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Key issues of the modern sports science for discussion



Forecasting the impact of a mega-sports event on the development of the region

It is known that major sporting events have a serious impact on the development of the region: the economy and infrastructure are changing, the level of labor resources is being provided, investment attractiveness is emerging.

Nevertheless, as practice shows, after the competition, positive expectations from the use of sports heritage are not always justified. Therefore, already at the stage of application formation, the administrative structures of the region should predict the main vectors of development, so that powerful financial influences do not turn into losses, but really open up new opportunities for obtaining maximum and long-term socio-economic effect.

Predicting the financial risks of a mega-event, one should assume a high probability of overspending. From the experience of holding mega-sporting events – the World Football Championships, the Olympic Games, the average budget excess reaches up to 30% of the planned volumes.

It is important to understand in advance that a mega-sporting event creates situations that go beyond the usual legal procedures. To meet the requirements of organizations such as the IOC or FIFA, it will be necessary to change the legal field not only of the region, but also of the entire state: tax benefits, security measures, the withdrawal of territories for the construction of facilities are only a small part of the legal problems that need to be

solved for the successful holding of a mega – sporting event.

It is very important to assess the social interest in the mega-sporting event, since it affects the lives of citizens. Urban planning of sports infrastructure will change the appearance of the city for a long time, the rhythm of life that has been debugged for years. The public of the city should be involved in the discussion of these issues and find optimal solutions.

The relocation of citizens is a special problem that should be taken into account and predicted before making a decision on holding a mega-sporting event. Relocation is a concomitant, but often painful factor for the residents of the organization of a sports mega-project. As a rule, resettlement is carried out forcibly, providing residents with monetary compensation. At the same time, the organizers should remember that in all likelihood, other long-term urban and regional development projects will have to be postponed, since the construction priorities will be redirected to sports facilities.

One of the factors of successful economic forecasting of a mega-sports event is the planning of future sales in the field of regional entrepreneurship, both during the competition and after them. Many companies consider sports mega-projects as a successful investment and promotion of their own brand.

When predicting the effectiveness of mega-sporting events, it should be taken into account that the IOC and FIFA oblige the host party to provide sufficient infrastructure capacity: the capacity of public transport, the airport, the number of hotels. This is due to the fact that during the competition, an additional load is created on the transport and social infrastructure due to the large flow of competition participants and fans. In order for the infrastructure built for mega-events not to become unprofitable, it is necessary to develop a business plan for its loading in advance.

The organizers should take into account that the driving factor for the development of the host region is the interest of political elites, which can lead to conflict situations between the administrative structures of the regional, federal and international levels in terms of making managerial decisions.

We invite scientists to publish articles that are aimed at finding new management solutions in conducting mega-sports events at the regional and federal levels.

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Weightlifting clean-and-jerk techniques: gender-specific biomechanics analysis

UDC 612.7:796.01



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Abstract

Objective of the study was to analyze the gender-specific biomechanics of the modern weightlifting clean-and-jerk techniques.

Methods and structure of the study. The study was timed to the altitude trainings of the Yug Sport Club at the Biomedical Technologies Center of the Federal Scientific and Clinical Center for Specialized Types of Medical Aid and Medical Technologies in Kislovodsk on the 1240m high Small Saddle Mountain. We sampled for the study 45 elite weightlifters of the both sexes qualified Masters of Sport and competing for the Russian national weightlifting team.

We used the BTS Motion System (made by BTS Bioengineering, Italy) described in our prior study using special weightlifting biomechanics processing and analyzing certified software (certificate RU 2020660143, 28.08.2020), with the snatch phase structure analyzed as provided by L.S. Dvorkin. Given on Figure 1 hereunder is a sample of the gender-specific squat phase 7 biomechanics analyzing snapshot.

Results and conclusion. The tests and analyses of the gender-specific clean-and-jerk biomechanics found a statistically significant leadership of the men's group in the strength, speed, power and weight response speed tests. The women's group was tested as high as the men's group in a few kinematic tests including the joint amplitude variation, horizontal weight movement tests and in some clean-and-jerk phases; with notably higher knee/ ankle joint flexion speeds and amplitudes. Based on the study data and analyses, we developed exemplary/ model gender-specific clean-and-jerk biomechanics with the clean-and-jerk technique control and correction recommendations. Some athletes in the sample were recommended to give special attention to the squat/ drop/ stand-up phase timings; dynamic emphases in the drop phase; and the weight control action speeds to improve the individual techniques.

Keywords: *biomechanics, sports technique, video analysis, tenso-dynamometry, kinematics, weightlifters, clean-and-jerk, gender specifics.*

Background. Modern sports techniques on the whole and weightlifting ones in particular are highly efficient and ergonomic i.e. customized to the musculoskeletal system and its capacity. Since the individual anthropometric characteristics, strength and speed-strength capacities are known to be expressly gender-specific, we assumed it could be beneficial to analyze the modern weightlifting techniques in gender groups.

Objective of the study was to analyze the gender-specific biomechanics of the modern weightlifting clean-and-jerk techniques.

Methods and structure of the study. The study was timed to the altitude trainings of the Yug Sport Club at the Biomedical Technologies Center of the Federal Scientific and Clinical Center for Specialized Types of Medical Aid and Medical Technologies in Kislovodsk on the 1240m high Small Saddle


A

B
Figure 1. Gender-specific squat phase 7 biomechanics analysis

Mountain. We sampled for the study 45 elite weightlifters of the both sexes qualified Masters of Sport and competing for the Russian national weightlifting team.

We used the BTS Motion System (made by BTS Bioengineering, Italy) described in our prior study [1] using special weightlifting biomechanics processing and analyzing certified software (certificate RU 2020660143, 28.08.2020) [2], with the snatch phase structure analyzed as provided by L.S. Dvorkin [3]. Given on Figure 1 hereunder is a sample of the gender-specific squat phase 7 biomechanics analyzing snapshot.

Results and discussion. Subject to the gender-specific clean-and-jerk biomechanics analy-

sis were the timing, strength and speed test rates with the movement range, kinematics and power parameters. The analysis found no statistically significant gender differences in the clean-and-jerk phase times. The strength test rates were unsurprisingly higher in the men's group including the vertical bipodalic strength component fixed by the force plate in the transitional point of the clean-and-jerk sequence, with the vertical bipodalic strength component maximums and averages fixed and analyzed: see Table hereunder.

The men's group was tested with the higher maximum speed test rates in the vertical bipodalic strength component sequence in every phase save for the stand-up one. Statistically significant in-

Table: Vertical bipodalic strength component maximums and averages in the gender groups, kg

Clean-and-jerk phase	Maximums			Averages		
	Men, M±σ	Women, M±σ	p<	Men, M±σ	Women, M±σ	p<
Pull 1.1	233,1±47,22	168,0±34,47	0,0001	135,9±29,01	108,7±24,35	0,02
Pull 1.2	243,3±47,12	173,8±33,50	0,0006	223,7±42,50	158,5±27,89	0,00005
Drop 2.1	262,7±52,16	206,7±35,65	0,002	207,1±45,86	155,5±25,80	0,006
Drop 2.2	262,7±52,16	214,5±35,64	0,0001	173,7±46,76	133,1±28,36	0,01
Squat 3.1	216,1±51,69	148,6±53,20	0,0007	57,75±22,48	37,84±17,17	0,01
Squat 3.2	297,9±52,96	239,4±52,35	0,003	214,6±35,98	160,8±29,55	0,0001
Stand-up 4	295,2±54,97	234,2±51,06	0,004	197,6±41,40	138,9±27,55	0,0002
Sub-squat 6.1	329,4±65,73	260,8±50,53	0,003	209,7±47,53	147,9±27,97	0,0005
Sub-squat 6.2	350,3±63,86	268,9±47,61	0,0008	271,3±61,70	202,7±41,37	0,003
Squat-under 7	165,5±64,11	132,3±50,13	-	75,21±41,54	52,56±29,66	0,04
Stand-up 8	198,9±41,94	132,5±31,72	-	126,7±41,17	84,54±32,21	0,006

Note: Mann-Whitney U- test

tergroup differences were found in pull 1.1 (men 800.5 ± 281.8 kg/ s, women 485.3 ± 241.9 kg/ s; $p < 0.001$), pull 1.2 (men 370.7 ± 237.1 kg/ s, women 183.0 ± 110.1 kg/ s; $p < 0.02$), drop 2.2 (men 1138.8 ± 861.1 kg/ s, women 596.1 ± 372.1 kg/ s; $p < 0.03$) and squat 3.1 (men 7615.9 ± 3046.9 kg/ s, women 5476.9 ± 2438.7 kg/ s; $p < 0.04$) phases.

The average lift height was higher in the men group in virtually every clean-and-jerk phase. The right hip joint angle in the transitional point was statistically significantly higher in the women's group at the end of the drop phase (men $170.3 \pm 9.14^\circ$; women $179.2 \pm 10.14^\circ$; $p < 0.02$); as well as the hip joint flexion amplitude in squat 3.2 (men $-35.97 \pm 15.12^\circ$; women $-50.91 \pm 8.72^\circ$; $p < 0.002$), sub-squat 6.1 (men $-18.73 \pm 7.54^\circ$; women $-27.39 \pm 10.79^\circ$; $p < 0.03$), and sub-squat 6.2 (men $21.21 \pm 11.56^\circ$; women $31.38 \pm 12.56^\circ$; $p < 0.02$) phases.

The hip joint angular flexion speed maximums were also different for the gender groups, with the men tested higher at the startup of the drop phase (men $409.2 \pm 352.2^\circ$ / s; women $401.2 \pm 87.56^\circ$ / s; $p < 0.03$), and women higher at the end of the drop (men $404.8 \pm 151.1^\circ$ / s; women $508.2 \pm 179.6^\circ$ / s; $p < 0.01$), squat 3.2 (men $316.3 \pm 110.7^\circ$ / s; women $454.6 \pm 175.3^\circ$ / s; $p < 0.03$), stand-up (men $196.7 \pm 47.16^\circ$ / s; women $266.1 \pm 94.82^\circ$ / s; $p < 0.03$) and sub-squat 6.1 (men $98.17 \pm 14.54^\circ$ / s; women $127.8 \pm 25.96^\circ$ / s; $p < 0.0004$) phases. We also found the knee joint angle intergroup differences at the end of the drop phase (men $166.2 \pm 8.87^\circ$; women $174.3 \pm 9.20^\circ$; $p < 0.01$) and in the stand-up phase (men $169.1 \pm 11.70^\circ$; women $181.2 \pm 3.58^\circ$; $p < 0.01$)

where it was higher in the women group; whilst in the sub-squat and squat-under phases it was higher in the men group. The knee joint angular flexion speed maximum and amplitudes were tested higher in the women group in every clean-and-jerk phase: see Figure 2.

The right ankle joint angles were higher in the men group in pull 1.1, drop 2.1, squat 3.2 and stand-up 8 phases. The women group showed higher ankle joint flexion amplitudes in drop phase 2.2. The men's group showed higher ankle joint flexion amplitude in pull 1.1 phase and stand-up phase; and the women's group was tested higher on this scale in drop 2.1, drop 2.2 and squat 3.2 phases.

The men group was also tested meaningfully higher in the vertical effective power maximum versus body weight (W/kg) test in every phase: see Figure 3.

Conclusion. The tests and analyses of the gender-specific clean-and-jerk biomechanics found a statistically significant leadership of the men's group in the strength, speed, power and weight response speed tests. The women's group was tested as high as the men's group in a few kinematic tests including the joint amplitude variation, horizontal weight movement tests and in some clean-and-jerk phases; with notably higher knee/ ankle joint flexion speeds and amplitudes. Based on the study data and analyses, we developed exemplary/ model gender-specific clean-and-jerk biomechanics with the clean-and-jerk technique control and correction recommendations. Some athletes in the sample were recommended to give special attention to

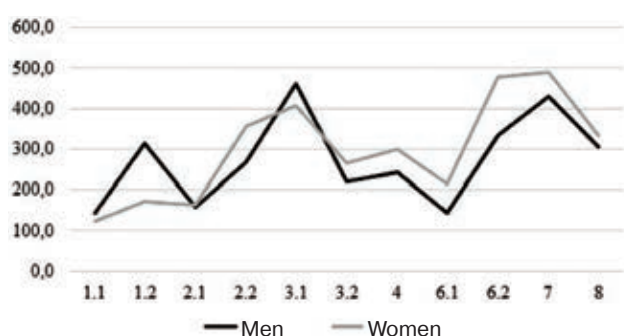


Figure 2. Gender group knee joint angular flexion speed maximum and amplitude averages, %/s (pull 1.1, pull 1.2, drop 2.1, drop 2.2, squat 3.1, squat 3.2, stand-up 4, sub-squat 6.1, sub-squat 6.2, squat-under 7; and stand-up 7 and 8 phases)

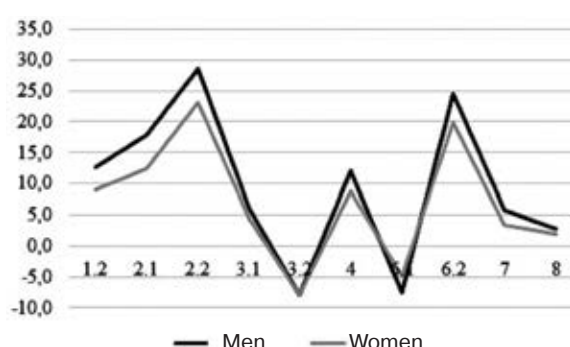


Figure 3. Gender group averages in the vertical effective power maximum versus body weight (W/kg) test: (pull 1.1, pull 1.2, drop 2.1, drop 2.2, squat 3.1, squat 3.2, stand-up 4, sub-squat 6.1, sub-squat 6.2, squat-under 7; and stand-up 7 and 8)



the squat/ drop/ stand-up phase timings; dynamic emphases in the drop phase; and the weight control action speeds to improve the individual techniques.

The study was performed under Governmental Contract #0173100014420000023 of 15.06.2020 endorsed by the national Ministry of Sports

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Workout intensity management standards for 6-7 years old wrestlers

UDC 796.015



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Abstract

Objective of the study was to offer workout intensity management standards for the 6-7 year-old wrestlers based on the energy mechanisms functionality and physical fitness tests and analyses.

Methods and structure of the study. We sampled for the study, on the family and coach's consent, three 7 year-old freestyle wrestlers having a two-year training experience, and tested them for: physical development (including body length and mass, BMI, muscle and fat mass, vital capacity, blood pressure and heart rate tests), physical fitness (including carpal strength, flexibility, standing long jump, shuttle sprint tests); speed-stepping treadmill tests till muscular failure (1.75 m/s stepped up by 0.25 m/s every 2 min). Exhaled carbon dioxide/ oxygen (CO₂/ O₂) was tested by Metalizer II Gas Analyzer test system (Cortex, Germany) and HR was tested prior to, during and after workouts with an ECG support. Blood lactate levels were tested after every workout stage in the rehabilitation process. The tests were designed to fix the maximal aerobic capacity, anaerobic threshold and oxygen uptake efficiency ratio. The anaerobic threshold range was verified by the pulmonary ventilation maximums with ventilation equivalents versus the lactate variations to obtain indirect anaerobic threshold rates and limits for the workout intensity zones.

Results and conclusion. Despite the individual differences in the run times and speeds and physiological energy costs, every sampled athlete was tested to mobilize mostly the anaerobic energy mechanisms in the failure workout tests, with the relative energy demand kept at certain level; and the same applies to efficiency of the aerobic-anaerobic transition mechanisms, whilst the lactic efficiency was tested relatively low. The study to produce the workout intensity zoning by the anaerobic metabolism threshold related HR found the age-specific threshold achieved at 170+ beats/min.

The key finding of the study is that the 6-7-year-old wrestlers' anaerobic threshold is attained at 170+ beats/ min and may be effectively used for the workout zoning purposes. Workout intensities in excess of this level may result, as we found, in irregularities of the cardiovascular system adaptation to the sport-specific workloads in long-time trainings.

Keywords: *physical working capacity, functionality of energy mechanisms, cardio-respiratory system, 6-7-year-old athletes.*

Background. Physical and functional progress in underage sports is known to be facilitated by prudently designed and managed workouts with due age-sensitive customization and individualization specifics different from the traditional adult standards [4]. Permissible workout intensity levels will be determined by the individual age-specific

functionality, energy mechanisms efficiency and cardio-respiratory system health tests [2, 4-7]. The age-related muscular performance is largely determined by the energy mechanisms formation and progress timeframe, with the aerobic mechanisms formation and functions known to be dominant in the pre-pubertal period followed by a faster pro-



gress in the anaerobic ones as soon as the puberty comes [2, 4].

Objective of the study was to offer workout intensity management standards for the 6-7 year-old wrestlers based on the energy mechanisms functionality and physical fitness tests and analyses.

Methods and structure of the study. We sampled for the study, on the family and coach's consent, three 7 year-old freestyle wrestlers having a two-year training experience, and tested them for: physical development (including body length and mass, BMI, muscle and fat mass, vital capacity (VC), blood pressure and heart rate tests), physical fitness (including carpal strength, flexibility, standing long jump, shuttle sprint tests) [1]; speed-stepping treadmill tests till muscular failure (1.75 m/s stepped up by 0.25 m/s every 2 min). Exhaled carbon dioxide/ oxygen (CO₂/O₂) was tested by Metalizer II Gas Analyzer test system (Cortex, Germany) and HR was tested prior to, during and after workouts with an ECG support. Blood lactate contents were tested after every workout stage in rehabilitation process. The tests were designed to fix the maximal aerobic capacity (rated by maximal oxygen consumption per kg, MOC/kg), anaerobic threshold (rated by the sprint speed versus the threshold OD) and the oxygen uptake efficiency ratio (OUE). The anaerobic threshold range was verified by the pulmonary ventilation maximums with ventilation equivalents versus the lactate variations to obtain indirect anaerobic threshold rates and limits for the workout intensity zones as provided by J. Skinner, McLellan, 1980 [6].

Results and discussion. The physical fitness / physical development tests found the sample falling within the standard age anthropometrics range [1] and somewhat different in the functionality/ physical fitness test rates, with Athletes 1 and 2 tested highest and lowest on the physical development / physical fitness scales, respectively: see Table 1. The sample was also tested different in the treadmill workout tests, with the run times and speeds varying within the ranges of 5-9 min and 2.13-2.63 m/s, respectively: see Table 2.

Leading in the tests was Athlete 1 who was tested the highest in the run speed, respiratory ratio and oxidative system capacity tests; the lowest in the pulmonary ventilation maximum test; and the highest in the oxygen uptake efficiency and lactate generation efficiency tests.

These test rates were accompanied by the highest HR, with the highest oxygen pulse indicative of the better oxygen delivery to the working muscles, good energy efficiency and, hence, fast HR maximizing time – with the minimal Stage 1 HR and the highest gap between the first- and last-stage HR.

Athlete 2 with his lowest run time and run speed was tested with the lowest maximal oxygen consumption due to the less active external respiration and high oxygen uptake efficiency in the working muscles, plus the high pulse sensitivity and lowest oxygen pulse, with the sub-maximal lactate level achieved by the relatively less intensive efforts. Athletes 1 and 2 were also different in the anaerobic threshold test rates, with Athlete 1 tested with the highest speed and oxygen demand at lower HR. These results generally agree with the

Table 1. Physical development / physical fitness tests rates of the sample

Physical development / physical fitness tests rates	Athlete 1	Athlete 2	Athlete 3	X	σ
Age, years	6,8	7,2	6,8	6,9	0,09
Body length, cm	118,7	121	118,8	119,5	1,32
Body mass, kg	21,8	21,9	21,2	21,6	0,43
BMI, kg/m ²	15,5	15	15	15,2	0,32
Muscle mass, %	46,3	43,8	45,6	45,2	1,28
Fat mass, %	9,9	12,0	9,4	10,4	1,42
Vital capacity, l	1,4	2,0	1,9	1,8	0,29
Blood pressure, mmHg	80/56	93/61	93/63	89/60	7,5/3,6
HR, bpm	78	96	99	91	11,4
Carpal strength, kg	10,0	6,0	9,0	8,3	2,13
Flexibility, cm	7,0	6,0	4,0	5,7	1,52
Standing long jump, cm	133	120	130	127,7	6,81
Shuttle sprint, s	9,16	10,74	9,19	9,70	0,904

**Table 2.** Physical efficiency/ functionality test rates of the sample

Physical working capacity / Physical fitness test rates	Athlete 1	Athlete 2	Athlete 3	X	V,%
<i>Physical working capacity</i>					
Run time, min	9,0	5,0	7,0	7,0	28,5
Run speed, m/s	2,63	2,13	2,38	2,38	10,5
<i>Energy mechanisms and cardio-respiratory system functionality test rates</i>					
Maximum breathing capacity l/min	51,5	52,1	54,9	52,8	3,4
Maximal oxygen consumption, l/min	1,231	1,169	1,175	1,192	2,9
MOC/kg, ml/min/kg	56,47	53,38	55,42	55,09	2,9
HR, bpm	206	206	201	204,3	1,4
MOC/ HR, ml/beat	5,98	5,67	5,85	5,83	2,6
Respiration index (RI), points	1,14	1,10	1,11	1,12	1,8
OUE, %	3,89	3,48	3,68	3,68	5,7
<i>Anaerobic/ glycolytic energy mechanisms functionality test rates</i>					
Stage 1 lactate, mmol/l	1,4	1,5	1,4	1,4	7,1
Failure lactate, mmol/l	5,9	5,6	4,5	5,3	13,2
<i>Anaerobic threshold test rates</i>					
Run speed, m/s	2,33	1,86	2,06	2,08	11,3
Speed ratio, % of the maximum	88,6	87,3	86,6	87,5	1,1
OUE, ml/min/kg	49,02	43,99	46,00	46,33	5,4
OUE, % of MOC	86,8	82,4	83,0	84,1	2,9
HR, bpm	178	182	180	180	1,1
<i>Heart rate variability test rates</i>					
Stage 1 HR, bpm	145	173	174	164	10,1
Failure HR, bpm	206	206	201	204,3	1,4
ΔHR, bpm	61	33	27	40,3	44,9

relevant study reports, although we found the higher maximal oxygen consumption and oxygen intake rates at the anaerobic threshold, whilst the maximal lactate levels in the 7 year-old sample were tested close to that in the untrained peers [1, 2].

Despite the individual differences in the run time and speed and physiological energy cost, every sampled athlete was tested to mobilize mostly the anaerobic energy mechanisms in the failure workout tests, with the relative energy demand kept at certain level; and the same applies to efficiency of the aerobic-anaerobic transition mechanisms, whilst the lactic efficiency was tested relatively low – below 5.9 mmol/l. The respiratory index was tested to vary under 1 – that is indicative of the energy mechanisms being dominated by carbohydrates in oxidation substrates; although it should be mentioned that the lactate accumulation profile appears to somewhat disagree with this assumption and may be rather indicative of heterochrony (timing disharmonies) in the substrate sup-

ply for muscular metabolism and ventilation-perfusion ratio (respiratory index) – explainable by the age-specific functional disharmony of the external respiration and blood circulation systems [1].

The sample was also tested with fairly close cardiovascular system activity test rates and HR maximizing time both in response to the top-intensity workouts and at the anaerobic threshold level – that may be indicative of the leading role of autonomic responses in the circulatory system under muscular stress, in the context of the age-specific disharmonies in the respiratory and anaerobic-lactate energy supply systems [1].

It may be pertinent to mention in this context the wide variation of test rates in the workout process (Table 2), with the highest variability (%) typical for the cardiovascular system reserve related test rates, and the lowest variability found for the physiology-related ones.

The study to produce the workout intensity zoning



by the anaerobic metabolism threshold related HR found the age-specific threshold achieved at 170+ beats/min.

Conclusion. The key finding of the study is that the 6-7-year-old wrestlers' anaerobic threshold is attained at 170+ beats/min and may be effectively used for the workout zoning purposes. Workout intensities in excess of this level may result, as we found, in irregularities of the cardiovascular system adaptation to the sport-specific workloads in long-time trainings.

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14-19 year-old basketball players' age- and game-position-specific fitness variation analysis

UDC 796.323.2/015.682



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Abstract

Objective of the study was to profile and analyze the age- and game-position-specific physical / technical fitness test data correlations in the 14-19 year-old basketball groups.

Methods and structure of the study. We sampled 95 junior 14-19 year-old basketball players for the study that was run in March through November 2019 at the Ravinsky Olympic Reserve Sports School No. 49. The players' physical and technical fitness were tested using the standard test toolkit.

Results and conclusion. The 14-15-year-old defenders were tested with 10 significant technical fitness / competitive success correlations. The highest (one-percent margin) technical fitness / competitive success correlations were found for the 5x6m shuttle sprint ($r = 0.616$) and standing high jump $r = 0.590$) tests. The 14-15-year-old attackers were tested with six significant (five-percent margin) technical fitness / competitive success correlations; whilst the centers were tested with only two significant technical fitness / competitive success correlations for the standing long jump and 10 penalty shots tests.

The 16-17-year-old defenders were tested with nine significant technical fitness / competitive success correlations, with the top correlation found for the defense square test ($r = 0.671$).

The study found that the 14-19 year-old basketball players with age are tested with the shorter numbers of significant technical / physical fitness test rate correlations – apparently indicative of the growing sports mastery levels.

Keywords: *physical fitness, technical fitness, test data correlations, junior basketball players, game position.*

Background. Modern basketball sport communities give a special priority to the physical fitness / technical fitness tests and test data correlation analyses, particularly at beginner stages of the long-term training systems when the sport skill sets are in formation and progress [1-5]. The youth basketball training systems are still in need of the relevant research findings and recommendations, and this was the reason for this study deemed relevant.

Objective of the study was to profile and analyze the age- and game-position-specific physical / technical fitness test data correlations in the 14-19 year-old basketball groups.

Methods and structure of the study. We sampled 95 junior 14-19 year-old basketball players for the study that was run in March through November 2019 at the Ravinsky Olympic Reserve Sports School No. 49. The players' physical and technical fitness were tested using the standard test toolkit.

Results and conclusion. The 14-15-year-old defenders were tested with 10 significant technical fitness / competitive success correlations. The highest (one-percent margin) technical fitness / competitive success correlations were found for the 5x6m shuttle sprint ($r = 0.616$) and standing high jump $r = 0.590$)



tests. The 14-15-year-old attackers were tested with six significant (five-percent margin) technical fitness / competitive success correlations; whilst the centers were tested with only two significant technical fitness / competitive success correlations for the standing long jump and 10 penalty shots tests.

The 16-17-year-old defenders were tested with nine significant technical fitness / competitive success correlations, with the top correlation found for the defense square test ($r = 0.671$). The 16-17-year-old attackers were tested with eight significant technical fitness / competitive success correlations, with the highest one found for the 5x6m shuttle sprint test ($r = -0.610$); whilst the centers were tested with only two significant technical fitness / competitive success correlations for the standing long jump ($r = 0.661$) and 10 penalty shots tests ($r = 0.650$).

The 18-19-year-old defenders were tested with 11 significant technical fitness / competitive success correlations, with the top correlations found for the 6m sprint ($r = -0.678$) and standing long jump ($r = 0.670$) tests. Most expresses for the 18-19-year-old attackers were the technical fitness / competitive success correlations in the complex technical fitness ($r = 0.639$) and slalom ball control ($r = -0.633$) tests; whilst the centers were tested with only two significant technical fitness / competitive success correlations for the 10 jump shots and 10 hook shots tests.

On the whole, we found the test rate correlations with the competitive success being game-position-specific. Most important for the defenders' and attackers' were the speed and speed-strength tests and fine motor skills tests; whilst the centers' skills were best tested by the shooting accuracy tests. It should be emphasized that the speed-strength tests were found beneficial for every game-position group. We also found benefits of the special physical fitness tests growing with age, with growth of the physical fitness test repetitions contributing to the test data accuracy.

We also analyzed the technical / physical fitness correlations in the sample. The 14-15-year-old defenders were tested with the highest (1% margin) correlation for the 20m sprint and 3x10m shuttle sprint ($r = 0.679$), long stuffed ball shooting and 30s wall rebound pass ($r = 0.664$) tests. Most beneficial for the 14-15-year-old attackers were the technical / physical fitness correlations of the 2x40m/ 3x10m shuttle sprint with the ball control ($r = 0.617$) test, and the 3x10m

shuttle sprint with the 20m sprint ($r = 0.616$) tests; and for the centers – 20m spring with 3x10m shuttle sprint tests ($r = 0.634$).

The 16-17 year-old defenders were tested with the highest correlations of the 20m sprint with the 5x6m shuttle sprint ($r = 0.677$), standing high jump and combined technical fitness ($r = -0.616$) test rates. The 16-17 year-old attackers were tested with the highest correlations of the 20m spring with 3x10m ball control ($r = 0.672$) test rates; whilst the centers showed the top correlations of the 2x40s and 5x6m sprint ($r = 0.694$) test rates.

Most beneficial for the 18-19-year-old defenders were the correlations of the 20m sprint with 3x10m ball control ($r = 0.664$) tests; for the attackers 2x40m with 3x10m ball control ($r = 0.636$) test rates; and for the centers - the 20m sprint with the 30s wall rebound passes ($r = -0.498$) test rates.

The technical / physical fitness correlations were found age-specific. Thus most beneficial for the 14-15-year-olds were the correlations of the ball reception and control skills under time pressure with the lower-limbs speed-strength qualities and speed-strength endurance of the torso flexors.

Most beneficial for the 16-17 year-olds were the footwork and high-speed ball control skills tests with the test data correlation analyses. Progress in the technical / physical fitness tests in this age group is recommended being facilitated by special complex motor coordination training tools. The group progress was also found to depend on correlations of the speed-strength qualities with the shooting accuracy under mounting fatigue. Most successful in this group were the players capable to maintain the high shooting accuracy under mounting fatigue – testable by the skills sustainability probes.

Most beneficial for the 18-19 year-olds were the special game-position-specific motor skills tests with the test data correlation analyses. Significant correlations in the group were found for the long-distance shooting, 30s both-hands passing and speed-strength test rates. The age- and game-position specific technical / physical fitness training systems are recommended being customized as dictated by the test data correlations.

Conclusion. The study found that the 14-19 year-old basketball players with age are tested with the shorter numbers of significant technical / physical fitness test rate correlations – apparently indicative of the growing sports mastery levels.



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Customized training service with health and fitness tests for cyclic sports elite in post-covid-19 rehabilitation period

UDC 76.015



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Abstract

Objective of the study was to analyze the respiratory system functionality in the cyclic sports elite in the clinically monitored post-COVID-19 rehabilitation periods to offer training system customization options sensitive to the respiratory system health conditions.

Methods and structure of the study. We sampled for the study the 19-22 year-old cyclic sports elite (n=16, including 6 males and 10 females) qualified CMS, MS and WCMS. The sample was tested four times per day as follows: (1) morning test; (2) post-aerobic-training test; (3) post-high-intensity (sub-maximal) anaerobic training test; and (4) rehabilitation-period test using a portable electrochemical NO-analyzer (NObreath, Bedfont Scientific Ltd.). The bronchial asthma and allergic rhinitis diagnosed individuals were excluded from the sample.

Results and conclusion. An individual training system will be prudently managed with the workouts customized to the energy corridor of aerobic and anaerobic metabolism. There are good reasons to believe that the post-COVID-19 regress is due to a sort of 'energy pits' with the athlete being unable to attain the pre-disease workloads within the anaerobic zone with the required anaerobic power. Premature transition in the anaerobic energy supply range in the early training process stages may expose the athletes to overstress risks, with regress in the functional fitness.

The study found the elite cyclic sports sample being less tolerant to trainings within the anaerobic metabolism zone; and for this reason we recommended the training system being prudently customized to make a special emphasis on the aerobic capacity development practices dominated by breathing exercises including those facilitated by breath training machines. We also recommended expanding the range of medical services and functional fitness tests in the training process using special individualized medical/ biological support service protocols with a special attention to the elite athletes' functional fitness test data flow variations.

Keywords: elite athletes, functional fitness, COVID-19, respiratory system disorders, preventive care.

Background. Modern sports communities report facing problems in their efforts to train and keep the elite athletes fit in post-COVID-19 rehabilitation periods. Clinical study reports show that standard rehabilitation protocols with the respiratory system complications prevention components are not always effective enough in the respiratory system health assurance even in cases of minor/ subclinical symptoms of the

disease. National health systems are still contradictory in the disease control/ rehabilitation issues, databases, rehabilitation service recommendations and service timing/ management aspects, and pharmacological support standards in cases of long-lasting symptoms and many other related issues. Particularly sensitive in this context are the modern elite cyclic sports with their great energy costs and dominant



aerobic energy mechanism, as their training systems need to be efficiently customized to the post-disease conditions with a special attention to the external respiration system functionality test data flows.

Many analysts in the above context have been interested in the NO (nitric oxide II) tests as this oxide is considered a fair biological marker of allergic and inflammatory conditions. Exhaled NO (NOex) level is known to notably grow in cases of prolonged respiratory system inflammations and/ or allergic conditions. Some aspects of this marker application, however, are still rather contradictory despite its extensive practical application experience in studies. It should be mentioned that many sports-specific NOex test methods are still underdeveloped. We believe, therefore, that the NOex tests and analyses in elite cyclic sports training systems in the post-COVID-19 rehabilitation periods could be beneficial for the practical sports research and sports health service.

Objective of the study was to analyze the respiratory system functionality in the cyclic sports elite in the clinically monitored post-COVID-19 rehabilitation periods to offer training system customization options sensitive to the respiratory system health conditions.

Methods and structure of the study. We sampled for the study the 19-22 year-old cyclic sports elite (n=16, including 6 males and 10 females) qualified CMS, MS and WCMS. The sample was tested four times a day as follows: (1) morning test; (2) post-aerobic-training test; (3) post-high-intensity (sub-maximal) anaerobic training test; and (4) rehabilitation-period test using a portable electrochemical NO-analyzer (NObreath, Bedfont Scientific Ltd.). The bronchial asthma and allergic rhinitis diagnosed individuals were excluded from the sample.

Results and discussion. Resting NOex was tested to average 24.5 ± 4.5 ppb; and to widely vary in trainings to peak at 35 ppb in the post-anaerobic-training tests, with the falls down to 14.2 ± 3.8 ppb in the rehabilitation-period tests. The NOex production was naturally tested to grow with the physical stress and fall in rehabilitation rehab time, with some variations indicative of the remaining pathological conditions associated with hyper-responsiveness of the airways – reasonably believed to be indicative of the virus-related long-lasting respiratory system conditions.

The NOex variations snapshot tests in the intensity-stepping physical trainings found the wavelike NOex production patterns significantly correlated with the anaerobic workout intensity. The 20+ ppb NOex

growth tested in some individuals may be indicative of hyper-production of this biological marker due to the chronic respiratory system inflammation on the verge of clinical conditions.


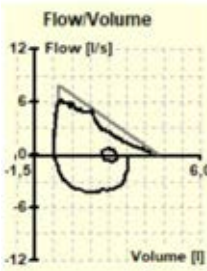
The above NOex tests were combined with spirometric tests that found insignificant falls in the FEV-1 (1-second forced exhale volume test) considered a marker of bronchial patency deficiency) under 80% of the norm. We believe that the still high FEV-1 test rates in the sample may be interpreted as indicative of good compensatory adaptation and high respiratory system resource due to the endurance training. A few individuals were tested with the 25+ ppb NOex rates and qualified with the dynamic monitoring group subject to special respiratory system malfunction prevention and correction service.

Special breathing practices with the central nervous system control effects will be in special priority in the respiratory system disease prevention service. These practices help improve the individual volitional breath control, strength and endurance of the main and supplementary respiratory system muscles, static/ dynamic respiratory volumes and capacities; and mobilize the cardio-respiratory system resource. Thereby they contribute to the hypoxia tolerance resource, speed up the respiratory system recovery processes and optimize the individual psycho-functional conditions.

Equally important for the post-COVID-19 respiratory system recovery service are the medical tests in the training process with special individualized medical/ biological support service protocols sensitive to the training stages. Such service will include the repeated external respiration tests, functional fitness tests with rhythmographs, biochemical marker tests (ALT, ALAT, creatine kinase, urea tests), plus special research to find the respiratory system damage/ chronic inflammation indicators with the risk assessment elements. The NOex should be prioritized among the other key respiratory system health test markers in the training process tests.

An individual training system will be prudently managed with the workouts customized to the energy corridor of aerobic and anaerobic metabolism. There are good reasons to believe that the post-COVID-19 regress is due to a sort of 'energy pits' with the athlete being unable to attain the pre-disease workloads within the anaerobic zone with the required anaerobic power. Premature transition in the anaerobic energy supply range at the early train-

Table 1. Post-anaerobic-zone training functional fitness test data

Functional fitness by rhythmographs	Respiratory system functionality																																																																
<p>Very low current FF (-2). Individual adaptability heavily compromised (1).</p>  <p>Physiological functions have seriously sagged [1].</p>	<div style="display: flex; align-items: flex-start;">  <table border="1" style="margin-left: 20px;"> <thead> <tr> <th colspan="4">Spirometry</th> </tr> </thead> <tbody> <tr> <td>IVC</td> <td>l</td> <td>4,34</td> <td>3,06 71%</td> </tr> <tr> <td>IRV</td> <td>l</td> <td>-</td> <td>1,98 -</td> </tr> <tr> <td>ERV</td> <td>l</td> <td>-</td> <td>1,37 -</td> </tr> <tr> <td>VT</td> <td>l</td> <td>-</td> <td>0,65 -</td> </tr> <tr> <th colspan="4">Flow/Volume</th> </tr> <tr> <td>FVCex</td> <td>l</td> <td>4,26</td> <td>4,00 94%</td> </tr> <tr> <td>FEV1</td> <td>l</td> <td>3,72</td> <td>3,09 83%</td> </tr> <tr> <td>FEV1/IVC</td> <td>%</td> <td>83</td> <td>101 121%</td> </tr> <tr> <td>MEF25</td> <td>l/s</td> <td>2,24</td> <td>1,31 58%</td> </tr> <tr> <td>MEF50</td> <td>l/s</td> <td>4,79</td> <td>2,80 58%</td> </tr> <tr> <td>MEF75</td> <td>l/s</td> <td>6,61</td> <td>5,11 77%</td> </tr> <tr> <td>MEF75-85</td> <td>l/s</td> <td>-</td> <td>5,40 -</td> </tr> <tr> <td>PEF</td> <td>l/s</td> <td>7,86</td> <td>6,18 79%</td> </tr> <tr> <td>PIF</td> <td>l/s</td> <td>-</td> <td>4,32 -</td> </tr> <tr> <td>AREAex</td> <td>l²/s</td> <td>14,91</td> <td>12,50 84%</td> </tr> </tbody> </table> <p style="margin-top: 10px;">FeNOex – 35 ppb Finding: Airway patency reduced the middle bronchi. Respiration resource low.</p> </div>	Spirometry				IVC	l	4,34	3,06 71%	IRV	l	-	1,98 -	ERV	l	-	1,37 -	VT	l	-	0,65 -	Flow/Volume				FVCex	l	4,26	4,00 94%	FEV1	l	3,72	3,09 83%	FEV1/IVC	%	83	101 121%	MEF25	l/s	2,24	1,31 58%	MEF50	l/s	4,79	2,80 58%	MEF75	l/s	6,61	5,11 77%	MEF75-85	l/s	-	5,40 -	PEF	l/s	7,86	6,18 79%	PIF	l/s	-	4,32 -	AREAex	l ² /s	14,91	12,50 84%
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Conclusion. The study found the elite cyclic sports sample being less tolerant to trainings within the anaerobic metabolism zone; and for this reason we recommended the training system being prudently customized to make a special emphasis on the aerobic capacity development practices dominated by breathing exercises including those facilitated by breath training machines. We also recommended expanding the range of medical services and functional fitness tests in the training process using special individualized medical/ biological support service protocols with a special attention to the elite athletes' functional fitness test data flow variations.

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Volleyball setting skills (second contact) trainings with practice targets

UDC 796.012



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Abstract

Objective of the study was to analyze benefits of special practice target for the overhand/ underhand setting skills training by non-setter players.

Methods and structure of the study. We sampled for the study the 21.3±4.7 year-old 187±9.7cm tall volleyball players (n=20) with the 5-plus-year experiences trained 3-plus times a week including 3 liberos, 6 central blockers, 7 side players and 4 diagonal players. The sample was randomly grouped into a visual feedback group (EG-1) and verbal feedback group (EG-2) tested virtually the same (with statistically insignificant differences) by the pre-experimental tests. During the eight-week experiment, the groups were trained three times a week. The EG-1 trainings were assisted by visual feedback with practice targets; and the EG-2 trainings included verbal/ instructive feedback from the coach. The group progress in overhand/ underhand setting skills was rated on the following scale

Results and conclusion. The pre- versus post-experimental underhand set test data analysis showed significant ($p < 0.05$) benefits of the practice-target-assisted feedback training versus the verbal/ instructive feedback procedure. It should be mentioned, however, that the latter also ensured statistically significant ($p < 0.05$) progress in game techniques. The study found the practice-target-assisted training system being beneficial for the setting skills training in volleyball as verified by the pre- versus post-experimental setting accuracy tests. Further practice-target-assisted trainings and studies are recommended giving a special priority to the setting skills training by non-setter players and attack success tests and analyses for combinations with sets from non-setters in trainings and competitions.

Keywords: volleyball, exercise machines, training session.

Background. Modern volleyball sport community applies a wide variety of exercise machines and practice targets in training systems to improve physical fitness and excel the passing, setting and attacking skills [2, 4, 5]. Some special practice targets / exercise machines are used to train visual control and feedbacks ranked among the key skills by every modern team sport. Basically, feedback may be interpreted as the pre- and post-game-action data flow processing analyzing capacity. As demonstrated by D.A. Vladimirov, the game-specific customizable feedback facilitates progress in game techniques [3]. Individual sensory-

perceptual system may be described as the internal component of the feedback that assesses the game techniques; whilst the outside data flow is an additional feedback channel complementing the internal feedback data flow [1, 6]. Coaches normally strive to excel and expand the feedback systems to help every trainee correct technical errors and excel the motor skills to perfection for success in trainings and competitions.

Objective of the study was to analyze benefits of special practice target for the overhand/ underhand setting skills training by non-setter players.



Methods and structure of the study. We sampled for the study the 21.3 ± 4.7 year-old 187 ± 9.7 cm tall volleyball players ($n=20$) with the 5-plus-year experiences trained 3-plus times a week including 3 liberos, 6 central blockers, 7 side players and 4 diagonal players. The sample was randomly grouped into a visual feedback group (EG-1) and verbal feedback group (EG-2) tested virtually the same (with statistically insignificant differences) by the pre-experimental tests. During the eight-week experiment, the groups were trained three times a week. The EG-1 trainings were assisted by visual feedback with practice targets; and the EG-2 trainings included verbal/ instructive feedback from the coach. The group progresses in overhand/ underhand setting skills were rated on the following scale: see Table 1.

Table 1. *Setting skills rating scale*

Points	Rate
81-100	Excellent
51-80	Good
31-50	Acceptable
0-30	Poor

The set progress test was designed as follows: the coach threw the ball to Zone 6 for pass; and the setter moved from Zone 5 for the pass to Zone 2 and from Zone 1 for the pass to Zone 4. The sets were targeted to the practice targets fixed 3m high and 0.5 far from

the net in the above zones. The movable circular practice targets were 1m in diameter with 0.5m internal circle. Every successful set on target to the internal and external circle was scored by 10 and 5 points, respectively. The players were given 10 overhand and 10 underhand attempts to set in every zone (Zones 2 and 4) with the tests video-captured and scored as described in Table 1. The individual scores of the 10 sets were summarized and classified by the zones and overhand / underhand styles.

Results and discussion. Table 2 gives the pre-versus post-experimental underhand set test data.

The pre- versus post-experimental underhand set test data analysis showed significant ($p < 0.05$) benefits of the practice-target-assisted feedback training versus the verbal/ instructive feedback procedure. It should be mentioned, however, that the latter also ensured a statistically significant ($p < 0.05$) progress in game techniques. Table 3 hereunder gives the pre-versus post-experimental overhand set test data.

The pre- versus post-experimental overhand set test data analysis showed significant ($p < 0.05$) benefits of the practice-target-assisted feedback training versus the verbal/ instructive feedback procedure. We also found the overhand sets by the non-setter players being significantly ($p < 0.05$) more accurate than the underhand ones: see Table 4.

We should also mention that the group pre- versus post-experimental overhand sets to Zone 4 were

Table 2. *Pre- versus post-experimental underhand set test data, group scores*

Group	Set to Zone 2		Set to Zone 4		Pre- versus post-experimental test data difference significance rate	
	Pre	Post	Pre	Post	Zone 2	Zone 4
EG-1	27,1±5,9	52,4±4,9	28,5±8,2	52±4,9	$p < 0,05$	$p < 0,05$
EG-2	29±10,7	42,6±10,3	27±10,1	42±11,4	$p < 0,05$	$p < 0,05$
Intergroup difference	$p > 0,05$	$p < 0,05$	$p > 0,05$	$p < 0,05$		

Table 3. *Pre- versus post-experimental overhand set test data, group scores*

Group	Set to Zone 2		Set to Zone 4		Pre- versus post-experimental test data difference significance rate	
	Pre	Post	Pre	Post	Zone 2	Zone 4
EG-1	44,5±6	65,6±5,2	50,5±6	71±7,4	$p < 0,05$	$p < 0,05$
EG-2	41,1±5,6	58,6±5,2	47,4±9,8	64,5±5,5	$p < 0,05$	$p < 0,05$
Intergroup difference	$p > 0,05$	$p < 0,05$	$p > 0,05$	$p < 0,05$		

Table 4. Post-experimental overhand versus underhand set success rates: group scores

Overhand / underhand set test	EG-1	EG-2
Overhand set to Zone 4	71±7,4	64,5±5,5
Underhand set to Zone 4	52±4,9	42±11,4
Difference significance rate	p<0,05	p<0,05
OH set to Zone 2	65,6±5,2	58,6±5,2
Underhand set to Zone 4	52,4±4,9	42,6±10,3
Difference significance rate	p<0,05	p<0,05

significantly ($p < 0.05$) more accurate than the ones to Zone 2, whilst both of the groups made progress in the sets for the experimental period. The accuracy gap in the underhand sets to both zones were not that wide (versus the overhand sets) both in the pre- and post-experimental tests. This finding may be explained by the players being trained to set to Zone 4 to the attacker when the setter fails to make an accurate overhand set or makes the first (serve reception) contact – and, hence, it is habitual for them to make resort to this game element automatically.

It should be also noted that libero players were much more accurate in sets to Zone 2 than Zone 4. We believe it may be due to the fact that they normally play in Zone 5 and make sets, when required, mostly to Zone 2 both in trainings and competitions. The sample, however, was non-representative of the libero game role ($n=3$ only) and, therefore, the finding cannot be considered significant in fact.

Conclusion. The study found the practice-target-assisted training system being beneficial for the setting skills training in volleyball as verified by the pre- versus post-experimental setting accuracy tests. Further practice-target-assisted trainings and studies are recommended giving a special priority to the setting skills training by non-setter players and attack success tests and analyses for combinations with sets from non-setters in trainings and competitions.

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Chess sport and chess trainings related dissertations: research methods, key subjects and content analysis

UDC 796.092



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Abstract

Objective of the study was to analyze the national chess training / chess sport related dissertations to systematize the key content, priority subjects and research approaches of special contribution to and benefits for the modern chess sport science.

Methods and structure of the study. We completed a content analysis of the national chess sport / chess training related dissertations that cover a wide range chess training systems and chess training psychology and pedagogy issues for the period of 1946-2020. We classified the priority research topics by scientific branches in accordance with the valid classifier of the Higher Attestation Commission. We sampled for analysis 213 dissertations partially or fully analyzing different chess sport / chess training issues, including two Doctoral dissertations with fundamental research and problems solutions and 211 PhD dissertations focused on practical and specific chess training / chess sport issues.

Result and Conclusion. Analysis of the national chess training / chess sport related dissertations made it possible to outline the key trends and priority subjects for research and the most efficient research approaches of special contribution to the modern chess sport science and chess training systems. Progress of the modern chess sport and chess training methods, models and tools is primarily due to the advanced new chess training technologies as demonstrated by the dissertations sampled for the study. The national research design and management approaches and cooperation of the chess sport / chess training researchers is facilitated by the established scientific schools, research teams and interests in multisided experimental studies.

Keywords: *education, chess sport, dissertations, methodology.*

Background. The chess training theory and methodology has transformed for the last three decades, with the chess training practices notably intensified; and at this juncture the sport communities report a strategic need for the accumulated chess training / chess sport knowledge and practices to be systematized, the practical research findings and content to be revised and abstracted to form logically designed and efficient chess sport / chess training databases and toolkits [2]. It may be beneficial in this context to have the chess sport / chess

training related dissertations analyzed with a special interest in the genesis of chess training innovations and thinking, key ideas, conceptual approaches, and core research subjects to advance the theoretical and practical chess training methods, psychological and practical chess training innovations etc. for progress of the chess sport science. Efforts to analyze content of the chess study reports, to process and systematize the most promising research issues, including special literature reviews and analyses of the most popular and cited research mate-

rials/ fields may be of high interest for the modern chess sport science [1].

Objective of the study was to analyze the national chess training / chess sport related dissertations to systematize the key contents, priority subjects and research approaches of special contribution to and benefits for the modern chess sport science.

Methods and structure of the study. We completed a content analysis of the national chess sport / chess training related dissertations that cover a wide range chess training systems and chess training psychology and pedagogy issues for the period of 1946-2020. We classified the priority research topics by scientific branches in accordance with the valid classifier of the Higher Attestation Commission. We sampled for analysis 213 dissertations partially or fully analyzing different chess sport / chess training issues, including two Doctoral dissertations with fundamental research and problems solutions and 211 PhD dissertations focused on practical and specific chess training / chess sport issues.

Result and discussion

Chess training research

The chess training related dissertations give a special priority to the theoretical and practical chess training service efficiency, new chess training models and tools, chess training service customization/ diversification issues etc., with more than 50% of the sample focused on these topics. Genesis and drivers of the growing chess training research for the last three decades (that has offered a wide range of new chess training concepts, views, models and tools spearheaded by the educational mission of chess sport) have been facilitated by the new chess training technologies and growing digitalization of the chess training systems on the whole.

About 40% of the sample analyzes general issues of the theoretical and practical chess training service

with the cultural aspects in the context of general pedagogy, history of pedagogy and education to generate new ideas on how the cognitive reserves should be mobilized and universalized for intellectual progress in modern chess sport. Some studies underline benefits of modern chess training tools for correctional training of people with disabilities, to facilitate their mental/ physiological progress, rehabilitation and socializing agendas. Given in Table 1 hereunder is the content analysis of the sampled dissertations grouped by the valid Classifier of Pedagogical Sciences.

Our content analysis of the national chess sport / chess training related dissertations for the period of 1946-2020 with their classification by the valid Classifier of Pedagogical Sciences made it possible to outline the key chess training trends and ideas by the growing chess sport schools, and fundamentals of the chess training systems applied by the national chess sport elite. Fundamental research by V.V. Knyazeva with analysis of the chess training subject content and progress in the national general education school system; plus the M.A. Vershinin dissertation with the new theory of the chess-sport-developed logical thinking and its practical applications – are considered highly beneficial for the modern chess sport / chess training theory and practice. Studies by M.R. Kobaliy, A.V. Ryazantsev and V.A. Potkin spell out the key provisions for progress of the theoretical and practical training service to the chess sport elite. And the chess training research publications by A.N. Kostyev, I.G. Sukhin, B.A. Zlotnik have been recognized worldwide and are being widely applied nowadays within the advanced educational systems.

Chess training psychology research

Presently the chess sport community takes efforts to develop an integrated psychological test and service system with the relevant reflection and mental control elements to attain due sport-specific neural plasticity.

Table 1. Content analysis of the sampled dissertations grouped by the valid Classifier of Pedagogical Sciences

Specialty groups	Research fields: N – dissertations, % of the total				Total
	13.00.01: General Pedagogy and History of Pedagogy and Education	13.00.02: Education and Training Theory (field-specific)	13.00.03: Correctional Pedagogy (surdopedagogy, tiflopedagogics, oligophrenopedagogy, speech therapy)	13.00.04 – Physical Education and Sports Training, Recreational and Adaptive Physical Education Theory and Practice	
N	11	10	1	30	52
%	22,1	19	1,9	57	100

**Table 2.** Content analysis of the sampled dissertations grouped by the valid Classifier of Psychological Sciences

Specialty group	Research fields: N – dissertations, % of the total					Total
	19.00.01: General Psychology, Personality Psychology, History of Psychology	19.00.02: Psycho-physiology	19.00.05: Social Psychology	19.00.07: Educational Psychology	19.00.13: Developmental Psychology, Acmeology	
N	1	2	5	3	2	13
%	7,7	15,5	38,4	22,9	15,5	100%

Of special interest are the social and educational psychology research with the modern chess viewed as a sort of ecosystem that facilitates individual intellectual progresses in the thinking, attention control, memorizing, perceptive, analyzing and cognitive domains. About 30% of the sample analyzes the chess training / chess sport psychology related issues with the relevant personality development and acmeological aspects. Special attention is paid to the chess sport psychophysiology to verify benefits of the special research for competitive success in the chess sport in the increasingly competitive environments with the growing pressure from the sport-specific mental stressors.

Fundamental research of mental activity by O.K. Tikhomirov; chess sport psychology study by N.V. Krogus with a generalizing analysis of the chess sport competitive psychology with its match control tools; the B.M. Blumenfeld's dissertation with a new chess player's psychology profiling method and analyses of reasoning and reflections – are representative of the modern trends in the chess sport psychology research. Given in Table 2 hereunder is the content analysis of the sampled dissertations grouped by the valid Classifier of Psychological Sciences.

Our content analysis of the national chess sport / chess training related dissertations for the period of 1946-2020 with their classification by the valid Classifier of Psychological Sciences gives understanding of the quantitative and qualitative mental health and competitive psychology/ environment testing methods, with implications for the chess training psychology and the theoretical and practical training service optimizing goals. Research by A.Y Gabbazova and E.N. Kuchumova analyzes the intellectual progress issues of the modern chess training systems and reflection as the key productive chess training method. Research publications by A.A. Bartashnikov and T.Y. Paramono-

va on the individual operational memory development issues with a psychological analysis as contributor to the strategic progress planning in modern chess sport have deepened and expanded our knowledge of the personality-sensitive neuropsychological test service models applicable in the chess sport.

Conclusion. Analysis of the national chess training / chess sport related dissertations made it possible to outline the key trends and priority subjects for research and the most efficient research approaches of special contribution to the modern chess sport science and chess training systems. Progress of the modern chess sport and chess training methods, models and tools is primarily due to the advanced new chess training technologies as demonstrated by the dissertations sampled for the study. The national research design and management approaches and cooperation of the chess sport / chess training researchers is facilitated by the established scientific schools, research teams and interests in multisided experimental studies.

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Alpine skiing and snowboarding instructor's motivations and social standing survey

UDC 796.075



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Abstract

Objective of the study was to survey motivations and social standings of the national Alpine ski and snowboard instructors.

Methods and structure of the study. We sampled for the questionnaire survey the Alpine skiing and snowboarding instructors (n=89) from Krasnaya Polyana Ski Resort in Sochi and Krylov Ski School in Moscow (National School of Professional Instructors) and collected their key personal data including gender, age, education, place of residence, sports qualification/ title, Alpine skiing and snowboarding instructor qualification, and other active businesses. Motivations of the sample were surveyed using the D. Barbutto and R. Skoll survey form [2, 5] including 5 groups of 6 questions (30 questions in total) to rate: (1) Internal Processes; (2) Instrumental Motivations; (3) External Self-concept; (4) Internal Self-concept; and (5) Goal Internalization.

Results and conclusion. The study data and analyses produced social standings of the Alpine skiing and snowboarding sample that was 66% male and dominated by with 23-60 year-old (90%) individuals. Most of the sample (71%) reported a higher education albeit no Alpine skiing and snowboarding sport qualifications/ titles; and 65% reported having Class C certificates for professional service to beginners. Most (73%) of the sample reported sufficient practical Alpine skiing and snowboarding instructing service experience indicative of a sound vocational self-identification. Dominant places of residence for the sample are Sochi (Krasnaya Polyana) and Moscow cities.

The survey found the Alpine skiing and snowboarding instructors' motivations dominated by their internal values and standards, with a special role played by the service satisfaction and individual goals compliant with the internal progress agendas (growth motivations). External motivations were ranked secondary by the sample, with the respondents reporting no interest in how their competences and services are rated by the others i.e. uninterested in the social recognition. Instrumental motivations related to material remuneration were ranked only fourth of five categories i.e. unimportant. It should be emphasized that the instrumental motivations were ranked mostly low, and one of them even negative.

Keywords: vocational motivation, Alpine skiing instructor, snowboarding instructor.

Background. Alpine skiing industry in Russia has reported progress and expansion for the last decade, with virtually every mountain region building ski trails, ski lifts and other service infrastructure to lure people to the alpine skiing or snowboarding sports among other popular physical activities [1]. The growing services have boosted a demand for the Alpine skiing and snowboarding

instructors although this profession has its natural seasonal limitations with the service limited by four-five months per year at most plus weather-dependent, with the relevant implications for the annual income flow.

Objective of the study was to survey motivations and social standings of the national Alpine skiing and snowboarding instructors.

Methods and structure of the study. We sampled for the questionnaire survey the Alpine skiing and snowboarding instructors (n=89) from Krasnaya Polyana Ski Resort in Sochi and the Krylov Ski School in Moscow (National School of Professional Instructors) and collected their key personal data including gender, age, education, place of residence, sports qualification/ title, Alpine skiing and snowboarding instructor qualification, and other active businesses. Motivations of the sample were surveyed using the D. Barbuto and R. Skoll survey form [2, 5] including 5 groups of 6 questions (30 questions in total) to rate: (1) Internal Processes; (2) Instrumental Motivations; (3) External Self-concept; (4) Internal Self-concept; and (5) Goal Internalization.

Results and discussion. The Alpine skiing and snowboarding instructor sample was found 66% male and 34% female, with 49%, 41% and 7% aged 23-34, 35-60 and 18-22 years, respectively; and only 3% 60-plus years old. High, secondary vocational and secondary education was reported by 71%, 15% and 14% of the sample, respectively; and only 11% of the sample reported having a formal Alpine skiing and snowboarding qualification. Furthermore, two, three, four and one reported having World Class Master of Sport, Master of Sport, Candidate Master of Sport, and Class I Athlete qualifications, respectively, and this finding was somewhat unexpected since it means that most of the sample has neither formal Alpine skiing and snowboarding certificates from private or public Alpine skiing and snowboarding schools nor Alpine skiing and snowboarding competitive experiences apart of the amateur/ tourist skiing records. However, 73% of the sample reported 3-plus-years of Alpine skiing and snowboarding instruction experience – that means that their vocational identifications are well-established. Most of the sample reported residing in Sochi (Krasnaya Polyana) and Moscow, with the others living in Voronezh, Ufa, Perm, Yekaterinburg, Kazan, Samara and some other cities.

The motivations survey found the following:

- Ranked on top by the sample was Internal Self-concept (No. 4) with its genuine values, standards and competencies; whilst the external incentives were rated secondary;
- Ranked second were Internal Processes (No. 1) with the internal motivations being more important than the external ones, i.e. the subjects are mostly

driven by the service satisfaction and interest in the job, and ranked the material incentives secondary;

- Ranked third was Goal Internalization (No. 5) that means that the sample is centered on the own service goals correspondent to the internal values;
- Ranked fourth were Instrumental Motivations (No. 2) i.e. the need for material remuneration for the service – that means that this motivation is not a decisive one in the vocational agenda; and
- Ranked fifth was the External Self-concept (No. 3), with this lowest ranking showing the sample being largely indifferent to how their competence, values and priorities are perceived by the others from the reference group. This means that most of the Alpine skiing and snowboarding instructors are disinterested in – or even rejecting – social recognition and external appreciation of their professional service skills and experiences.

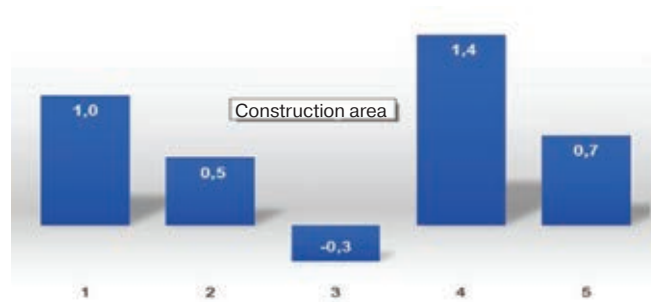


Figure 1. Averaged motivations survey data

Conclusion. The study data and analyses produced social standings of the Alpine skiing and snowboarding sample that was 66% male and dominated by with 23-60 year-old (90%) individuals. Most of the sample (71%) reported a higher education albeit no Alpine skiing and snowboarding sport qualifications/ titles; and 65% reported having Class C certificates for professional service to beginners. Most (73%) of the sample reported sufficient practical Alpine skiing and snowboarding instructing service experience indicative of a sound vocational self-identification. Dominant places of residence for the sample are Sochi (Krasnaya Polyana) and Moscow cities.

The survey found the Alpine skiing and snowboarding instructors' motivations dominated by their internal values and standards, with a special role played by the service satisfaction and individual goals compliant with the internal progress agendas



(growth motivations). External motivations were ranked secondary by the sample, with the respondents reporting no interest in how their competences and services are rated by the others i.e. disinterested in a social recognition. Instrumental motivations related to material remuneration were ranked only fourth of five categories i.e. unimportant. It should be emphasized that the instrumental motivations were ranked mostly low, and one of them even negative.

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Physical self imaging method to improve adaptability after severe physical injuries in sports

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Abstract

Objective of the study was to analyze individual post-disabling-severe-physical-injuries adaptabilities of athletes and test benefits of a new physical self-image improvement model.

Methods and structure of the study. We sampled for the study the 18-38 year-old athletes (n=120, including 80 males and 40 females) with severe disabling musculoskeletal injuries. We have developed a psychological service model with integrated rehabilitation elements to help form positive physical self-images for the individual adaptability mobilizing and rehabilitation purposes. The new model testing experiment was run at Maryino and Krylatskoye Therapeutic/ Rehabilitation Centers.

We tested the individual physical self-image and adaptive conditions in the EG and RG in the physical self-image excelling model testing experiment. Both the men and women groups were tested with denial as a psychological defense mechanism used to mitigate the disabling factors and stressors – correlated at the same time with the physical self-image distortions ($r = 0.412$, $p < 0.01$). The individual corporeality perceptions were also found distorted by the acute need for recognition, self-pity and egocentrism, with the anatomical aspects being often exaggerated ($r = 0.343$, $p < 0.01$) to merge as much as possible the real/ mirror physical self with the ideal physical self-image ($r = 0.505$, $p < 0.01$).

The women group was tested with the close positive correlation between the denial test rates and social aspects of the physical self-image ($r = 0.401$, $p < 0.01$); with the 'repressive' psychological defense mechanism found to distort the physical self-image towards perceived hypertrophied non- attractiveness ($r = 0.397$, $p < 0.01$); versus the rationalization psychological defense that secures the physical self-image evolving towards adequacy ($r = 0.614$, $p < 0.01$) [7]. These findings once again verify the known correlations of the physical self-image in post-disabling-severe-physical-injuries periods with the individual psychological defense mechanisms.

Results and conclusion. The study demonstrated benefits of the psychological service model facilitating positive physical self imaging for the adaptability mobilizing and fast rehabilitation of athletes in the post-disabling-injury periods.

Keywords: *t psychological adaptation, athlete, severe physical injury, athlete's adaptability, physical self-image.*

Background. Modern sports medicine gives a special attention to integrated rehabilitation methods to facilitate recovery after severe musculoskeletal injuries [2] with contributions from experts in every scientific field. The post-musculoskeletal-injury adaptation process as such is being studied

mostly by the medical science on the whole with some aspects analyzed by psychology. At the same time, mental stressors and complications associated with severe physical injuries have been thoroughly analyzed by the national and foreign psychology (S. Auerbach, D. Bright, B. Goldstone, S.



Gramming, J. Greenberg, F. Jones, WB Kennon, G. Selye et al.), with some studies giving a special priority to the post-injury mental conditions methods for senior and adolescent groups. However, correlations of the integral physical Self image with adaptation in cases of disabling severe physical injuries and somatic diseases are still underexplored in many aspects by the modern psychology and deserve special analyses.

The disabling severe physical injuries as such will undoubtedly be ranked among the extreme stressors, with the individual stress tolerance dependent on both adaptability and past traumatizing experience. These factors largely determine the situation-specific adaptability with its volitional and unconscious stress coping strategies collectively referred to as the individual adaptation and resulting adaptive conditions ranked among the personality resource components.

As far as the structure and content of a physical self-image are concerned, they may be interpreted as the unity of cognitive (referring to the physical/ bodily awareness and self-perception adjusted for its distortion by consciousness to a degree), affective (attitudes to physical self, including stresses from its non-conformity with the social and perceived individual/ external physical perfection standards) and behavioral (with the ways to present own Self to others) components.

Contents of the above components may vary with distortions in cognitive, attitudes-specific (affective) and operational/ behavioral aspects of the physical Self caused by the individual anxiety about the following three key physical self components: anatomical (mismatches with imaginary ideal bodily proportions), functional (physical personality qualities) and image-related (body presentation) characteristics. In the psychological framework, they may be interpreted as the correlation of the actual physical Self with its ideal shape and content, plus the physical self apprehension in the past, present and future [8].

It should be also mentioned that the modern psychological literature makes no clear distinction between the physical and bodily Selves, although at the same time it is quite common to separate to a degree the physical/ bodily Self image with its dominant perceptive aspect from the corporal/ physical Self as such that refers not only to the perceptions but also to feelings triggered by such reflections [7].

Objective of the study was to analyze individual post-disabling-severe-physical-injuries adaptabilities of athletes and test benefits of a new physical self-image improvement model.

Methods and structure of the study. We sampled for the study the 18-38 year-old athletes ($n=120$, including 80 males and 40 females) with severe disabling musculoskeletal injuries. We have developed a psychological service model with integrated rehabilitation elements to help form positive physical self-images for the individual adaptability mobilizing and rehabilitation purposes. The new model testing experiment was run at Maryino and Krylatskoye Therapeutic/ Rehabilitation Centers.

We tested the individual physical self-image and adaptive conditions in the EG and RG in the physical self-image excelling model testing experiment. Both the men and women groups were tested with denial as a psychological defense mechanism used to mitigate the disabling factors and stressors – correlated at the same time with the physical self-image distortions ($r = 0.412$, $p < 0.01$). The individual corporeality perceptions were also found distorted by the acute need for recognition, self-pity and egocentrism, with the anatomical aspects being often exaggerated ($r = 0.343$, $p < 0.01$) to merge as much as possible the real/ mirror physical self with the ideal physical self-image ($r = 0.505$, $p < 0.01$).

The women group was tested with the close positive correlation between the denial test rates and social aspects of the physical self-image ($r = 0.401$, $p < 0.01$); with the 'repressive' psychological defense mechanism found to distort the physical self-image towards perceived hypertrophied non-attractiveness ($r = 0.397$, $p < 0.01$); versus the rationalization psychological defense that secures the physical self-image evolving towards adequacy ($r = 0.614$, $p < 0.01$) [7]. These findings once again verify the known correlations of the physical self-image in post-disabling-severe-physical-injuries periods with the individual psychological defense mechanisms.

Results and discussion. Of special interest in the model testing experiment was the physical self-image progress in the EG versus RG. The EG was tested with progress in leveling down the physical self-image distortions in every training session, plus growing satisfactions with the own anatomical and functional characteristics and more positive/ con-



structive physical disability correction agendas in the post-injury rehabilitation periods.

We found, among other things, a growing correlation between the satisfaction with own physique and severity of depression, anxiety, perceived loneliness, dispositional hope levels, vital activity and existential problems coping strategies. We also tested the EG with meaningful progress versus the RG on the well-being, activity, mood, aggression, anxiety, frustration, hope and existential fulfillment scales.

The fast-recovering athletes were tested significantly higher in every physical self-image component test versus their slower rehabilitating peers, with the goal-setting and positive internal dialogue found to heavily contribute to the progress. Such fast-recovering athletes were notably better in the ability to set immediate/ short-term goals in the rehabilitation process for successful and fast recovery to the professional fitness standards.

Conclusion. The study demonstrated benefits of the psychological service model facilitating positive physical self imaging for the adaptability mobilizing and fast rehabilitation of athletes in the post-disabling-injury periods.

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First-year physical education masters' career ambitions survey

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Abstract

Objective of the study was to survey and analyze the first-year physical education masters' career ambitions.

Methods and structure of the study. The first-year physical education masters' career ambitions / values survey was run in 2020. We sampled for the survey the Surgut State University (SSU) physical education and sports masters (n=36) and split them up into the following Experimental Groups (EG) by their master courses: (1) Physical Education and Sports Theory and Practice course: EG1 (n=12); (2) Adaptive Physical Education Service for Disabled People: Adaptive Physical Rehabilitation and Health curriculum: EG2 (n=12); and (3) Elite Sports Training Systems curriculum in the Sports course: EG3 (n=12). The groups were surveyed using the E. Shein Career Anchors Survey Method; with the group survey data processed and statistically analyzed using the Mann-Whitney U-test.

Results and Conclusion. The survey found the following dominant career values in every group. The first-year physical education and sports masters ranked high the socially appreciated career values including Service, Stable Job, Autonomy, Management, Business, Professional Motivation and some others – that means that the sample is sensitive to the modern socio-economic and political situations. Professional Competence and Stable Residence career values were ranked lowest in the career values hierarchy by the sample, and this finding gives reasons to believe that the first-year masters are still under-committed for the declared values and priorities and unclear on the ways their career ambitions may be realized. We believe that one of the ways to address this problem is to give a higher priority to studies in the Self-management and Progress and Leadership and Project Teamwork courses designed to help the young people explore the opportunities for their abstract aspirations being analyzed and shaped up so as to set clear specific progress goals and effectively forecast, design and manage own individual and professional progress agendas.

Keywords: *career values, sports activity, personality qualities, volitional and behavioral control.*

Background. The national physical education and sports personnel education system gives a special priority to the physical education and sport service in the northern areas of the country due to the harsh climatic conditions of potential detriment for public health. Of special theoretical and practical interest in this context may be the individual psychological characteristics, values, priorities and

career ambitions on the whole of the physical education and sports master course graduates recruited for the physical education and sport service in these areas – all the more that many authors believe [1, 2] that the career ambitions are naturally formed in the early learning and maturation stages to keep fairly stable for a long time thereafter being often realized unconsciously.



Objective of the study was to survey and analyze the first-year physical education masters' career ambitions.

Methods and structure of the study. The first-year physical education masters' career ambitions / values survey was run in 2020. We sampled for the survey the Surgut State University (SSU) physical education and sports masters (n=36) and split them up into the following Experimental Groups (EG) by their master courses: (1) Physical Education and Sports Theory and Practice course: EG1 (n=12); (2) Adaptive Physical Education Service for Disabled People: Adaptive Physical Rehabilitation and Health curriculum: EG2 (n=12); and (3) Elite Sports Training Systems curriculum in the Sports course: EG3 (n=12). The groups were surveyed using the E. Shein Career Anchors Survey Method [1]; with the group survey data processed and statistically analyzed using the Mann-Whitney U-test.

Results and discussion. The survey found the following dominant career values in every group: Service, Stable Job, Autonomy and Lifestyle Integration scored by 7.8, 7.6, 7 and 7 points on average, respectively.

Service as the lead value means that the students strive to help people and communities with their physical education and sports knowledge, skills and experience as successfully as possible to achieve certain individual and social goals. The U-test showed the EG2 vs. EG3 difference being insignificant ($U_{emp.} = 39.5$); EG1 vs. EG2 difference uncertain ($U_{emp.} = 26$), and EG1 vs. EG3 difference significant ($U_{emp.} = 7.5$) in the Service domain.

Stable Job with its dependability and social guarantees from the employer was ranked second career values by the sample. The EG2 vs. EG3 difference was tested statistically significant ($U_{emp.} = 12.5$); EG1 vs. EG2 difference insignificance ($U_{emp.} = 51.5$); and the EG1 vs. EG3 difference uncertain ($U_{emp.} = 19$) on the Stable Job scale.

Autonomy and Lifestyle Integration values were also ranked reasonably high by the groups as they are perceived important for the professional progress, independent work and decision-making for success in the individual physical education and sports careers. At the same time, the sample showed an aspiration to keep the individual lifestyle harmonized with the professional career that should ideally respect and facilitate the individual/ family agendas. The survey found no statistically signifi-

cant intergroup differences on these scales.

The sample ranked medium the following career values: Management, Professional Motivation, Challenge, Business and Professional Competence scored by 6.7, 6.3, 5.8, 5.7 and 5.0 points on average, respectively.

Thus the Professional Motivation Career Values was ranked high enough (with the statistically insignificant intergroup differences) since the sample appeared to understand that the professional successes, job satisfactions and individual/ professional progress agendas largely depend on the individual job-specific motivations with their focuses, intensities, sustainability, scopes and driving forces.

Business career values were also ranked high in association with the Stable Job career values that gives reasons to assume that the sample strives to serve others not only within the formal public physical education and sport system but also establish a private business to effectively make the dreams come true and attain the individual goals.

Professional Competence career values was ranked lower than the above listed eight career values. It should be mentioned that EG2 was tested statistically significantly different from the other two groups ($U_{emp} = 25$) on this scale; and this means that the masters of Adaptive Physical Education and Sport Service for disabled people appreciate more than the other groups the professional knowledge, skills and experience supported by the self-learning and training agendas as beneficial for the adaptive physical education and sport service and practical progresses.

Ranked lowest by the sample was Stable Residence scored by 3.4 points on average, that means that the sample appreciates the jobs and career option in their home cities being prepared at the same time to resettle if the physical education and sport service vacancies in other cities are of interest for them.

Conclusion. The first-year physical education and sports masters ranked high the socially appreciated career values including Service, Stable Job, Autonomy, Management, Business, Professional Motivation and some others – that means that the sample is sensitive to the modern socio-economic and political situations. Professional Competence and Stable Residence career values were ranked lowest in the career values hierarchy by the sam-



ple, and this finding gives reasons to believe that the first-year masters are still under-committed for the declared values and priorities and unclear on the ways their career ambitions may be realized. We believe that one of the ways to address this problem is to give a higher priority to studies in the Self-management and Progress and Leadership and Project Teamwork courses designed to help the young people explore the opportunities for their abstract aspirations being analyzed and shaped up so as to set

clear specific progress goals and effectively forecast, design and manage own individual and professional progress agendas.

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Comparative analysis of main characteristics of technique of elite hurdlers (men and women)

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Abstract

Objective of the study was to compare the main spatiotemporal and angular parameters of the technique of elite hurdlers (men and women)

Methods and structure of the study. This article analyzes the spatiotemporal and angular characteristics of running technique and hurdling by the finalists of the World Championships 2017 (London) in 110 m hurdles (men) and 100 m hurdles (women). The study used data from the IAAF Biomechanical Reports [2,3] and Statgraphics plus 5.0 for data processing.

Results and conclusions. The research shows that in the hurdle clearance phase statistically significant differences are observed between men and women in the take-off and landing distances and the hurdle flight time. While running between hurdles, the length and flight time of the first step in women is greater ($p < 0,001$), and the length of the second step is shorter ($p < 0,05$). The trunk-thigh angle at toe-off during the take-off phase and the lead leg knee angle at touchdown in the two groups also differ ($p < 0,05$). Many of the studied parameters have a significant range of values: in women, the lead leg knee angle ($53-90^\circ$) and the trail leg knee angle ($141-173^\circ$) during the take-off phase, the trunk angle at touchdown ($48-64^\circ$) and toe-off during the landing step ($63-78^\circ$); in men - the trunk-thigh angle during the take-off phase ($53-82^\circ$) and the lead leg knee angle at touchdown ($150-177^\circ$).

Keywords: hurdling technique, biomechanical analysis, short hurdle events.

Introduction: Hurdling is a technical type of athletics, in which the result is determined by both well-developed physical qualities, primarily speed-power, and motor skills, namely the technique of overcoming hurdles and running between hurdles. Different rules of competition for men and women hurdlers (height and placement of hurdles, distance length) and differences in anthropometrical data place specific requirements on the choice of training means [1].

The study and comparative analysis of the technical skill of the world's leading athletes allows us to model and form the optimal technique for motor actions when training athletes at various levels. In our work, the main spatiotemporal and angular parameters

of the technique of clearing and running between hurdles were studied.

Objective of the study was to compare the main spatiotemporal and angular parameters of the technique of clearing and running between hurdles by the world's strongest hurdlers specializing in the short hurdle sprint, and also to identify common factors.

Methodology and structure of the study. The research involved a statistical analysis and a processing of the spatiotemporal and angular characteristics of the technique employed by the finalists in the 2017 World Athletics Championship (London) who were running the 110 m hurdles (men) and 100 m hurdles



(women). The initial data was obtained from IAAF Biomechanical Reports [2,3].

Results and Discussion. Table 1 shows the spatiotemporal characteristics of clearing the hurdle (the 6th one for men and the 5th for women) and running between hurdles by participants in the finals the 100 and 110 meters hurdles from the World Championship in 2017. The athletes are presented in order of final ranking.

The length of the hurdle step in men is significantly greater than in women ($p < 0.001$). Average values are 3.80m and 3.16m, respectively. Moreover, the greatest difference is observed in the landing distance. In men, it is half a meter more ($1,56 \pm 0,06$ m and $1,06 \pm 0,04$ m, respectively, $p < 0,001$). The take-off distance is on average 15 cm longer. We can see the greatest range of values among men within the groups. The world record holder at this distance, A. Merrit, has the smallest landing distance of 1,34 m, but the longest take-off distance of 2,52cm. In women, H. Nelson, a silver medalist, has the smallest landing distance, and she has one of the longest take-off distance – 2,20 m.

The contact time during the take-off phase in wom-

en is also slightly better than in men, at an average of 0,12 s. Sally Pearson, Olympic and World Champion, has the best figure of 0,107 s. This value is similar to those of the contact time of the strongest sprinters.

The total time taken to clear the hurdle for women is significantly better than for men, on average by 0,05 s. The average value for women is $0,280 \pm 0,006$ s, for men $0,331 \pm 0,006$ s ($p < 0,001$). The best result among men is 0,307 s by the Jamaican, 8th placed H. Parchment. One of the best hurdlers in the world of recent years, 2015 World champion and the silver medalist in this final, the Russian, Sergey Shubenkov, clears the hurdle in 0.320 s, which is the third-best result. It is worth noting that in women, the winner of this championship, S. Pearson, has one of the worst result – at 0,30s. The best values belong to the 7th and 8th places respectively, to N. Visser and N. Ali with 0,26 s.

The following pattern can be distinguished in running between hurdles. The average value of the contact time at the landing phase has approximately the same value for men and women at 0,09 s. At the same time, the flight time of the first step in men is much less - $0,046 \pm 0,002$ s; in women $0,072 \pm$

Table 1. Spatiotemporal characteristics of the hurdle clearance phase and steps between hurdles for the 110m and 100m hurdles for the 2017 World Championship finalists

Finalist	Hurdle clearance				First step			Second step		
	Contact-time (s)	Take-off, (m)	Landing (m)	Flight time (s)	Contact-time (s)	Flight time (s)	Length (m)	Contact-time (s)	Flight time (s)	Length (m)
Men (110 m hurdles)										
O. McLeod	0,127	2,15	1,73	0,333	0,093	0,053	1,37	0,113	0,100	1,91
S. Shubenkov	0,127	2,10	1,73	0,320	0,087	0,053	1,42	0,120	0,100	2,04
B. Baji	0,113	2,21	1,79	0,347	0,100	0,033	1,36	0,120	0,100	1,89
G. Darien	0,140	2,28	1,39	0,313	0,087	0,053	1,47	0,127	0,093	2,01
A. Merrit	0,127	2,51	1,34	0,347	0,087	0,047	1,45	0,113	0,120	2,07
R. Brathwait	0,133	2,11	1,55	0,327	0,100	0,040	1,35	0,107	0,133	2,14
O. Ortega	0,120	2,24	1,63	0,353	0,087	0,040	1,35	0,120	0,120	2,06
H. Parchment	0,133	2,30	1,34	0,307	0,093	0,047	1,42	0,127	0,113	2,20
$\bar{x} \pm S_x$	$0,127 \pm 0,003$	$2,23 \pm 0,05$	$1,56 \pm 0,06$	$0,331 \pm 0,006$	$0,091 \pm 0,002$	$0,046 \pm 0,002$	$1,39 \pm 0,02$	$0,118 \pm 0,002$	$0,110 \pm 0,005$	$2,04 \pm 0,04$
σ	0,008	0,13	0,06	0,017	0,005	0,007	0,05	0,007	0,14	0,11
Women (100 m hurdles)										
S. Person	0,107	2,11	1,15	0,300	0,087	0,067	1,70	0,113	0,113	1,67
H. Nelson	0,127	2,20	0,80	0,267	0,093	0,067	1,54	0,120	0,107	2,05
P. Dutkiewich	0,113	2,11	1,11	0,280	0,087	0,087	1,70	0,107	0,100	1,80
K. Harrison	0,120	2,08	1,06	0,280	0,100	0,073	1,57	0,113	0,107	1,90
C. Manning	0,127	2,10	1,02	0,273	0,087	0,067	1,57	0,120	0,100	2,01
A. Talay	0,113	2,23	1,10	0,313	0,087	0,060	1,63	0,113	0,113	1,71
N. Visser	0,127	1,95	1,08	0,260	0,093	0,093	1,72	0,113	0,107	1,95
N. Ali	0,133	2,05	1,15	0,267	0,113	0,060	1,54	0,120	0,100	2,02
$\bar{x} \pm S_x$	$0,121 \pm 0,003$	$2,10 \pm 0,03$	$1,06 \pm 0,04$	$0,280 \pm 0,006$	$0,093 \pm 0,003$	$0,072 \pm 0,004$	$1,62 \pm 0,03$	$0,115 \pm 0,001$	$0,105 \pm 0,002$	$1,88 \pm 0,05$
σ	0,009	0,09	0,11	0,018	0,009	0,012	0,08	0,004	0,005	0,15
p	>0,05	<0,05	<0,001	<0,001	>0,05	<0,001	<0,001	>0,05	>0,05	<0,05



Table 2. Angular kinematics at the hurdle clearance phase of 110m hurdles and 100m hurdles for the 2017 World Championship finalists

	Take-off phase					Landing phase			
	Lead leg knee angle	Trail leg knee angle	Deviation angle	Trunk angle	Trunk-thigh angle	Lead leg knee angle	Trail leg knee angle	Trunk angle	
								Touch-down	Toe-off
Men (110 m hurdles)									
O. McLeod	77,2	153,9	64,0	75,7	70,5	177,6	79,4	65,4	86,4
S. Shubenkov	74,7	159,0	64,4	64,1	53,9	175,4	80,2	62,6	78,9
B. Baji	76,0	167,7	65,0	71,8	68,9	169,3	76,4	65,9	79,3
G. Darien	77,1	158,9	60,8	72,4	65,1	165,2	81,8	60,3	73,5
A. Merrit	73,9	155,7	65,6	63,8	57,1	173,3	82,5	54,7	68,2
R. Brathwait	69,8	159,1	65,6	76,2	82,8	150,0	82,9	65,0	79,9
O. Ortega	70,9	163,7	66,0	76,6	80,4	161,4	81,3	61,0	82,5
H. Parchment	75,7	166,1	63,4	82,2	66,1	157,5	79,7	49,7	70,9
$\bar{x} \pm S_x$	74,4± 1,0	160,5± 1,7	64,4± 0,6	72,9± 2,2	68,1± 3,5	166,2± 3,4	80,5± 0,7	60,6± 2,0	77,4± 2,2
σ	2,7	4,9	1,7	6,3	10,0	9,5	2,1	5,7	6,1
Women (100 m hurdles)									
S. Person	67,7	162,4	66,9	74,9	88,7	173,6	80,6	59,5	78,4
H. Nelson	53,2	156,6	63,1	71,0	74,8	150,6	83,7	48,7	63,5
Dutkiewich	63,9	155,5	63,1	67,6	67,7	153,4	77,4	64,2	76,5
Harrison	90,5	167,8	62,9	71,4	84,0	151,5	78,3	67,9	79,8
Manning	69,7	159,0	59,9	70,8	76,5	154,9	82,9	54,4	70,8
Talay	60,5	141,6	64,2	72,8	80,9	146,7	82,2	57,2	77,6
Visser	65,6	153,9	63,4	71,1	74,0	162,9	78,5	62,5	75,1
N. Ali	79,1	173,8	59,1	73,7	80,7	152,5	74,5	58,3	78,9
$\bar{x} \pm S_x$	68,7± 4,1	158,8± 3,4	62,8± 0,9	71,6± 0,8	78,4± 2,3	155,7± 3,0	79,8± 1,1	59,1± 2,1	75,1± 1,9
σ	11,5	9,7	2,4	2,4	6,5	8,6	3,1	6,0	5,4
p	>0,05	>0,05	>0,05	>0,05	<0,05	<0,05	>0,05	>0,05	>0,05

0,004 s, ($p < 0,001$). This data is consistent with the shorter first step length in men (mean value of 1,39 m). In women it is 1,62 m. The contact of the second step for almost all the athletes under consideration is 0,11-0,12 s. The average value of the flight time is somewhat faster for women (0,11-0,12 s), but for men there is a wider range of values (from 0,09 to 0,12 s). The length of the second step in men, compared to the first, is longer by an average of 15 cm. But strong differences are also observed within the groups. In men, one of the tallest participants R. Baji has the shortest second step of 1,89m and the largest one belongs to H. Parchment at 2,20 m. On average, the increase in the second step compared to the first is 36-55%. Curiously, women demonstrate both a decrease in the second step compared to the first (S. Pearson by 3 cm), and an increase of 8-10 cm in

A. Talay and P. Dutkiewich – whilst the rest show an increase of 20-50 cm.

Table 2 shows the angular characteristics of the hurdle clearance. The value of the deviation angle in men is practically the same as in women - ($64,4 \pm 0,6^\circ$ and $62,8 \pm 0,9^\circ$, respectively, $p > 0,05$). Moreover, in men, it has a direct correlation with the contact time at take-off phase ($k = 0,73$, $p < 0,05$). This means runners with sharper deviation angle clear it faster. In women, the deviation angle has a negative correlation with the contact time ($k = -0,82$, $p < 0,05$). In this case, the indicators of the Olympic champion and the winner of this World Championship, S. Pearson, could be noteworthy. She demonstrates the fastest contact time (including men) – 0,107 s and at the same time the greatest deviation angle – $66,9^\circ$.



The trunk angle does not show significant differences – $72,9 \pm 2,2^\circ$ in men and $71,6 \pm 0,8^\circ$ in women ($p > 0,05$). However, the range of values among male-hurdlers is significantly greater than among female-hurdlers – from the 64° of S. Shubenkov and A. Merrit to the 82° of H. Parchment. The lead leg knee angle at toe-off does not show any significant differences ($p > 0,05$). But if for men this indicator is relatively stable and is in the range of $70-77^\circ$, then for women there are some significant differences ($53-90^\circ$). An analogous situation is in the trail leg knee angle. Among men, the trail leg during the take-off phase is flexed most strongly by O. McLeod (153°), who is the shortest among the participants in the final at 180 cm. The tallest flex the trail leg least of all, like B. Baji ($167,7^\circ$) and H. Parchment ($166,1^\circ$). Women demonstrate a significant range of values, from 141° for A. Talay to 173° for N. Ali. Significant differences between men and women are observed in the trunk-thigh angle at take-off phase ($68,1 \pm 3,5^\circ$ and $78,4 \pm 2,3^\circ$, respectively, $p < 0,05$).

In the landing phase at touch down, significant differences were observed only in the lead leg knee angle: $166,2 \pm 3,4^\circ$ in men and $155,7 \pm 3,0^\circ$ in women ($p < 0,05$). O. McLeod, S. Shubenkov and A. Merrit bend their leg least of all (about 175° , i.e. the leg is placed almost straight on the ground). For women, about the same value is observed for the winner, S. Person. For the rest of the participants, the leg bends significantly more ($146^\circ-154^\circ$).

There are relatively equal values for men and women in the deviation angle at landing phase (the angle between a straight line drawn from the center of mass to the spot where the foot is placed on the support and the horizontal): $74-83^\circ$. The average value of the trunk angle at touchdown in both groups is about 60° . Here, the minimum and maximum values are approximately equal, about 49° and 67° , respectively. During the first step, at the moment of removing the leg from the sup-

port, this angle increases on average to 77° for men, and up to 75° for women.

Conclusion. The main significant differences between men and women in a short hurdle sprint are observed in the take-off and landing distances, hurdle flight time and distance, in the flight time of the first step, the length of the second step and the change in the length of the second step in relation to the first. Among the angular parameters, there are significant differences in the trunk-thigh angle at toe-off, and the lead leg knee angle at touchdown. The presented findings can be used in the development and use of technical training means for top level athletes.

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Changes in physiological indicators of anaerobic performance under normobaric hypoxic exposure

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Abstract

Objective of the study was to determine the level of tolerance of the physiological systems of athletes working in the anaerobic mode to normobaric hypoxic exposure.

Methods and structure of the study. The study was carried out at the premises of the Research Institute of Sports and Sports Medicine (Russian State University of Physical Education, Sport, Youth and Tourism). Sampled for the study were the active highly-skilled swimmers (Group 1 - n=10, Group 2 - n=10). The individual glycolytic anaerobic power and capacity were tested in Wingate test on a Monark Ergonomic 894E Peak Bike vertical cycle ergometer (Sweden): three times of 90" with the rest intervals of 180". The following indicators were recorded: relative working capacity (W/kg), maximum working capacity per unit of time (W/kg), average working capacity (W/kg), fatigue coefficient (c.u.), relative maximum oxygen (O₂) consumption (ml/min/kg), absolute oxygen consumption (l/min), carbon dioxide (CO₂) content in the exhaled air (l/min), lung ventilation (l/min), ventilatory equivalent for O₂, heart rate (HR), HLa. The following gas exchange indicators were recorded: lung ventilation, O₂ and CO₂ contents in the exhaled air; O₂ consumption, and other related comprehensive diagnostic parameters. HR was measured on the cycle ergometer using Polar T34 pulsometer (Finland). HR and blood oxygenation during the hypoxic tests were recorded in three stages: at rest – before the hypoxic exposure, for 1 min; during the 30-min exposure to the 9% O₂ gas mixture; after the hypoxic exposure (recovery period) – under normal breathing conditions, for 3 min.

Results and conclusions. The findings showed an ambiguous reaction of the body of athletes to the single and multiple hypoxic exposure when working in the anaerobic mode. The multiple hypoxic exposure in the anaerobic mode decreases many physiological indicators, especially working capacity. The efficiency of hypoxic exposure is largely determined by the rate of recovery of the functional systems of the body and individual hypoxic tolerance rate. The use of hypoxia with the low content of O₂ in the inhaled air adversely affects many functions of athletes' body.

Keywords: athletes, working capacity, hypoxia, anaerobic load.

Background. Until recently, various hypoxic exposure techniques have been extensively used in sports to improve athletes' physical working capacity, speed up the short-term recovery processes, maintain their high training level over a long period of time, increase the body functionality and adaptation reserves [1-4]. All athletes face hypoxic issues, though exercise-induced hypoxia is most expressed in athletes engaged

in cyclic sport disciplines (middle, long, and extra-long distances) [4-6]. Therefore, the main direction in the training of athletes of various specializations is hypoxic training aimed to determine the metabolic pathway, enhance the enzymatic activity in terms of aerobic and anaerobic resynthesis of ATP, as well as improve the systems responsible for oxygen supply to the working muscles.

Objective of the study was to determine the level of tolerance of the physiological systems of athletes working in the anaerobic mode to normobaric hypoxic exposure.

Methods and structure of the study. The study was carried out at the premises of the Research Institute of Sports and Sports Medicine (Russian State University of Physical Education, Sport, Youth and Tourism). Sampled for the study were the active highly-skilled swimmers (Group 1 - n=10, Group 2 - n=10). The individual glycolytic anaerobic power and capacity were tested by Wingate test on a Monark Ergonomic 894E Peak Bike vertical cycle ergometer (Sweden): three times of 90'' with the rest intervals of 180''. The following indicators were recorded: relative working capacity (W/kg), maximum working capacity per unit of time (W/kg), average working capacity (W/kg), fatigue coefficient (c.u.), relative maximum oxygen (O₂) consumption (ml/min/kg), absolute oxygen consumption (l/min), carbon dioxide (CO₂) content in the exhaled air (l/min), lung ventilation (l/min), ventilatory equivalent for O₂, heart rate (HR), HLa. The spirometric studies were conducted using the Cortex METALYZER 3B-R2 gas

analyzer (Germany). The following gas exchange indicators were recorded: lung ventilation, O₂ and CO₂ contents in the exhaled air; O₂ consumption, and other related comprehensive diagnostic parameters. HR was measured on the cycle ergometer using Polar T34 pulsometer (Finland). The pulse oximetry method implied the use of the following devices (pulse oximeters): stationary - NONIN8600 (USA); carpal - MD300W (China). The pulse oximetry method enabled to continuously record arterial oxygen saturation (blood saturation - SO₂) and HR. HR and blood oxygenation during the hypoxic tests were recorded in three stages: at rest – before the hypoxic exposure, for 1 min; during the 30-min exposure to the 9% O₂ gas mixture; after the hypoxic exposure (recovery period) – under normal breathing conditions, for 3 min.

Results and discussion. Given in Tables 1, 2, 3 are the athletes' HR and levels of oxygen saturation (SO₂) under the single and multiple hypoxic exposure.

It is shown that under the multiple hypoxic exposure, the blood saturation rate decreased, while HR increased. There is a close correlation between these indicators, which is linear and negative. Un-

Table 1. Dynamics of changes in SO₂ and HR of athletes under single hypoxic exposure, before anaerobic load ($\bar{X} \pm \sigma, n=10$)

Indicator	Unit of measurement	Single hypoxic exposure using the hypoxicator, before anaerobic load		
		Initial state	Hypoxic test	Recovery
Time	min	1	30	3
SO ₂	%	95 ± 6.14	91 ± 5.52	94 ± 1.14
HR	bpm	70 ± 11.77	84 ± 13.17	78 ± 11.43

Table 2. Dynamics of changes in SO₂ and HR of athletes under multiple hypoxic exposure, before and after anaerobic load ($\bar{X} \pm \sigma, n=10$)

Indicator	Unit of measurement	Multiple hypoxic exposure using the hypoxicator, before and after anaerobic load		
		Initial state	Hypoxic test	Recovery
Time	min	1	30	3
<i>Hypoxic exposure before the 1st anaerobic load (3x90 sec)</i>				
SO ₂	%	94 ± 6.90	85 ± 8.75	92 ± 3.97
HR	bpm	67 ± 9.63	78 ± 11.69	72 ± 9.14
<i>Hypoxic exposure before the 2nd anaerobic load (3x90 sec)</i>				
SO ₂	%	95 ± 1.34	86 ± 6.96	95 ± 3.32
HR	bpm	101 ± 21.39	97 ± 6.13	84 ± 6.28

Table 3. Dynamics of changes in SO_2 and HR of athletes before and after hypoxic exposure, before anaerobic load on cycle ergometer ($\bar{X} \pm \sigma$, $n=10$)

Indicator	30-min hypoxic exposure using the hypoxicator	
	Delta: before and after single hypoxic exposure, %	Delta: before and after multiple hypoxic exposure, %
SO_2	- 4.2	- 10.1
HR	+ 20.3	+ 11.1

der the single normobaric hypoxic exposure, blood oxygenation decreased slightly, as under the multiple exposure, but HR increased by 20% relative to the initial level. The low HR values under the multiple hypoxic exposure appear to be associated with the adaptation mechanisms developed under hypoxic conditions.

There was a decrease in the level of blood oxygenation under the single and multiple hypoxic exposure, at which the rate of deviation of the average blood saturation values in the athletes of EG 2 changed slightly and corresponded to the signal deviations under the single hypoxic exposure in EG 1. Under the multiple hypoxic exposure, after the anaerobic load, the athletes' HR increased significantly during the 2nd test, probably due to the fast recovery and insufficient liquidation of the oxygen debt. However, increased HR was maintained throughout the entire 30' hypoxic test.

The figure illustrates the initial blood lactate concentration rate under the multiple hypoxic exposure before the 1st and 2nd tests in the anaerobic mode. The 30-min hypoxic exposure was found to adversely affect the rate of decrease in the blood lactate concentration rate. The great signal deviations in the lactate concentration up to 97% after the 2nd hypoxic test were associated with a high rate of individual response to the combined effect of the hypoxic exposure and anaerobic load.

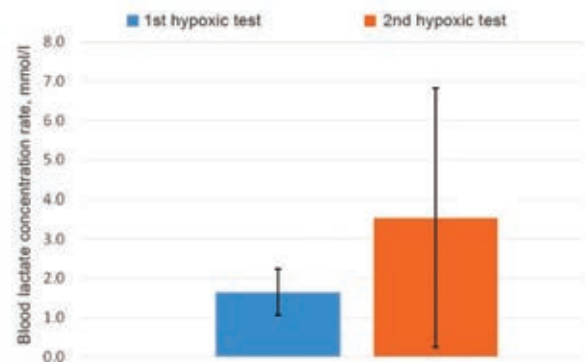


Fig. 1. Blood lactate concentration rate in athletes under multiple hypoxic exposure before anaerobic load.

In EG1, in the recovery period after the anaerobic load under the 30-min hypoxic exposure, there was an increase in $W_{gen.}$, $W_{crit.}$, $W_{avg.}$ in 90 sec against the background of accumulated fatigue, which resulted in the increased anaerobic glycolysis efficiency as well as increased power and capacity.

Given in Table 4 are the data on the performance rates in EG 2 in the anaerobic mode and recovery period.

It is shown that after the multiple hypoxic exposure, the lung ventilation rates, maximum HR, and working capacity rates decreased. In addition, the fatigue coefficient and ventilatory equivalent for O_2 statistically

Table 4. Dynamics of changes in physiological indicators in EG2 in recovery period after anaerobic load under 30' multiple hypoxic exposure

Indicator	Unit of measurement	Stages of recovery after anaerobic work on cycle ergometer		
		5th min	7th min	10th min
$\dot{V}O_{2rel.}$	ml/min/kg	11± 3.31	10± 2.90	8± 1.94
$\dot{V}O_{2abs.}$	l/min	0.79± 0.27	0.73± 0.24	0.60± 0.16
$\dot{V}CO_2$	l/min	0.86± 0.30	0.73± 0.22	0.55± 0.18
HR	bpm	124± 23.72	117± 19.10	110± 14.42
V_E	l/min	38.9± 16.28	32.2± 11.10	24.6± 7.73
$V_E/\dot{V}O_2$	c.u.	45.4± 7.06	41.5± 7.92	37.9± 6.98
HLa	mmol/l	13.7± 2.22	12.9± 1.96	11.7± 2.68



significantly decreased due to the onset of decompensation and inability to maintain gas homeostasis. After the single and multiple hypoxic exposure - 3x90'' at the recovery stages, the relative and absolute O₂ consumption, CO₂ content in the exhaled air, and lung ventilation rates decreased.

Conclusions. The findings showed an ambiguous reaction of the body of athletes to the single and multiple hypoxic exposure when working in the anaerobic mode. The multiple hypoxic exposure in the anaerobic mode decreases many physiological indicators, especially working capacity. The efficiency of hypoxic exposure is largely determined by the rate of recovery of the functional systems of the body and individual hypoxic tolerance rate. The use of hypoxia with the low content of inhaled O₂ adversely affects many functions of athletes' body.

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Effects of physical activity on acoustic somnological parameters of human body

UDC 796.071.424.2, 612.821.7



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Abstract

Objective of the study was to test by experiment the application of the acoustic activity recording devices during sleep to assess the processes of recovery after physical loads.

Methods and structure of the study. The experiment involved the 19-20 year-old males (n=36) specializing in cyclic sports with three trainings in a weekly microcycle: average body mass - 74.6 kg, height - 176.5 cm, heart rate at rest - 62 bpm, blood pressure at rest - 120/80 mmHg.

The subjects' somnological parameters were recorded using the SleepCycle 5.5.3 application, which allows for contactless and non-invasive registration of the flow of acoustic accompaniment of physiological activity during daily sleep. The application was developed by the research group Northcube AB (Gothenburg, Sweden) led by Maciek Drejak.

The intensity and duration of physical loads were recorded based on the athletes' notes in the diaries.

Two series of studies were conducted. In the first study series, 24 subjects were tested for 7 days against the background of their routine, daily physical activity under the academic training program.

In the second study series, 12 subjects were tested for 14 days to estimate their acoustic activity during sleep: the first 7 days - against the background of their routine, daily physical activity, the next 7 days - after a dosed physical load in the afternoon.

The processing of the recording of the individual acoustic activity during sleep made it possible to calculate the duration of night sleep, the duration of each cycle and its average value, the time to fall asleep, the depth of sleep, the total time of deep and shallow sleep, the quality of sleep.

Results and conclusion. The data obtained are consistent with the studies conducted by A.M. Vein's group (1991) with the application of the method of polysomnographic recording during aerobic activity. The applied hardware, not related to classic polysomnography, method of recording sleep parameters makes it possible to obtain a wide range of data and study the effects of physical activity on the human body. This approach can probably be used in further detailed elaboration as a method of control and assessment of the effectiveness of the training process.

Keywords: *somnogram, aerobic activity, acoustic activity of the human body during sleep.*

Background. Physical loads activate the physiological, biochemical, and psychological reserves of the body. At the same time, long-term physical activity depletes these reserves, which cannot but affect the structure and quality of subsequent recovery processes [6, 7, 9]. Sleep is an essential part of athletes'

recovery. Numerous attempts were made to study the relationship between the specific features of physical training and their manifestations during sleep [2-4]. The introduction of polysomnography in the methodological arsenal of scientists has set these studies on the scientific ground [4, 5]. However, the organization-

al and hardware complexity of the polysomnographic approach did not allow sports somnology to develop properly [8].

In recent years, significant progress in computational and communication electronics has led to the emergence of promising mobile applications for sports somnology at free and resource-light access. These applications help more and more effectively monitor the state of the body under loads and during recovery, including at night [12]. In this view, there is a new opportunity to apply polysomnography in the assessment of load efficiency, which, in turn, will make it possible to update training design and control.

Objective of the study was to test by experiment the application of the acoustic activity recording devices during sleep to assess the post-exercise recovery processes.

Methods and structure of the study. The experiment involved the 19-20 year-old males (n=36) specializing in cyclic sports with three trainings in a weekly microcycle: average body mass - 74.6 kg, height - 176.5 cm, heart rate (HR) at rest - 62 bpm, blood pressure (BP) at rest - 120/80 mmHg.

The subjects' somnological parameters were recorded using the SleepCycle 5.5.3 application, which allows for contactless and non-invasive registration of the flow of acoustic accompaniment of physiological activity during daily sleep. The application was devel-

oped by the research group Northcube AB (Gothenburg, Sweden) led by Maciek Drejak [11].

The intensity and duration of physical loads were recorded based on the athletes' notes in the diaries.

Two series of studies were conducted. In the first study series, 24 subjects were tested for 7 days against the background of their routine, daily physical activity under the academic training program.

In the second study series, 12 subjects were tested for 14 days to estimate their acoustic activity during sleep: the first 7 days - against the background of their routine, daily physical activity, the next 7 days - after a dosed physical load in the afternoon (continuous swimming at a moderate rate, at HR of 120-150 bpm, 30 minutes).

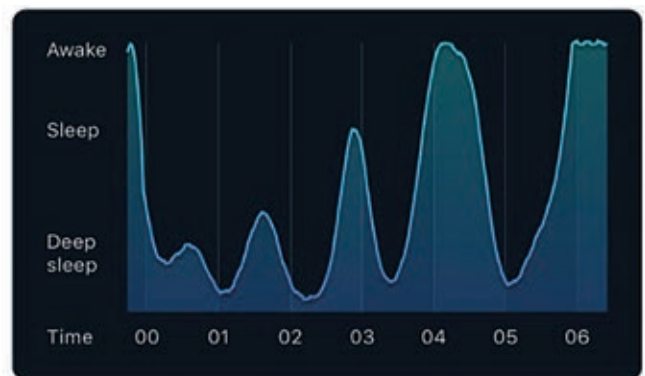
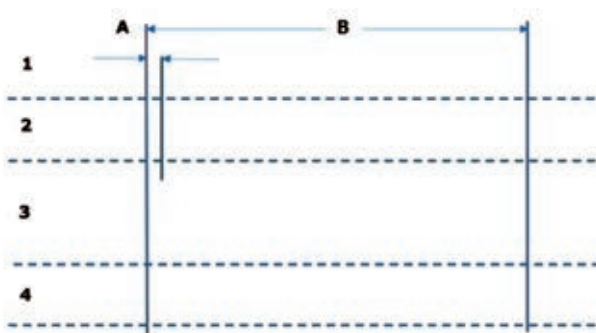
The processing of the recording of the individual acoustic activity during sleep made it possible to calculate the duration of night sleep, the duration of each cycle and its average value, the time to fall asleep, the depth of sleep, the total time of deep and shallow sleep, the quality of sleep (see Figure 1).

Results and discussion. Given in Table 1 are the data on the processing of the individual somnograms in EG1 registered by SleepCycle.

The proper values of the calculated parameters were obtained by means of polysomnography in application to young males and taken from various literary sources [1, 2, 3, 5, 10]. The comparison of the data obtained indicated a reliable degree of matching of

Table 1. Acoustic data ($M \pm \sigma$) in EG 1 and their proper (P) values

Parameter/ Groups	Time to fall asleep (min)	Night sleep (hrs)	Sleep cycle (min)	Depth of sleep (units)	Deep sleep (min)	Shallow sleep (min)	Quality of sleep (%)	Deep sleep (%)	Shallow sleep (%)
M	19.8	7.9	96	3.2	106	118	78.6	22.4	24.9
Σ	4.7	1.5	16.9	0.24	38	41	12.3	8.02	8.65
Proper	14	8.25	90	-	63 - 107	90 - 133	86	12.7 - 21.6	18.2 - 26.9



Subjects' acoustic activity during sleep: 1 – wakeful state; 2 – shallow sleep; 3 – sleep; 4 – deep sleep; A – time to fall asleep; B – total sleep duration.

**Table 2.** Somnological parameters before (B) and after (A) physical loads

Parameter/ Groups		Time to fall asleep (min)	Night sleep (hrs)	Sleep cycle (min)	Depth of sleep (units)	Deep sleep (min)	Shallow sleep (min)	Quality of sleep (%)	Deep sleep (%)	Shallow sleep (%)	
Load	B	M	27.8	6.87	78.03	2.82	2.37	1.38	66.4	34.5	20.1
		σ	5.68	0.74	7.57	0.24	0.47	0.11	4.1	6.7	2.91
	A	M	15.8	7.98	78.1	3.01	3.23	1.09	82.5	40.5	13.7
		σ	3.9	0.32	8.8	0.21	0.67	0.23	4.9	3.7	3.4

the somnographic data obtained by different methods.

Given in Table 2 are the quantitative values of the somnographic data obtained in EG2 before and after physical loads.

The comparative analysis of the acoustic data obtained before and after physical loads revealed that moderate aerobic activity significantly reduces the time to fall asleep, increases the duration of sleep in an ad libitum mode (as one pleases), as well as improves the quality of sleep, according to the SleepCycle app. At the same time, aerobic exercise affected the structure of sleep. Thus, the total duration of deep sleep significantly increased, while the duration of shallow sleep significantly decreased.

The data obtained are consistent with the studies conducted by A.M. Vein's group (1991) with the application of the method of polysomnographic recording during aerobic activity [3].

Conclusion. The applied hardware, not related to classic polysomnography, method of recording sleep parameters enables to obtain a wide range of data and study the effects of physical activity on the human body. This approach can probably be used in further detailed elaboration as a method of control and assessment of the effectiveness of the training process.

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Changes in physical development, sexual maturity and physical fitness of girls from southern podlasie between years 1980 and 2015

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Abstract

The objective of the study was to analyze the changes taking place in the physical development, the rate of reaching sexual maturity, and the physical fitness level of girls from southern Podlasie between the years 1980 and 2015 against the background of peers from Eastern Poland and nationwide research.

Methods and structure of the study. In order to implement the subject of the presented report, the results of studies from 1980 (9 074 girls), 1985 (8 182 girls), 2005 (1 907 girls), and 2015 (2 583 girls) were selected. The results of studies from southern Podlasie and the entire eastern region were compared with the results of nationwide studies. Using Martin's measurement technique of height and weight, the results from individual stages of the research were normalized to the results of research from 1980. Using the "status quo" method, counting the fraction of already menstruating girls in relation to all respondents, the mean age of menarche was calculated using the probit method according to Finney. The level of physical fitness at individual stages of the researches was determined by the results of the International Physical Fitness Test.

Results and conclusions. Among the examined girls from southern Podlasie there were clear secular trends in increasing height and weight (2.28 cm and 1.27 kg per decade). A similar tendency occurred in the case of lowering the mean menarche age. Girls from southern Podlasie lowered the menarche age from 13.333 years in 1985 to 12.580 years in 2015. There was a clear decrease trend in the general physical fitness level in all analyzed environments. Particularly unfavorable changes occurred among the examined girls and their peers from the eastern region. While in the studies carried out in 1985 both groups obtained results exceeding the nationwide standards, in the following stages of the research they lost this advantage.

Keywords: girls, body height and weight, menarche age, physical fitness level, secular trends, environmental conditions.

Background. The socio-economic transformations that have been taking place in Poland for 35 years have a different course in different regions of the country. The eastern region of Poland, as a typical agricultural one, experienced the crisis of the 1980s quite mildly. The socio-systemic changes in the 90s and the first decade of 20 century resulted in many negative aspects. There is hope that the proper use of funds from various European Union programs, as well as those purposefully directed to this region, will stimulate an increase in standards of living of the Eastern Poland people. An objective measure of the changes

taking place will be their positive impact on the pace of development of children and youth.

Objective of the study was to analyze the changes in the physical development, the rate of reaching sexual maturity, and the physical fitness level of girls from southern Podlasie between the years 1980 and 2015 against the background of peers from Eastern Poland and nationwide research.

Methods and structure of the study. In order to implement the subject of the presented report, the results of studies from 1980 (9 074 girls), 1985 (8 182 girls), 2005 (1 907 girls), and 2015 (2 583 girls) were

selected. The results of studies from southern Podlasie and the entire eastern region were compared with the results of nationwide studies carried out by Waliszko et al. [1], Przewęda and Trzeźniowski [2], Przewęda and Dobosz [3] and Dobosz et al. [4]. Using the Martin's measurement technique of height and weight, the results from individual stages of the research (the southern Podlasie, the eastern region and the whole country), were normalized to the results of my own research from 1980. The rate of sexual maturity was estimated based on the mean age of the menarche. Using the "status quo" method, counting the fraction of already menstruating girls in relation to all respondents, the mean age of menarche was calculated using the probit method according to Finney [5]. The level of physical fitness at individual stages of the researches was determined by the results of the International Physical Fitness Test. The analysis of changes taking place in the general physical fitness level was based on converting the results into T scale points [6].

Results and discussion. Comparing the results of the research (Fig. 1) obtained in the subsequent stages in relation to 1980, we notice a clear increase in body height. Between 1985 and 1980, girls from southern Podlasie became higher of 0.233 standard deviations, which was a slightly better result than their peers from the entire east region (0.202 SD). The greatest changes were recorded among girls from the nationwide studies (0.367 SD), however, it should be added that they started from a slightly higher level (0.151) recorded in 1980. As it was expected, a greater distance occurred in the second stage of the study (2005), girls from southern Podlasie increased their body height by 0.752 SD, although at this stage, the girls from the entire east region obtained a better result of 0.858 SD. The lowest level of changes occurred in the nationwide studies (0.662 SD). When assessing the changes in the period covered by the study (1980-2015), the examined girls from southern Podlasie increased their height by 1.169 SD, the girls from the eastern region of Poland became 1.32 SD higher, while the average height for the whole country girls increased by 0.954 SD.

Similar relations of changes occurred in the case of body weight (Fig. 2). Girls from southern Podlasie in the first stage of the study (1980-1985) increased their body weight by 0.083 SD, in nationwide studies by 0.086 SD, while a slightly higher level was recorded among peers from the eastern region by 0.122 SD. In the studies carried out in 2005, the order was respected, girls from the eastern region increased their body weight by 0.356 SD, examined girls from all over the country by 0.332 SD, and a slightly lower

level (0.233 SD) was found among the surveyed girls from southern Podlasie. In the years 1980-2015, girls from southern Podlasie became heavier by 0.642 SD, in the eastern region by 0.591 SD, and nationwide by 0.529 SD.

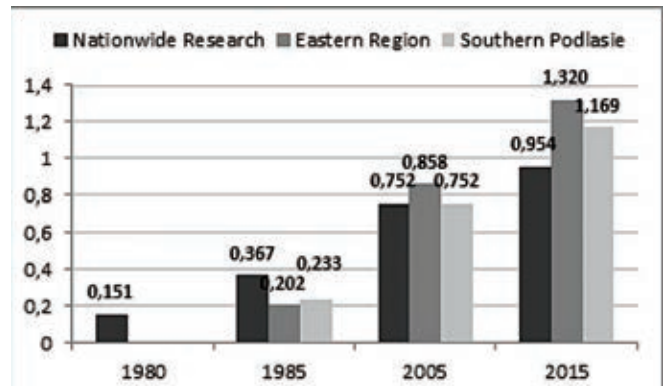


Fig. 1. Changes in the body height of girls from southern Podlasie compared to their peers from the eastern region and nationwide research (values normalized to the results of the 1980 research).

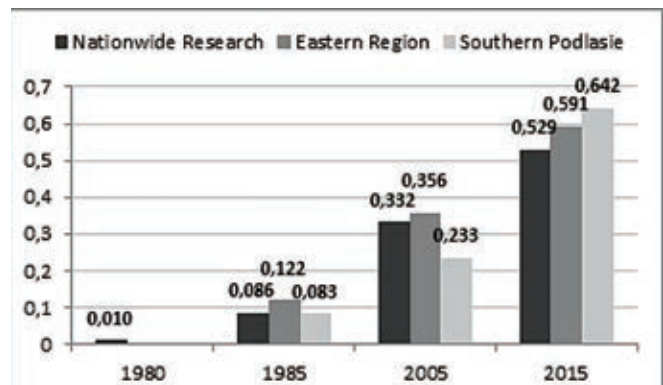


Fig. 2. Changes in body weight of girls from southern Podlasie compared to their peers from the eastern region and nationwide research (values normalized to the results of the 1980 research).

Analyzing the changes in the mean age of menarche, results show a gradual decrease in the age of the first menstruation. In 1980 girls from southern Podlasie menstruated on average at the age of 13.406 (SD = 1.06) and thirty-five years later at the age of 12.580 (SD = 1.26) – the age of first menstruation decreased by 0.826 years. The results of studies carried out in 1980, 1983, and 1990 show a very slow rate of acceleration of the menarche age – only by 0.093 years per decade. After 1990, this process accelerated, and by 2015 girls from southern Podlasie lowered their menarche age by a further 0.733 years. Comparing the rate of menarche age changes of the examined girls to their peers from the eastern region



and girls from nationwide studies (Fig. 3), it should be stated that the examined girls from southern Podlasie between 1985 ($\bar{x} = 13,333$; $SD = 1.10$) and 2015 ($\bar{x} = 12,580$; $SD = 1.26$) decreased the age of menarche by 0.75 year, while in the entire eastern region, the decrease was 0.81 year (1987 – $\bar{x} = 13,44$, $SD = 1.31$; 2017 – $\bar{x} = 12,63$, $SD = 1.21$). During the twenty years between 1985 and 2005, the average menarche age of girls from southern Podlasie decreased per decade by 0.26 years, while between 2005-2015 the pace of changes slightly decreased to 0.21 years. Similar changes occurred among girls from the entire eastern region of the country where between 1987 and 2007 decrease was 0.29 years per decade, and in the decade of 2007-2017, the decrease was also slower and amounted to 0.21 years. The nationwide research shows that over twenty years rural girls lowered their menarche age by 0.489, small-town girls by 0.356, and girls from large cities by 0.198, which per decade is respectively 0.244 in a rural environment, 0.178 in a small-town environment and 0.099 in a big city environment. A similar tendency occurs among the surveyed girls from southern Podlasie and the entire eastern region, reducing the distances between individual environments.

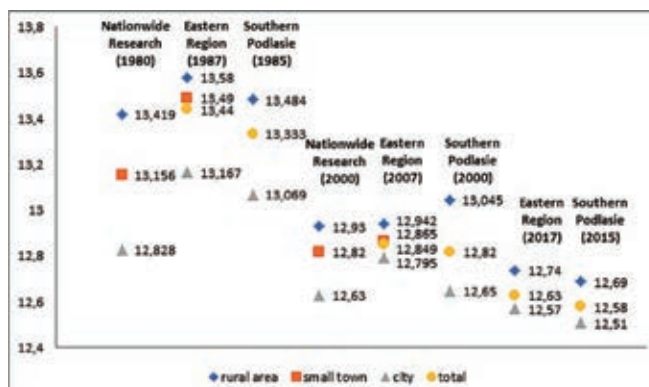


Fig. 3. Average menarche age of girls from southern Podlasie compared to their peers from the eastern region and nationwide research

Figure 4 presents changes in the general physical fitness level of the examined girls compiled with their peers from the discussed environments, expressed in the T-scale point values. The presented data illustrate the reduction of the general physical fitness level in all analyzed environments. In the studies carried out in 1985, the highest level of 53.65 points was reached by girls from the eastern region of the country, the examined from southern Podlasie were ranked at an almost identical level of 53.63 points. Both groups exceeded the level of 52.04 points set by girls from the nationwide

research. The results of the research from 2005 show a much lower level of physical fitness, in the case of the study group it was 51.48 points and was slightly higher than the result of girls from nationwide research (51.42). At this stage girls from the eastern region reached the worst score of 49.27 points. During the next decade (2005-2015) the rate of the decline in the physical fitness level increased even more. Girls from southern Podlasie reached the level of 48.91 points, their peers from the eastern region obtained 48.47 points. At this stage of the study, both groups were clearly worse than the girls from the nationwide survey, who managed to achieve 50.33 points despite the decline.

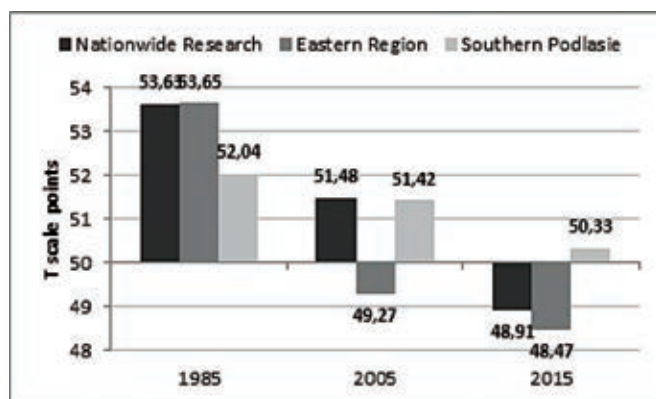


Fig. 4. Changes in the physical fitness level of girls from southern Podlasie compared to their peers from the eastern region and nationwide studies (values presented in T scale points).

The presented results of changes in basic somatic parameters (height and weight) correspond with the authors' from other regions of the country. The secular trend in the physical development of children and adolescents was noted in the environment of Wrocław, Kielce, Bydgoszcz, Warsaw, and Rzeszów. Furthermore, the high growth rate of basic somatic parameters was presented by Bielicki [7] based on extensive nationwide research conducted in 1955-1978. These studies also show the rapid rate of acceleration of the menarche age that occurred in all surveyed regions and social groups. The improvement in living conditions positively stimulated the lowering of the menarche age for rural and small-town girls [8]. This process was hampered by the social and economic crisis in the 70s and 80s of the last century. The rate of physical development and deceleration of the menarche age have stabilized, especially in the urban environment, and its negative effects have also been noted in the rural environment [8].

The assessment of changes in the physical fitness level is not so clear. The results of nationwide surveys from the turn of the 60s and 70s document a system-



atic improvement of the results obtained in the physical fitness tests [2]. However, during the last three decades, the process of lowering the physical fitness level was visible in the regional as well as nationwide researches [3, 4, 9]. The presented results document a further decrease in the physical fitness level of girls in the eastern region and southern Podlasie due to a decrease in endurance from 69.6 points in 1985 to 48.91 points in 2015, a decrease in the explosive force from 56.08 to 50.17, or the strength of the hands and shoulder girdle (hanging on a bar) from 59.66 points to 56.42. Similar changes in increasing somatic parameters and lowering the physical fitness level were noted even among academic youth studying courses such as physical education or sport [10].

Conclusions.

1. Among the examined girls from southern Podlasie and the entire eastern region, clear secular trends in increasing height and weight were observed. Per decade, the body height increased by 2.28 cm in southern Podlasie, by 2.04 cm in the eastern region, and in nationwide research by 1.64 cm. The secular trend of body weight per decade was at the level of 1.27 kg among the examined girls, 1.16 kg in the eastern region, and 1.17 kg in nationwide studies.

2. A similar tendency occurred in the case of lowering the mean menarche age. Girls from southern Podlasie lowered the menarche age from 13.333 years in 1985 to 12.580 years in 2015, while girls from the eastern region menstruated in 1987 at the age of 13.440 and thirty years later (2017) at 12.630 years of age. In nationwide research from 1980, the average menarche age among rural girls was 13.419, 13.156 in small towns and 12.828 in large cities, and two decades later it decreased to 12.93 in rural areas, 12.82 in small towns, and 12.63 in large cities.

3. There was a clear decrease trend in the general physical fitness level in all analyzed environments. Particularly unfavorable changes occurred among the examined girls and their peers from the eastern region. While in the studies carried out in 1985 both groups obtained results exceeding the nationwide standards, in the following stages of the research they lost this advantage. In 2015, they were definitely inferior to the girls from the nationwide research, and their physical fitness level did not exceed 50 points.

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Effects of inspiratory muscle strength on physiological response to exercise in elite rowers and healthy men

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Abstract

Objective of the study was to determine the degree of respiratory muscle fatigue in relation to fitness level, and to determine the relationship between inspiratory muscle strength and exercise respiratory indices.

Methods and structure of the study. Elite rowers ($n=10$) and untrained healthy university students ($n=28$) performed progressive maximal tests. Respiratory indices were measured, including maximal inspiratory pressure (P_{lmax}) at rest and 3 min after exercise in both groups. In the literature, P_{lmax} is considered as an indicator of respiratory muscle strength.

Results and conclusion. In the group of rowers, significantly higher resting P_{lmax} (167 ± 30 cmH₂O) was observed compared to the group of students (117 ± 29 cmH₂O). However, after exercise, the percentage difference between resting and exercise pressures did not significantly differentiate between the groups. In both elite rowers and non-athlete students, respiratory muscle fatigue was recorded in about 60% of cases. There were no significant correlations between resting P_{lmax} and pulmonary ventilation, VO_{2max}, or oxygen equivalent; only in the group of students, respiratory muscle strength correlated significantly and positively with BMI. The present study confirmed that even a high level of fitness does not prevent respiratory muscle fatigue induced by a progressive maximal effort.

Keywords: elite rowers, healthy men, indices of inspiratory muscle function, response to exercise.

Background. The results of the studies published over the last several years have demonstrated that similar to other skeletal muscles, respiratory muscles are also fatigued during exercise [1, 9]. In general, the observed degree of respiratory muscle fatigue has been shown to depend on the testing effort used and the level of fitness of the study participants. A review of the literature suggests that symptoms of fatigue in these muscles may increase during both prolonged [11] and short-term high-intensity exercise [2]. In swimmers, the occurrence of respiratory muscle fatigue may take place even after swimming a single 200 m freestyle distance at maximum intensity [4].

Various testing procedures have been used to assess respiratory muscle fatigue. These included stimulation of the phrenic nerve, the use of electromyography (EMG), or measurement of maximal respiratory pressure [5]. Due to its non-invasive nature and simplicity, the evaluation of maximum inspiratory pressure (P_{lmax}) before and after exercise, considered an indicator of inspiratory muscle strength, is one of the most common methods [4, 12]. From the practical point of view, the problems of assessing respiratory muscle fatigue, which can reduce the exercise capacity of athletes, is particularly interesting. Therefore, there is a need for further characterization of the functional status of respiratory muscles after various types of exercise.



Objective of the study was to assess the degree of respiratory muscle fatigue depending on the level of fitness and to determine the relationships between inspiratory muscle strength and selected morphological and respiratory indices.

Research methods and structure. Subjects. The research involved 28 students of the University of Physical Education and 10 elite lightweight and heavyweight rowers (members of the U23 national team and the senior national team). The characterization of the study participants is presented in Table 1. The examinations of the rowers were conducted during the preparatory phase after obtaining the approval of the Research Bioethics Commission of the Institute for Sport, whereas those concerning the students were approved by the relevant Commission of the University of Physical Education.

Exercise tests. The rowers performed a stepwise incremental test on the rowing ergometer (Concept 2, C model, Nottingham, UK). The exercise lasted 3 min and was interrupted by 30s intervals [3]. The first exercise load was 200 W in the lightweight and 220 W in the heavyweight rowers, increased in subsequent efforts by 30 or 50 W, respectively. The students performed an intermittent incremental stress test consisting of several trials lasting 3 minutes, with 1-minute intervals between the trials, on the Corival bicycle ergometer (Lode B.V., Netherlands). The power used in the initial trial was 50 W, and it was increased by 50 W in each successive trial to exhaustion.

Lactate concentrations (LA) were measured in the blood collected from the fingertip at rest, immediately after the subjects completed each trial, and 3 minutes after the entire test was completed, using the Super GL2 device (Dr Müller, Germany). During the tests, breath-by-breath (BxB) respiratory indices were continuously recorded using a MetaMax 3B ergospirometer (Cortex Biophysik GmbH, Germany) in students and a Vmax 29 series apparatus (Yorba Linda, CA, USA) in rowers.

Estimation of the maximal inspiratory mouth pressure (P_{lmax}). Measurements of P_{lmax} were

performed at rest and 3 minutes after the test in both groups. This parameter, often used to estimate the strength of the inspiratory muscles, reflects the capacity to generate pressure by the combined maximal activity of these muscles during a short, almost static, contraction with the nearly total closure of the airways [3].

According to the procedure described earlier by other authors [8], all subjects performed 10 (minimum) to 15 (maximum) technically satisfactory breaths and the three highest measurements with less than 5% variability were regarded as maximum. The initial position of the inspiratory muscles was checked at the beginning of each effort with the residual volume (RV). All the tests were performed in the standing position. To attain maximal values, verbal encouragement was given to the tested subjects, who received visual feedback informing them of the applied inspiratory pressures. The measurements were recorded electronically utilizing the Lungtest 1000 software (MES, Kraków, Poland).

Statistical analysis. The statistical analyses were conducted with the Statistica 13.0 software. The normal distributions of variables were examined using the Shapiro-Wilk test. The U Mann-Whitney test was used to assess the relevance of differences. The strength of relationships between the variables was determined based on Spearman's rank correlation or Pearson coefficients. The level of statistical significance was set at $p \leq 0.05$. **Results and discussion.** Significantly higher resting P_{lmax} (167±30 cmH₂O) levels in the group of rowers were observed compared to the group of students (117±29 cmH₂O). However, the post-exercise percentage difference between resting and exercise pressures (P_{lmax} Δ) did not significantly differentiate between the groups, with -3.6±6.9 and -1.5±9.6%, respectively, Table 2. In both elite rowers and non-athletes students, respiratory muscle fatigue (negative P_{lmax} Δ levels) was recorded in about 60% of cases. No significant correlations were found between the levels of resting P_{lmax} and: pulmonary ventilation, VO₂max, and oxygen equivalent. Only in the

Table 1. Basic morphological characteristics of students and elite rowers (mean±SD)

Variable/Group	Students (n=28)	Rowers (n=10)	P
Age (years)	21.7 ± 2.0	25.6 ± 3.9	0.002
Body height (cm)	180.5 ± 5.1	185.0 ± 3.2	0.006
Body weight (kg)	74.7 ± 8.5	77.9 ± 6.5	0.214
BMI (kg/m ²)	22.9 ± 1.9	22.7 ± 1.5	0.855
Training experience (years)	-	11.6 ± 5.0	-



Table 2. Test time, Peak power, maximal oxygen uptake (VO_{2max}), post-exercise lactate concentration (LA), and maximum inspiratory pressure (P_{lmax}) in groups of students and rowers (mean \pm SD)

Variable/Group	Students (n=28)	Rowers (n=10)	P
Test time (min:s)	16:06 \pm 2:08	21:42 \pm 2:21	0.000
Peak power (W/kg)	3.86 \pm 0.52	5.40 \pm 0.16	0.000
VO_{2max} (ml/kg/min)	46.0 \pm 6.8	63.3 \pm 4.2	0.000
LA (mmol/l)	12.5 \pm 2.1	14.1 \pm 2.5	0.034
P _{lmax} Rest (cmH ₂ O)	117 \pm 29	167 \pm 30	0.000
P _{lmax} 3 min (cmH ₂ O)	115 \pm 32	161 \pm 31	0.001
P _{lmax} Δ (%)*	-1.5 \pm 9.6	-3.6 \pm 6.9	0.423

* - P_{lmax} Δ = (P_{lmax} Rest - P_{lmax} 3 min) / P_{lmax} Rest x 100

Table 3. Values of correlation coefficients between resting maximum inspiratory pressure (P_{lmax} Rest) and selected morphological and respiratory indices (P_{lmax} Δ - differences between resting and post-exercise values P_{lmax}, VE - pulmonary ventilation, VO_{2max} - maximal oxygen uptake, and VE/ VO_{2max} - oxygen equivalent) in groups of students and rowers

Variable/Groups	P _{lmax} Rest (cmH ₂ O)	
	Students (n=28)	Rowers (n=10)
Body height (cm)	-0.095	-0.006
Body weight (kg)	0.234	0.508
BMI (kg/m ²)	0.395*	0.578
P _{lmax} Δ (%)	0.134	0.014
VE _{max} (l/min)	0.212	0.085
VO_{2max} (ml/kg/min)	-0.004	0.407
VE/ VO_{2max} (l/min)	0.085	-0.535

* - p<0.05

group of students, respiratory muscle strength correlated significantly and positively with BMI, see Table 3.

Resting P_{lmax} values significantly differentiated between students and rowers and confirmed the beneficial effect of training on improving respiratory muscle strength. However, it should be noted that a reduction in post-exercise P_{lmax} was observed in ca. 60% of individual cases of both students and rowers. Similarly, Romer et al. [7] emphasized that respiratory muscle fatigue can also lead to reduced exercise capacity in highly trained cyclists. The high resistance to respiratory muscle fatigue demonstrated in individual cases is noteworthy, as the P_{lmax} increased by up to several percent after the completion of maximal exercise (in students, the highest increase was by up to 19.0%, whereas in rowers - by 6.3%). Similarly, in a study of moderately trained male individuals, the reduction in P_{lmax} following the shuttle run test to total failure averaged 8.0 \pm 7.5%, while individual cases showed a simultaneous increase of several percent in respiratory muscle strength [6].

There were also no significant relationships between respiratory muscle strength and breathing economy as assessed by oxygen equivalence. In previous studies, rowers with greater inspiratory muscle strength were characterized by improved breathing economy through increased tidal volume and decreased respiratory rate [12]. In our study, a significant positive correlation between resting P_{lmax} and BMI was found only in the group of students, which may point to a relationship between the inspiratory muscle strength and the total muscle mass.

In our study, no significant relationship was observed between inspiratory muscle strength and their susceptibility to fatigue (P_{lmax} changes Δ , %), (Table 3). In contrast to these data, some authors [6] have shown the presence of this relationship in moderately trained men. It was suggested that higher levels of inspiratory muscle strength may lead to lower relative force generation requirements during exercise and consequently reduce the occurrence of fatigue symptoms in these muscles.



Conclusion. The most significant finding of this study was that, regardless of the fitness level, respiratory muscle fatigue was observed after the test exercise in both study groups. The literature data [10, 12] and our findings presented here justify the need for the implementation of isolated respiratory muscle training in athletes as a method that can potentially reduce the occurrence of adverse effects of respiratory muscle fatigue.

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Motor skills training model to improve school physical education service quality

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Abstract

Objective of the study was to substantiate and analyze benefits of a new motor skills training model to improve the school physical education service quality.

Methods and structure of the study. The new motor skills training model includes the physical education teaching mastery, physical exercise difficulty and motor giftedness tests, with each aspect rated on a 10-point scale and verified by an expert team of university professors and experience school physical education teachers. The study was run at secondary schools of Volgograd and Moscow cities in 2014-2019 school years. We sampled for the study university physical education experts (n=12), school physical education teachers (n=47) and the 5-11-graders (n=705).

The physical education teaching mastery was rated with account of the physical education service record and formal physical education qualification by the physical education / sports teaching service quality tests supported by expert valuations; and the school students' motor giftedness was rated by the physical fitness, motor activity and motor skills progress tests verified by the expert valuations. The motor skills difficulty levels were ranked by the primary error rates. The school motor activity was rated by enthusiasm/ determination in the physical education practices, and the motor giftedness was classified by the time costs of specific physical exercises, with every success in the physical exercises scored on a 10-point scale. Prior to and after every physical exercises, we rated the physical education teaching mastery, trainees' motor gifts and motor skills difficulty levels, with the individual progresses in every physical exercises per session being indicative of the motor skills training abilities/ progress.

Results and conclusion. The new motor skills training model was tested beneficial for the school physical education service. The motor skills progress testes in the school physical education course are recommended to be complemented by the physical education teaching mastery tests/ expert valuations, motor skills difficulty rankings and the trainees' motor giftedness tests.

Keywords: *assessment, efficiency, technique of motor actions, schoolchildren, physical education teacher, criteria.*

Background. Presently the physical education curricula in the national secondary school education system are non-standardized and rather inconsistent [1, 6] that means that the training service is often inefficient, and many school physical education teachers are still in need of special theoretical knowledgebase [2-4] and competency in specific motor skills train-

ing and progress tests [5]; whilst effective motor skills training models for school applications are still underdeveloped.

Objective of the study was to substantiate and analyze benefits of a new motor skills training model to improve the school physical education service quality.



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Results and discussion. Average physical education teaching records rated on a grade-specific basis ranged from 5.65 to 6.04 points; with the physical education qualifications scored by 5.47 to 5.96 points; and the actual physical education service quality scored by 6.53 to 6.85 points versus the expert valuations ranging from 6.14 to 6.22 points. Therefore, the physical education teaching mastery of the sample was scored by 5.98 to 6.35 points. The trainees' physical fitness was scored by 3.87 to 5.43 points, motor activity by 3.67 to 5.45 points, motor skills training ability by 4.78 to 5.23 points; and the motor gifts by 4.87 to 5.28 points.

The motor skills training was tested most successful in the three-attempts rope climbing tests (6.8 points) in grade 5; two-attempts climbing test in grade 6 (6.2 points); backward somersault to split test (girls) test (6.2 points) and 9-11-step-run-up long

jump test (boys) test (5.8 points) in grade 7; acrobatic combination (6.7 points for boys and 6.5 points for girls) test in grade 8; volleyball pike test (5.6 points) for grade 9; serve reception test (5.6 points) in grade 10; and serve test (5.8 points) in grade 11.

The motor skills training ability were ranked by the following levels: poor 2.7 points; low 4.0 points; acceptable 5.4 points; good 6.8 points; and excellent 8.5 points. On the whole in the 5-11-grade sample the motor skills training ability was initially low, with some motor skills training progress found in the physical education service due to the physical exercises being repeated in the standard school physical education curriculum. Generally, the progress in the motor skills training practices was higher in the standard gymnastic exercises and much lower in the situational team sports practices. We believe that the school physical education service should be complemented by the situation-specific motor skills trainings to improve the secondary school physical education service quality.

The new motor skills training and progress test model makes it possible to rank the physical exercises by the difficulty levels and manage the physical education service so as to effectively master every physical exercises. Our study found the physical exercises success rates varying from 27.0% in expert valuations of the physical education teaching mastery to 58.2% in the trainee's physical fitness tests.

Furthermore, the trainees' physical fitness was tested to fall with age from 5.34 to 3.92 points. The 5-7-graders were tested with the highest motor skills training ability scored by 5.06 ± 0.29 points; with the boys tested with the higher motor activity, whilst the motor skills training abilities were found virtually gender-unspecific (no significant differences). The physical exercises tests on the physical education teaching mastery and trainee's motor skills success scales made it possible to design individual progress trajectories in the secondary school physical education service. Our test data analyses found the following priorities in the motor giftedness elements: motor skills training ability for grades 5-7 (20.7%); motor activity for grades 8-9 (21.3%); and physical fitness (20.3% for boys); and motor skills training ability (21.4% for girls) in grades 10-11.

The grade 5-7 boys were tested with the motor skills training ability correlated with the motor skills learning efficiency ($r = 0.433$) and individual physi-



cal fitness; and the motor activity was found correlated with the physical education / sports teaching mastery ($r = 0.437$). The grade 5-7 girls were tested with correlations of the motor skills training abilities with the motor skills teaching efficiency ($r = 0.524$); the physical education / sports teaching mastery ($r = 0.411$); and expert-validated physical fitness rates ($r = 0.405$).

The grade 8-9 boys were tested with the motor skills training ability being correlated with the motor skills learning efficiency ($r=0.537$); and the physical fitness correlated with the motor skills learning efficiency in expert valuations ($r=0,474$) and the motor skills training ability ($r=0,472$). The grade 8-9 girls were tested with correlations of the motor skills training abilities with the motor skills learning efficiency ($r=0.496$), motor activity ($r=0,464$) and motor gifts ($r=0.432$), and correlations of the motor skills learning ability with the motor gifts ($r = 0.430$).

The grade 10-11 boys were tested with significant correlations between the motor skills training ability and motor activity ($r=0.527$); and the physical fitness and motor skills learning efficiency in expert valuations ($r=0.503$). And the grade 10-11 girls were tested with correlations of the motor skills training abilities with the motor skills learning efficiency ($r=0.512$), and motor activity with motor gifts ($r = 0.430$).

Conclusion. The new motor skills training model was tested beneficial for the school physical education service. The motor skills progress testes in the school physical education course are recommend-

ed to be complemented by the physical education teaching mastery tests/ expert valuations, motor skills difficulty rankings and the trainees' motor giftedness tests.

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Changes in physical fitness rates of female students of non-core universities induced by various physical education technologies

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Abstract

Objective of the study was to detect changes in the female students' physical fitness induced by the fitness aerobics practices introduced under the traditional physical education programs.

Methods and structure of the study. The educational experiment with the use of the computerized monitoring technologies (as part of the educational process under the physical education and sports disciplines) involved 206 female students. The Experimental Group girls (n=103) were trained at Irkutsk National Research Technical University under the elective academic aerobics discipline, while the Control Group ones (n=103) were trained at the Health and Fitness Center of Irkutsk State University under the elective body conditioning course.

The study was carried out using the methodological recommendations on the tests developed in the All-Russia Scientific Research Institute of Physical Culture and Sport: "5x10 shuttle run" – to test "speed endurance qualities and agility associated with the change of direction and alternation of acceleration and deceleration"; "bent suspension" – to determine "strength and static endurance of the arm and shoulder muscles"; "sit and reach" – to test the level of "active flexibility of the spine and bending at hips"; "sit-ups for 30 sec" – to determine "dynamic endurance of the flexors of the back"; "1000 m run" – to determine "general endurance"; "20 m run from standing start" – to assess "speed qualities"; "standing long jump" – to evaluate "dynamic strength of the lower limb muscles". In addition to these qualifying standards, the following tests were also used at the technical university also: "abdominal crunches" – to determine "strength and dynamic endurance of the anterior abdominal wall muscles"; "push-ups" – to assess "dynamic strength of the arm and shoulder muscles".

Results and conclusions. The findings showed that the physical education lessons with the use of the fitness aerobics tools significantly improved the female students' physical fitness levels, as opposed to the girls trained under the traditional academic physical education program. The beneficial influence of this technology is due to the fuller realization of female students' physical potential, as well as due to its consistency with the interests and demands of this contingent of students.

Keywords: *physical education, physical fitness, monitoring, fitness aerobics, female students.*

Background. Modern universities are being modernized with the latest innovative technologies and new hardware and software, and university physical education system is no exception [7, 9]. In the conventional organization of academic physical education and sports activities, it is almost impossible for students to choose the type of physical activity, and for physical education teachers – to implement an

individual approach to each student [4]. In addition, some standard types of physical activity are no longer relevant for young people or are limited to students' health conditions [2, 5, 8].

Therefore, in the training process, while intensifying students' intellectual labor, it is necessary to reflect on the need for a new-quality organizational and content structure of the educational system [1] and to



create innovative pedagogical approaches that would be aligned with the times and consistent with the modern concept of education, which aims at an individual, his health, interests, and needs [3].

Objective of the study was to detect changes in the female students' physical fitness induced by the fitness aerobics practices introduced under the traditional physical education programs.

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also used at the technical university also [3]: **"abdominal crunches"** – to determine "strength and dynamic endurance of the anterior abdominal wall muscles"; **"push-ups"** – to assess "dynamic strength of the arm and shoulder muscles".

Results and discussion. The comparative analysis of the changes in the girls' physical fitness indicators revealed that, except for the running skills (speed - Fig. 1 and general endurance - Fig. 2), the most significant changes occurred in EG rather than in CG.

At the same time, at the beginning of their university studies, the girls had no significant differences in most physical fitness rates, while in the "sit-ups for 30 sec" (Fig. 2) and "bent suspension" (Fig. 4) tests, more significant ($p<0.05$) differences were observed in EG.

In the first two years of study, when the female students were trained using specific physical exercises but different educational technologies, the EG girls were found to have a more dynamic increase ($p<0.001$) in the studied indicators.

Throughout the third year of study, the female students of both groups demonstrated a general downward trend in their physical fitness levels; however, in EG, the physical fitness rates were still significantly ($p<0.01$, $p<0.001$) higher than in CG. These changes were taking place against the multidirectional changes in the girls' physical skills. No differences between the groups were determined in two physical qualities only – "speed endurance and agility" (Fig. 5) and "dynamic strength of the lower limb muscles" (Fig. 6).

Notably, the analysis of the changes in the "active flexibility of the spine and bending at hips" (Fig. 7) and "strength and dynamic endurance of the anterior abdominal wall muscles" (Fig. 8) revealed that, when entering the university, the girls of both groups had no

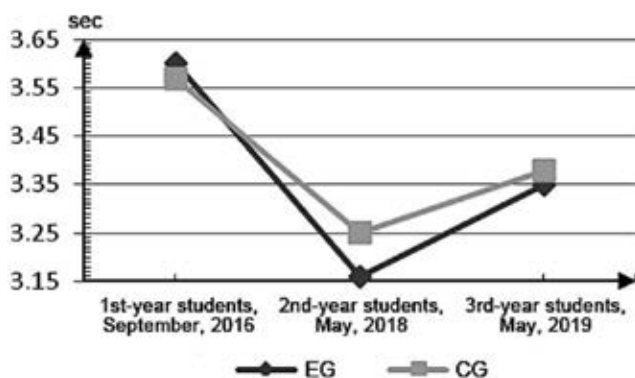


Fig. 1. Comparison of "20 m run" from standing start" test results

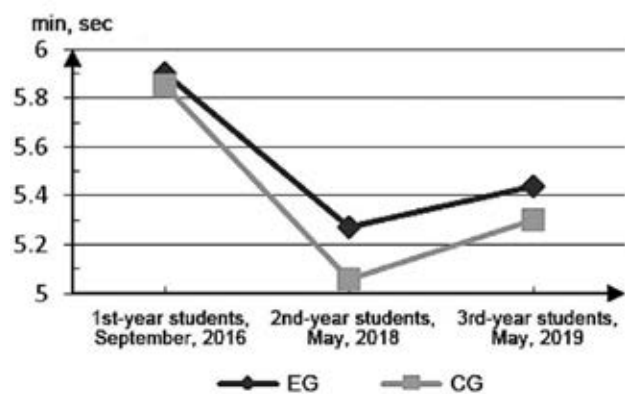


Fig. 2. Comparison of "1000 m run test results

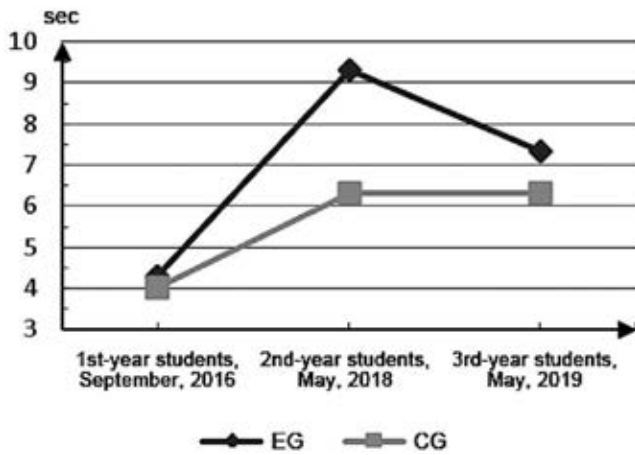


Fig. 3. Comparison of "bent suspension" test results

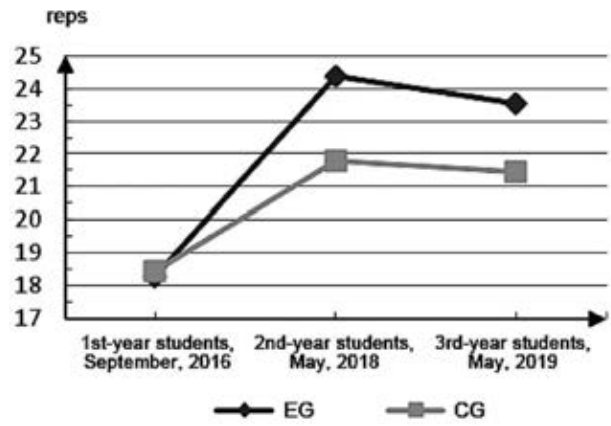


Fig. 4. Comparison of "sit-ups for 30 sec" test results

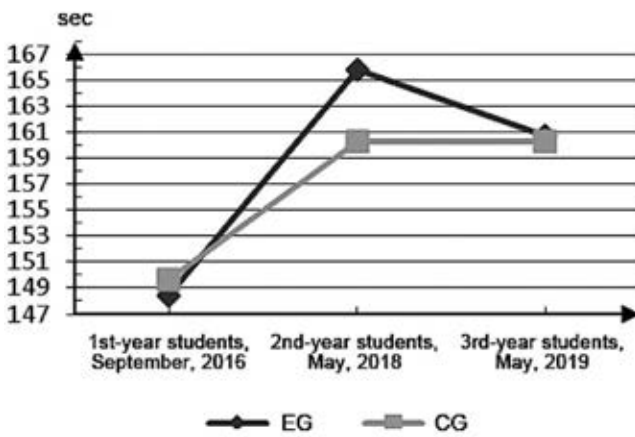


Fig. 5. Comparison of "shuttle run" test results

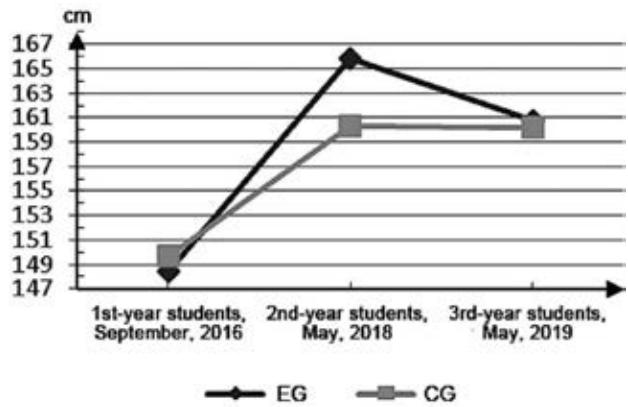


Fig. 6. Comparison of "standing long jump" test results

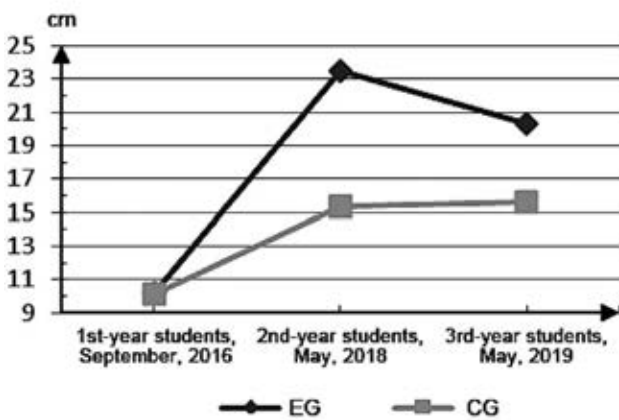


Fig. 7. Comparison of "abdominal crunches" test results

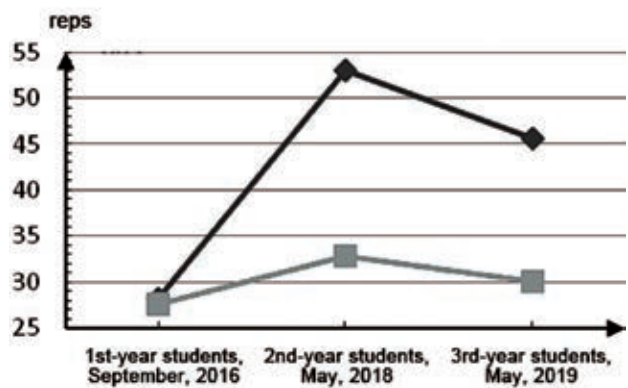


Fig. 8. Comparison of "sit and reach" test results

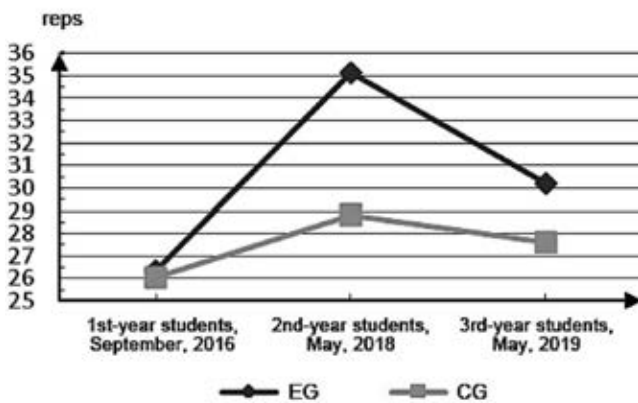


Fig. 9. Comparison of "push-ups" test results

differences in their physical fitness levels. However, it was found that, throughout the entire period of study, the analyzed indicators were improving more significantly ($p < 0.001$) in EG rather than in CG.

The analysis of the changes in the "dynamic strength of the arm and shoulder muscles" (Fig. 9) also showed no differences between the groups when the girls entered the university, and throughout the entire period of study, the analyzed indicators were significantly ($p < 0.001$) higher in EG rather than in CG.

Conclusions. The findings showed that the physical education lessons with the use of the fitness aerobics tools have significantly improved the female students' physical fitness levels, as opposed to the girls trained under the traditional academic physical education program. The beneficial influence of this technology is due to the fuller realization of female students' physical potential, as well as due to its consistency with the interests and demands of this contingent of students.

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Distance learning in elective academic physical education disciplines: health tests and progress analyses

UDC 796.015:378.018.4



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Abstract

Objective of the study was to analyze benefits and drawbacks of the academic distance learning formats for the students' physical fitness in the pandemic period versus the pre-pandemic physical fitness test data.

Methods and structure of the study. The distance learning format was introduced by Irkutsk National Research Technical University (INRTU) in March through June 2020, with the Physical Education Department making a transition to the Moodle learning platform. The physical education and sport staff offered the distance physical education models customized to the students' health, age, physical fitness and individual progress needs, with the recommended sets of exercises mobilizing every key muscle group mostly by own body weight application practices. We sampled for the study the 2-year students (n=221) qualified with the Health Group III and split them up into Reference Group (RG, n=103) trained in the pre-pandemic 2018-19 period and Experimental Group (EG, n=118) trained in the pandemic 2019-20 period. The RG and EG were virtually identical in the primary health conditions and diagnoses.

Practical self-reliant/ distant physical trainings were run twice a week and fixed by video-reports. Since the isolation requirements complicated the traditional speed and endurance trainings, the exercise sets were dominated by the strength, coordination and flexibility centered practices.

The physical education progress test technology offered a set of test exercises on the university website to profile the students' physical development and physical fitness.

Results and conclusion. The study data and analyses showed that the distance learning format of the academic physical education service for the Health Group III may be recommended only in very limited and provisional training models complementary to the traditional physical education service curricula. It may be beneficial only for the students knowledgeable and skillful in the independent physical education practices plus well equipped with the training technologies and basic self-test systems. It should be mentioned at the same time that the modern university distance learning website with the advanced digital physical education technologies effectively encourages the INRTU students' cognitive activity and independence. Such the distance learning facilities developed and advanced by many national universities may be beneficial for the self-reliant trainings of the responsible and determined senior students in many domains including modern physical education models for optimal customizable physical activity and healthy lifestyles.

Keywords: distance learning, physical fitness, students.

Background. Practical academic physical education service is commonly recognized pivotal for the students' health protection and improvement programs [1] – in the context of the progress in high tech-

nologies, medicine and physical activity encouraging methods and models still failing to effectively reverse the youth health deterioration trends. The students' health issues have been aggravated for the last few



years by the growing priority to independent learning formats in the university education curricula – often since the very first academic years when students are still mostly irresponsible and uncommitted for studies and healthy lifestyle. The serious epidemiological situation for the last two years has forced the higher education system to make a fast transition to the distance learning formats – that come in conflict to a degree with the health protection and improvement policies and practices as they only contribute to the growing physical inactivity with the associating detriments for the physical development, physical fitness, functionality and morbidity statistics [2]. Practical experience has demonstrated that distance physical education models may be successful in the health protection aspects only when they facilitate progress in the self-reliant physical education and sports trainings. Regretfully, the ongoing pandemic complicates the independent trainings, and this is why we believe it could be beneficial to make an emphasis on the personality progress values of the physical education and sports culture in the life quality improvement context [3].

Objective of the study was to analyze benefits and drawbacks of the academic distance learning formats for the students' physical fitness in the pandemic period versus the pre-pandemic physical fitness test data.

Methods and structure of the study. The distance learning format was introduced by Irkutsk National Research Technical University (INRTU) in March through June 2020, with the Physical Education Department making a transition to the Moodle learning platform. The physical education and sport staff offered the distance physical education models customized to the students' health, age, physical fitness and individual progress needs, with the recommended sets of exercises mobilizing every key muscle group mostly by the own body weight application practices. We sampled for the study the 2-year students ($n=221$) qualified with the Health Group III and split them up into Reference Group (RG, $n=103$) trained in the pre-pandemic 2018-19 period and Experimental Group (EG, $n=118$) trained in the pandemic 2019-20 period.

The RG and EG were virtually identical in the primary health conditions and diagnoses.

Practical self-reliant/ distant physical trainings were run twice a week and fixed by video-reports. Since the isolation requirements complicated the traditional speed and endurance trainings, the exercise sets were dominated by the strength, coordination and flexibility centered practices.

The physical education progress test technology offered a set of test exercises on the university website to profile the students' physical development and physical fitness. It is traditional for the INRTU to test the physical development / physical fitness by the pre-versus post-academic-year tests; and so we analyzed the EG versus RG test data (2019-20 versus 2018-19) to rate the distance learning service efficiency for the elective physical education disciplines: see Table 1. The students were required to run and report the post-year functionality tests independently using the Stange/ Gench Breath-Holding Probe. Note that the student numbers in the tests varied due to some of them barred from the tests in cases of contraindications. The test data were statistically processed and analyzed using the Student's t-test.

Results and discussion. As could be expected, the breathing tests showed regress, as well as the pull-ups test – apparently due to many students having no horizontal bar at home. Despite the generally good external respiration test rates, the regress may be interpreted as indicative of the decreased circulatory and oxygen-supplying system functionality and, hence, lower hypoxic tolerance and worse general fitness. However, the EG was tested with significant progress in the 30s sit-ups and push-ups tests and insignificant progress in the flexibility tests.

The physical education benefits and drawbacks of the distance learning format were rated by the RG versus EG physical fitness test data for the two years: see Table 2. The study showed benefits of the traditional physical education service in the RG, with significant ($p < 0.05$; 0.01) group progress in every pre- versus post-year-2 test. Having compared the RG and EG test data, we found clear advantages of the RG in every test save for the push-ups.

Table 1. EG physical fitness test data: pre-distance-learning and distance learning periods in 2019-20

Year	Stange test, s	Gench test, s	30s sit-up test, reps	Pull-ups, count	Sitting leans, cm	Push-ups, reps
Pre-year 3	73.2±0.6	34.1±0.4	18.8±0.3	11.1±0.8	10.3±0.4	20.4±0.4
Post-year 2	69.7±0.8	32.7±1.3	24.9±0.7	9.7±0.6	12.4±0.6	24.6±0.8
p	$p > 0.05$	$p > 0.05$	$p < 0.05$	$p > 0.05$	$p > 0.05$	$p < 0.05$

**Table 2.** EG versus RG physical fitness test data of 2019-20

Year	Stange test, s	Gench test, s	30s sit-ups test, reps	Pull-ups, reps	Sitting leans, cm	Push-ups, reps
Pre-year-2: RG	71,9±0.6	32.2±0.1	19.1±0.4	9.4±0.5	12.3±0.2	19.4±0.7
Post-year-2: RG	75.7±0.7	38.7±0.5	27.9±0.4	12.1±0.6	16.4±0.6	26.0±0.4
p: RG	p<0.05	p<0.01	p<0.01	p<0.05	p<0.05	p<0.01
Pre-year-2: p (RG-EG)	p>0.05	p>0.05	p>0.05	p>0.05	p>0.05	p>0.05
Post-year-2: p (RG-EG)	p<0.01	p<0.01	p<0.05	p<0.05	p<0.05	p>0.05

Having analyzed the above test data, we found the following:

- The traditional pre-pandemic format of the academic elective physical education service is better in every physical fitness / physical development aspect;
- The distance learning format of the academic physical education is effective enough for the strength and speed-strength training goals but not for the flexibility ones. Progress in the distance learning format was found limited by the shortages of training equipment and space;
- Shortages or limitations of the training equipment and space in the distance learning format limit the students' and teachers' progress in the physical education service;
- In cases of health issues or training regress due to the physical stress in the distance learning format, the teacher may be unable to help the student on a timely and efficient basis;
- Since the teacher cannot control the training process on an uninterrupted basis, he/ she is mostly unable to effectively manage and individualize the training service; and
- Progress in the isolated trainings and tests may be hampered by the lack of competitive motivations typical for the traditional academic physical education classes.

Conclusion. The study data and analyses showed that the distance learning format of the academic physical education service for the Health Group III may be recommended only in very limited and provisional training models complementary to the traditional physical education service curricula. It may be beneficial only for the students knowledgeable and skillful in the independent physical education practices plus well equipped with the training technolo-

gies and basic self-test systems. It should be mentioned at the same time that the modern university distance learning website with the advanced digital physical education technologies effectively encourages the INRTU students' cognitive activity and independence. Such the distance learning facilities developed and advanced by many national universities may be beneficial for the self-reliant trainings of the responsible and determined senior students in many domains including modern physical education models for optimal customizable physical activity and healthy lifestyles.

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7-8 year-olds' gender group sensorimotor response tests and analysis

UDC 371.7



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Abstract

Objective of the study was to test and analyze the gender-specific sensorimotor responses in the 7-8 year-olds.

Methods and structure of the study. We sampled for the study the 7.38±0.08 years boys (n = 20) and 7.18±0.05 year-old girls (n = 20) without known medical contraindications to physical trainings at a Moscow school. The sample was tested by UPFT-1/30 "Psycho-physiologist" Test System with application of 35 response triggers/ stimuli. The central nervous system functions were rated by the simple and complex visual-motor response and response to moving object tests.

Results and conclusion. The simple visual-motor response tests found the girls' central nervous system functions being 20% faster ($p=0.0002$) and better synchronized than the boys' ones. The complex visual-motor response tests indicative of the individual operational functions under time pressure (withing tight time limits) also ranked the girls group higher. The complex visual-motor response test data analysis ranked the girls group significantly higher on the response speed ($p=0.03$), response stability ($p=0.03$) and error scoring ($p=0.05$) scales despite the fact that the group responses were collectively on the 'below average' level on the whole – versus he boys group ranked on the 'low' level ($p=0.007$). It should be mentioned that the girls group is close to the upper limit of the low level versus the boys group averaging close to the lower limit of this level.

The test data and analyses found the metropolitan 7-8 year-olds' sensory activity and progress gender-specific in many aspects, and this fact is to be taken into account in the school education curricula, to have the education service and individual progress trajectories sensitively customized to the individual abilities and progress. The physical education teachers in their analyses of the physical fitness and motor skills test data should know that the 7-8 year-old girls' response speed is normally higher than the boys' ones due to the higher central nervous system mobilization fitness and better response speed control.

Keywords: 7-8 year-olds, central nervous system, sensorimotor response, gender specifics.

Background. The early school age is known to be particularly sensitive to the movement speed, coordination [3] and cognitive qualities and functions excelling trainings [6] due to the inter-hemispheric interactions rapidly progressing with the movement control and culture [1]. Generally, this age group is believed to go through the cerebral functionality control restructuring process [5], with the active central nervous system processes facili-

tating the child's adaptation to life on the whole and school learning challenges in particular. Maladaptive conditions in this critical period may negatively affect the central nervous system functionality [2], and this regress may be prevented by special physical education service with a special emphasis on the health protection and sensory system functionality improving practices including the movement coordination and control qualities and skills building



ones. Modern studies report gender differences in the sensorimotor responses since 11 years of age, particularly expressive in the complex sensorimotor response, with the male age group tested with faster progresses in sensorimotor response test rates [4].

Objective of the study was to test and analyze the gender-specific sensorimotor responses in the 7-8 year-olds.

Methods and structure of the study. We sampled for the study the 7.38 ± 0.08 years boys ($n = 20$) and 7.18 ± 0.05 year-old girls ($n = 20$) without known medical contraindications to physical trainings at a Moscow school. The sample was tested by UPFT-1/30 "Psycho-physiologist" Test System with application of 35 response triggers/ stimuli. The central nervous system functions were rated by the simple and complex visual-motor response and response to moving object tests.

Results and discussion. The simple visual-motor response tests found the girls' central nervous system functions being 20% faster ($p=0.0002$) and better synchronized than the boys' ones. The complex visual-motor response tests indicative of the individual operational functions under time pressure (withing tight time limits) also ranked the girls group higher. The complex visual-motor response test data analysis ranked the girls group significantly higher on the response speed ($p=0.03$), response stability ($p=0.03$) and error scoring ($p=0.05$) scales despite the fact that the group responses were collectively on the 'below average' level on the whole – versus he boys group ranked on the 'low' level ($p=0.007$). It should be mentioned that the girls group is close to the upper limit of the low level versus the boys group averaging close to the lower limit of this level.

Boys group was tested 30% higher on the maximal response time ($p = 0.05$) and 10% lower ($p = 0.05$) on the response stability scales – that may mean that the group strives to respond as fast as possible despite the errors made. On the whole, the girls group was notably lower (3.5 versus 4.07) in the total errors scoring scale that may mean that girls of this age are much more attentive to the performance quality and accuracy.

The response to moving object test indicative of the nervous processes balancing function ranked the girls group twice lower on the 'anticipatory response' ($p = 0.05$) and 22% higher on the 'early response' test scales ($p = 0.05$). We found insig-

nificant gender group differences in the 'total late response' rates, although the 'total anticipatory response times' was 30% higher ($p = 0.05$) in the girls group. These test data may be interpreted as indicative of the excitation processes dominating in the girls group over inhibition ones.

Both groups were tested with the late responses heavily dominating over anticipatory responses – that may mean that the sample is vulnerable to functional stressors. The late, early and normal response ratios were estimated at 45:29:28 and 45:23:28 in the girls and boys groups, respectively. Knowing that the 'balancing ratio' in the girls group was significantly lower and the response to moving object insignificantly lower than in the boys group, we have grounds to assume that the central nervous system stress in the boys group is higher.

Conclusion. The test data and analyses found the metropolitan 7-8 year-olds' sensory activity and progress gender-specific in many aspects, and this fact is to be taken into account in the school education curricula, to have the education service and individual progress trajectories sensitively customized to the individual abilities and progress. The physical education teachers in their analyses of the physical fitness and motor skills test data should know that the 7-8 year-old girls' response speed is normally higher than the boys' ones due to the higher central nervous system mobilization fitness and better response speed control.

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Federal health monitoring program: physical fitness test toolkit for public schools

UDC 796.011



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Abstract

Objective of the study was to analyze benefits of the physical fitness test toolkit for the public school physical education service as provided by the Federal health monitoring program.

Methods and structure of the study. The study was designed to test physical fitness of the 1-11 graders in the public school system. Specific physical fitness test results were summarized to produce integral physical fitness test rates. The specific physical fitness aspects test exercises were designed on an age-specific basis to rate the individual speed, movement coordination, speed-strength, strength, endurance and flexibility as follows: grades 1-3 were tested by 4 physical fitness tests; grade 4 by 5 tests; grades 5-9 by 6 tests; and grades 10-11 by 6 tests. Individual successes in the tests were scored by 1-3 points and failures by 0 points.

Results and conclusion. The physical fitness tests of the Surgut public school population under the Federal health monitoring program ranked 54.0% of the main health group sample (n=23,943) moderate, 34.9% (n=15,492) high and 11.1% (n=4,906) low on the physical fitness test scales. The physical fitness test data made it possible to objectively rate and analyze health of the municipal public school population, with the highest physical fitness test rates demonstrated by the 10-11 graders. The physical fitness test data are recommended for attention of the public school physical education teaching community for the physical education curricula updating and practical physical education service quality improvement purposes.

Keywords: *physical fitness, students, 1-11th grades, tests, scores.*

Background. Presently the national public school system runs physical development and physical fitness tests to profile health of the school population. As required by the valid school physical education service concept, the schoolchildren's physical development with harmonized progress in every basic physical quality will be facilitated and tested by standard physical fitness tests. One of the key problems of the public school physical education service is that the physical education teachers still have little means to effectively design and manage the physical education process without modern physical fitness testing and analyzing tools [1, 3, 4, 6]. This means that the public school

physical education system needs standard modern physical fitness testing and monitoring methods to objectively track and correct individual physical fitness progress with a special emphasis on the health aspects in the school physical education service based on the relevant constructive management decisions [1, 5].

Objective of the study was to analyze benefits of the physical fitness test toolkit for the public school physical education service as provided by the Federal health monitoring program.

Methods and structure of the study. The study was designed to test physical fitness of the 1-11 grad-



ers in the public school system. Specific physical fitness test results were summarized to produce integral physical fitness test rates. The specific physical fitness aspects test exercises were designed on an age-specific basis to rate the individual speed, movement coordination, speed-strength, strength, endurance and flexibility as follows: grades 1-3 were tested by 4 physical fitness tests; grade 4 by 5 tests; grades 5-9 by 6 tests; and grades 10-11 by 6 tests. Individual successes in the tests were scored by 1-3 points and failures by 0 points: see Table 1.

We sampled for the study 50,211 public school students in Surgut city, including 44,572 (88.8% of the total) healthy individuals qualified with the main health group. Tested school population totaled 44,341 individuals (99.5% of the main health group).

Results and discussion. Given in Table 2 hereunder are the specific physical fitness (speed, movement coordination, speed-strength, strength, endurance and flexibility) test data of the sample.

Grade 1 tests ranked 507, 3079 and 2000 (9.1%, 55.1% and 35.8%) students low (0-4 points), moderate (5-8 points) and high (9-12 points) on the physical

fitness test scales, respectively. Grade 2 tests ranked 517, 2721 and 1906 (10.1%, 52.9% and 37.1%) students low (0-4 points), moderate (5-8 points) and high (9-12 points) on the physical fitness test scales, respectively. Grade 3 tests ranked 580, 2720 and 1564 (11.9%, 55.9% and 32.2%) students low (0-4 points), moderate (5-8 points) and high (9-12 points) on the physical fitness test scales, respectively.

Grade 4 tests ranked 611, 2538 and 1409 (13.4%, 55.7% and 30.9%) students low (0-5 points), moderate (6-10 points) and high (11-15 points) on the physical fitness test scales, respectively. Grade 5 tests ranked 415, 2389 and 1567 (9.5%, 55.7% and 35.9%) students low (0-6 points), moderate (7-12 points) and high (13-18 points) on the physical fitness test scales, respectively. Grade 6 tests ranked 599, 1979 and 1410 (15.1%, 49.7% and 35.2%) students low (0-6 points), moderate (7-12 points) and high (13-18 points) on the physical fitness test scales, respectively. Grade 7 tests ranked 445, 2303 and 1474 (10.5%, 54.6% and 34.9%) students low (0-6 points), moderate (7-12 points) and high (13-18 points) on the physical fitness test scales, respectively. Grade 8 tests ranked 470, 2252 and 1310

Table 1. Integral physical fitness test data of the school main health group sample, points

Physical fitness level	Grades 1-3: 4 tests	Grade 4: 5 tests	Grades 5-9: 6 tests	Grades 10-11: 6 tests
Low	0-4	0-5	0-6	0-6
High	9-12	11-15	13-18	13-18
Moderate	5-8	6-10	7-12	7-12

Table 2. Age-specific speed, movement coordination, speed-strength, strength, endurance and flexibility test data of the main health group sample

Grade	Physical fitness levels and shares (%)					
	Low		Moderate		High	
	n	%	n	%	n	%
1	507	9,1 %	3079	55,1%	2000	35,8%
2	517	10,1 %	2721	52,9%	1906	37,1%
3	580	11,9%	2720	55,9%	1564	32,2 %
4	611	13,4%	2538	55,7 %	1409	30,9%
5	415	9,5%	2389	54,7 %	1567	35,9 %
6	599	15,1 %	1979	49,7%	1401	35,2%
7	445	10,5%	2303	54,6 %	1474	34,9%
8	470	11,7 %	2252	55,9 %	1310	32,5 %
9	364	10,5 %	1876	54,0%	1234	35,5%
10	225	10,7%	1059	50,4%	816	38,9 %
11	173	8,6%	1027	51,1 %	811	40,3%
Total	4906	11,1%	23943	54,0%	15492	34,9%



(11.7%, 55.9% and 32.5%) students low (0-6 points), moderate (7-12 points) and high (13-18 points) on the physical fitness test scales, respectively. Grade 9 tests ranked 364, 1876 and 1234 (10.5%, 50.0% and 35.5%) students low (0-6 points), moderate (7-12 points) and high (13-18 points) on the physical fitness test scales, respectively. Grade 10 tests ranked 225, 1059 and 816 (10.7%, 50.4% and 38.9%) students low (0-6 points), moderate (7-12 points) and high (13-18 points) on the physical fitness test scales, respectively. And Grade 11 tests ranked 173, 1027 and 811 (8.9%, 51.1% and 40.3%) students low (0-6 points), moderate (7-12 points) and high (13-18 points) on the physical fitness test scales, respectively.

Conclusion. The physical fitness tests of the Surgut public school population under the Federal health monitoring program ranked 54.0% of the main health group sample (n=23,943) moderate, 34.9% (n=15,492) high and 11.1% (n=4,906) low on the physical fitness test scales. The physical fitness test data made it possible to objectively rate and analyze health of the municipal public school population, with the highest physical fitness test rates demonstrated by the 10-11 graders. The physical fitness test data are recommended for attention of the public school physical education teaching community for the physical education curricula updating and practical physical education service quality improvement purposes.

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Major sports events: regional development catalyzing effects

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Abstract

Objective of the study was to analyze the key provisions for the major sports events being beneficial for the regional development, with the Sverdlovsk Oblast major sports events hosting experience taken for the case study.

Methods and structure of the study. We used for the purposes of the study a standard research toolkit with its analyzing, synthesizing and benchmarking tools.

Results and conclusion. Major sports event offers great potential opportunities for long-term projects and benefits including the tangible and intangible ones for the federal, regional and municipal progress agendas, with a special priority to the sustainable regional development aspects. The major sports events heritage, benefits and success on the whole may be analyzed in the following five key dimensions.

The major sports events host programs should be designed on an integral basis to secure good synergy of shareholder interests with the flows of investments – in the context of the hosts' long-term municipal/ regional development master plans. This context will help the potential investors to have clear vision of the future regional development to forecast progress of the local markets well ahead and, hence, paybacks on their investments in the post-major-sports-event periods. Such business planning with the contingency, risk assessment and ROI elements will provide a strong foothold for the potential investments and, hence, make the major sports events projects attractive.

The Sverdlovsk Oblast Government and the relevant local agencies have the necessary resource and competences for the major sports events hosting and efficient management; plus excellent competences and experience in the sports infrastructure development projects, technical servicing, television broadcasting, refereeing services, sports delegation reception and servicing, transport and logistics, clientele-specific volunteering servicing and many other major sports events related issues – to facilitate the regional development initiatives in every social, economic, political, communicative, PR, infrastructural and environmental domain.

Keywords: *acceleration of regional development, major sports event, heritage of major event, physical education and sports development, sports infrastructure.*

Background. Modern major sports events with their huge social, economic and many other benefits on the one hand and potential excessive overpressures on the governmental budgets with overspendings and resource management inefficiencies on the other hand – are still ranked among the key drivers of regional development programs [5-7]. This is the rea-

son why the federal and regional governments need to prudently design and manage the major sports events on a sound and systematic basis with due account of every economic and social benefit and risk. The major sports events in this context may be ranked among the key catalysts of regional reforms since they encourage investments in the physical education and sport sys-



tem and public infrastructure development projects – conditional on the investments being well planned, analyzed, designed and managed for progress of the host regions and cities.

Objective of the study was to analyze the key provisions for the major sports events being beneficial for the regional development, with the Sverdlovsk Oblast major sports events hosting experience taken for the case study.

Methods and structure of the study. We used for the purposes of the study a standard research toolkit with its analyzing, synthesizing and benchmarking tools.

Results and discussion. Major sports event offers great potential opportunities for long-term projects and benefits including the tangible and intangible ones for the federal, regional and municipal progress agendas, with a special priority to the sustainable regional development aspects. The major sports events heritage, benefits and success on the whole may be analyzed in the following five key dimensions.

1. Economic dimension related to the economic costs and benefits of the major sports events with account of every direct and indirect one.

2. Regional infrastructure development dimension including the major-sports-events-related large-scale infrastructure development projects, with a special attention to their post-major-sports-events operation and maintenance aspects and business benefits to avoid such projects degrading to the so-called "white elephants" i.e. expensive, unpopular, inoperable and loss-making assets.

3. Political/ communicative/ PR dimension related to the major sports events viewed as a global platform for the local political/ PR messages and agendas, with a special contribution to the local major sports events hosting and management experiences, and with the host country/ region/ cities using the major sports events to brand their names and images as efficient and hospitable hosts.

4. Social dimension related to the education, social and public awareness programming, social consolidation and increased popularity of both the sports events and mass physical education and sports / health movements and healthy lifestyles on the whole.

5. And environmental dimension in the context of the local and national environmental sustainability related initiatives. The hosts are expected to rate the major sports events benefits for the environmental components of the regional sustainable development projects

including their energy saving, public transportation, carbon footprint reduction, efficient waste management, biological diversity preservation, pollution prevention/ mitigation and other related aspects [4].

For the major sports events being successful and beneficial for the regional development programs, the host region/ cities need to:

1. Establish, on a timely and efficient basis, the major sports events host infrastructure via long-term investments in the major sports events assets and sports equipment procurements;

2. Analyze the post-major-sports-events asset management, with due market research projects and operation and maintenance business plans to ensure the major sports events host infrastructure being beneficial for the local communities for a long time after the event; and

3. Control the major sports events financial management system by a variety of methods including independent external audits, to ensure strict responsibility for the major-sports-event-related flows of finance.

The major sports events host programs should be designed on an integral basis to secure good synergy of shareholder interests with the flows of investments – in the context of the hosts' long-term municipal/ regional development master plans. This context will help the potential investors to have clear vision of the future regional development to forecast progress of the local markets well ahead and, hence, paybacks on their investments in the post-major-sports-event periods. Such business planning with the contingency, risk assessment and ROI elements will provide a strong foothold for the potential investments and, hence, make the major sports events projects attractive.

The Sverdlovsk Oblast with its vast major sports events hosting experience (including the 2018 FIFA World Cup matches hosting in Yekaterinburg) is much interested in further hosting of global and national sports events. The Sverdlovsk Oblast Government reports hosting more than 8 thousand sports events a year including 30-plus international ones. Thus in 2019 the Sverdlovsk Oblast reportedly hosted 8,484 sports events attended by 2 million 182 thousand 567 people.

The Sverdlovsk Oblast government ranks the upcoming 2023 FISU Summer World University Games in August among the regional development catalyzing major sports events. The qualifiers for the event will compete in Yekaterinburg city for 248 sets of medals in 18 sports including 15 FISU-mandated disciplines



(badminton, basketball, water polo, volleyball, judo, track and field athletics, table tennis, swimming, diving, gymnastics, archery, tennis, taekwondo, fencing and rhythmic gymnastics); plus 3 optional sports (boxing, sambo and rugby-7).

The 2023 FISU Summer World University Games Board of Executives has come up with an operational budget supported by business analyses and cost estimates. In August 2019 the cost estimates and consolidated budgetary requirements were submitted to the Ministry of Finance, with the Federal and Sverdlovsk Oblast Government budgets expected to finance 70% and 30% of the event costs, respectively.

As far as the post-major-sports-event benefits ('regional development legacy') of the Games are concerned, we would mention that they will be hosted by 31 venues in 4 Sverdlovsk Oblast municipalities (Yekaterinburg, Verkhnyaya Pyshma, Pervouralsk and Sysert) to meet expectations and requirements of the FISU and the relevant international sports federations. It should be mentioned that 22 of the 31 venues are already in place, and 9 need to be constructed or rehabilitated.

The Sverdlovsk Oblast Government was driven by the cost efficiency considerations when taking an untraditional decision to host the above 9 sports in venues of the Yekaterinburg-EXPO International Exhibition Center (IEC). Four IEC venues will host seven competitive courts and 10 training gyms to largely meet the demand for the sports facilities. The remaining 3 venues will be financed by the Federal Governmental budget and constructed in Yekaterinburg, including a multiservice indoor facility in the Judo Palace, a Water Sports Palace, and a Rhythmic and Aesthetic Gymnastics Center.

Furthermore, the Sverdlovsk Oblast Government will finance construction of a Football Center of the Ural Football Academy; the N.V. Karpol Academy of Volleyball Physical Education and Sport / Health Complex; Sambo Palace in Verkhnyaya Pyshma; and Tennis Center in Sysert. In addition, a private-public partnership of the Sverdlovsk Oblast Government and Ice Arena JSC will construct a multiservice indoor ice sport venue.

Most of the survey and design works under the sports assets rehabilitation projects for the World Summer University Games have been completed, including the Yekaterinburg Arena stadium adaptation for the multiservice operations in the post-event period. The hosts have also come up with the Terms of

Reference for the project design and cost estimates to restore the football field and tracks at the Yeltsin Ural Federal University. The project design and rehab works are funded by the Federal Ministry of Education and Science and scheduled for completion by March 2023.

Conclusion. The Sverdlovsk Oblast Government and the relevant local agencies have the necessary resource and competences for the major sports events hosting and efficient management; plus excellent competences and experience in the sports infrastructure development projects, technical servicing, television broadcasting, refereeing services, sports delegation reception and servicing, transport and logistics, clientele-specific volunteering servicing and many other major sports events related issues – to facilitate the regional development initiatives in every social, economic, political, communicative, PR, infrastructural and environmental domain.

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Federal physical education and sports development programs: conceptual basics

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Abstract

Objective of the study was to develop conceptual basics and notions for the civic interests being respected by the federal physical education and sports development programs.

Methods and structure of the study. The study was run at the Institute of State and Law of the Russian Academy of Sciences using the relevant historical, logical, dialectical cognitive and other research tools with the socio-legal interpretations of the key terms to identify the subject notions in application to the national physical education and sport sector.

Results and conclusion. Having analyzed the reference literature on physical education and sports, we found our hypothetical concept giving the top priority of civic interests in developing the key governmental policy principles for the physical education and sport sector development programs being supported by some study reports.

It is the relevant federal and regional executive agencies, local governments and public organizations in charge of the physical education and sport services that should provide adaptive physical education and sport services to disabled people. The above entities are responsible for providing unlimited access for disabled people to every social facility including the physical education and sports facilities.

The study data and analysis showed that when the governmental policy principles and provisions are fixed by supreme legal enactments, they form a set of milestones for progress of the nation on the whole and its constituent entities in particular including the local governments and federal executive agencies; and make it possible for them to design their target development programs at every level within the valid domestic and foreign policy vectors. Persistent efforts to have implemented the governmental policy principles analyzed herein in practice will help transform Russia into a genuinely social state.

Keywords: *physical education and sports, citizens, interests, public agencies, responsibilities, special social protection.*

Background. Governmental policy fundamentals are generally framed and formed by a system of principles. Special literature defines the governmental policy principles as the basic operational rules for the public agencies, social groups and individuals of influence on the key social processes. The social science interprets these rules as the commonly binding primary legal provisions of high universality, common

recognition and top imperativeness that provide a framework for the legal regulations with a set of criteria to legitimize operations of every party to the regulated relationship.

When such governmental policy basics and provisions are fixed by supreme legal enactments, they form a set of milestones for progress of the nation on the whole and its constituent entities in particular in-



cluding the local governments and federal executive agencies; and make it possible for them to design their target development programs at every level within the valid domestic and foreign policy vectors. As far as the priorities in the governmental policy principles are concerned, one should proceed from the assumption that the principles as such originate from the relevant social processes and only on this condition are established in the relevant legal provisions by the government acting as the social control system leader.

The above reasoning holds true for the governmental policy principles applicable to the national physical education and sport system. It may be pertinent to emphasize that these principles are formed in the context of the actual situation in the subject social sphere and its progress logics and agenda, including the physical education and sport social role and position, specific popular individual and collective needs and interests in the physical education and sports sector, and the expected accomplishments of every relevant social entity.

Objective of the study was to develop conceptual basics and notions for the civic interests being respected by the federal physical education and sports development programs.

Methods and structure of the study. The study was run at the Institute of State and Law of the Russian Academy of Sciences using the relevant historical, logical, dialectical cognitive and other research tools with the socio-legal interpretations of the key terms to identify the subject notions in application to the national physical education and sport sector.

Results and discussion. Having analyzed the reference literature on physical education and sports, we found our hypothetical concept giving the top priority of civic interests in developing the key governmental policy principles for the physical education and sport sector development programs being supported by some study reports [1, p. 136; 2, p. 43-45].

The study data give reasons to believe that basically the governmental policy principle is twofold with every part referring to different physical education and sports components. The first part binds the Government and federal executive agencies in charge of the physical education and sports-related governmental policy to develop the latter with due respect to the civic interests. It is beyond doubt that addressing every interest of every social group is hardly possible in practice, albeit this requirement is still extremely important since it obliges the relevant executive authori-

ties to consider interests of the diverse social groups/strata when drafting their target FP. We would mention as an example of a focused public physical education / health/ mass sport program the RF Government Decree of December 29, 2001 No. 916 "On the All-Russian health monitoring system for adults, children, adolescents and youth" that provides a basis for the ongoing large-scale physical cultural initiatives by the national educational institutions, corporate entities and local communities.

It should be mentioned that this principle obliges the decision-makers to respect every civic interest in the physical education and sport sector development governmental policy drafting, approval and effectuation process. It could be also beneficial to apply this principle to the regional physical education and sports development programs since the federal legislation in the matters of joint federal-and-local control is intended to lay the control basics (guiding framework) for the specific relationship building by the local legislature.

The second part of the principle under consideration refers to the citizens, since the governmental initiative as such with its mass physical education and sports facilitation provisions and physical education and sport service infrastructure for the mass physical education and sports advancement is not enough for success in fact. Citizens should take their own efforts to demonstrate the initiative, determination and interest in the physical education and sports projects. We would agree with reservations with N.A. Ignatyuk who argues that "a legal responsibility of citizens is out of question in this case for their abstaining from sports cannot be sanctioned or penalized" [4]. The only exclusion we see are the citizens bound by some institutional/ legal responsibilities implying specific departmental physical education and sports standards (e.g. for personnel of educational institutions, military academies/ special services/ corps, children's and youth sports schools, etc.); with the citizen's failure to comply with such standards being subject to the departmental disciplinary, material or civil liability.

To put the analysis on a more comprehensive and inclusive basis, it may be pertinent to consider application of this principle to people with disabilities, health disorders and other vulnerable population groups in need of special social protection (2007 Federal Law "On Sports", clause 8, article 3). Special physical education and sport service to disabled people is recognized instrumental for their social adaptation and



physical rehabilitation with potential integration into the global disabled sports community. Modern disabled sports are respected as an important socio-cultural phenomenon all over the world, and even provide a source of income for the disabled sport professionals [3, p. 45]. The disabled sports are basically classified into the hearing impaired/ deaf; visually impaired/ blind; sports for people with musculoskeletal disabilities, mental retardations etc.

The Federal Law of the Russian Federation "On Social Protection of Disabled Persons in the Russian Federation" Article 9 nominates the institutions in charge of social protection of people with disabilities including the educational, health, social security and social protection agencies and organizations; with the special physical education and sport service and events mentioned among the key rehabilitation services for disabled people.

It is the relevant federal and regional executive agencies, local governments and public organizations in charge of the physical education and sport services that should provide adaptive physical education and sport services to disabled people. The above entities are responsible for providing unlimited access for disabled people to every social facility including the physical education and sports facilities. As provided by the Ministry of Sports Order of July 24, 2014 No. 578 "On approving the Practical Recommendations for access of disabled athletes and other disabled people to sports events on their needs-sensitive basis", every physical education and sports facility must be adapted for unlimited access of disabled persons. It should be emphasized that active efforts pursuant to the above Order are taken by the regional govern-

ments that endorse and implement the relevant projects, with the relevant physical education and sports / health services and events financed by the local budgets and borrowings.

Conclusion. The study data and analysis showed that when the governmental policy principles and provisions are fixed by supreme legal enactments, they form a set of milestones for progress of the nation on the whole and its constituent entities in particular including the local governments and federal executive agencies; and make it possible for them to design their target development programs at every level within the valid domestic and foreign policy vectors. Persistent efforts to have implemented the governmental policy principles analyzed herein in practice will help transform Russia into a genuinely social state.

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