardial and muscle damage throughout training cycle, Tn, ng/l (a) and total CK activity d/l (b), see explanations in text*

greater sensitivity compared to the CK-MB level. Further study of the CK-MB dynamics was not helpful, and it was decided to remove the marker from further studies.

The competitive period started in December and lasted until the end of March. After a three-month training, the second phase of the study was carried out (January-February 2019). At this time, the biathletes trained and participated in national competitions; one athlete came down with mononucleosis and was excluded from the study. The subjects (n=9) were to ski using a freestyle technique in the evening. To standardize the physical loads, the training model characteristics were compared to the results obtained in October. The functional load on the body was similar to that in autumn; the subjective assessment of well-being during training did not differ from the data obtained at the first stage of the study. A correlation analysis using the Pearson criterion was carried out to assess the correlation between the sports results (10 km sprint event of biathlon) and myocardial damage biomarker level. There was a weak positive (r=0.49) correlation between the Tn level and the result of the race. Increased Th levels correlated with the decrease in the biathletes' speed at the distance. No such correlation was found between the CK activity, other biochemical indicators, and net time in the sprint race. The majority of the athletes were in good fitness shape both in terms of the laboratory tests and the coach's evaluation. The biathletes' overexertion and overtraining due to a large number of competitions in the previous month were not observed. The changes in the biochemical indicators of the biathletes demonstrated the degree of adaptation of their body to the loads proposed within the training macro-cycle (3 months) (Fig. 1, a).

In the competitive period, the Tn level and CK activity decreased compared to the results obtained after training in November. In November, the level of Tn after physical loads in several athletes increased many times in a state of rest. At the second stage, the cardiac Tn level was normalized in all athletes, except Athlete 3,. It can be argued hence that from November to February, the Tn intensity was adequate for the athletes, their functional condition improved (Fig. 1, b).

The decline in the total CK activity from the preparatory to the competitive periods indicated the adaptation of the athletes' skeletal muscles. These typical changes in the CK activity are also noted in the work of I.L. Rybina [3].

To compare the effects of training loads on the level of muscle and myocardial damage biomarkers, the body reaction of the handball players was studied. The tests were conducted at the same time, the intensity and duration of the training loads did not differ significantly from those in the EG. The handball players (n=10) were characterized by the high activity of total CK at the first and second stages of the study (on average 598.2±130.7 u/l). The training effects of the situational sport discipline did not affect the cardiac Tn (in autumn, the next morning after training 2.9±0.7 ng/l, at the second stage - 3.4±1.3 ng/l). It can be assumed that the heart performance in this sport discipline determines the athletic result to a lesser extent. An abnormal increase in the total CK activity was detected in one handball player (21009 u/l) in spring. We believe that such a CK level was primarily due to his game position - a goalkeeper. As a result of massive muscle damage from the ball, the blood level of CK increased significantly.

Conclusion. The biochemical control using the high-tech methods for determining the blood levels of cardiac Tn, CK, urea nitrogen, and other laboratory blood readings helps coaches to determine the effects of training loads on the body of athletes in a timely and objective manner, adjust the training process, estimate the body's adaptation to training loads, and detect cardiac and muscle disorders.

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Peter lesgaft's educational heritage and humanistic personality progress ideas

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Abstract

Objective of the study was to analyze the core ideas of P.F. Lesgaft in the context of the physical education system design and management basics that he developed with a special attention to their humanistic priorities.

Results and discussion. Peter F. Lesgaft was one of the renowned public figures of the late 19 to early 20 centuries. His research and educational service was heavily influenced by the ideas of these and other progressive thinkers, revolutionary democrats and natural scientists of Russia. He comprehensively and extensively analyzed the-then physical education service design and management experiences of England, Germany, France, Greece, etc. to demonstrate their scientific inconsistency and offer his own physical exercising systems on the whole and gymnastics systems in particular.

He underlined the drawbacks of the above one-sided systems when formed and presented to the scientific community his core idea of the individual comprehensive and harmonic development driven by a well-designed physical education service. He firmly believed that such physical education service secures progress not only in the specific physical qualities and motor skills but also in spiritual and moral values and intellectual resource. Peter Lesgaft was particularly successful in developing an original individual harmonic progress theory for what he called an "ideal normal personality". He also argued that physical, mental, moral and aesthetic education process and progress are inextricably correlated, with every success in one of these domains always beneficial for the others. Peter Lesgaft gave a special priority to the morality building education considered "consequential to the strictly designed and managed intellectual and physical education".

Results and conclusion. The Peter Lesgaft's physical-education-related ideas and concepts are still highly appreciated and considered systemic and inclusive as they combine the deep knowledge of anatomy, physiology and pathology with no less extensive knowledge of psychology and pedagogy, plus exceptional theoretical and practical physical education knowledge. This knowledgebase and ideas are still relevant nowadays as they effectively encourage and inspire deeper research in the physical education sector to better understand the nature of physical education as a cultural phenomenon within the evolving framework of the modern physical education theory.

Keywords: *Peter Lesgaft, educational heritage, physical education and sports.*

Background. Lesgaft National State University of Physical Education, Sport and Health (St. Petersburg) proudly celebrates its 125th anniversary in 2021 making a glorious evolution from the Peter Lesgaft Higher Courses for Physical Education Teachers and Managers to the modern multidisciplinary educational establishment reporting to the Ministry of Sports of the Russian Federation.

Presently the national physical education and sports community gives a high priority to the academic physical education system modernization initiatives with a special emphasis on its humanizing and cultural functions to build up spiritual values and priorities and facilitate the general cultural and professional progress of every student. This is the reason why the physical education theory needs to be revised so as to offer new progress paradigms on a sound theoretical and practical basis. It should be emphasized that the national physical education and sports community highly appreciates the invaluable contribution and original ideas of Peter Lesgaft, an outstanding scientist, teacher and social servant [1, 3].

Objective of the study was to analyze the core ideas of P.F. Lesgaft in the context of the physical edu-

cation system design and management basics that he developed, with a special attention to their humanistic priorities.

Results and discussion. Peter F. Lesgaft was one of the renowned public figures of the late 19 to early 20 centuries including L.N. Tolstoy, N.G. Chernyshevsky, N.A. Dobrolyubov, N.I. Pirogov, D.F. Ushinsky, A.D. Butovsky et al. His research and educational service was heavily influenced by the ideas of these and other progressive thinkers, revolutionary democrats and natural scientists of Russia. He comprehensively and extensively analyzed the-then physical education service design and management experiences of England, Germany, France, Greece, etc. to demonstrate their scientific inconsistency and offer his own physical exercising systems on the whole and gymnastics systems in particular.

He underlined the drawbacks of the above one-sided systems when formed and presented to the scientific community his core idea of the individual comprehensive and harmonic development driven by a well-designed physical education service. He firmly believed that such physical education service secures progress not only in the specific physical qualities and motor skills but also in spiritual and moral values and intellectual resource. P.F. Lesgaft was particularly successful in developing an original individual harmonic progress theory for what he called an "ideal normal personality". He also argued that physical, mental, moral and aesthetic education process and progress are inextricably correlated, with every success in one of these domains always beneficial for the others. Peter Lesgaft gave a special priority to the morality building education considered "consequential to the strictly designed and managed intellectual and physical education" [2].

We give a special credit to Peter Lesgaft for the close correlation between human anatomy, physical education and history that he found and then always emphasized that the principle of historicism is critical for understanding evolution of any science. He even opens up his physical education manual for preschoolers by a historical background. This publication was in fact the first truly scientific work on the global physical education history – since the prior physical education-related foreign and national publications were designed exclusively on a chronological facts-listing basis. Peter F. Lesgaft was the first to theoretically analyze the physical education history and facts from the early antique period to the late 19th century. It may be pertinent to mention in this context that thereby he laid a basis for the physical education history as a new research discipline.

Furthermore, Peter Lesgaft was the first to come up with the idea of biological and anthropological aspects of the theoretical and practical physical education service, and repeatedly underlined the key role of physical activity for individual health agenda. He used this concept to develop his biological and pedagogical doctrine followed by a systemic physical education theory.

In his efforts to develop the individual physical education and culturing system, Peter Lesgaft established a number of basic laws, including the law of harmony, law of gradual consistent progress, and the exercise law which deserves special attention and appreciation as a basis of the modern physical education system. He also designed an "ideal normal personality" model with the harmonized spiritual and physical (physical education) progress components. It is important that he closely correlated the physical education service with the labor education plus spiritual and moral values and qualities cultivation service; and this is the fundamental difference of the Peter Lesgaft's physical education theory from other physical education systems and theories.

It may be said with confidence that the Peter Lesgaft's physical education system is still relevant nowadays as it rests on a sound scientific foundation. The core idea of the system is to develop respect to labor and diligence in a young person for efficient physical work and social contributions. Peter Lesgaft gave a comprehensive theoretical substantiation for a wide variety of physical education models and tools customizable for the age groups and individual progress needs and abilities; with much attention paid to team sports and some other sports disciplines including athletics, swimming, skating, wrestling, etc. He offered a few brilliantly designed practical physical education systems for a range of training goals, with the individual physical education progress testable by systematic anthropometric tests. Peter Lesgaft was the first to critically analyze, on a sound research foundation, foreign gymnastics systems and misleading theories of physical activity. He was particularly demanding to the physical education service management training system. On the whole, the physical education system he designed and promoted still inspires the physical education and sports communities by its great pedagogical enthusiasm and optimism [4]. P.F. Lesgaft

paid great attention to the studies of the structures and shapes of the human organs in the context of their functions, external environmental effects, age-specific variations and reasons for the anomalies.

The Peter F. Lesgaft's study "On the physical education relation with anatomy" and a few other studies demonstrated the physical education benefits for modern society, conditional on the physical education service being designed and managed on sound theoretical provisions. It was due to his exceptional erudition that he created a physical education system totally different from the prior systems in many aspects, particularly in the comprehensive scientific foundation formed by the-then physical education theory.

Every natural-scientific, pedagogical and journalistic publication by Peter Lesgaft is well supported by good methodological provisions. He considered scientific methodology as an indispensable progress driver and emphasized that "every science should have its own philosophy, since no science exists without a subject-analyzing philosophy". He expected a scientific thinking being progressive, with the mission of secondary and higher education being rather to "develop the individual thinking resources to effectively analyze and encourage the progress agendas" than only accumulate knowledge as such. His concepts of theoretical anatomy opened up the way to the knowledge synthesizing and broad objective generalization initiatives [1].

Conclusion. The Peter Lesgaft's physical-education-related ideas and concepts are still highly appreciated and considered systemic and inclusive as they combine the deep knowledge of anatomy, physiology and pathology with no less extensive knowledge of psychology and pedagogy, plus exceptional theoretical and practical physical education knowledge. This knowledgebase and ideas are still relevant nowadays as they effectively encourage and inspire deeper research in the physical education sector to better understand the nature of physical education as a cultural phenomenon within the evolving framework of the modern physical education theory.

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Education research schools at lesgaft university: founders, followers and progress milestones

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Abstract

Objective of the study was to analyze the education and research progress history of the Lesgaft Na-tional State University of Physical Education, Sport and Health.

Results and Conclusion. It should be emphasized that many biomedical schools in the country were founded by P.F. Lesgaft. One of them is the Sports Functional Anatomy Research School at the Anat-omy Department.

The multisided research activity of the education research school at the Anatomy and Physiology De-partments encouraged many successful solutions and achievements in the sports training individualiz-ing/ customizing and sports genetics and immunology domains, including studies of genetic markers of sports gifts.

It may also be pertinent to mention a few other no less reputable and successful research schools:

- Training Systems in Wrestling Sports: Theory, Practice and Progress Provisions research school;
- Modern Sports Training, Recreation and Health Technologies research school;
- Aquatic Pedagogy research school;
- Team Sports Transformative Didactics for Athletes and Coaches research school;
- Gymnastics Training Theory and Practice research school

The education research schools have been progressing at the University for 125 years due to contribu-tions from a few generations of the gifted and enthusiastic researchers and educators, students and fol-lowers of Peter Lesgaft, with their achievements and ideas highly appreciated both by the University faculty and students and the national physical education community on the whole. The schools are rec-ognized by the relevant governmental agencies and listed by the Science and Academic Education Committee of the St. Petersburg Government in its Education Research School Register.

Keywords: *Lesgaft University, education research school.*

Background. In 2021 Lesgaft National State University of Physical Education, Sport and Health celebrates its 125th anniversary since the Russian government licensed the first ever women's Physical Training and Team Sports managers courses that originated the brand new physical education system pioneered by P.F. Lesgaft, an outstanding biologist, anatomist, anthropologist, physician and education specialist, who founded the University. He was the first to formulate the research and education service synergy principle that have been since then pursued by many excellent researchers and academicians, including Academician and Nobel Prize winner I.P. Pavlov, Academicians A.F. Ioffe, A.A. Ukhtomsky, E.V. Tarle, L.A. Orbeli, V.L. Komarov and many others. This principle is still ranked among the education research school pillars by the modern University faculty [2-4].

Objective of the study was to analyze the education and research progress history of Lesgaft National State University of Physical Education, Sport and Health.

Results and discussion. It should be emphasized that many biomedical schools in the country were founded by Peter Lesgaft. One of them is the Sports Functional Anatomy Research School at the Anatomy Department now headed by Biological Science Doc-

tor, Professor M.G. Tkachuk. The school progress has been facilitated by great contributions from the P.F. Lesgaft's followers and students of a few generations including A.A. Krasuskaya, V.F. Martynov, S.I. Lebedkin, E.A. Kotikova, A.A. Smirnov, F.V. Sudzilovskiy and T.I. Vikhruk. All of them headed the Anatomy Department in different periods to lay a foundation for a few new fields of functional anatomy including the Dynamic Anatomy and Sports Morphology. The core research thrusts of the Anatomy Department education research school are "The Peter Lesgaft's historical heritage"; "Individual age- and skills-specific typological characteristics of athletes"; "Gender-specific morphological and functional indicators of sports accomplishments"; "Immunological reactivity test and control methods", etc.

The Physiology Department was founded by Academician L.A. Orbeli back in 1919. A wide range of fundamental studies geared to explore the physiological effects of physical practices have been run by the Adaptation in Elite Sports: Physiological Mechanisms and Logics Education Research School presently headed by Professor A.N. Vetosh. The school progress has been spurred up by contributions from Professors A.N. Krestovnikov, N.V. Zimkin, E.K. Zhukov, E.B. Sologub, A.B. Gandelsman, V.V. Vasilieva, S.A. Razumov, A.S. Mozzhukhin and others [2, 3, 5].

The multisided research activity of the education research school at the Anatomy and Physiology Departments encouraged many successful solutions and achievements in the sports training individualizing/ customizing and sports genetics and immunology domains, including studies of genetic markers of sports gifts. These studies have been run by the Boxing Theory and Practice Department and resulted in formation of the Individual Styles in Elite Sports education research school founded and presently headed by Honored Trainer of Russia, Honored Academic Worker, Pedagogical Science Doctor, Professor V.A. Tajmazova, University President. Special great contributions in the school progress have been made by Associate Professor, PhD in Pedagogy S.N. Belousov; University Rector, Doctor of Education, Professor, Honored Physical Education Worker, Honored Coach, Professor S.E. Bakulev; Honored Master of Sports of the USSR G.I. Shatkov and many others.

The Physical Education Theory and Practice Department presently headed by Pedagogical Science Doctor, Professor, Honored Academic Worker Y.F. Kuramshina, has formed the Modern Trends in Physical Education Theory education research school due to contributions and achievements of Professors A.A. Krasuskaya, I.M. Koryakovsky, S.V. Yananis, K.Kh. Grantyn, G.D. Kharabug, V.M. Vydrin, N.I. Ponomarev, B.V. Evstafiev, G.F. Shitikova, Y.M. Nikolaev, Y.F. Kuramshin et al. [6].

The Biomechanics of Strength Abilities research school presently headed by Doctor of Education, Professor A.V. Samsonova and the Biomechanics Department have grown from the Body Movement Theory course that was developed and delivered by Peter Lesgaft. Later on the active educational and research contributions from A.A. Krasuskaya, E.A. Kotikova, E.G. Kotelnikova, I.M. Koryakovsky and others facilitated the formation of the Physical Training Biomechanics discipline. The education research school has been particularly successful in the following subjects: concept of the skeletal muscle hypertrophy applicable in a few biomedical disciplines (A.V. Samsonova); special strength practice improvement principles (L.L. Tsipin), with their practical applications in athletics, cyclic sports and combat sports; biomechanical factors of influence on the health benefits of physical training systems; etc. [1-3, 5].

The Sports Psychology research school as an independent knowledge field was established on the initiative of Professor, Doctor of Psychology A.T. Puni and advanced by his many students including the Psychology Department Professors, Doctors of Psychology T.T. Jamgarov, I.P. Volkov, E.N. Surkov, G. D. Gorbunov, N.B. Stambulova, L.K. Serova, A.N. Nikolaev et. al. The school has developed and advanced the following: basic concept of psychological training in sports; anticipation mechanisms in sports; psychological provisions for technical, tactical and physical training in sports; psychological classification of sports disciplines; principles of psychological support in sports; sports-specific mental control/ self-conditioning and rehabilitation methods and tools in sports; sports career and its psychological guidance concept; coaching service psychology concept; etc.

The Athletic Performance Control and Biochemical Test Methods research school was established back in the 1950s based on the research contributions from Doctor of Medicine, Honored Scientist and Professor N.N. Yakovlev who was in fact a founder of the national sports biochemistry and the relevant education discipline. The school was advanced by special contributions of Professors S.S. Mikhailov, E.A. Factor, E.V. Rosengard, Associate Professor N.D. Golberg and many others. The education research school has been particularly successful in the following research domains: biochemical patterns of muscle activity; rational sports diets and biochemical test basics; studies of

super-compensation phenomenon as a basis for the sports training system staging models; cholecalciferol metabolites as triggers of depression and suicides in young people; etc.

The relatively new Adaptive Physical Education Theory, Practice and Tools education research school was established in 1995 as the first national Adaptive Physical Education Faculty later on evolved into the Adaptive Physical Education Department and then into the Adaptive Physical Education Institute. The Adaptive Physical Education_Theory, Practice and Tools Department was particularly active, fruitful and creative when leaded by its first Head and founder of the Adaptive Physical Education Institute, Corresponding Member of the Russian Academy of Education, Honored Academic Worker, Doctor of Education, Professor S.P. Evseev; with special contributions from the incumbent Adaptive Physical Education Institute Head, Doctor of Education, Professor O.E. Evseeva; Professors D.F. Mosunov, L.N. Rostomashvili, L.V. Shapkova, A.A. Potapchuk, S.Y. Kalishevich, A.V. Shevtsova et al. who secured leadership of the faculty in the adaptive physical education_theory and practice at the federal level.

It may also be pertinent to mention a few other no less reputable and successful research schools:

- Training Systems in Wrestling Sports: Theory, Practice and Progress Provisions research school;
- Modern Sports Training, Recreation and Health Technologies research school;
- Aquatic Pedagogy research school;
- Team Sports Transformative Didactics for Athletes and Coaches research school;
- Gymnastics Training Theory and Practice research school; etc.

Conclusion. The education research schools have been progressing at the University for 125 years due to contributions from a few generations of the gifted and enthusiastic researchers and educators, students and followers of Peter Lesgaft, with their achievements and ideas highly appreciated both by the University faculty and students and the national physical education_community on the whole. The schools are recognized by the relevant governmental agencies and listed by the Science and Academic Education Committee of the St. Petersburg Government in its Education Research School Register.

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Distance physical education service: students' attitudes and adaptation survey

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Abstract

Objective of the study was to survey the students' progress in adaptation to the modern distance physical education service formats, their benefits and drawbacks.

Methods and structure of the study. We sampled for the survey the 18-20 year-old (1-3-year) special health group students (n=768, 64.7% female and 35.3% male sample) from the Humanities, Natural Sciences and Physics and Mathematics Departments of National Research Tomsk State University. Own distance physical education adaptation was rated excellent, good, satisfactory and poor by 34%, 42%, 20% and 4% of the sample, respectively. Most of the Russian universities keep their own distance learning web-platforms dominated by Moodle SDU toolkit that was originally designed to complement the full-time education service. Satisfaction with the Moodle SDU system was reported positive, negative and uncertain by 68%, 12% and 20% of the sample.

The other part of the questionnaire form was designed to survey attitudes to the distance physical education service, with 75%, 13% and 12% of the sample rating it positively, negatively and uncertain, respectively. We further analyzed reasons for the positive attitude to distance physical education service.

Results and conclusion. The distance physical education service was found beneficial under certain conditions as it makes the training process more versatile, optional, mobile, free in time and space and, hence, more effective; albeit such service formats may be still challenging when combined with the traditional collective trainings in classes and gyms. Generally, the modern distance physical education service formats may be beneficial for many academic physical education goals. The questionnaire survey data and analyses of the students' adaptation and attitude to the distance physical education give grounds to make recommendations on how the distance physical education service should be designed and managed for success. We would recommend the most efficient distance physical education models to be prudently implemented as complementary to the traditional academic physical education service for the special health group to effectively encourage the students' interest in and motivations for theoretical and practical progress in physical education.

Keywords: distance education, COVID-19 pandemic.

Background. Since 2020 with its COVID-19 pandemic related restrictions, many academic Physical Education and Sports Departments in Russia have reported multiple problems due to transition to distance learning service formats [1-3] bereft of the traditional physical education and sport service benefits including live teacher-student communication, well-equipped gyms, apparatuses and accessories and many other progress facilitating aspects [4, 5]. Special problems have been reported by the special health groups in need of special/adapted distance physical education service options.

Objective of the study was to survey the students' progress in adaptation to the modern distance physical education service formats, their benefits and drawbacks.

Methods and structure of the study. We sampled for the survey the 18-20 year-old (1-3-year) special health group students (n=768, 64.7% female and 35.3% male sample) from the Humanities, Natural Sciences and Physics and Mathematics Departments of National Research Tomsk State University.

Results and discussion. Own distance physical education adaptation was rated excellent, good, satisfactory and poor by 34%, 42%, 20% and 4% of the sample, respectively. Most of the Russian universities keep their own distance learning web-platforms dominated by Moodle SDU toolkit that was originally designed to complement the full-time education service. Satisfaction with the Moodle SDU system was re-

ported positive, negative and uncertain by 68%, 12% and 20% of the sample correspondingly.

The other part of the questionnaire form was designed to survey attitudes to the distance physical education service, with 75%, 13% and 12% of the sample rating it positively, negatively and uncertain, respectively. We further analyzed reasons for the positive attitude to distance physical education service and found 68.5% of the group happy with the physical education videos offered by the teacher; 39.6% appreciating the video reports of own physical education practices making it possible to analyze own performance and progress from the outside; and 4.1% of the group emphasized benefits of the live online trainings in a conference format when the teacher watches every trainee and helps him/ her by timely theoretical and practical instructions.

The survey found benefits of the live scheduled online trainings with video records of the training process for further analysis in free time. In the distance physical education design and practical aspects, the teacher always has an option of prior recording to freely control and correct the trainees' execution watching them on a monitor later on. The students who opt for the self-reliant trainings are required to submit video reports of such trainings with own reflections/ analysis of the progress, problems and limitations.

It should be mentioned that the distance physical education service facilitates the students' progress in working with video equipment and application software plus their analytical skills, to develop a deep insight into the movement techniques and progress opportunities. This fact was particularly appreciated as found by the survey, with 38.1% of the sample reporting progress in the video capturing/ editing/ analyzing aspects; and 10.3% reporting progress in own creativity due to the distance physical education process recording, analyzing and reporting, with special benefits for their physical education interest and motivations.

Furthermore, the distance physical education practices were found to improve the student's self-esteem and determination in contrast to live collective physical education sessions – since some of the special health group students are unsurprisingly shy to train with the others due to their poor physical fitness and body shape, whilst home physical education practices release them of this stress and mental limitations. In addition, home distance physical education was found appreciated for the freedom in space and time – since every student is free to train on his/her own schedule and discretion. This positive factor and its motivational aspects were reported by 84.9% of the sample.

The question of whether or not the teacher uses special means to keep the students informed on their progress in the physical education and healthy lifestyles was responded negatively by 62% of the sample, whilst many actually emphasized the need for such progress information that could be made available via the popular social networks – such as VKontakte and Telegram favored by 72.1% and 34.6% of the sample, respectively.

Conclusion. The distance physical education service was found beneficial under certain conditions as it makes the training process more versatile, optional, mobile, free in time and space and, hence, more effective; albeit such service formats may be still challenging when combined with the traditional collective trainings in classes and gyms. Generally, the modern distance physical education service formats may be beneficial for many academic physical education goals. The questionnaire survey data and analyses of the students' adaptation and attitude to the distance physical education give grounds to make recommendations on how the distance physical education service should be designed and managed for success. We would recommend the most efficient distance physical education models to be prudently implemented as complementary to the traditional academic physical education service for the special health group to effectively encourage the students' interest in and motivations for theoretical and practical progress in physical education.

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Benefits of physical fitness and endurance training model for senior women

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Abstract

Objective of the study was to find benefits of a physical training model for the senior women's physical fitness and endurance.

Methods and structure of the study. We sampled for the study the 62-74 year-old women (n=35) and split them up into the Younger Group (YG, n=20 aged 62-70 years) and Elder Group (EG, n=15 aged 71-74 years). Both groups were trained twice a week as follows: the YG was trained once in the gym and once in the swimming pool under the Active Longevity program; and the EG trainings were dominated (80%) by the pool swimming complemented (20%) by the traditional conditioning practices; with the 2-3-day rest breaks in between the trainings. The training sessions included: health walking missions; agility training tennis ball throw practices; coordination training body balances; narrow line walking and other practices; carpal strength training ball rotation and fitball throw exercises; static endurance training planks; strength endurance training abs exercises (push-ups, fitball practices, etc.) [5]; with every training session finalized by 3-4 low-pace flexibility exercises with the reps growing with physical fitness.

Results and conclusion. The group physical fitness / health progress was tested by the SF-36 questionnaire surveys that are commonly used nowadays the world over to rate the senior people's health and life quality [5]. The post-experimental survey found the sample appreciating the physical training service, with most of sample reporting improvements in health (93.4%); walking speeds (64.3%), wellbeing and moods; plus about 70% of the sample reported progress in working capacity and pain relief. The mental-emotional progress survey data were complemented by the physical fitness tests customized to the actual individual ages and health conditions, with the group progress analyzed and averaged. The post-experimental physical fitness tests included: 25m swimming (s); 12-minute swimming (m); standing long jump (cm); bench leaning (cm); and prone push-ups (count) tests.

The six-month training experiment to test benefits of the new physical training model for the senior women's physical fitness and health showed the model being beneficial as verified by the pre- versus post-experimental physical fitness tests and SF-36 health surveys. The physical training model, therefore, may be recommended to improve the physical fitness, health and indirectly life quality of senior people, conditional on the trainings being prudently customized to the actual health, age and lifestyle of the senior trainees.

Keywords: *physical fitness, senior women, endurance practices.*

Background. People have always been highly interested in the methods to slow down the aging process, with the first attempts to identify the reasons for aging and ways to prevent or mitigate it found in ancient records [1, 3]. The aging science has always been highly relevant and accumulated a broad knowledgebase with contributions from physiologists, philosophers, biologists, psychologists, sociologists, educators, historians, lawyers and many others.

Objective of the study was to find benefits of a physical training model for the senior women's physical fitness and endurance.

Methods and structure of the study. We sampled for the study the 62-74 year-old women (n=35)

and split them up into the Younger Group (YG, n=20 aged 62-70 years) and Elder Group (EG, n=15 aged 71-74 years). Both groups were trained twice a week as follows: the YG was trained once in the gym and once in the swimming pool under the Active Longevity program; and the EG trainings were dominated (80%) by the pool swimming complemented (20%) by the traditional conditioning practices; with the 2-3-day rest breaks in between the trainings. The training sessions included: health walking missions; agility training tennis ball throw practices; coordination training body balances; narrow line walking and other practices; carpal strength training ball rotation and fitball throw exercises; static endurance training planks; strength endurance training abs exercises (push-ups, fitball practices, etc.) [5]; with every training session finalized by 3-4 low-pace flexibility exercises with the reps growing with physical fitness.

Results and discussion. The group physical fitness / health progress was tested by the SF-36 questionnaire surveys that are commonly used nowadays the world over to rate the senior people's health and life quality [5]. The post-experimental survey found the sample appreciating the physical training service, with most of sample reporting improvements in health (93.4%); walking speed (64.3%), wellbeing and mood; plus about 70% of the sample reported progress in working capacity and pain relief. The mental-emotional progress survey data were complemented by the physical fitness tests customized to the actual individual ages and health conditions, with the group progress analyzed and averaged. The post-experimental physical fitness tests included: 25m swimming (s); 12-minute swimming (m); standing long jump (cm); bench leaning (cm); and prone push-ups (count) tests.

The group physical training model made a special emphasis on the body balancing, speed-strength, muscle strength, endurance, speed, flexibility and some other workouts. The highest and significant ($p < 0.05$) progress was found by the pre- versus post-experimental endurance-testing 12-min swimming test, with the YG and EG progress making up 27.6% (75m) and 26.5% (70.84m), respectively.

The group progress was facilitated by the senior women's beliefs in health/ physical fitness benefits of swimming practices, plus good group climate and enthusiasm. The pool swimming practices included a range of options for versatility and interest, namely: style-changing slow-pace swim; aquatic gymnastics; long-distance non-stop swim; high-speed interval (10-15m) swims; etc. These versatile trainings were found highly beneficial for the swimming speed. Considering the senior ages and relatively limited training time (six months), the physical training model has proved extremely successful, particularly in the 25m swimming tests where the YG and EG made progress of 4.93s (-8.8%) and 4.85 s (-8.43%), respectively.

The YG progress in the speed-strength rating pre- versus post-experimental standing long jump test was 0.88cm versus 0.99cm, respectively, i.e. the 12.5% growth for six months. The EG, despite the significant age difference, was also significantly ($p < 0.05$) successful in these tests, with the progress estimated at 9.5% for the period.

The physical fitness training model gives a special priority to flexibility as the physical quality of special importance for senior people – since they are commonly known to lose flexibility fast with age, with this regress considered one of the key indications of aging and health deterioration process. Such regresses in flexibility are normally tested by the falling movement amplitudes in every body part (neck, shoulder girdle, spine, hips, ankles, carpal joints etc.). The situation is further complicated by the shortage of the seniors' physical activity versus flexibility rating research, analysis and statistics. However, a few researchers [2, 4, et al.] who studied the issue have unanimously recommended systemic physical training practices to keep up due physical fitness including the movement amplitudes, otherwise the growing stiffness in the key joints may seriously complicate the everyday elementary motor functions – like reaching things in a closet, combing hair, tying the shoes, etc.

Therefore, our physical training model was designed with a special priority to the flexibility trainings, with every session assigning 10-15 final minutes to specific stretching exercises. We used customizable sets of individual/ couple exercises to stretch the pectoral muscles, posterior muscles of the thighs and shins; lumbar and thoracic muscles; shoulder girdle muscles etc. in multiple body positions (standing, sitting, prone, recumbent). The pre- versus post-experimental flexibility tests found the YG and EG making the 27.5% and 33.2% progresses for the six-month training period, respectively. This progress demonstrated once again the special need in flexibility trainings to maintain due physical fitness in whatever age group.

And the most exciting group progress was fixed in the strength rating prone push-ups tests, with the

YG and EG showing 76.5% and 30.1% significant ($p < 0.05$) growth in the results, respectively.

Conclusion. The six-month training experiment to test benefits of the new physical training model for the senior women's physical fitness and health showed the model being beneficial as verified by the pre- versus post-experimental physical fitness tests and SF-36 health surveys. The physical training model, therefore, may be recommended to improve the physical fitness, health and indirectly life quality of senior people, conditional on the trainings being prudently customized to the actual health, age and lifestyle of the senior trainees.

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Innovative technologies for supplementary adaptive physical education specialist training service

UDC 796/799

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Abstract

Objective of the study was to analyze benefits of innovative technologies for adaptive physical education specialist supplementary training service.

Methods and structure of the study. We used the following theoretical research methods: reference literature analysis; relevant legal/ regulatory framework analysis, data systematization and classification; analysis and synthesis; and data generalization. Benefits of the innovative adaptive physical education specialist supplementary training service technologies developed by Lesgaft National State University of Physical Education, Sport and Health (St. Petersburg) have been tested and analyzed since 2011 including the latest tests under the "Accessible Environment" and "Sports a Life Norm" Federal Projects.

Results and conclusion. The innovative technologies analyzed herein are grouped into (1) the ones applicable upon the secondary vocational education or advanced education or both; and (2) technologies applicable in the secondary vocational education / advanced education process.

The modern market-demand-sensitive socio-economic interests on the whole and educational service in particular need to be prepared for fast responses to the rapidly changing market realities, and this is particularly true for the professional adaptive physical education specialist training service with its specialist qualification system. The educational service should give a special priority to the modern innovative adaptive physical education specialist supplementary training service technologies due to their cost- and time-efficiency in the adaptive physical education specialist trainings sensitive to the trainees' individual backgrounds and practical experiences in the core service fields.

Keywords: *innovative training technologies, specialist supplementary training service, adaptive physical education, physical education, sports, education levels.*

Background. In the context of the national educational system reforms to improve its labor market sensitivity and the valid professional standards with the independent specialist qualification systems and many other factors, the supplementary education system needs to implement modern innovative technologies, primarily in the relatively new adaptive physical education specialist training domain. These initiatives are associated with the tighter professional standards and specialist training requirements in this education sector; a wide range of the health and age groups (newborns to seniors) served by the adaptive physical education specialists; a wide range of adaptive physical education service disciplines (adaptive physical education as such; adaptive health sports; adaptive motor rehab service; physical rehabilitation, extreme sports; and creative body-shaping/ correctional practices); plus the versatile and volatile market demands for the adaptive physical education specialists in the context of the newly emerging adaptive physical education methods and models with the changing adaptive physical education service standards and requirements [1-3]. These volatile factors seriously complicate attempts to develop an ideal Federal State

Adaptive Physical Education Standard to secure a lifelong education basics for an adaptive physical education specialist.

This is the reason why Federal Law of December 29, 2012 No. 273-FL "On Education in the Russian Federation" gives a special priority to the supplementary professional education service geared to ensure high flexibility, mobility and service sensitivity to the individual progress needs by the individual training trajectories and special emphases on the progress barriers, gifts and growth opportunities of every physical education specialist.

Objective of the study was to analyze benefits of innovative technologies for adaptive physical education specialist supplementary training service.

Methods and structure of the study. We used the following theoretical research methods: reference literature analysis; relevant legal/ regulatory framework analysis, data systematization and classification; analysis and synthesis; and data generalization [1, 7]. Benefits of the innovative adaptive physical education specialist supplementary training service technologies developed by Lesgaft National State University of Physical Education, Sport and Health (St. Petersburg) have been tested and analyzed since 2011 including the latest tests under the "Accessible Environment" and "Sports a Life Norm" Federal Projects [4-7].

Results and discussion. The innovative technologies analyzed herein are grouped into (1) the ones applicable upon the secondary vocational education or advanced education or both; and (2) technologies applicable in the secondary vocational education / advanced educational process.

Group 1 of the innovative adaptive physical education specialist supplementary training service technologies should be implemented conditional on the trainees being grouped into at least the advanced training group, professional retraining group and internship planning group. Basically the grouping may be made based on the primary professional background into (1) trainees with master or specialist degrees; (2) trainees with bachelor degrees; (3) trainees having secondary vocational education degrees.

Each of the above groups, or two-three of them, should be further classified into [1, 2]: (1) trainees having adaptive physical education specialist backgrounds; (2) trainees having education in the adaptive-physical-education-related knowledge fields including physical education, medicine, biology, correctional pedagogy i.e. defectology (typhlo-, surdo- [hearing-impaired], oligophrenic pedagogy, speech therapy, etc.); (3) trainees having backgrounds in pedagogy and psychology; (4) trainees with adaptive-physical-education-unrelated backgrounds like economics, law, technical and other sciences etc.

The adaptive physical education specialist supplementary training course curricula developers should take into account the trainees' advanced education time periods and practical experiences/ service records in the adaptive-physical-education-related, unrelated and other special service fields. These and other considerations need to be respected when developing the customizable adaptive physical education specialist supplementary training course curricula with timeframes varying from 16 to 200 hours. It should be emphasized that the adaptive physical education should not be viewed as only a special physical education knowledgebase including elements of physical education, medicine and correctional pedagogy (defectology), but also as a special evolving knowledge domain where many relevant sciences interpenetrate and synergize on a specific theoretical, practical and empirical bases to find effective solutions for every of the above six adaptive physical education service disciplines [2].

Knowing the above specifics of the modern adaptive physical education service, and provided the trainees are grouped as described above, the adaptive physical education specialist supplementary training course curricula will be developed to ensure due flexibility and mobility of the supplementary educational service, with every trainee's progress secured by the individual education trajectory, with every progress barrier timely removed to facilitate growth of the professional knowledgebase, experience and competencies. The innovative adaptive physical education specialist supplementary training technologies should be implemented so as to complement and empower the traditional and modern adaptive physical education specialist training methods and tools [1, 7]. The latter may include: internships at the relevant educational institutions licensed for the adaptive physical education specialist training service; field refresher adaptive physical education specialist courses (as provided by S.P. Evseev, 1998), when an interested local corporate customer contracts a few (normally five to six) teachers to train 50-100 students at a local establishment; networking adaptive physical education specialist supple-

mentary training service formats; distance learning formats of the refresher/ retraining adaptive physical education specialist supplementary training courses; "cumulative certificate" producing adaptive physical education specialist supplementary training service formats that include many short-term thematic adaptive physical education workshops, conferences, round tables in a few of the six adaptive physical education disciplines; inclusive adaptive physical education service formats when the health groups are trained together with their healthy peers, etc. It should be mentioned that every of the above adaptive physical education specialist supplementary training service formats have been repeatedly tested in practice and recognized beneficial [1-6].

Group 2 of the innovative adaptive physical education specialist supplementary training service technologies applicable in the SCE/ advanced education process have proved particularly beneficial for the students majoring in the adaptive physical education for disabled, Physical Education and Sports disciplines. The bachelor/ master course students majoring in the adaptive physical education for disabled people may be offered special advanced training/ retraining service to complement their standard physical education and Sports curricula; whilst the bachelor/ master course students majoring in the Physical Education and Sports may complement their studies by the special adaptive physical education specialist supplementary training service course.

Conclusion. The modern market-demand-sensitive socio-economic interests on the whole and educational service in particular need to be prepared for fast responses to the rapidly changing market realities, and this is particularly true for the professional adaptive physical education specialist training service with its specialist qualification system. The education service should give a special priority to the modern innovative adaptive physical education specialist supplementary training service technologies due to their cost- and time-efficiency in the adaptive physical education specialist trainings sensitive to the trainees' individual backgrounds and practical experiences in the core service fields.

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Socio-humanistic aspects of academic physical education and sports specialist training service

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Abstract

Objective of the study was to analyze the socio-humanistic aspects of the academic physical education and sport specialist training service.

Methods and structure of the study. Methodologically, we designed the study at the junction of theoretical and empirical approaches with an analysis of the valid educational service standards for the master and bachelor training services provided by the academic physical education and sport specialist training universities.

Results and conclusion. The academic physical education and sport specialist training service is ranked among the top priorities in the situation when the democratic society is further developed and statehood is strengthened in Russia, with the educational process designed to effectively form a patriotic personality with high spiritual and ethical values. The national academic physical education and sport system develops and implements special training curriculum as required by its mission and goals. A special priority is given to the social (humanitarian) aspect of the physical education and sport specialist training service to develop a sound knowledgebase, social/ civic experience and standing, and individual humanitarian culture for progress in the specific professional socio-cultural environment (community) and life, with understanding that an educational system should be based on the principles of humanism. An educational service mission is to develop a multisided creative personality for the graduate to be fit for effective service sensitive to the changing demands and environments, prepared to make good managerial decisions, socially active, dedicated and creative in enterprising. Such a university graduate will be appreciated for his communal activity and professional service within the relevant socio-cultural group.

Keywords: *humanistic paradigm, higher professional education, curriculum, physical education and sports, quality of education, humanization, education reforms.*

Background. Presently the national educational system gives a growing priority to the new educational strategies in response to many challenges arising in the ongoing digitalization of the educational service with the inevitable alienation and isolation – detrimental for the personality formation goals of the system. This is one of the key reasons why the national researchers, practitioners and decision-makers take special efforts to reform the educational service in the most efficient and beneficial format.

The valid Scientific and Technological Development Strategy of the Russian Federation gives a special attention in its list of priorities and progress avenues to the response models geared to cope with the major challenges in the environmental and technological safety domains, with a special contribution from the relevant social institutions and shareholders of the global development process, striving to take benefits of the modern humanitarian and social sciences in these efforts.

When analyzing the potential options for the national academic physical education and sport specialist training service humanization, we cannot ignore the major contradiction. On the one hand, the educational community acknowledges the need for humanization of the educational service; and on the other hand, such efforts may hardly be effective unless governed by a theoretically grounded model of the humanistic

values prioritizing academic physical education and sport specialist training service – that is still underdeveloped at this juncture in fact.

Objective of the study was to analyze the socio-humanistic aspects of the academic physical education and sport specialist training service.

Methods and structure of the study. Methodologically, we designed the study at the junction of theoretical and empirical approaches with an analysis of the valid educational service standards for the master and bachelor training services provided by the academic physical education and sport specialist training universities.

Results and discussion. The humanistic idea in the physical education theory emerged in the Renaissance period, when the physical education service prioritized the following two interrelated fields in the socio-pedagogical domain. First, the movement culture was mastered mostly in dancing practices with the relevant physical education knowledge summarized to explore and analyze health benefits of physical practices. And second, a special attention was paid to the humanistic ideal that implies formation of a comprehensively developed personality governed by the relevant ethical standards.

The humanistic idea was formed in the system of pedagogical views of Erasmus of Rotterdam, Thomas More, Fran ois Rabelais, Michel Montaigne and a few other renowned scholars whose education models prioritized formation of a socially active and productive individual. Generally the classical education, physical development and civic culturing services (an educational triad of the Renaissance period) were based on the three major education pillars – antiquity, the Middle Ages and emerging ideas of the New Age.

Thomas More largely borrowed his pedagogical system from the Ancient Greece and saw its mission in fostering a strong and well-developed body by mostly gymnastics and combat exercises. The physical education service self-control mechanism in his model was governed by the dialectical principle of the synergized individual and social benefits generated by the service. The body development concept within this model was driven by the idea of the physical training being an obligatory individual responsibility to the community and state on the whole.

Michel Montaigne designed his educational service model giving a higher and more consistent priority to the socio-pedagogical values of the physical education service. Central for his physical education service concept and model were the ethical foundations for an individual progress with its culturing and educational components. He made a special emphasis in this concept on the service elements geared to foster civic feelings and patriotism, with the child encouraged to evolve into a loyal and selflessly devoted servant of Fatherland by the inclusive education and culturing services covering every element of the personality progress agenda.

The humanistic idea was further advanced by P.F. Lesgaft who prioritized harmonic multisided personality development as the key mission of an educational process with a special emphasis on the individual consciousness, independence and ethics – three notions pivotal for his physical education system. Much in the Lesgaft's heritage is still relevant and beneficial for the physical education theory and practice, including the academic physical education and sport specialist training service.

Many experts tend to believe that the humanistic values prioritizing academic physical education and sport specialist training service should be systemic and sensitive to the modern physical education and sport service progress trends; and designed on a modern technological basis to effectively encourage professional progress of every student in the context of the state order (public demand) for the physical education and sport specialists and the valid physical education and sports education standards.

A prime idea of Pierre de Coubertin and his followers was to establish the new human development domain governed by the universal human values and spirit of cooperation. We believe that skeptical and negative attitudes to the modern sports humanization models tend to neglect the mounting global problems that the humanity has faced since the early XXI century. These problems urge the humanists to not only declare the humanistic idea, but also pursue it in practice in every life field.

Lately the Russian academic educational system has seen major reforms, with reductions in numbers of the national universities, their grouping into categories, ownership classes, funding sources, etc. The national statistics as of 2020 reported 724 universities providing professional training service (versus 1115 universities in 2010); including 495 public and 229 private ones (68.4% and 31.6% of the total, respectively).

One of the key goals of the academic education system reform was to diversify the education service into the bachelor, specialty and master training components [7] with the range of the academic curricula

expanded correspondingly. As a result, the physical education and sport specialist training universities presently offer 19 bachelor and 14 master training curricula within the relevant larger specialty groups and courses (vectors). This versatility of the physical education and sport specialist training curricula has been largely necessitated by the new demands from the physical education and sports market for the trained specialists in many new physical education and sport service domains.

Conclusion. The academic physical education and sport specialist training service is ranked among the top priorities in the situation when the democratic society is further developed and statehood is strengthened in Russia, with the educational process designed to effectively form a patriotic personality with high spiritual and ethical values. The national academic physical education and sport system develops and implements special training curriculum as required by its mission and goals. A special priority is given to the social (humanitarian) aspect of the physical education and sport specialist training service to develop a sound knowledge-base, social/ civic experience and standing, and individual humanitarian culture for progress in the specific professional socio-cultural environment (community) and life, with understanding that an educational system should be based on the principles of humanism. An educational service mission is to develop a multisided creative personality for the graduate to be fit for effective service sensitive to the changing demands and environments, prepared to make good managerial decisions, socially active, dedicated and creative in enterprising. Such a university graduate will be appreciated for his communal activity and professional service within the relevant socio-cultural group.

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Sports science integration for progress of gymnastics disciplines

UDC 796.071

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Abstract

Objective of the study was to analyze the objective elementary gymnastic biomechanics by difficulty classes to facilitate technical progress and expert valuations.

Methods and structure of the study. We used for the purposes of the study the following research methods: analysis of the reference literature and relevant regulatory frameworks; training progress analysis, questionnaire surveys, expert scoring, tests, contactless video replays with movement sequencing analyses, skin electromyography, stabilography and training experiments. The test data were processed and analyzed by the standard mathematical statistics STATGRAPHICS Plus toolkit. Subject to the execution quality analysis were the elite competitive routines in modern gymnastics disciplines including individual/ group rhythmic gymnastics; artistic gymnastics, aesthetic gymnastics, trampoline gymnastics and acrobatic rock-n-roll.

Results and conclusion. Based on the study data and analyses, we offer theoretical provisions for a new elements valuation matrix to improve the valid FIG Code of Points; facilitate the specific elements training/ excellence systems and training system design and management; and facilitate the expert valuations of every execution aspect. The analysis and recommendations may be beneficial for progress in every gymnastic discipline.

Keywords: *rhythmic gymnastics, rules of competitions, Code of Points, skills, routines, difficulty score, expert valuation, progress algorithms, technical execution scores.*

Background. Modern elite gymnastics is getting increasingly challenging and competitive, with the competitive progress secured by hard work to improve every technical skill and execution artistry on the whole. This is one of the key reasons why the modern elite gymnastics has to heavily rely on sports research. The individual progress agendas need to be facilitated by objective competitive resource/ skills tests and scores with perfect understanding of the actual versus model execution biomechanics so as to timely and efficiently fix and interpret every execution variation in the training process and manage the individual competitive progress trajectories based on fair and precise expert scoring systems. The research foundation for the progress management service should include a profound scientific knowledge of athlete viewed as a 'biological system' tested and analyzed using modern digital test systems offered by human sciences. The Lesgaft National State University of Physical Culture, Sports and Health's Gymnastics Theory and Methodology Department has accumulated a profound research experience that demonstrates efficiency and benefits of such progress testing and scoring systems.

Objective of the study was to analyze and classify on an objective research and test basis the execution difficulty biomechanics in the modern gymnastics to provide benchmarks for competitive progress and expert scoring systems.

Methods and structure of the study. We used for the purposes of the study the following research methods: analysis of the reference literature and relevant regulatory frameworks; training progress analysis, questionnaire surveys, expert scoring, tests, contactless video replays with movement sequencing

analyses, skin electromyography, stabilography and training experiments. The test data were processed and analyzed by the standard mathematical statistics STATGRAPHICS Plus toolkit. Subject to the execution quality analysis were the elite competitive routines in modern gymnastics disciplines including individual/ group rhythmic gymnastics; artistic gymnastics, aesthetic gymnastics, trampoline gymnastics and acrobatic rock-n-roll.

Results and discussion. Having analyzed the valid rules of competitions, Codes of Points and successful competitive routines in the above gymnastic disciplines, we found [4-8] the competitive progresses being secured mostly by the highest technical and compositional difficulty standards associated with top artistic merits.

The sports community takes special efforts to develop new original elements and compositions in every routine/ exercise design and training process. It should be emphasized, however, that it is not unusual that the actual scores of such new elements in the valid Codes of Points differ from their true/ fair values. Thus, our analysis for the group rhythmic gymnastics routines showed [1] that experts tend to underscore the exchanges and collaborations due to:

– Limitations of the exchange/ collaboration difficulty and originality scoring standards with the traditional blanket applications and virtually no attention to the dynamism and artistry of the elements/ compositions; and

– Tendency to level down the exchange/ collaboration scores by these elements being classified with the relevant difficulty groups using too general criteria.

Our analysis of the group exchange/ collaboration harmony/ synch showed that in many cases high execution difficulty and versatility of elements, rearrangements, apparatus handling skills and their combinations require special hard work in the training systems and need to be scored correspondingly [9].

The gymnastic competitive routines analysis generally shows that the total gymnastic routine execution score will include the technical, compositional and artistic scores applicable to:

– Every technical element as such and their combinations in the routine on the whole;

– Execution harmony with special attention to the dance and plastic elements;

– Single/ group/ sequential execution elements;

– Fast-/ slow-pace elements;

– Elements executed in collaborations with partner(s);

– Apparatus handing/ exchange elements; and

– Dynamic elements with arrangements, rearrangements etc. [1, 4-6, 8, 9].

An objective expert scoring system will fairly rate every element of a competitive routine to motivate the gymnasts and coaches to give high priority not only to the top difficulty as such but also to the routine harmonizing/ synch aspects with a special attention to versatile and expressive artistic forms.

Modern gymnastic training service may be encouraged and facilitated by focused efforts to improve the existing technical and compositional difficulty scoring system based on the movement biomechanics and movement sequencing test and research data and analyses. Such research foundation will provide a scientifically sound framework and benchmarks for execution difficulty expert scoring systems, and for the gymnastic training and routine design and logical sequencing systems: see Figure 1.

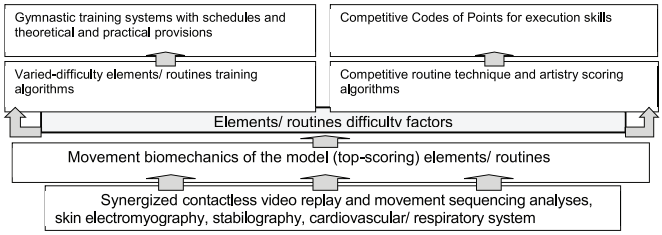

Figure 1. *Modern biomechanical research to offer technical provisions for the rhythmic gymnastics trainings and competitions*

Benefits of the expert scoring system were demonstrated by many studies [3, 10] that showed the following gymnastics competitive routine difficulty and artistry factors being the most influential:

– Physical qualities of the apparatuses, equipment, floor and environment need to be controlled by special muscular efforts in the routines;

– Postural control in dynamics for success of the group exchanges/ collaborations and apparatus handling;

– Emphases and priorities in execution for harmony of the group limb movements and model conduct;

– Body/ apparatus movement vectors/ planes;

– Movement amplitudes and distances, heights of the throws, etc.;

– Every element execution style with elementary movement symmetries/ synchs;

– Spatial movement/ apparatus control quality; and

– Harmony and artistry of the static and dynamic elements in the routine.

Our comparative analysis of the skills execution factors showed that they need to be perfectly balanced for high technical and artistic scores and compositional harmony of a competitive routine. Modern competitive routine elements are highly difficult and skills-intensive and, hence, a special priority should be given to the elementary transitions control logics i.e. harmonized execution styles with one element smoothly flowing into the other for excellent synch, plasticity and completeness of every composition in the routine.

Tests and analyzes of the muscle movement biomechanics and electrical activity showed that the execution plasticity, expressiveness and artistry may be objectively rated by the muscle reciprocity and bioelectrical activity tests – that are generally indicative of how balanced the muscle activation/ inhibition processes are in every elementary movement phase and routine on the whole [2]. These data and findings give reasons to believe that artistry scores may use much the same criteria that apply to the movement biomechanics within the relevant laws of motion.

Conclusion. The study data and analyses showed that the FIG (International Gymnastics Federation) discipline-specific Codes of Points need to be updated so as to encourage natural progress of the gymnastic disciplines rather than limit and slow down them by unnatural scoring barriers. One of the potential ways to encourage progress is to put the technical scoring systems on a sound research foundation to fairly rate merits of a wide variety of competitive routines. The scoring systems shall factor in the execution difficulty biomechanics and their specific factors in the technical values sets. Such fair scoring systems will facilitate progress of the modern gymnastic disciplines on a consistent, efficient and sustainable bases.

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E-training (distance learning) elements for supplementary sports tourism education service: benefits analysis

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Abstract

Objective of the study was to analyze benefits of modern electronic training elements for the supplementary educational system, with the children's and youth sports tourism service taken for the case study.

Methods and structure of the study. The first stage of the study in April-May 2020 was designed to update the academic curriculum and implement distance learning elements, and provide a special electronic training basics course for the school physical education teachers to make them fit for the new service format. We sampled for the study the 9-18 year-old students (n=72) from six children's and youth sports tourism departments of the supplementary education children's and youth schools in the Tomsk Oblast; and the supplementary education school teachers (n=8) supported by the National Research Tomsk State University faculty members (n=3).

The second stage of the study was run in September through December 2020 and designed to implement the electronic training elements and other relevant distance learning tools in the departmental curricula. The electronic training service offered the simplest communication tools including those provided by the popular social networks and messengers. The learning materials and electronic training tasks were combined into modules using the open online Google Classroom toolkit, with its individual progress tests.

The third stage was scheduled for January-February 2021 to make a comparative analysis of the students' progress in every competence module.

Results and conclusion. The study data and analyses generally showed benefits of modern electronic training elements for the supplementary children's and youth sports tourism supplementary education service, particularly in the Local History, Ecology and Life Safety competence module where the distance learning tools were found to effectively facilitate progress due to special motivations. The distance learning formats with a wide variety of modern electronic training tools, however, were tested little beneficial for practical tourist skills and competitive performance in the sports tourism events.

Keywords: *sports tourism, children's and youth sports tourism, electronic training, supplementary education.*

Background. Nowadays many sectors of the national economy have to cope with the modern challenges dominated by the Covid-19 pandemic that since 2020 that forced the educational system to make an unexpected transition to online education formats, close virtually every educational establishment, and instantly convert every service and event into online formats having almost no time to adapt the valid academic curriculum [1]. It should be mentioned that the general, vocational and advanced educational systems have been more or less successful in the transition, whilst the supplementary educational system on the whole and its sports educational services in particular have reported serious transitional problems [2].

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Theoretical materials in every competence module under the academic curriculum were delivered in presentations, texts and videos; with the interactive communication, online training tools and tasks designed mostly in gaming formats using learningapps.org, classflow.com, linoit.com, flippity.net, h5p.org and other relevant resources. The project team developed audio guides and quests on the izi.travel platform to encourage the students' outdoor physical activity within at least the WHO recommended limits with the parallel training tasks – so as to meet the requirements of the academic curriculum to the practical elements of the training service. The social networks and virtual whiteboard tools were used to facilitate teamwork of the students, with a special priority to rewards and other motivational electronic training / gaming elements to encourage progress in both the theoretical and practical (active physical) domains. We also analyzed the students' progresses and accomplishments in the traditional regional competitions that were for the first time run on a distance basis.

The third stage was scheduled for January-February 2021 to make a comparative analysis of the students' progress in every competence module. The theoretical knowledge of the sample was tested by the pre- versus post-experimental tests, and practical skills were tested in the weekend group hikes in winter time [4] on a 100-point scale. The sample was split up into the following age groups as required by the children's and youth sports tourism standards: 9-11 years old group (prioritizing the cognitive and practical motivations); 12-13-year-old group (practical and cognitive motivations); 14-15-year-old group (emotional and practical motivations); and the 16-18 years old group (emotional and cognitive motivations) [3]. Gender grouping was omitted in this study.

Results and discussion. The electronic training service benefits for the children's and youth sports tourism supplementary education curricula were rated in the following competence modules: Local History; Ecology; Life Safety; Teamwork; Tourism Technology and Sports Fitness; Physical Fitness; and the Research and Creativity (see Table 1 hereunder). The distance learning format was found particularly beneficial for the Local History competence module as it significantly improved knowledge of the regional specifics and the key tourist attractions and recreational resources. The interactive maps and the age-specific electronic data on the local history facilitated the groups making an average progress of 20.5 points in the competence module – and this was the highest progress among the competence modules, with the highest success (24 points) in the competence module made by the 9-11-year-old group. We found the group Local History training being the most beneficial when the online learning is designed in a gaming manner to keep up the children's motivations and interest.

The group progresses were also tested significant in the following competence modules: Ecology (14 points), Life Safety (13.7 points), Teamwork (14 points) and Research and Creativity (11.5 points). We combined in the Ecology competence module a range of the environmental protection and local recreational resource related competences. The Life Safety competence module included the life safety knowledge and skills necessary for tourists, plus the first aid skills. The special interactive electronic training materials and group tasks were found successful in motivating the students for studies of the environmental safety and tourist life safety issues, and this was the reason for the group progress in the competence module knowledge and skills. The Teamwork competence module included interpersonal communication, cooperation and tourist group teamwork competences. And the Research and Creativity competence module included the research, project design and creativity related competences and practical skills. Of special benefits for these competences training were the special online learning formats with the joint research projects and creative missions.

It should be mentioned, however, that the groups have made virtually no significant progress in the Phys-

Table 1. *Group pre- versus post-experimental competences/ skills tests, points*

Competence module	Age groups, years								Group averages	
	9-11		12-13		14-15		16-18			
	Pre-exp.	Post-exp.	Pre-exp.	Post-exp.	Pre-exp.	Post-exp.	Pre-exp.	Post-exp.	Pre-exp.	Post-exp.
Local History	54±2,1	78±1,7*	52±0,9	71±2,1*	58±1,8	78±1,3*	62±2,5	81±2,1*	56,5±2,2	77,0±2,1*
Ecology	67±1,8	82±1,0*	72±2,1	84±2,2*	70±1,5	84±1,8*	71±1,9	86±1,9*	70,0±1,0	84,0±0,8*
Life Safety	49±1,5	60±1,3*	54±1,8	66±2,3*	53±2,1	68±1,5*	58±2,3	75±1,5*	53,5±1,8	67,2±3,0*
Teamwork	63±2,3	71±2,0*	62±1,5	78±1,9*	60±0,9	78±1,2*	66±1,8	80±1,3*	62,7±1,2	76,7±2,0*
Tourist Techniques	63±2,0	49±2,1*	65±1,3	50±1,7*	66±2,1	48±2,0*	68±1,7	51±1,3*	65,5±1,0	49,5±0,6*
Physical Fitness	70±2,2	72±1,7	68±2,2	67±2,3	73±1,4	76±1,9	72±2,1	75±2,3	70,7±1,1	72,5±2,0
Research and Creativity	43±1,9	55±1,9*	48±2,0	59±2,2*	55±1,9	67±0,9*	62±1,3	73±1,9*	52,0±4,1	63,5±4,0*

Note: * significant group progress, $p<0.05$

ical Fitness competence module as the total group growth was tested to average only 1.8 points. In the Tourism Technology and Sports Training competence module, the groups showed even regress of 16 points on average – due to, as we believe, the distance learning tools being not efficient enough in training special sports tourist competencies and skills including the tent-setting, backpacking, campfire making, orienteering and other knowledge and skills required for the modern sports and health tourism. The 14-15-year-old group scored the highest regress of 18 points in this competence module, and the regress was verified by the poorer competitive performance of the group in the traditional children's and youth sports tourism events, as compared with the pre-pandemic periods.

Conclusion. The study data and analyses generally showed benefits of the modern electronic training elements for the supplementary children's and youth sports tourism supplementary educational service, particularly in the Local History, Ecology and Life Safety competence module where the distance learning tools were found to effectively facilitate progress due to special motivations. The distance learning formats with a wide variety of modern electronic training tools, however, were tested little beneficial for practical tourist skills and competitive performance in the sports tourism events.

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