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Contents

A STUDY OF THE COGNITIVE LEVEL AND SOME BASIC SKILLS IN BASKETBALL AMONG SECONDARY STUDENTS ACCORDING TO GENDER AND INTELLIGENCE VARIABLES

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Abstract The curriculum of physical education and sports through sports activities programmed in the secondary stage seeks to achieve a set of goals of mobility, cognitive and socio-emotional to serve the goals of physical education and sports at this stage. We find a basketball game one of these activities which need a degree of intelligence and knowledge that helps in developing the skill level of the students and selecting the teacher for the appropriate exercises to teach different basic skills. In this context, our study aims to measure the cognitive level of the students of the third secondary level, as well as their level in some basic skills. The study was conducted using a cognitive test in basketball and the selection of some technical tests according to the objectives of the curriculum, then comparing the level according to the sex variables and the level of intelligence and interaction between them and identifying the relationship between these variables. One of the students of the third year secondary school in the city of Mostaganem (Algeria), and after the statistical treatment of the results was reached the results of the most important:

1. The absence of a gender effect and the level of logical and physical intelligence and interaction between them at the cognitive level while being influenced by the level of space intelligence in favor of those with high intelligence.
2. There is a difference in the level of skill of pointing, scrolling and dialogue for the benefit of males, and there is no impact on the level of intelligence, whether logical or physical or space.
3. There is an impact of the interaction between sex and the level of spatial intelligence at the cognitive level, where males and females with high intelligence showed more response.
4. The interaction of sex and the level of intelligence, whether logical, physical or spatial, has no impact on the skills of correction, scrolling and dialogue.
5. There is a direct correlation between IQ and cognitive level as well as basic skills in basketball.

Key words cognitive level, some basic skills in basketball, secondary students, intelligence variables

Introduction

The cognitive outcomes associated with any sporting activity have become recognized in contemporary societies that are experiencing economic, social and sporting prosperity because of their obvious contribution in helping the individual to understand the issues surrounding them. The thinker Phoenix points out that one of the symptoms of contemporary cultural decay is the intellectual aspects of education. There is a clear chapter on the physical aspects, although physical education and sports in principle offer the best opportunity for personal progress, as a whole process, in harmony. It is obtained by the means of games, in which intelligence, skill, aesthetic imagination, social sensitivity, and morality make the effort worthwhile and purposeful. Hara mentioned the value of the cognitive field of sport and physical education. He pointed out that the training and teaching of mental cognitive abilities has been an indispensable part of learning stages of sport. The most successful trainers are aware of the importance of mental and cognitive aspects and they have planned to impart theoretical knowledge to learners. As Welgos pointed, the general educational goals are transformed into direct educational goals focused on three types of human behavior (cognitive, dynamic, emotional). This classification format provides a useful tool for determining the contents of the curriculum, so that the topics of learning are selected more efficiently in physical education.

The measurement of knowledge objective evaluation methods are used alongside tests that measure physical and skillful aspects (Al Said, 2001). Scientific research has shown that all cognitive tests are among the most widely used, if not the most widely used, assessment tools (Hassanein, 1995). Cognitive processes at the beginning are often predominated by motor skills training, but basic information about skills should also be provided to the students properly.

Acquiring knowledge and using it while learning or during sports competition in basketball requires some intelligence to facilitate this process. Intelligence as an ability to think, understand, innovate and solve problems and issues that are encountered by the individual is essential in acquiring mathematical knowledge and use it appropriately and purposefully while performing skill during the learning process, or during the competition in basketball, where the intelligence factor enables the individual to use their mental and physical abilities in the performance of the skills with less strength and ability of mobility and speed with minimal effort (Jabbar, 2011).

The skills involved include balance, motor synergy, speed, flexibility and a sense of movement in order to solve a problem. Complex and multiple situations during sports competitions require a high degree of intelligence to deal with different expectations and make appropriate decisions within the playing field, and this applies to the game of basketball, which is characterized by complex laws and a small arena and a small circle of correction, and here contributes high intelligence to overcome the difficult and quick situations in a correct and appropriate manner during learning and training.

Basketball game is characterized by rapid focus and understanding of the different relationships given the nature of different situations in order to perform accordingly to the information provided and to understand the relationship between all the elements with insight into the results of their performance. The ability to apply the motor duty accurately is also of high importance. Based on the above, the subject of the study was limited in the attempt to identify the relationship between the level of knowledge and some basic skills in basketball according to the level of intelligence and gender in the students who pass the baccalaureate (17–18) years.

Research Objectives

1. To measure the level of knowledge in basketball for third-year students, differentiated sex and level of intelligence, by building a cognitive knowledge test that allows students to be classified.

2. To measure the level of performance in the basic skills in basketball (third-year students) by gender and level of intelligence through the selection of skill tests to suit the content of the ministerial curriculum for physical education and sports in the secondary stage in terms of level and possibilities available for application.

3. To recognize the level of knowledge of the impact of interaction between sex and level of intelligence at the level of knowledge and the level of skill of correction and scrolling and dialogue in basketball at the third year secondary students.

Research Methodology

Due to the nature of the subject, we relied on the survey as a descriptive approach.

The research sample

The study sample included 60 students from the third year of secondary school; 30 males and 30 females of the 2017/2018 academic year. They were randomly selected, in addition to the 60 students who applied the cognitive test in its preliminary form after the approval of a number of experts to extract the difficulty and discrimination coefficients of the test words.

Study tool

The questionnaire and the personal interview were used to determine the technical tests and build the cognitive test. Three tests that measure some of the basic skills in basketball were selected among the nine tests that were presented to 10 experts in the Institute of Physical Education and Sports Specialists in basketball.

An objective test was built to measure the level of knowledge in basketball according to the ministerial program scheduled for the third year secondary, where the test included 120 questions. After its presentation to the experts, 20 questions were canceled and the test of 100 words was applied to a sample of 60 students from the third year secondary to extract the difficulty and discrimination factors. Accordingly, 37 statements were canceled and the final examination was made up of 63 words about 6 aspects: skill, schematic aspect, hardware and tools, laws and rules, physical aspect and arbitration.

Howard Gardner's multi-intelligence test was also used to determine in particular logical intelligence, physical intelligence and spatial intelligence. The students were classified according to three levels: high, intermediate and low level.

Presentation and discussion of the results

Comparison by gender and logical intelligence level

Table 1 presents that:

1. There is a statistical significance of the gender variable at level 0.05 in the skills of correction and scrolling and at the level of 0.01 in the skill of dialogue for the benefit of males with no statistical indication of the level of knowledge.
2. There is a lack of statistical significance in the level of knowledge and level of basic skills according to the logical intelligence variable.
3. There is no statistical indication of the interaction between logical intelligence and gender at the cognitive level and basic skills, except for the skill of scrolling as illustrated in Figures 1, 2, 3 and 4.

Table 1. Comparison of the level of knowledge and basic skills by gender and the level of logical intelligence

	Source of variation	Total squares	Degree of freedom	Average squares	F calculate	Significance
The cognitive level	Between the sexes	8.98	01	8.98	1.38	Non significant
	Between levels of intelligence	10.77	02	5.38	0.82	Non significant
	Interaction	13.05	2	6.52	0.89	Non significant
	In the groups	394.83	54	7.31	–	
Shooting	Between the sexes	42.83	01	42.83	7.16	0.05
	Between levels of intelligence	8.14	02	4.07	2.28	Non significant
	Interaction	3.57	02	1.78	0.29	Non significant
	In the groups	331.5	54	6.14	–	
Passing	Between the sexes	21.43	01	21.43	5.62	0.05
	Between levels of intelligence	5.3	02	2.65	6.79	0.01
	Interaction	0.78	02	0.39	0.10	Non significant
	In the groups	212.82	54	3.94	–	
Dribbling	Between the sexes	28.21	01	28.21	16.69	0.01
	Between levels of intelligence	3.01	02	1.5	1.03	Non significant
	Interaction	2.91	02	1.45	0.85	Non significant
	In the groups	92.16	54	1.71	–	

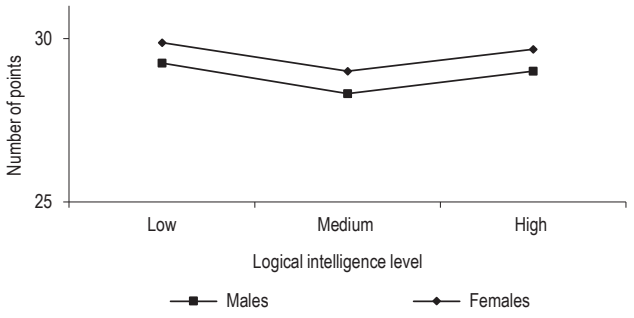

Figure 1. Interaction between gender and the level of logical intelligence at the cognitive level

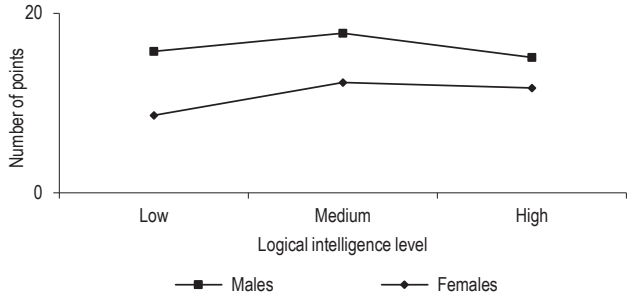

Figure 2. Interaction between sex and the level of logical intelligence in the skill of shooting

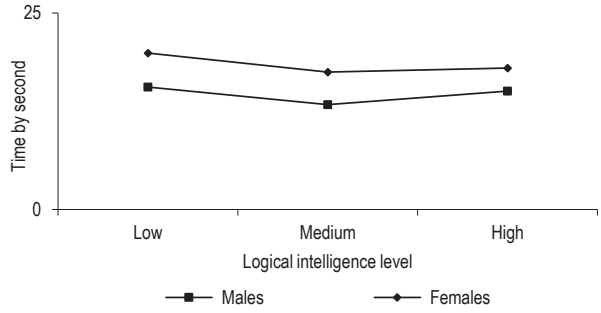

Figure 3. Interaction between sex and the level og logical intelligence in the skill of passing

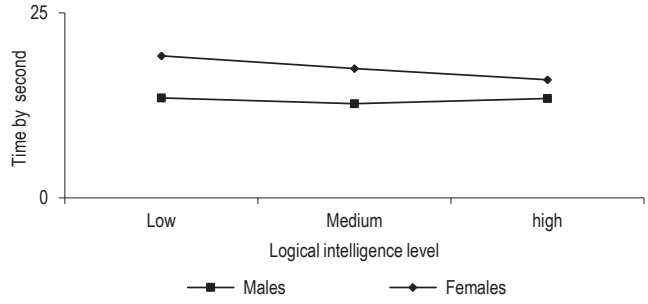

Figure 4. Interaction between sex and the level of logical intelligence in the skill of dribbling

We conclude from the above that:

1. The level of knowledge of students is not affected by the gender variable and the level of logical intelligence nor the interaction between these two variables.
2. The level of skills of correction, scrolling and dialogue was influenced by the gender variable in favor of males, and was not affected by the level of logical intelligence except the skill of scrolling, where males with higher IQs showed better results.

3. The level of knowledge and basic skills were not affected by the interaction between sex and level of intelligence.

Comparison by gender and level of physical intelligence

Table 2 presents that:

1. There is a statistical indication of the gender variable at the level of 0.01 in the basic skills (correction, scrolling and dialogue) in favor of males with no statistical significance at the cognitive level.
2. There is no statistical indication of the level of physical intelligence in the cognitive level and the level of basic skills.
3. There is no statistical indication of the interaction between physical and motor intelligence at the cognitive level and basic skills.

Table 2. Comparison in the level of knowledge by sex and level of physical intelligence

Tests	Source of variation	Total squares	Degree of freedom	Average squares	F calculate	Significance
The cognitive level	Between the sexes	7.13	01	7.13	2.85	Non significant
	Between levels of intelligence	11.15	02	5.57	2.23	Non significant
	Interaction	10.12	02	5.06	2.02	Non significant
	In the groups	135.01	54	2.50	–	
Shooting from specific areas	Between the sexes	46.04	01	46.04	7.90	0.01
	Between levels of intelligence	4.64	02	2.32	0.40	Non significant
	Interaction	4.54	02	2.27	0.38	Non significant
	In the groups	322.04	54	5.96	–	
Passing and receiving the ball	Between the sexes	32.44	01	32.44	13.68	0.01
	Between levels of intelligence	6.63	02	3.13	1.32	Non significant
	Interaction	0.85	02	0.42	0.17	Non significant
	In the groups	131.87	54	2.44	–	
Dribbling speed	Between the sexes	23.79	01	23.79	15.15	0.01
	Between levels of intelligence	4.00	02	2.00	1.27	Non significant
	Interaction	2.63	02	1.32	0.83	Non significant
	In the groups	85.52	54	1.58	–	

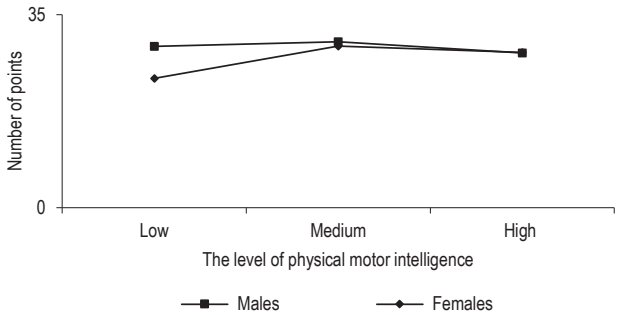

Figure 5. Interaction between sex and the level of physical intelligence at the cognitive level

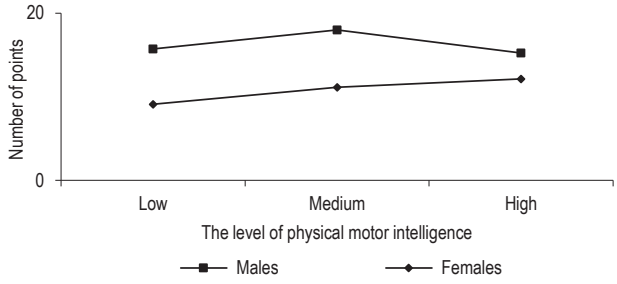

Figure 6. Interaction between sex and the level of physical intelligence in the level of shooting

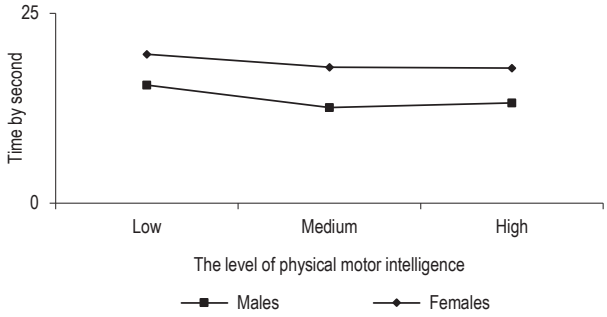

Figure 7. Interaction between sex and the level of physical intelligence in the level of passing

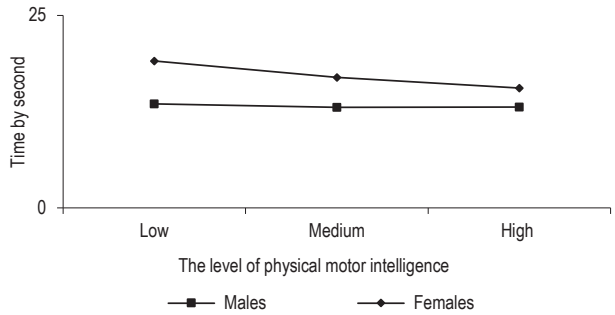

Figure 8. Interaction between sex and the level of physical intelligence in the dribbling level

We conclude from the above that:

1. The level of knowledge and the level of physical intelligence of males and females, and the interaction between them was not affected.
2. There is a difference in the level of skill of correction, scrolling and dialogue according to the sex variable for the benefit of males, and there is no effect on the level of physical intelligence as well as interaction between him and sex.

Comparison between males and females by level of spatial intelligence

Table 3 presents that:

1. There is a statistical significance between levels of intelligence at the cognitive level in favor of high IQ, and there is no statistical significance according to gender variable.
2. There is a statistical significance in the basic skills between the sexes in favor of males.
3. There is a statistical significance of the interaction between sex and level of intelligence in the level of knowledge in basketball for the benefit of males and females with high IQ.
4. There is no statistical significance of the interaction between sex and the level of intelligence in the level of basic skills in basketball.

Table 3. Comparison in the level of knowledge by sex and level of spatial intelligence

Tests	Source of variation	Total squares	Degree of freedom	Average squares	F calculate	Significance
The cognitive level	Between the sexes	9.17	01	9.17	1.56	Non significant
	Between levels of intelligence	155.15	02	77.57	13.26	0.01
	Interaction	50.1	02	25.05	4.28	0.05
	In the groups	316.13	54	5.85	–	
Shooting	Between the sexes	47.26	01	47.26	8.26	0.01
	Between levels of intelligence	3.79	02	1.90	0.33	Non significant
	Interaction	5.73	02	2.86	0.49	Non significant
	In the groups	314.52	54	5.82	–	
Passing	Between the sexes	34.41	01	34.41	16.23	0.01
	Between levels of intelligence	7.35	02	3.67	1.73	Non significant
	Interaction	0.59	02	0.30	0.14	Non significant
	In the groups	118.02	54	2.18	–	
Dribbling	Between the sexes	23.44	01	23.44	15.22	0.01
	Between levels of intelligence	4.46	02	2.23	1.45	Non significant
	Interaction	2.80	02	1.40	0.9	Non significant
	In the groups	83.36	54	1.54	–	

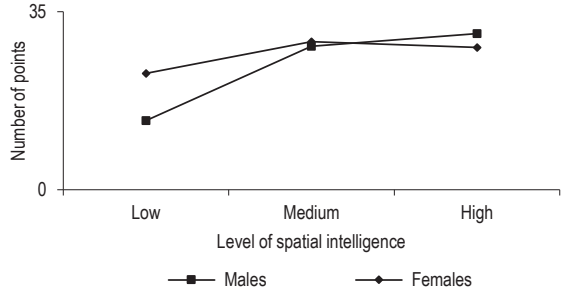

Figure 9. Interaction between sex and the level of spatial intelligence at the cognitive level

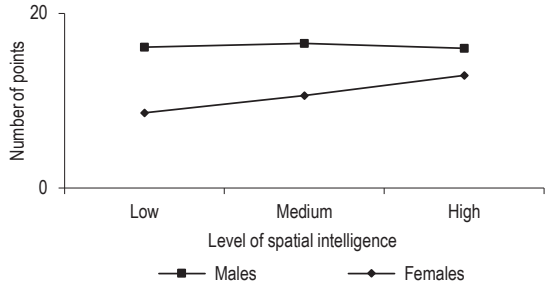

Figure 10. Interaction between gender and the level of spatial intelligence in the skill of shooting

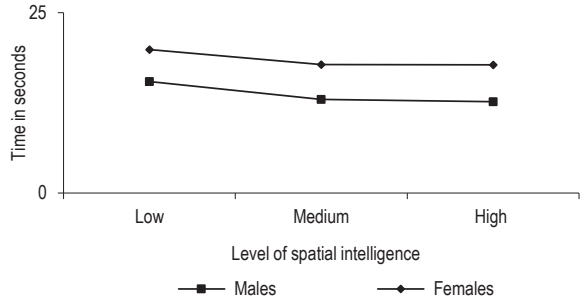

Figure 11. Interaction between sex and the level of spatial intelligence in the skill of scrolling

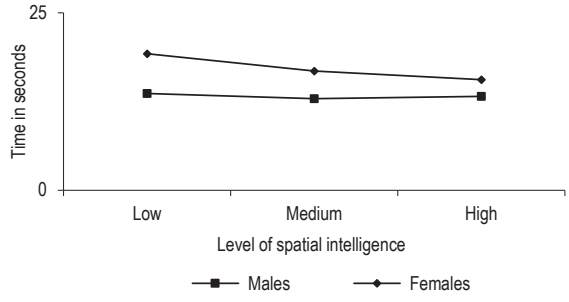

Figure 12. Interaction between gender and the level of spatial intelligence in the skill of dribbling

We conclude from the above that:

1. There is an impact of the level of space intelligence at the cognitive level in favor of medium and high intelligence, with no trace of sex influence.
2. There is an impact of the interaction between sex and the level of space intelligence on the cognitive level, as males and females with higher IQ have shown more response.

3. There is a difference in the skill level of correction for males, and there is no effect on the level of spatal intelligence nor interaction between this and sex.

A study of the relationship between intelligence, cognitive level and basic skills

Table 4 presents a statistical significance of correlation coefficients at the level of 0.05 and 0.01, which means that there is a positive relationship between IQ types and cognitive level, as well as basic skills in basketball.

Table 4. The relationship between intelligence types, cognitive level and level of basic skills in basketball

Intelligence type/skill	The cognitive level	Shooting	Passing	Dribbling
Zonal	0.55**	0.35*	0.41*	0.62**
Body	0.36*	0.37*	0.38*	0.57**
Spatial	0.42*	0.46*	0.40*	0.60**

* D at 0.05; **D at 0.01.

Discussion

The results of the study indicate that there is a positive relationship between the types of intelligence (logical, physical, motor, spatial) and basic skills as well as the level of knowledge in basketball, with the impact of sex and intelligence and interaction between them. These results ephasize the importance of teaching according to multiple intelligence types in order to improve the process of teaching and talent discovery. This approximates the results of the K. M. Sarouphim's studies (1997; 2002), which showed the importance of estimation according to different intelligences, and also the study of Y. Reid et al. (1999), which showed the importance of evaluation performance on the activities of solving problems based on the theory of multiple intelligences in the students, and the study of Abdul Rahman Nasser and Ghadir Star Abbas (2016), which showed the existence of the relationship between physical intelligence and handling skills and correction and discretion in basketball.

The researchers believe that pupils representing multiple intelligence types, which is one of the most important mental abilities, must characterize basketball players in order for them to address the rhythms of rapid movement as well as accuracy. This is valid especially in the case of goal correction, which requires using at least three types of intelligence to be performed successfully. Motor intelligence and – characterized by this type of intelligence – the ability to use parts of the body skillfully during a performance require knowledge of the body and sense of movement and balance, strength, speed and flexibility (Cooper, 2008). The advantage of this intelligence ability is making one able to gain knowledge through physical sensation and lead the movements well.

Spatial intelligence requires visual sensation as much as it requires awareness and the ability to think with images. The one who has this type of intelligence has the ability to think in mental images.

In the game of basketball students need to think when implementing correction, for example, by taking responsibility and showing self-confidence in order to achieve a successful correction. According to the types by Novell (2010), the ability of self-discrepancy in terms of strengths and weaknesses, also awareness of internal mix and motives and self-esteem, if combined with these types of intelligence working together allows for implementation

of the skills that are especially difficult. The harder the skill required, the most number of types of intelligence have to engage.

Conclusions

1. There is an absence of a gender effect and the level of logical and physical intelligence and interaction between them at the cognitive level while the level of spatial intelligence is affected in favor of high intelligence.

2. There is a difference in the level of skill of pointing and scrolling and dialogue for the benefit of males, and there is no impact on the level of intelligence, whether logical, physical or spatial.

3. There is an impact of the interaction between sex and the level of spatial intelligence at the cognitive level, where males and females with high intelligence showed more response.

4. Gender interaction and the level of intelligence, whether logical, physical or spatial, have no impact on the skills of correction, scrolling and dialogue.

5. There is a direct correlation between the types of intelligence and cognitive level as well as basic skills in basketball.

References

Abdul Sattar Jabbar (2011). *Mathematical Intelligence.* Amman: Zahran Publishing House.

Amin al-Khuli, Mahmoud Adnan (1990). *Physical Education School.* Cairo: Arab Thought House.

Amin Anwar Al-Khouli (1990). *Sport and society.* Cairo: The World of Knowledge Series.

Armstrong, T. (2008). *Multiple intelligence in the classrom.* Alexandria, Virginia : Association for Prevision and Curriculum Developement.

Cabrini, M. (1999). *The Psychology of Soccer.* Spring City, PA: Reedswain.

Coakley, J. (1997). Sport in Society. Issues and Controversies. 5th Edition. Times Mirror/Mosby College.

Eccles, J.S., Harold, R.D. (1991). Gender differences in sport involvement: Applying Eccles' Expectancy-Value Model. *Journal of Applied Sport Psychology*, *3*, 7–35.

Gardner, H. (1999). *Intelligence – Reframed – Multiple intellgences for the 21st century.* New York: Basic Books.

Gardner, H. (1997). Multiple intelligences as partner in school improve. *Educational leadership*, *55* (1).

Hara (1975). *Origins of Sports Training.* Mosul: Dar Maaref.

Huffman and others (1996). *Psychology in action. Intelligence and intelligence testing.* New York.

Jaber Abdul Hamid Jaber (1979). *Education and education technology.* Cairo: Arab Renaissance House.

Kleingeld, A., Mierlo, H., Arends, L. (2011). The effect of goal setting on group performance: A meta-analysis. *Journal of Applied Psychology*, *96* (6), doi: 10.1037/a0024315.

Kyllo, L.B., Landers, D.M. (1995). Goal setting in sport and exercise: A research synthesis to resolve the controversy. *Journal of Sport and Exercise Psychology*, *17*, 117–137.

Lindley, L.D. (2001). *Personality and unpublished human ph.d. thesis.* University of Lows: Retrieved from: www.lip.umi.com/dissertation.

Mohammed Al-Hamahmi Amin Al-Kholi (1990). *The foundations of building sports education programs.* Cairo: Arab Thought House.

Mohammed Subhi Hassanein (1995). *Measurement and Evaluation in Physical Education and Sports.* Cairo: Arab Thought House.

Morgan, H. (1992). *Analysis's of Gardner's theory of multiple intelligence.* The Annual Meeting of the Eastern Educational Research Association.

Rejoice of Mr. Layla (2001). *Mathematical cognitive measurement.* Cairo: Dar Al Ma'aref.

Shebenou, R.J. Johnsen, S.K. (1990). *Test of Nonverbal Intelligence: A Language-free measure of cognitive ability, examiner's manuel Second Edition.* Austin: Pro-ed.

Weinberg, R. Gould, D. (2003). *Foundations of Sport and Exercise Psychology.* Illinois: Human Kinetics, pp. 222–223.

Yperen, N.W.V., Blaga, M., Postmes, T. (2014). A Meta-Analysis of Self-Reported Achievement Goals and Non-self-Report Performance across Three Achievement Domains (Work, Sports, and Education).

Yukelson, D. (1998). Communicating effectively. In. J. Williams (ed.) *Sport Psychology: Personal growth to peak performance* (pp. 142–157). CA: Mountain View, Myfield.

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IMPACT OF PHYSIOTHERAPEUTIC PROCEDURES ON THE TREATMENT OF DAMAGED ROTATOR CUFF MUSCULES OF THE SHOULDER GIRDLE

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Abstract Damage to the rotator cuffs within the shoulder girdle is one of the many causes of the painful shoulder syndrome. The main symptom is the accompanying pain limiting partial or complete mobility in the shoulder joint. Weakness and atrophy of the deltoid and supraspinous muscles of the shoulder are secondary symptoms caused by immobilization of the upper limb. The aim of the study was to evaluate the effects of the use of physical therapy in women with damaged rotator cuff muscles of the shoulder girdle. The study involved 30 women aged 45–70, who were divided into two groups: professionally active (n = 15) and professionally inactive (n = 15). The muscle strength of the shoulder joint rim, strength of the hand grip and pain assessment according to the VAS scale were analyzed. The assessment of upper limb fitness was assessed before and after 20 physiotherapy procedures. Professionally active women returned to physical fitness faster, gaining greater strength of the shoulder girdle, strength of the hand grip and reduction of perceptible pain.

Key words tens currents, kinesiotherapy, Lovett scale, VAS scale, rotator cuff

Introduction

Damage to the rotator cuff muscles of the shoulder girdle (supraspinatus, infraspinatus, subscapularis, teres minor) is one of many causes of the painful shoulder. Muscle damage causes changes in joint biomechanics. Pain occurs mainly at night. It is difficult to perform everyday activities. Symptoms may be chronic or acute. There are four phases, different sizes of damage, including partial or total damage (Ślęzak, 2018; Clark, Harryman, 1992). The exact cause of the appearance of this dysfunction is not fully known. It is suspected that it may be the result of excessive tensile forces, degenerative changes and degenerative cone-building structures, subluxation or dislocation of the shoulder joint, joint inflammation, clavicle fracture, muscular weakness due to age, improper sports training and the associated occurrence joint overload, exposure to overload or long-term exercise in a static job position (Ault, 2002; Lesiak, 2002; Herberts, Kadefors, Högfors, Sigholm, 1984; Sobierajska-Rek, 2017). Imaging tests (including ultrasound, X-ray, magnetic resonance) and physical examination of the patient are used in

the diagnostics, which allows a more accurate determination of the site and degree of structural damage (Zanetti, Gerber, Hodler, 1998, Nakagaki, Ozaki, Tomita, Tamai, 1995; Dziak, 2003). The complaints are pain in the shoulder area of the shoulder joint rotator cuff, limited mobility and the associated limited self-service options and daily activities. The rehabilitation process includes both pharmacotherapy and physiotherapy, including kinesitherapy, physical therapy (electrotherapy – mainly TENS, laser therapy, local cryotherapy, ultrasounds, magnetotherapy), massage and balenotherapy. In the field of pharmacotherapy, calcitonin-based drugs, corticosteroids, GABA antagonists and sympatholytics, non-steroidal anti-inflammatory drugs and steroid injections are most commonly used. According to the recommendations (WHO), the use of pharmacotherapy in this dysfunction should be performed in accordance with a two-level scheme, including treatment from smaller to increased doses of the drug (Kujawa, Gawroński, Szyguła, Furgała, Janiszewski, 2003; Gawroński, 2003). The use of physiotherapy treatments allows to achieve the full range of mobility, prevents the reduction of strength and muscle mass, motivates for further rehabilitation. It affects psychophysical abilities, improves the perceived quality of life. The procedure of motor rehabilitation after rotator cuff injury includes counter-factorial exercises, isometric exercises in closed kinematic chains, passive unloading on the CPM rail, active exercises, active resistance, passive movements, dynamic shoulder rehabilitation exercises, general developmental exercises. It is possible to use neurophysiological methods, such as PNF (Czamara, 2003, Demkiewicz, Krawiec, Hendzelek, 2015; Rotter, Mosiejczuk, Żugaj, Ptak, Lubińska, 2005). One of the supporting methods is kinesiology taping. Unfortunately, sometimes conservative procedures are not enough. When the taper of the rotator muscle is completely ruptured, it is necessary to perform a surgical procedure. Only then physiotherapeutic and pharmacological activities are implemented. The prognosis depends on many factors, such as the age of the patient, the degree of structural damage, the speed of assistance and the implementation of treatment. The healing process is additionally hampered by nerve damage that causes progressive muscular atrophy. Reoperation is sometimes required (Albritton, Graham, Richards, Basamania, 2003; Gerber, Fuchs, Hodler, 2000; Cofield, 1982; Bigliani, Cordasco, McIlveen, Musso, 1992; Post, Silver, Singh, 1983). A person who has had a rotator cuff muscle disease should remember that he is exposed to a joint re-sprain. Most often this occurs within two years from the end of treatment of the previous injury, when the cause of joint instability has not been established (Bartoft, 2002). That is why prevention and appropriately selected physical activity are so important. It happens that the patient will be forced to change the nature of work (Gore, Murray, Sepic, Gardner, 1986).

Aim of the study

The aim of the study was to assess the effect of therapeutic effects after the application of physiotherapeutic procedures in the damage of damaged rotator cuff muscules of the shoulder girdle in two groups of professionally active and inactive women.

Research questions

1. Do women professionally active return to physical fitness faster than professionally inactive women after damage to the rotator cuff muscles of the shoulder girdle?

2. Do physiotherapeutic treatments reduce the pain of the shoulder girdle in women after damage to the rotator cuff?

3. Did the physiotherapy treatments increase the strength of the shoulder girdle muscle and the strength of the hand grip?

Material of research

The examination of women after damage to the cone of the rim of the shoulder girdle was performed at the Center of Occupational Medicine in Legnica in the Department of Rehabilitation in December 2016 and January 2017. 30 women aged between 45 and 70 joined the study. The average age was 58.6. 15 women were professionally active (average age – 52.7) and 15 were professionally inactive (mean age – 64.5). The average age of inactive women was higher than the average age of active women and this difference was statistically significant.

Test method

The work assessed the strength of the shoulder muscles of the shoulder joint with the Lovett test with movements of bending, straightening, abduction and restoration as well as the strength of the hand grip with the Collins force gauge. The VAS scale was used to assess the pain. The examinations of the efficiency of the upper limb after damage to the rotator cuff were performed at the beginning of the therapeutic improvement and after 20 treatments. In both groups, the test and control, the same physiotherapeutic treatments were used: TENS currents, laser, ultrasounds, local cryotherapy and kinesiotherapy.

Methods of statistical analysis

Distributions of the analyzed features were presented by determining the following parameters: arithmetic mean, standard deviation and range of variation (minimum and maximum value). Changes in the mean values of the measured values were evaluated using Student's t-test for dependent samples. Group comparisons were conducted using Student's t-test for independent trials. The statistical significance assessment was determined at the significance level of $p < 0.05$. The calculations were made using the STATISTICA 12 package from Stat.Soft (Ferguson, Takane, 1997; Stanisz, 2007).

Results

Analysis of pain perception:

The physiotherapy treatments applied in both groups led to a reduction in the intensity of pain. The average level of pain assessed on the VAS scale decreased after surgery in the group of active women by 1.6 and this change was statistically significant. In the group of inactive women, the mean decrease in perceived pain was 1.1 on the VAS scale and was not statistically significant ($p = 0.069$; $p > 0.05$). The greater effectiveness of the treatments used in the group of active women is emphasized by the fact that in this group the reduction in pain was noted in 87% of the subjects and there were no cases of pain. In contrast, in the group of inactive women, pain reduction occurred in 67% of subjects, and in 27% there was an increase in pain experienced despite physiotherapy (Table 1).

Table 1. Evaluation of the statistical significance of changes in the level of perceived pain after physiotherapy in a group of active and inactive women

Group	Pain in the VAS scale					Student's test	
	before treatments		after treatments		average change		
	average	stand. dev.	average	stand. dev.		t	P
Professionally active	5.5	2.4	3.9	2.5	–1.6	5.87	<0.001
Professionally inactive	5.4	2.2	4.3	2.2	–1.1	1.97	0.069

Analysis of hand grip strength:

Physiotherapy performed in the majority of women surveyed led to increased strength of the hand grip. In the group of professionally active women, the increase in hand strength was found in 93% of the subjects (n = 14), and in 7% (n = 1) the strength of the grip decreased despite the improvement process. In turn, in the group of inactive women, the increase in hand strength occurred in 60% of the respondents (n = 9), in 3% remained unchanged, while in 27% (n = 4) the strength of hand grip decreased despite treatments. The average changes in hand grip strength after the treatments were higher in the group of active than inactive women, and the change in the average value of hand grip strength after treatments was statistically significant in the group of statistically active women, and statistically insignificant in the group of inactive women ($p = 0.105$; $p > 0.05$) (Table 2).

Table 2. Evaluation of statistical significance of changes in hand grip strength after physiotherapy in a group of active and inactive women

Group	Hand strength (kG)					Student's test	
	before treatments		after treatments		average change		
	average	stand. dev.	average	stand. dev.		t	p
Professionally active	16.1	8.5	20.3	9.2	4.3	4.41	<0.001
Professionally inactive	11.6	6.0	14.0	6.5	2.4	1.74	0.105

Analysis of the assessment of the strength of the shoulder girdle muscles:

Paddle muscle:

Applied physiotherapy treatments resulted in an increase in the strength of the deltoid muscle in 87% of the examined women in the group of professionally active women (n = 13) and in 47% of women in the group of professionally inactive (n = 7). Among active women, there were no cases of decrease in subs by mice, while in the group of inactive women there were two such cases (n = 2) (13%). Strength of the subscapular muscle assessed by the Lovett test increased on average after treatments in both groups of women examined. The increase in the mean subscapular muscle strength after surgery was clearly higher in the group of professionally active women. The mean value of the subscapular muscle increase after surgery was 0.9 points on the Lovett scale in the group of professionally active women and was statistically significant. In the group of inactive women, the mean change in strength of this muscle was three times smaller and was not statistically significant.

The trapezius muscle and the oblong smaller muscle:

There were no effects of the applied physiotherapeutic treatments on the strength of the trapezius and oblong muscles in both groups of the studied women. The assessment of the strength of these muscles with the Lovett test before and after the treatments was the same. Only the mean value of the Lovetta strength score was in the group of professionally active women slightly higher than the average in the group of professionally inactive women, but the mean values in both groups did not differ significantly in terms of statistics.

Supraspinatus muscle:

In turn, the applied physiotherapeutic treatments contributed to the increase of the supraspinatus muscle assessed by the Lovett test. In the group of professionally active women the strength of this muscle increased in all individuals by 1 point in the Lovett scale, while in the group of professionally inactive women the increase in supraspinous muscle was observed in only 53% of subjects (n = 8). There have been no reports of a reduction in the strength of this muscle after the procedures. The mean increase in supraspinous muscle strength in the group of professionally active women was statistically significantly higher ($p = 0.002$; $p < 0.05$) than the average increase in muscle strength in the group of professionally inactive women.

Discussion

One of the reasons that make it difficult to assess muscle strength when it comes to damage to the rotator cuff muscles of the shoulder girdle pain is a concomitant significantly disturbing the function of the shoulder joint and limiting the range of motion in the limb. The reduction in the range of active movements was particularly noticeable. The changes that occur within the muscles: supraspinous, infraspinous, minor and subscapular muscles, can arise through micro-injuries and overloads, or through so-called indirect mechanism. The occurrence of pain at night is characteristic for this disease. J. Kuhn (2009), after analyzing the available literature, noted that performing exercises in the treatment of damaged rotator cuff results in a significant reduction in the occurrence of pain and improvement of general functioning. The type of physiotherapeutic treatments and exercises used in the rehabilitated process should be selected individually (Horrigan, Shellock, Mink, Deutsch, 1999). P.D. McCann, M.E. Wootten, M.P. Kadaba, L.U. Bigliani (1993) emphasize the important role of isometric exercises and resistance during rehabilitation. According to these researchers, these exercises contribute the most to improving both well-being and improving the functional state of the limb. M. Decker, J. Tokish, H. Ellis, M. Torry, R. Hawkins (2003) emphasize that during rehabilitation one should take into account not only the place, the extent of structural damage and the degree of dysfunction, but also what functions the individual muscles perform. R. Hughes (1996) in his research emphasized that in the training of muscles involved in the construction of the rotator cuff, the internal rotation of the joint should be limited. P. Millett, R. Wilcox, J. O'Holleran, J. Warner (2006) described in detail four stages of recovery in patients undergoing surgical treatment of damaged shoulder joint structures. The overall goal of rehabilitation is to return to the full range of mobility in the joint and strengthen muscles, which will additionally serve as a protective function against further injuries to joint structures. Rehabilitation should be carried out gradually. Initially, it should be run to a limited extent. The therapy will focus on improving flexibility and increasing the strength and durability of the muscles building the shoulder girdle and those muscles responsible for the mobility of the spatula. In the final stage of rehabilitation, the entire muscular corset, including postural muscle, should be strengthened to improve overall muscle performance and strength (Jobe, Moynes, Brewster, 1987). Many researchers deal with issues related to

therapeutic rehabilitation and optimization of the process of rehabilitation of patients who have suffered muscle trauma to the rotator cuff. Unfortunately, the complexity of the issue, the multifaceted clinical picture, the variety of symptoms and accompanying symptoms makes this issue still very problematic and there is a need to develop newer and better programs for improving and implementing prophylaxis (Ainsworth, 2006).

The research results indicate that the professionally active people returned more efficiently to greater efficiency. Applied physiotherapy in both groups reduced pain, which promoted the improvement of the quality of life and at the same time encouraged to continue to attend rehabilitation, motivated to take further therapeutic measures. The analgesic effects in both groups were satisfactory, but not all the patients had the desired effect. At the same time, it can be stated that well-chosen treatments can have an impact on accelerating the healing process. Early correct diagnosis and treatment increases the likelihood of a positive treatment effect.

Conclusions

1. It was found that professional activity and the use of appropriate physiotherapeutic treatments have a huge impact on the progress of the process of improving the upper limb after injury of the rotator cuff of the shoulder girdle in women.
2. The physiotherapy treatments applied in both groups reduced the intensity of pain and this change was statistically significant in professionally active women.
3. Professionally active women returned to physical fitness faster than less active.
4. The muscle strength of the shoulder girdle and hand grip was higher in professionally active peers.

References

Ainsworth, R. (2006). Physiotherapy rehabilitation in patients with massive, irreparable rotator cuff tears. *Musculoskeletal Care*, *4* (3), 140–151.

Albritton, M., Graham, R., Richards, II R.S., Basamania, C. (2003). An anatomic study of the effects on the suprascapular nerve due to retraction of the supraspinatus muscle after a rotator cuff tear. *Journal of Shoulder and Elbow Surgery*, *12* (5), 497–500.

Ault, J. (2002). Zespół cieśni podbarkowej. *Rehab Med*., *6*, 26–33.

Bartoft, E. (2002). Zespół bolesnego barku z punktu widzenia fizjoterapeutycznego – przegląd literatury. *Reh. Med*., *6*, 52–80.

Bigliani, L.U., Cordasco, F.A., McIlveen, S.J., Musso, E.S. (1992). Operative treatment of failed repairs of the rotator cuff. *The Journal of Bone and Joint Surgery. American Volume*, *74* (10), 1505–1515.

Clark, J.M., Harryman, D.T. (1992). Tendons, ligaments, and capsule of the rotator cuff. Gross and microscopic anatomy. *The Journal of Bone and Joint Surgery. American Volume*, *74* (5), 713–725.

Cofield, R.H. (1982). Subscapular muscle transposition for repair of chronic rotator cuff tears. *Surgery, Gynecology & Obstetrics*, *154* (5), 667–672.

Czamara, A. (2003). Program fizjoterapii po zwichnięciach przednich stawu ramiennego. *Med. Sportiva*, *7* (2), 139–150.

Decker, M., Tokish, J., Ellis, H., Torry, M., Hawkins, R. (2003). Subscapularis Muscle Activity during Selected Rehabilitation Exercises. *The American Journal of Sports Medicine*, *31* (1), 126–134.

Demkiewicz, D., Krawiec, D., Hendzelek, A. (2015). Uwzględnienie treningu motorycznego w rehabilitacji zespołu cieśni podbarkowej. *Praktyczna Fizjoterapia i Rehabilitacja*, *63*, 34–38.

Dziak, A. (2003). Zasady diagnostyki zespołu bolesnego barku. *Med. Sportiva*, *7* (2), 81–92.

Ferguson, A.G., Takane, Y. (1997). *Analiza statystyczna w psychologii i pedagogice*. Warszawa: Wydawnictwo Naukowe PWN.

Gawroński, W. (2003). O krioterapii raz jeszcze. *Med. Sportiva*, *7* (2), 155.

Gerber, Ch., Fuchs B., Hodler, J. (2000). The Results of Repair of Massive Tears of the Rotator Cuff. *JBJS*, *82* (4), 505.

Gore, D.R., Murray, M.P., Sepic, S.B. (1986). Gardner G.M. Shoulder-muscle strength and range of motion following surgical repair of full-thickness rotator-cuff tears. *The Journal of Bone and Joint Surgery. American Volume*, *68* (2), 266–272.

Herberts, P., Kadefors, R., Högfors, C., Sigholm, G. (1984). Shoulder pain and heavy manual labor. *Clinical Orthopaedics and Related Research*, *191*, 166–178.

Horrigan, J.M., Shellock, F.G., Mink, J.H., Deutsch, A.L. (1999). Magnetic resonance imaging evaluation of muscle usage associated with three exercises for rotator cuff rehabilitation. *Medicine and Science in Sports and Exercise*, *31* (10), 1361–1366.

Hughes, R. (1996). Force Analysis of Rotator Cuff Muscles. *Clinical Orthopaedics and Related Research*, 330, 75–83.

Jobe, F.W., Moynes, D.R., Brewster, C.E. (1987). Rehabilitation of shoulder joint instabilities. *The Orthopedic Clinics of North America*, *18* (3), 473–482.

Kuhn, J. (2009). Exercise in the treatment of rotator cuff impingement: A systematic review and a synthesized evidence-based rehabilitation protocol. *Journal of Shoulder and Elbow Surgery*, *18* (1), 138–160.

Kujawa, J., Gawroński, W., Szyguła, Z., Furgała, W., Janiszewski, M. (2003). Wybrane metody terapii fizykalnej w rehabilitacji chorych po urazach barku. *Med. Sportiva*, *7*, 125–135.

Lesiak, A. (2002). Zespół bolesnego barku - patogeneza, obraz kliniczny i leczenie. *Rehabilitacja Medyczna*, *6*, 26–43.

McCann, P.D., Wootten, M.E., Kadaba, M.P., Bigliani, L.U. (1993). A kinematic and electromyographic study of shoulder rehabilitation exercises. *Clinical Orthopaedics and Related Research*, *288*, 179–188.

Millett, P., Wilcox, R., O'Holleran, J., Warner, J. (2006). Rehabilitation of the Rotator Cuff: An Evaluation-Based Approach. *Journal of the American Academy of Orthopaedic Surgeons*, *14* (11), 599–609.

Nakagaki, K., Ozaki, J., Tomita, Y., Tamai, S. (1995). Function of supraspinatus muscle with torn cuff evaluated by magnetic resonance imaging. *Clinical Orthopaedics and Related Research*, *318*, 144–151.

Post, M., Silver, R., Singh, M. (1983). Rotator cuff tear. Diagnosis and treatment. *Clinical Orthopaedics and Related Research*, *173*, 78–91.

Rotter, I., Mosiejczuk, H., Żugaj, J., Ptak, M., Lubińska, A. (2005). Assessment of the influence of selected kinesitherapeutic methods on the function of the shoulder girdle in patients with the shoulder impingement syndrome. *Journal Of Public Health, Nursing And Medical Rescue*, *1*, 65–72.

Sobierajska-Rek, A. (2017). Uszkodzenia stożka rotatorów w podeszłym wieku. Rehabilitacja pooperacyjna i w leczeniu zachowawczym. In: M. Podgórska (red.), *Choroby XXI wieku – wyzwania w pracy fizjoterapeuty* (pp. 9–29). Gdańsk: WSZ.

Stanisz, A. (2007). STATISTICA Stat.Soft. Kraków.

Ślęzak, M. (2018). Zespół bolesnego barku. *Praktyczna Ortopedia I Traumatologia*, *9*, 38–46.

Zanetti, M., Gerber, Ch., Hodler, J. (1998). Quantitative assessment of the muscles of the rotator cuff with magnetic resonance imaging. *Investigative Radiology*, *13* (3), 163–170.

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THE PLACE OF LIVING, SCHOOL AND FAMILY INFLUENCE ON THE PATTERN OF PHYSICAL ACTIVITY AND SEDENTARY BEHAVIOR OF ADOLESCENTS: A CROSS SECTIONAL STUDY

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Abstract The aim of this study was to determine the influence of place of living, type of school, and family background on the physical activity and sedentary behavior of adolescents. 1,280 adolescents took part in the research: 694 boys and 586 girls aged 16–19 from Poland. Physical activity (PA) and sedentary behavior (SB) were evaluated by IPAQ-long version. A multiple regression analysis was used to evaluate the influence of socio-economic factors on physical activity and sedentary behavior. The results suggested a difference between boys and girls in all domains of physical activity and sedentary behavior. The results also indicated that social factors influence physical activity and sedentary behavior in different ways. After adjusting the model to BMI and age tested, the key determinants for boys' physical activity were: type of leisure time in the family and place of living, while for girls – type of school and type of leisure time in the family. Sedentary behavior of both sexes were strongly dependent on type of school, and – for boys – parents' education and type of leisure time in the family were also important. The results suggest the need for continuous monitoring of physical activity and seated behavior as well as taking into account a wide spectrum of social factors in which adolescents grow. Interventions and strategies to promote physical activity should focus on family involvement and uniting family and educational institutions operating in local environments.

Key words adolescents, physical activity, sedentary behaviors, family support, place of living, type of school

Introduction

Recently, the problem of diminishing physical activity has intensified significantly. It especially concerns societies in countries with high standards of living, where the development of new information and communication technologies means that people spend less time on physical activities (Badland, Schofield, 2006; Owen et al., 2011;

Pate, Mitchell, Byun, Dowda, 2011). Public health experts agree that the genetically determined need for physical activity, which is vital for maintaining a person's metabolic functions and health on an optimal level, has been disturbed (Tremblay, Colley, Saunders, Healy, Owen, 2010). It is a worrying phenomenon since lack of physical activity greatly influences health and costs of treatment for entire societies. Deficiency or lack of physical activity favors the development of overweight and obesity, as well as other chronic diseases which are Non Communicable Diseases, including the cardiovascular system and metabolic diseases, strokes and certain carcinomas (Janssen, LeBlanc, 2010; Reiner, 2013). A high level of sedentary behavior accounts for over 3 million preventable deaths, as a result influencing the quality of life and life expectancy (Owens, Crone, James, 2013).

The habit to spend leisure time in an active way often forms in childhood and most frequently in adolescence (Van der Horst, Paw, Twisk, Van Mechelen, 2007). If such habits are formed early, it usually means that physical activities are continued in later life. Not only is the level of physical activity formed by individual traits but also the environment we live in. The influence of the environment is on two main micro levels (the family and peers) and macro levels (among others: support of institutions and place of living) (Katzmarzyk et al., 2008). Their scope and the effects of influence may be independent or in synergy, so the evaluation of their influence and the strength of associations are complicated problems and impossible to be explained explicitly, which is confirmed by varied results of studies to date. Since the conditions of the environment are changing dynamically, they must be constantly monitored. In this way not only may we understand the interrelations and the mechanism of their changes better, but also develop better strategies of action adapted to different age groups, which will eventually lead to a fitter society, less susceptible to the numerous consequences of a sedentary lifestyle (Solomon, Rees, Ukoumunne, Metcalf, Hillsdon, 2013).

Many authors suggest that the key to understanding the influence of the environment on physical activity is the fast development of urbanization. It is usually accompanied by demographic, economic, social and ecological changes, as well as changes in the pattern of behavior in people with consequences for health, which are difficult to predict (Report ICSU, 2011). Some of the significant advantages of the urban environment in comparison with the rural environment, are better access to education and health care, as well as better facilities to organize more interesting leisure time activities, both active and inactive (Vlahov, Galea, 2002; Machado-Rodriques et al., 2014). Other potential factors such as: stress, air pollution, safety, fast pace of life and the system of city communication may be, in theory, risk factors of sedentary behavior and lower physical activity (Vlahov, Galea, 2002; Vlahov et al., 2007). It is not surprising though that it was often assumed that city dwellers frequently demonstrated a lower potential for physical activity and a higher potential for sedentary behaviors in comparison with dwellers of rural areas. Such assumption is supported by results of certain research (Albarwani, Al-Hashmi, Al-Abri, Jaju, Hassan, 2009; Springer, Hoelscher, Castrucci, Perez, Kelder, 2009). However, most research lead to opposite conclusions, proving that there is a significantly higher level of physical activity in adolescents from urban areas than in adolescents from rural areas (Kristjansdottir, Vilhjalmsson, 2001; Machado-Rodriques et al., 2014). The influence of the place of living is not only limited to linking the place of living to physical activity. The influence of access to playgrounds, extra-curricular sports activities, preferred means of transport, the neighborhood etc. on physical activity are well known (Davison, Lawson, 2006).

There is much research that describe the influence of family background on the physical activity of children and adolescents. The economic situation, parental educational level, support from the closest family given during

the process of learning motor skills and physical activities, as well as forming a proper attitude towards their own health, seem to have a significant in fluence on PA and SB (Lasheras, Aznar, Merino, Lopez, 2001; Van der Horst et al., 2007). Studies demonstrate that a higher level of education of parents and SES has a significant influence on a higher level of physical activity in adolescents (Finger, Mensink, Banzer, Lampert, Tylleskär, 2014). Moreover, it has been observed that parents' physical activity, especially that of the fathers, as well as spending leisure time together, involvement in children's sports training and transporting children to training and other physical activities, has a positive effect on the probability of long term involvement of children and adolescents in sports and recreational activities (O'Connor, Jago, Baranowski, 2009; Beets, Cardinal, Alderman, 2010). Definitely less attention has been dedicated to the school environment, especially in regards to adolescents. While it does not raise doubts that there is higher level of physical activity in private schools than in state schools, the findings by K. Van der Horst et al. (2009) were surprising. They noticed a varied influence of different types of state schools on PA and SB. The process of forming attitudes towards different forms of physical activity seems to be inextricably linked with the system of physical exercise and sports included in syllabuses in all types of schools and on every level of education. Negative habits towards health and lower level of PA as well as more frequent sedentary behaviors are usually more characteristic for vocational school students rather than grammar school students (Van der Horst et al., 2009). This phenomenon intensifies with age and is more typical for girls than for boys (Huang, Schnaub, Gross, John, Mayer, 2013). It was observed that there was a higher percentage of students from vocational schools and technical high schools who do not know the optimal time for daily moderate and intensive physical activity, and sedentary behaviors recommended by WHO and pediatricians (Loucaides, Jago, Theophanous, 2011).

Study results regarding the above-mentioned problems of physical activity factors clearly suggest a significant influence of all elements of the environment we live in on physical activity and sedentary behaviors. While the importance of family, school and place of living is understandable in regard to children and younger adolescents, it is more unclear and more difficult to interpret their connection with PA in regard to older adolescents.

Moreover, most studies focus on analyzing individual social or economic factors and not many studies consider the importance of many environmental factors and their influence on PA. Hence, the aim of this work is to analyze the associations between the place of living, school, family (parental educational level), habits regarding spending leisure time together and preferred ways of spending free time, and physical activity and sedentary behaviors in adolescents aged 16–19.

Material and methods

The procedure of this study was accepted by the bioethical committee of the Jan Kochanowski University's Faculty of Health Sciences (10/2015). Students aged 16–19 from grammar schools, technical high schools and vocational schools from the Świętokrzyskie Voivodeship participated in this study, which was conducted from 26 March 2015 to 26 April 2015. 1,280 students, 694 boys and 586 girls, took part in this study. Detailed characteristics of the participants in terms of family background, the type of school and place of living are shown in Table 1. This study constitutes as a part of a broader study on physical activity of adolescents and young adults aged 15–25 from the Świętokrzyskie Voivodeship (Poland).

Schools for this study were selected by stratified sampling. Schools were drawn taking into account two strata. The first stratum was the environment of the school: a big town or city (more than 100,000 residents), and a medium or small town (less than 100,000 residents). The second stratum was the type of school: grammar schools, technical

high schools and vocational schools. The research was mainly done by the authors but the management in three schools did not agree to this procedure so the questionnaires were handled by fully trained PE teachers.

Evaluation of physical activity

The participants self-reported their own physical activity from the previous week by means of the International Physical Activity Questionnaire-long version (*IPAQ*, 2012). The IPAQ has been evaluated in 14 studies and found to have good test-retest reliability and a modest Spearman correlation (r = 0.30) with PA measured by accelerometer (Craig et al., 2003). The IPAQ captures activity information on walking, moderate-intensity, and vigorous-intensity activities. The total general physical activity was calculated by summing time in minutes and its frequency in days for all forms of physical activity. Different forms of activity e.g. moderate, vigorous walking were calculated by weighing each type of activity by its energy needs, defined in METs (multiples of resting metabolic rate). Sedentary behavior during last week was determined on a basis of time spent in a sitting position on weekdays and weekends. Next the average number of hours a day was calculated (*IPAQ*, 2012).

Evaluation of physical development

Based on Seca 213 body height measurement and Seca 799 electronic weight, BMI values were calculated according to BMI formula: body mass (kg)/body height $(m)^2$.

Demographic data

Data regarding the place of living of the participants were also collected. The distinction of place of living into rural and urban areas was done according to the classification of the Central Statistical Office of Poland. Two categories of towns were distinguished: towns with more than 100,000 inhabitants and those with less than 100,000 inhabitants. Rural areas were defined as areas where the density of the population was lower than 150 people per km^2, or the number of inhabitants lower than 5,000 (*Statistical Yearbook*, 2013). Parental educational level, separately for the mother and the father, was classified according to the official Polish system of levels of education (Czapiński, Panek, 2014). The 4 levels of education are: elementary education or not completed elementary education, vocational education, secondary education, higher education. There were three types of school that the adolescents attended: 3-year-long grammar schools, 4-year-long technical high schools and 3-year-long vocational schools. The role of the family in encouraging physical activity was determined by two categories: the preferred way of spending free time together with the family (active, passive) and habits regarding spending free time (together with the family or separately). In order to determine age with 0.01 margin, the adolescents were asked about their date of birth. The questionnaires were filled in by the participants of the study.

Statistical analysis

The data collected were analyzed statistically by means of the Statistica 10.0 software. For quality variables the percentage was calculated, separately for each sex and the power of associations was calculated using nonparametric Chi-squared test.

In the case of quantity features: age, BMI $[kg/(m)^2]$, total, moderate, vigorous PA (MET/min/day) and sedentary behavior (hours/day), distribution was verified by Kolmogorov-Smirnov test. Basic statistical characteristics were

calculated: means, standard deviation, medians and Q1–Q3 (interquartile range). T Student test was used in order to determine differences between both sexes in age, body height, body mass and BMI. U Mann-Whitney test was used to evaluate the difference between boys' PA and girls' PA in their particular aspects: moderate, vigorous, walking PA, total PA and sedentary behaviors.

In order to estimate the influence of given environmental variables on the level of physical activity expressed in MET, a multiple regression analysis was conducted. The following variables were taken into consideration in each model: place of living (1 – urban, 0 – rural), the type of school the participants attend (1 – grammar school, 2 – technical high school, 3 – vocational school). Following E. Korzeniowska and K. Puchalski's (2010) suggestion, a minimum high school education of parents, separately for mother and father, was recognized as a significant factor of health awareness of the parents. Thus, a dichotomous division of their level of education was included in the analysis: elementary and vocational – 0, high school and college – 1. The model also took into account habits concerning mutual leisure time (0 – together with the family, 1 – not with the family), and the preferred way of spending leisure time (1 – active, 0 – passive). Transformation of PA values in each aspect and sedentary behaviors into natural logarithms was used. Each model was adjusted to age and BMI. Statistically significant values for each calculated parameter were determined at $p \leq 0.05$.

Results

Boys had a significantly higher body height, body mass and BMI than girls (respectively: 178.90 ±7.03 cm vs. 166.14 ±6.96 cm; $p < 0.001$; 71.10 ±10.90 kg vs. 56.77 ±6.06 kg; $p < 0.001$; 21.87 ±3.58 kg/m^2 vs. 20.28 ±3.66 kg/m^2; $p < 0.001$). There were no significant differences in the age of the subjects (boys: 17.77 ±1.06; girls: 17,76 ±1.02; $p = 0.977$).

More than half of the participants of this study lived in rural areas (Table 1). Girls lived in the country more often than boys. On the other hand, more boys lived in towns with more than 100,000 inhabitants and cities ($p \leq 0.01$). More than 69% of the participants declared that the most common way of spending leisure time in their families is in a passive way. It was significantly more frequent among girls than among boys ($p \leq 0.05$). Relations between parental educational level, their habits of spending leisure time together and the sex of the participant were statistically insignificant ($p \leq 0.01$).

Table 1. Family background, type of school and place of living of the participants

Environmental variables	Boys (N = 698)	Girls (N = 592)	Total (N = 1290)
	N (%)	N (%)	N (%)
1	2	3	4
Place of living ($p \leq 0.01$)			
Rural	133 (19.05)	68 (11.49)	201 (15.58)
Urban <100 thousand habitants	146 (20.92)	136 (22.97)	282 (21.86)
Urban ≥100 thousand habitants	397 (56.88)	380 (64.19)	777 (60.23)
Missing data	22 (3.15)	8 (1.35)	30 (2.33)
Type of school ($p \leq 0.001$)			
Grammar school	151 (21.63)	322 (54.39)	473 (36.66)
Technical high school	450 (64.47)	242 (40.88)	692 (53.64)
Vocational school	97 (13.90)	28 (4.73)	125 (9.70)

1	2	3	4
Mother's education (p ≤ 0.001)			
Elementary	53 (7.59)	60 (10.14)	113 (8.76)
Vocational	210 (30.08)	220 (37.16)	430 (33.33)
High school	254 (36.39)	214 (36.15)	468 (36.28)
College	173 (24.78)	90 (15.20)	263 (20.39)
Missing data	8 (1.16)	8 (1.35)	16 (1.24)
Father's education (p ≤ 0.001)			
Elementary	56 (8.02)	52 (8.78)	108 (8.37)
Vocational	285 (40.83)	308 (52.03)	593 (45.97)
High school	237 (33.95)	173 (29.22)	410 (31.78)
College	114 (16.33)	46 (7.77)	160 (12.41)
Missing data	6 (0.87)	13 (2.19)	19 (1.47)
Preferred way of spending leisure time in the family (p ≤ 0.05)			
Passive	457 (65.47)	429 (72.47)	886 (68.68)
Active	211 (30.23)	147 (24.83)	358 (27.75)
Missing data	30 (4.30)	16 (2.70)	46 (3.57)
Habits of spending leisure time (n.s)			
Family spend leisure time together	373 (53.44)	310 (52.37)	683 (52.95)
Family don't spend leisure time together	304 (43.55)	275 (46.45)	579 (44.88)
Missing data	21 (3.01)	7 (1.18)	28 (2.17)

Source: authors' own elaboration.

Energy expenditure connected with total PA during a day was significantly higher in boys than in girls, on average by 295.75 MET/min/day (Table 2). For moderate PA it was usually 145.25 MET/min/day, and for vigorous PA 160.37 MET/min/day. While in girls it was on average 0.92 MET/min/day more on sedentary behaviors than in boys. Differences between sexes in walking PA were not statistically significant.

Table 2. Physical activity (MET/min/day) and sedentary behavior (hrs/day) in adolescents

PA and SB	Boys		Girls		p
	$\bar{x}$; sd	Me; Q1–Q3	$\bar{x}$; sd	Me; Q1–Q3	
Total PA	1,916.07; 1,313.54	1,686.00; 918.00–2,671.29	1,620.32; 1,109.13	1,395.86; 815.71–2,258.14	**≤0.001**
Walking PA	491.95; 402.03	396.00; 274.29–1,114.29	501.83; 399.92	414.86; 169.71–735.43	n.s
Moderate PA	779.93; 685.89	600.00; 274.29–1,114.29	634.68; 523.38	520.00; 257.14–882.86	**≤0.01**
Vigorous PA	644.19; 563.14	537.14; 171.43–1,028.57	483.82; 494.13	325.71; 102.86–771.43	**≤0.001**
Sedentary behavior	4.79; 2.83	4.79; 2.71–7.00	5.43; 2.91	5.71; 3.43–7.86	**≤0.001**

Source: authors' own elaboration.

Regressive analysis allowed us to distinguish important predicators for various physical activities in adolescents (Table 3). The percentage of explaining the total variability of different aspects of PA and SB by factors taken into

consideration in regressive analysis fluctuated in boys between 1.54% in case of total PA and 6.48% regarding SB (Table 3). In girls R^2 was on similar level, from 2.45% for walking PA and to 4.59% for vigorous PA (Table 4).

Table 3. Evaluation of parameters for the regressive analysis model – boys[A]

Independent variables list	Dependent variables β (95% CI) p				
	sedentary behaviors	walking PA	moderate PA	vigorous PA	total PA
Type of school[1]	–0.140 (–0.226–(–0.054)) **0.01**	–0.053 (–0.138–0.032) ns	0.054 (–0.028–0.137) ns	0.113 (0.024–0.203) **0.05**	–0.030 (–0.115–0.056) ns
Mother's education[2]	–0.145 (–0.243–(–0.047)) **0.01**	0.015 (–0.081–0.111) ns	–0.007 (–0.101–0.087) ns	–0.032 (–0.133–0.068) ns	–0.016 (–0.113–0.081) ns
Father's education[2]	0.153 (0.053–0.254) **0.01**	–0.004 (–0.101–0.093) ns	–0.003 (–0.089–0.093) ns	–0.027 (–0.129–0.074) ns	0.036 (–0.062–0.135) ns
Place of living[3]	0.069 (–0.019–0.157) Ns	0.107 (0.020–0.193) **0.05**	–0.095 (–0.179–00.010) **0.05**	–0.018 (–0.109–0.072) ns	0.011 (–0.076–0.098) ns
Type of leisure time in family[4]	–0.169 (–0.253–(–0.084)) **0.001**	0.116 (0.033–0.200) **0.01**	0.090 (0.008–0.179) **0.05**	0.120 (0.033–0.207) **0.01**	0.106 (0.021–0.190) **0.05**
The habits of leisure time in family[5]	0.043 (–0.042–0.127) Ns	–0.026 (–0.110–0.058) ns	–0.142 (–0.224–0.172) **0.001**	0.035 (–0.053–0.122) ns	–0.108 (–0.192–(–0.023)) **0.05**
R^2(p)	0.0648 **(0.001)**	0.0194 **(0.01)**	0.0365 **(0.001)**	0.0165 **(0.05)**	0.0154 **(0.05)**

[A] model adjusted for BMI and age; [1] 0 – grammar school; 1 – technical high school; 2 – vocational school; [2] 0 – elementary, vocational education; 1 – high school, college education; [3] 0 – rural; 1 – urban; [4] 0 – active; 1 – passive; [5] 0 – leisure time together; 1 – leisure time separately.

Source authors' own elaboration.

The type of school the boys taking part in this study attended demonstrated a positive connection with vigorous PA, and negative with sedentary behaviors (Table 3). Students of vocational schools expended more energy on physical activity and less on sedentary behaviors than their peers from technical high schools and grammar schools. The way of spending leisure time in the family was important for the type and intensity of physical activity in boys. It had positive correlation with total, vigorous and moderate PA and walking PA (respectively: β = 0.106; β = 0.20; β = 0.09; β = 0.107), and negative with sedentary behaviors (β = –0.169). Active leisure time preferred by the family resulted in expending more energy on physical activity than on sedentary behaviors. Habits regarding spending leisure time together with the family has negative influence on moderate and total PA (respectively: β = –0.142; β = –0.108). No habit of spending leisure time together in the family had negative influence on physical activity.

The place of living had a positive correlation with walking PA (β = 0.107) and negative with moderate PA (β = –0.095). An urban environment was in favor of activities connected with walking but influenced a lower expenditure of energy on moderate PA.

Parental educational level was significantly connected with sedentary behaviors. The higher the education of the mother (β = –0.145), the less time the male participants of this study devoted to sedentary behaviors, however, in case of the fathers, this correlation was positive (β = 0.153).

Significant predicators of physical activity in girls were the type of school they attended and preferred way of spending leisure time in the family (Table 4). In case of walking PA, a significant influence of place of living and habits of spending leisure time together with the family was observed.

Table 4. Evaluation of parameters for the regressive analysis model – girls[A]

Independent variables list	Dependent variables β (95% CI) p				
	sedentary behaviors	walking PA	moderate PA	vigorous PA	total PA
Type of school[1]	–0.174 (–0.266–(–0.082)) **0.001**	0.122 (0.032–0.212) **0.01**	0.095 (0.007–0.183) **0.05**	0.177 (0.081–0.273) **0.001**	0.102 (0.012–0.191) **0.05**
Mother's education[2]	–0.022 (–0.123–0.079) ns	–0.022 (–0.122–0.078) ns	0.025 (–0.073–0.124) ns	–0.037 (–0.145–0.072) ns	–0.003 (–0.103–0.097) ns
Father's education[2]	–0.049 (–0.149–0.051) ns	–0.061 (–0.160–0.078) ns	0.056 (–0.041–0.152) ns	0.076 (–0.031–0.182) ns	0.027 (–0.071–0.125) ns
Place of living[3]	0.007 (–0.084–0.097) Ns	0.093 (0.006–0.181) 0.05	–0.010 (–0.096–0.077) ns	–0.017 (–0.112–0.077) ns	0.051 (–0.037–0.139) ns
Type of leisure time in family[4]	–0.051 (–0.141–0.038) ns	0.040 (–0.048–0.128) ns	0.123 (0.036–0.210) **0.01**	0.143 (0.049–0.237) **0.01**	0.145 (0.057–0.232) **0.01**
The habits of leisure time in family[5]	0.056 (–0.033–0.145) ns	–0.092 (–0.180–(–0.005)) **0.05**	–0.058 (–0.144–0.028) ns	–0.005 (–0.098–0.089) ns	–0.074 (–0.161–0.012) ns
R^2 (p)	0.0343 **(0.001)**	0.0245 **(0.01)**	0.0251 **(0.01)**	0.0459 **(0.001)**	0.0299 **(0.01)**

[A] adjusted for age and BMI; [1]0 – grammar school; 1 – technical high school; 2 – vocational school; [2] 0 – elementary, vocational education; 1 – high school, college education; [3]0 – rural; 1 – urban; [4] 0 – active; 1 – passive; [5]0 – leisure time together; 1 – leisure time separately.

Source: authors' own elaboration.

Female students of vocational schools expended significantly more energy on each form of physical activity in comparison with female students from technical high schools and grammar schools (respectively: β = 0.122; β = 0.095; β = 0.177; β = 0.102), and less energy on sedentary behaviors (β = –0.174). A preference by the family of an active way of spending leisure time encouraged a higher level of physical activity. The girls taking part in this study expended more energy on moderate, vigorous and total PA (moderate: β = 0.123; vigorous: β = 0.143; total PA: β = 0.145). While in families that prefer spending leisure time together (β = –0.092) and in the urban environment (β = 0.093), a higher level of physical activity connected with walking PA was observed.

Discussion

This study, based on multiply analysis, presents a complex approach to determining the most important predicators of physical activity and sedentary behaviors based on three variables: place of living, the type of school adolescents attend, and family background. In accordance with previous studies, the male participants were more active in every aspect of PA (Azevedo et al., 2007; Belcher et al., 2010; Vašíčková, Groffik, Frömel, Chmelík, Wasowicz, 2013). The observed disproportions in the level of PA in relation to the sex of the participants resulted

first of all from the context of the form of PA, its intensity and the accepted social behavior patterns. Generally, girls preferred going for walks, riding a bicycle or other activities of moderate intensity while boys preferred activities of moderate or high intensity and of a typically sports character (Van der Horst et al., 2007; Cadogan, Keane, Kearney, 2014). Due to this pattern, males can maintain a higher value of PA on each stage of development (Telama, Yang, Hirvensalo, Raitakari, 2006).

The results of this study regarding the influence of environmental factors on PA in late adolescence show that the type of school is important. In both sexes expenditure of energy on vigorous PA, as well as walking PA, moderate and total PA in girls, was higher in students of vocational schools and technical high schools than in students from grammar schools. Moreover, a lower level of SB in students of vocational schools and technical high schools was observed. Results of the study conducted by M. Aarnio et al. (Aarnio, Kujala, Kaprio, 1997; Aarnio, Winter, Kujala, Kaprio, 2002) demonstrate that a higher level of physical activity was closely connected with attending grammar schools rather than technical high schools or vocational schools. The association is especially evident in boys. C.A. Loucaides et al. (2011) pointed out that the percentage of physically active adolescents was at its lowest in technical and vocational schools, especially in girls. The knowledge of recommended time for sedentary behaviors was also poorer in technical and vocational schools. According to A.M. Jones, N. Rice and P.R. Dias (2012), the connection of positive healthy behaviors with grammar schools most probably results from criteria playing a decision making role in choosing the school. Achieving academic competency earlier is a key factor in choosing the school and future career (Hill et al., 2004). A connection between academic results and healthy behaviors was proven as well. A lower number of risky behaviors was connected with a higher level of academic competency (Bryant, Schulenberg, Bachman, O'Malley, Johnston, 2000; Tammelin, Näyhä, Laitinen, Rintamäki, Järvelin, 2003), as well as higher physical activity (Delisle, Werch, Wong, Bian, Weiler, 2010). Thus, adolescents with high school competence and most likely a high awareness of healthy behaviors usually attend grammar schools (Echols, Willms, 1995; Green, Navarro-Paniagua, Ximénez-De-Embún, Mancebón, 2014), whereas adolescents who do not satisfy these criteria attend vocational schools. An analysis of data collected in Poland by 'Health Behavior in School-aged Children: A WHO Collaborative Cross-National Study' also confirmed that lack of physical activity was more frequent in students of vocational schools rather than students of schools of other types (Jodkowska, Oblacińska, Mikiel-Kostyra, Tabak, 2012). As we can see, the results of our study are contrary to results of studies to date.

Additionally, calculated differences in activity that take into account the factors of sex and place of living, demonstrated in individual domains significant statistical differences in activity connected with school and work, between students from vocational schools and grammar schools (87.45 vs. 68.64; $p < 0.01$), moving around (42.94 vs. 31.17; $p < 0.01$), household physical activities (3,464.05 vs. 2,158.62; $p < 0.001$). Whereas type of school and sex factors demonstrated that adolescents from urban areas are significantly more active in the domain of additional activities in comparison with their peers from rural areas. (3,475.27 vs. 3,066.88; $p < 0.05$). On the other hand, adolescents from rural areas expend much more energy on household physical activities (2,673.34 vs. 2,221.96; $p < 0.01$). Studies conducted in Poland show that 32.2% of boys and 19.2% of girls from rural areas devote at least one hour a day to work on their parents' farm, which additionally increases their energy expenditure (Lachowski, Zagórski, 2011; Lachowski, 2013). It seems that the phenomenon described above appears on a large scale among the participants of this study who come from typical agricultural regions. The results did not show significant differences in activity regarding place of living in girls, but in boys a confirmation of this phenomenon may be a significantly higher expenditure of energy on moderate PA in rural areas than in urban areas. Another

explanation of higher PA among students of vocational schools and technical high schools in comparison with students from grammar schools may be the fact that the former group serves apprenticeship in companies which usually means physical activity of a different degree of intensity. Moreover, parents from rural areas less often have a higher education than parents from urban areas (8% of fathers with higher education in rural areas vs. 20.1% in urban areas and respectively 26.2% vs. 31.1% in mothers). 61.9% of fathers from rural areas have elementary or vocational education vs. 43.8% in urban areas. Among mothers, 48.7% of mothers from rural areas have elementary or vocational education vs. 20.9% of mothers from urban areas. The factor that significantly limits spontaneous physical activity in children and adolescents who have parents with higher level of education and higher SES may be the higher number of hours devoted to extra-curricular classes and tutorials (Suliga, 2010). A strong focus on good academic results can be observed in parents with a higher level of education and in families with higher SES, which results in organizing such classes for children (e.g. tutorials from school subjects, foreign language classes etc.). It may be assumed that this phenomenon will mainly concern students of grammar schools. Whereas a more liberal attitude of parents towards upbringing, which usually occurs in families with low SES and with a lower level of education of parents may be in favor of more freedom of choice, more possibilities for spontaneous physical activity and in this way it may compensate for more extra-curricular sports activities observed in children and adolescents from families with higher SES, more frequently attending grammar schools. As a consequence, it can be assumed that lower socio-economic status of families from rural areas influenced the PA results regarding the type of school the students attended.

Studies to date mostly emphasize a positive influence of big urbanized areas on PA (Machado-Rodriques et al., 2014). Higher physical activity is possible due to better planned layout of an urban area than a rural area, including: access to public communication, closer location of shops, work, friends etc., which may induce other forms of actively moving around. Moreover, due to large-scale campaigns promoting health by physical activity, the number of all-year-round sports facilities available for the general public is definitively bigger in towns and cities than in the country, which enables more varied forms of physical activity in towns and cities. The results of this study show that only walking PA in both sexes confirms the results of previous studies that there is a positive influence of urban environment on physical activity. Higher energy expenditure on moderate PA was observed in boys from rural areas, and in other cases there were not statistically significant differences in PA. Other studies conducted in Poland showed that place of living did not differentiate the level of total PA (Bergier, Bergier, Paprzycki, 2014). It was only observed that adolescents from rural areas did more moderate and vigorous PA and adolescents from urban areas – more walking PA. Árnadóttir (2010) studied older people and she concluded that the total PA was the same for people from rural and urban areas. Yet rural females received the highest scores of all in household physical activity while rural males were more physically active than the others in the work-related domain. Physical activity in leisure time was more common in urban societies than in rural societies, though. Thus, the differences of physical activity in separate domains that we discussed previously support the results above. Moreover, Świętokrzyskie voivodeship is one of 3 voivodeships in Poland with the lowest standards of living, it is also one of the poorest regions of the European Union (http://ec.europa.eu/eurostat, 2015). Then, it is possible that sports facilities in towns and cities of this voivodeship are not as developed as in urbanized areas in other European countries and they do not create equally good opportunities to engage in physical activity. Researchers of physical activity in regions with low GDP per capita should take this into consideration when analyzing separate domains of PA. If only PA in leisure time is analyzed, the total level of PA may be underestimated. However, if we only analyze total PA, we overlook

many data about its structure. Moreover, this analysis shows that it is possible to utilize different means to fulfill recommendation regarding physical activity in different environments.

Studies of many authors pointed out that parental educational level has a vital influence on the level of physical activity and sedentary behaviors in adolescents (Kantomaa, Tammelin, Näyhä, Taanila, 2007; Elinder, Heinemans, Zeebari, Patterson, 2014; Finger et al., 2014). High level of education of both parents has a positive influence on active participation in extra-curriculum physical activities organized by sports clubs. It concerns children of both sexes in younger age groups (Finger et al., 2014) and slightly older female participants of the studies (Kantomaa et al., 2007; Elinder et al., 2014). A study done in 7 European countries showed that parental educational level (PEL) was directly associated with children's PA only in Greek and Spanish girls' and boys' PA in Norway, and parental education level was also directly associated with PA in Hungarian boys (Jimenez-Pavon et al., 2012). In our study, we only observed a significant association of parental educational level and sedentary behaviors in boys. The lack of a significant influence of this factor on PA in adolescents may have several causes. It is probable that parental educational level does not have a vital influence on parents' income. Thus, material support of children's physical activity is comparable in families of different levels of education. Another explanation of this phenomenon is the fact that with age the influence of parents on the physical activity of their children gradually becomes lower (Alderman, Benham-Deal, Jenkins, 2010). The first symptom of this phenomenon may be the lower influence of parental educational level, which as a factor is more significant in the first years of children's lives, when conscious concern for proper development of the child makes parents actively involved in ensuring optimal conditions for the development and formation of a positive attitude towards health, physical activity and therefore limiting sedentary behaviors. In subsequent years of development, other factors are more prominent, including school and peers (Kirby, Levin, Inchley, 2011). Moreover, many studies show that the level of education is a part of a complex set of indicators that represent standards of living in the family and less frequently it is taken into consideration as an independent factor that influences PA and SB. It is possible that cultural diversity of comparable societies and interrelations of parental educational level with other factors of the socio-economic environment may influence the results. It is suggested that it is not the level of education that has a major influence on physical activity, but parents' support connected with high SES (Hoefer, Mckenzie, Sallis, Marshall, Conway, 2001). In regards to the lack of physical activity it is possible that its determinants are different to those for physical activity, and may be more socio-demographic in nature.

Preference to spend leisure in the family in an active way was a vital predicator for physical activity in both sexes, as well as sedentary behaviors in boys. Spending leisure time together with the family was a significant factor for physical activity. Our study confirmed earlier findings of other authors who emphasized the importance of family in shaping patterns of physical activity in children and adolescents, and also their sedentary behaviors (McGuire, Hannan, Neumark-Sztainer, Cossrow, Story, 2002; Welk, Wood, Morss, 2003; Biddle, Whitehead, O'Donowan, Nevill, 2005; Sukys, Majauskienė, Cesnaitiene, Karanauskiene, 2014). Family support for any forms of recreational exercises plays an important role in shaping health awareness and physical activity. While according to Social Learning Theory (Sallis, Nader, 1998), observation and parroting is very important in the case of younger children, in older children and adolescents direct and indirect influence of the physical, socio-economic, cultural, and socio-cognitive aspects of the environments are more significant. It was proven that the support of sons and daughters differs considerably. Boys, in comparison with girls, receive more support regarding access to sports facilities and opportunities to take part in sports activities (Welk et al., 2003; Sallis, Nader, 1998). Parental support manifests

itself also as transferring positive behavioral patterns. That is why children and adolescents from families where parents are more physically active are more supported and encouraged to higher physical activity, whereas children of parents who are less physically active are also less supported and encouraged. Sukys et al. (2014) pointed out that the influence of physical activity of parents is significant only in case of adolescents and concerns participation in sport. Such associations are particularly visible in girls (McGuire et al., 2002). Additionally, studies on Lithuanian adolescents emphasize quite a significant influence of at least one parent's physical activity on girls' physical activity, while an important predicator of PA in boys was the father's PA, especially in the age groups of 15–16 years old and 17–18 year old boys (Sukys et al., 2014). M.T. McGuire et al. (2002) found that even in younger adolescents (grades 7–10), the physical activity of parents and their attention to fitness not only positively associates with the physical activity of their children, but also negatively with the time devoted to watching TV. S.J.H. Biddle et al. (2005) pointed out that although there is an important positive influence of parental physical activity on the PA of adolescents of both sexes, other forms of parental support seem to be more significant. It appears that the key factor to adolescents' physical activity may also be family habits regarding the spending of leisure time. Although at puberty and maturation, adolescents usually spend time with their peers, spending leisure time with parents is still an important element of building close relationships. The lack of some important interrelations among girls may confirm that the influence of parents diminishes with age and the influence of peers increases (Larson, Richards, Moneta, Holmbeck, Duckett, 1996).

One must take into account that this study has several limitations. First of all, the data regards adolescents in the post-pubertal period and is cross-sectional. Consequently, it does not allow us to follow dynamic changes in physical activity or changes in interrelations of PA with indicators of the environment. The study did not take into account income per capita in the family. It seems that this factor may have a stronger influence on physical activity and sedentary behaviors than the level of education. The participants of the study came from one region of Poland, so the results do not necessarily apply to the whole population of Poland. A strong advantage of this study is the fact that it researched a large, randomly chosen group of people in a narrow age bracket. Although the evaluation of physical activity was subjective, its advantage is the fact that is not arduous for the participants of the study and therefore it does not influence their behavior. What is more, it allowed us to analyze total physical activity connected with all aspects of life. The advantage of IPAQ is a set of precise methodological rules that allows one to compare data from different countries and the officially registered Polish version of the questionnaire takes into account local conditions and specific aspects of the local way of life.

Findings regarding the influence of family background and the school environment on forming physical activity have a significant value since they allow one to introduce to Physical Education syllabuses programs that would increase health awareness in adolescents. They may also help in realizing small research projects in order to estimate the influence of additional physical exercise on the health of the persons studied. It is recommended to include in such projects adolescents, especially girls, in the period of their life when their identity and health awareness are being formed, as well as patterns associated with spending leisure time when the plasticity of the mind is still high and it is susceptible to the influence of adults.

Conclusions

According to this study, the type of school the participants attended, the way of spending leisure time with the family, and in boys also spending leisure time together with the family, are the most important factors that influence physical activity and sedentary behaviors.

Future research should take into consideration the analysis of physical activity in separate domains. Evaluating physical activity only on the basis of total PA means that we oversee much important information about its structure, which can be helpful in designing efficient strategies that promote physical activity in different milieus and social groups.

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References

Aarnio, M., Kujala, U.M., Kaprio, J. (1997). Associations of health-related behaviors, school type and health status to physical activity patterns in 16 year old boys and girls. *Scand J Public Health*, *25* (3), 156–167.

Aarnio, M., Winter, T., Kujala, U., Kaprio, J. (2002). Associations of health related behaviour, social relationships, and health status with persistent physical activity and inactivity: a study of Finnish adolescent twins. *Br J Sports Med.*, *36* (5), 360–364.

Albarwani, S., Al-Hashmi, K., Al-Abri, M., Jaju, D., Hassan, M.O. (2009). Effects of overweight and leisure-time activities on aerobic fitness in urban and rural adolescents. *Metab Syndr Relat Disord.*, *7* (4), 369–374.

Alderman, B.L., Benham-Deal, T.B., Jenkins, J.M. (2010). Change in parental influence on children's physical activity over time. *Journal of Physical Activity & Health*, *7* (1), 60–67.

Árnadóttir, S.A. (2010). Physical activity, participation and self-rated health among older community-dwelling Icelanders. A population – based study. *Umeå University Medical Dissertations*, New Series, *361*, 25–30.

Azevedo, M.R., Araújo, C.L., Reichert, F.F; Siqueira, F.V, Da Silva, M.C., Hallal, P.C. (2007). Gender differences in leisure-time physical activity. *Int J Public Health*, *52* (1), 8–15.

Badland, H., Schofield, G. (2006). Understanding the relationship between town size and physical activity levels: a population study. *Health Place*, *12* (4), 538–546.

Beets, M.W., Cardinal, B.J., Alderman, B.L. (2010). Parental social support and the physical activity-related behaviours of youth: a review. *Health Educ Behav.*, *37* (5), 621–644.

Belcher, B.R., Berrigan, D., Dodd, K.W., Emken, B.A., Chou, C.P., Spuijt-Metz, D. (2010). Physical activity in US youth: impact of race/ethnicity, age, gender, and weight status. *Med Sci Sports Exerc.*, *42* (12), 2211–2221.

Bergier, B., Bergier, J., Paprzycki, P. (2014). Level and determinants of physical activity among school adolescents in Poland. *Ann Agric Environ Med.*, *21* (1), 75–78.

Biddle, S.J.H., Whitehead, S.H., O'Donowan, T.M., Nevill, M.E. (2005). Correlates of participation in physical activity for adolescent girls: A systematic review of resent literature. *J Phys Act Health*, *2*, 423–434.

Bryant, A.L., Schulenberg, J., Bachman, J.G., O'Malley, P.M., Johnston, L.D. (2000). Understanding the links among school misbehavior, academic achievement, and cigarette use: a national panel study of adolescents. *Prev Sci. 1* (2), 71–87.

Cadogan, S.L., Keane, E., Kearney, P.M. (2014). The effects of individual, family and environmental factors on physical activity levels in children: a cross-sectional study. *BMC Pediatr. 14*, 107. DOI:10.1186/1471-2431-14-107.

Craig, C.L., Marshall, A.L., Sjöström, M., Bauman, A.E., Booth, M.L., Ainsworth Be, Prat, M., Ekelund, U., Yngwe, A., Sallis, J.F., Oja, P. (2003). International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc. 35* (8), 1381–1395.

Czapiński, J., Panek, T. (eds.) (2014). *Diagnoza społeczna 2013. Warunki i jakość życia Polaków. Raport*. Warszawa: MPiPS.

Davison, K.K., Lawson, K.T. (2006). Do attributes in the physical environment influence children's physical activity? A review of literature. *Int J Behav Nutr Phys Act*., *3*, *19*. DOI: 10.1186/1479-5868-3-19.

Delisle, T.T., Werch, C.E., Wong, A.H., Bian, H., Weiler, R. (2010). Relationship between frequency and intensity of physical activity and health behaviors of adolescents. *J Sch Health, 80* (3), 130–140.

Echols, F.H., Willms, J.D. (1995). Reasons for school choice in Scotland. *J Educ Policy, 10* (2), 143–156.

Elinder, L.S., Heinemans, N., Zeebari, Z., Patterson, E. (2014). Longitudinal changes in health behaviours and body weight among Swedish school children – associations with age, gender and parental education – the SCIP school cohort. *BMC Public Health*, *14*, 640. DOI:10.1186/1471-2458-14-640.

Finger, J.D., Mensink, G.B.M., Banzer, W., Lampert, T., Tylleskär, T. (2014). Physical activity, aerobic fitness and parental socio-economic position among adolescents: the German Health Interview and Examination Survey for children and adolescents 2003–2006 (KiGGS). *Int J Behav Nutr Phys Act. 11* (1), 43. DOI: 10.1186/1479-5868-11-43.

Green, C.P., Navarro-Paniagua, M,., Ximénez-De-Embún, D.P., Mancebón, M.J. (2014). School choice and student wellbeing. *Econ Educ Rev. 38*, 139–150.

Hill, N.E., Castellino, D.R., Lansford, J.E., Nowlin, P., Dodge, K.A., Bates, J.E., Pettit, G.S. (2004). Parent academic involvement as related to school behavior, achievement, and aspirations: demographic variations across adolescence. *Child Dev*., *75* (5), 1491–1509.

Hoefer, W.R., Mckenzie, T.L., Sallis, J.F., Marshall, S.J., Conway, T.L. (2001). Parental provision of transportation for adolescent physical activity. *Am J Prev Med*., *21* (1), 48–51.

Huang, S., Schnaub, M.P., Gross, C.S., John U., Mayer, C. (2013). Predictors of hazardous drinking, Tobacco smoking and physical inactivity in vocational school students. *BMC Public Health*, *13*, 475. DOI: 10.1186/1471-2458-13-475.

http://ec.europa.eu/Eurostat (30.07.2017).

IPAQ: Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (IPAQ) – Long Form, (2012). Retrieved from: http://www.ipaq.ki.se/scoring.pdf (14.03.2017).

Janssen, I., Leblanc, A.G. (2010). Systematic review of health benefits of physical activity and fitness in school-aged children and youth. *Int J Behav Nutr Phys Act*., *7*, 40. DOI: 10.1186/1479-5868-7-40.

Jimenez-Pavon, D., Fernandez-Alvira, J.M., Te Velde, S.J., Brug, J., Bere, E., Jan, N., Kovacs, E., Androutsos, O., De Bourdeaudhuij, I., Moreno, L.A. (2012). Associations of parental education and parental physical activity (PA) with children's PA: The ENERGY cross-sectional study. *Prev Med*., *55* (4), 310–314.

Jodkowska, M., Oblacińska, A., Mikiel-Kostyra, K., Tabak, I. (2012). The frequency of risk factors for atherosclerosis in youth aged 16 and 18 years – students of upper-secondary schools in Poland. *Dev Period Med*., *16* (2), 96–103.

Jones, A.M., Rice, N., Dias, P.R. (2012). Quality of schooling and inequality of opportunity in health. *Empire Economics*, *42*, 369–394.

Kantomaa, M.T., Tammelin, T.H., Näyhä, S., Taanila, A.M. (2007). Adolescents' physical activity to family income and parents education. *Prev Med*., *44* (5), 410–415.

Katzmarzyk, P.T., Baur, L.A., Blair, S.N., Lampert, E.V., Oppert, J.M., Riddoch, C. (2008). International conference on physical activity and obesity in children: summary statement and recommendation. *Appl Physiol Nutr Metab*., *33*, 371–388.

Kirby, J., Levin, K.A., Inchley, J. (2011). Parental and peers influences on physical activity among Scottish adolescents: a longitudinal study. *J Phys Act Health*, *8* (6), 785–793.

Korzeniowska, E., Puchalski, K. (eds.) (2010). Nisko wykształceni pracownicy a zdrowie – wyzwania dla edukacji zdrowotnej. Projekt LEEECH. The Nofer Institute of Occupational Medicine. Retrieved from: http://www.imp.lodz.pl (5.05.2017).

Kristjansdottir, G., Vilhjalmsson, R. (2001). Sociodemographic differences in patterns of sedentary and physically active behavior in older children and adolescents. *Acta Paediat*., *90* (4), 429–435.

Lachowski S.,, Zagórski J. (2011). Child labour for the benefit of the family in rural Poland. *Ann Agric Environ Med*., *18* (2), 386–392.

Lachowski, S. (2013). Health consequences of work in childhood in opinions of respondents from agricultural families. *Ann Agric Environ Med*., *20* (3), 624–630.

Larson, R.W., Richards, M.H., Moneta, G.B., Holmbeck, G., Duckett, E. (1996). Changes in adolescents' daily interactions with their families from ages 10 to 18: Disengagement and transformation. *Dev Psychol*., *32* (4), 744–754.

Lasheras, L., Aznar, S., Merino, B., Lopez, E.G. (2001). Factors associated with physical activity among Spanish youth through the National Health Survey. *Prev Med*., *32* (6), 455–465.

Loucaides, C.A., Jago, R., Theophanous, M. (2011). Physical activity and sedentary behaviours in Greek-Cypriot children and adolescents: a cross-sectional study. *Int J Behav Nutr Phys Act*., *19* (8), 90. DOI:10.1186/1479-5868-8-90.

Machado-Rodriques, A.M., Coelho-E-Silva, M.J., Mota, J., Padez, C., Martins, R.A., Cumming, S.P., Riddoch, C., Malina, R.M. (2014). Urban-rural contrast in fitness, physical activity, and sedentary behaviour in adolescents. *Health Promot Int*., *29* (1), 118–129.

McGuire, M.T., Hannan, P.J., Neumark-Sztainer, D., Cossrow, N.H., Story M. (2002). Parental correlates of physical activity in a racially/ethnically diverse adolescent sample. *J Adolesc Health*, *30* (4), 253–261.

O'Connor, T.M., Jago, R., Baranowski, T. (2009). Engaging parents to increase youth physical activity a systematic review. *Am J Prev Med*., *37* (2), 141–149.

Owen, N., Sugiyama, T., Eakin, E.E., Gardiner, P.A., Tremblay, M.S., Sallis. J.F. (2011). Adults' sedentary behavior determinants and interventions. *Am J Prev Med*., *41* (2), 189–196.

Owens, C.S., Crone, D., James Dr. (2013). Physical activity and sedentary behavior among adolescents. In: A. Parker, D. Vinson (eds.), *Youth sport, physical activity and play: policy, interpretation and participation* (pp. 113–125) (1st ed.). New York: Roudledge.

Pate, R.R., Mitchell, J.A., Byun, W., Dowda, M. (2011). Sedentary behaviour in youth. *Br J Sports Med*., *45* (11), 906–913.

Reiner, M. (2013). Long-term health benefits of physical activity – a systematic review of longitudinal studies. *BMC Public Health*, *13*, 813. DOI:10.1186/1471-2458-13-813.

ICSU (2011). Report of the ICSU Planning Group on Health and Wellbeing in the Changing Urban Environment: a Systems Analysis Approach. International Council for Science, Paris.

Sallis, J.F., Nader, P.R. (1998). Family Determinants Of Health Behaviors. In: D.S. Gochman (ed.), *Health Behavior: Emerging Research Perspectives* (pp. 107–124). New York: Plenum.

Solomon, E., Rees, T., Ukoumunne, O., Metcalf, B., Hillsdon M. (2013). Personal, social, and environmental correlates of physical activity in adults living in rural south-west England: a cross-sectional analysis. *Int J Behav Nutr Phys Act*., *10*, 129. DOI:10.1186/1479-5868-10-129.

Springer, A.E., Hoelscher, D.M., Castrucci, B, Perez, A., Kelder, S.H. (2009). Prevalence of physical activity and sedentary behaviors by metropolitan status in 4th-, 8th, and 11-grade students in Texas, 2004–2005. Abstract. *Prev Chronic Dis*., *6* (1), A21. Retrieved from: http://www.cdc.gov/ pcd/issues/2009/jan/07_0252.htm (20.02.2016).

Statistical Yearbook, in Polish: Rocznik Statystyczny. (2013). GUS, Warszawa.

Sukys, S., Majauskienė, D., Cesnaitiene, V.J., Karanauskiene, D. (2014). Do parents' exercise habits predict 13–18-year-old adolescents' involvement in sport? *J Sports Sci Med,. 13* (3), 522–528.

Suliga, E. (2010). Parental education and living environmental influence on physical development, nutritional habits as well as level of physical activity in Polish children and adolescents. *Anthropol Anz*., *68* (1), 53–66.

Tammelin, T., Näyhä, S., Laitinen, J., Rintamäki, H., Järvelin, M.R. (2003). Physical activity and social status in adolescence as predictors of physical inactivity in adulthood. *Prev Med*., *37* (4), 375–381.

Telama, R., Yang, X., Hirvensalo, M., Raitakari, O. (2006). Participation in organized youth sport as a predictor of adult physical activity: a 21-year longitudinal study. *Ped Exerc Sci*., *17*, 76–88.

Tremblay, M.S., Colley, R.C., Saunders, T.J., Healy, G.N., Owen, N. (2010). Physiological and health implications of a sedentary lifestyle. *Appl Physiol Nutr Metab*., *35* (6), 725–740.

Van Der Horst, K., Paw, M.J., Twisk, J.W.R., Van Mechelen. W. (2007). A brief correlates of physical activity and sedentariness in youth. *Med Sci Sports Exerc*., *39* (8), 1241–1250.

Van Der Horst, K., Oenena, A., Te Velde, S.J., Brug, J. (2009). Gender, ethnic and school type differences in overweight and energy balance – related behaviours among Dutch adolescents. *Int J Ped Obes*., *4* (4), 371–380.

Vašíčková, J., Groffik, D., Frömel, K., Chmelík, F., Wasowicz, W. (2013). Determining gender differences in adolescent physical activity levels using IPAQ long form and pedometers. *Ann Agric Environ Med*., *20* (4), 749–755.

Vlahov, D., Freudenberg, N., Proietti, F., Ompad, D., Quinn, A., Nandi, V., Galea, S. (2007). Urban as a determinant of health. *J Urban Health*, *84* (1), 16–26.

Vlahov, D., Galea, S. (2002). Urbanisation, urbanicity and health. *J Urban Health*, *79* (1), 1–12.

Welk, G., Wood, K., Morss, G. (2003). Parental influences on physical activity in children: an exploration of potential mechanisms. *Pediatr Exerc Sci*., *15* (1), 19–33.

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THE INFLUENCE OF FUNCTIONAL MOVEMENT SCREEN RESULTS ON THE FREQUENCY OF SPORTS INJURIES IN SOCCER PLAYERS

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Abstract Functional Movement Screen (FMS) is a functional screen test of the motor system which is steadily gaining recognition and popularity among individuals interested in prevention of sports injuries. The FMS test battery includes seven mutually related motor activities to analyse the quality of basic movement patterns. An in-depth interpretation of the performed test design provides good conditions to determine the weakest links in the kinematic chain and to estimate the risk of injury.

The objective of this study was to determine the effect of the FMS test results on frequency of sports injuries in soccer players. With the main objective of the study in mind the following research hypothesis was formulated: "a group of players in the lowest interval (14–17 FMS test points) will have a high frequency of injuries in comparison to a group in the upper interval (18–21 points in the FMS test)". The tests were carried out on a group of 102 younger and older junior soccer players representing the Soccer Academy of KKS Lech Poznań. For that the test design with FMS test procedure was used, followed by a six month period in which the injuries of the individuals in the study group were recorded.

The research hypothesis was not confirmed. In the analysis of the results no statistical significance was noted between the total number of points obtained in the FMS test and the number of injuries. It was noted that the number of injuries was statistically significantly correlated with the results of the Shoulder Mobility test of the right side (for all participants and for the players in the lower interval), Hurdle Step test of the left side (for a group of players in the lower interval), and the In-line Lunge test of the left side (for upper interval players). The results of the single variable logistic regression showed that injuries occurred more often in players of the lower interval. A forest plot indicates the direction of the increased risk of injury in players in the lower interval of points: OR = 1.14 (95% CL; 0.71 : 1.83).

Key words FMS, trauma risk, junior players

Introduction

For many years soccer has been the world's most popular sport discipline, with a steadily increasing number of new players. The report of the Polish Central Statistical Office (GUS) on physical culture in 2016 indicates

that in Poland physically active people are most interested in team sports (58.4% of exercising people), of which soccer accounts for as much as 39.5% (Główny Urząd Statystyczny, GUS, 2017 yr.). At the moment a constant development of tactical systems and the motor preparation of players can be observed. The consequence of these phenomena is an increase in the pace of play which requires the players to shorten their reaction time to an absolute minimum. As a result soccer has become a sort of martial art, leading to an increase in the number of injuries and accidents in players every year. The financial aspect associated with the costs of treatment is particularly noticeable in smaller clubs and organizations, which cannot afford to cover the costs of a player's recovery, as a consequence extending the period of player's absence from sports activities (Hadała, Bieganowski, Wierzbowska, de Bernardo Tajedor, Snela, 2006; Żołnowski, Wrona-Żołnowska, Gębska, Wojciechowska, Żyżniewska-Banaszak, 2013).

The study of M. Hadała et al. (2006) shows that more than 85% of players sustain an injury during a season. The body part most susceptible to injury in soccer is the lower extremity (97%), while other injuries were noted within the trunk, head and the upper extremity. This is a consequence of acute mechanical injuries usually related to duels with the opposition players, but also as a result of excessive training and match loads, as a result of which individuals are overtrained and initially minor microinjuries within the motor organ accumulate. Athlete's injuries may be defined as acute or chronic. The former in the soccer world are mainly associated with direct confrontation with the opposition player and are of one-time character manifested by sudden acute symptoms. Chronic injuries however are difficult to determine in time, develop gradually, even for years as a result of cumulative microinjuries which did not heal or as a result of incorrect movement patterns practiced for a long time. The analysis of statistics of the World Cup in Japan and South Korea shows match situations in which players were injured. The results show clearly that as many as 73% of all recorded injuries during 64 World Cup matches occurred as a result of contact between players of opposite teams (Adamczyk, 2005). The group of injuries (27%), which did not result from the interference of second parties, is extremely significant. This situation is very worrying and may indicate that such a high percentage of injuries is a consequence of the nature of dynamics of play in modern soccer. Identical statistical studies carried out in England show that as many as 59% of all injuries were contactless, and the mechanism of injury resulted from motor activity of players (Adamczyk, 2005). Nowadays a very concerning phenomenon may be observed, namely that 85% of injuries in the group of people playing soccer are injuries of young players, below 23 years of age (Żołnowski et al., 2013). Bearing in mind that a sustained injury in itself is a factor increasing the risk of another trauma in the motor system, more emphasis should be put on prevention of injuries in young players (Grygorowicz, Głowacka, Wiernicka, Kamińska, 2010).

Due to the characteristics of the motor activity and effort, soccer can be classified as a endurance and speed discipline. It is assumed that during a match a player performs approximately 1,000 various motor activities related to the unique character of moving on the pitch (Bangsbo, Mohr, Krustru, 2006). Team games are characterized by a whole range of complex functional movements which suggests that the player's activity is a three-plane movement act. The system of neuromuscular control supervises stimulation of muscle groups to various functions during activities in the conditions of an open and closed biokinematic chains (Rzepka, Grzybczak, Więcek, 2009). In the analysis of the complex term which is functional movement (performed simultaneously in three planes) one can conclude that it is a total of actions of various muscle groups playing various functions in relation to each other (stabilization, agonists, antagonists, synergists), which is expressed as a correct performance of a movement pattern. The function of small specialized muscle groups, the actions of which consists in stabilization of individual links of the kinematic chain during dynamic activity, is extremely significant for the effectiveness of the motor organ

during three-plane motor activities. Disturbed function leads to creation of replacement compensatory movements. The consequence is the inability to perform an effective movement pattern correctly, resulting in unfavorable conditions predisposing to damage, overstrain changes and more compensation within the motor organ (Kiesel, Plisky, Butler, 2011; Kiesel, Plisky, Voight, 2007; Rzepka, et al., 2009).

Functional Movement Screen created by Gray Cook is a screen test of seven movement patterns. The tests use various positions and movements closely related to correct development and progress. It was noted that fundamental movement patterns tested by FMS are the basis for much more complex activities practiced in everyday life and in sport. The greatest advantage of the screen test is the fact that FMS is an simple and easily available way to analyze the quality of movement patterns, mobility with stability, and co-ordination of the neuromuscular system. The concept of the test is based on seven movement tasks and three additional pain-provocation tests identifying any deficits and asymmetries, making it possible to assess the risk of injury in a player and creating beneficial conditions to set up a long-term corrective training plan. A significant number of publications using FMS focus on the issue of modification of training programs, progress in the quality of movement patterns, mobility and stability, and the system of neuromuscular control of athletes. According to the reports the FMS test makes it possible to identify individuals with potentially higher risk of injury. The main intention of this study was to analyze the effect of FMS test results on the frequency of sports injuries in soccer players. The assumed research hypothesis was that "a group of players in the lower range (14–17 points in the FMS test) should displays a higher frequency of injury compared to the group of the group in the upper range (18–21 points in the FMS test)" (Adamczyk, Pepłowski, Boguszewski, Białoszewski, 2012; Lemiesz et al., 2013; Minick et al., 2010).

Material and methods

The study group

The study material consisted of a group of 102 trained soccer players of Academy KKS Lech Poznań with its seat in Wronki, representing older and younger junior teams. The oldest players in the group were born in 1998 and the youngest in 2001. Every week the group took part on average in five training units (in total 8 hours) and one match which usually took place on Saturday or Sunday. After every league game activities related to sports recovery were immediately implemented. The day after the game was usually free from activities and the focus was on players' recovery. The FMS test was performed from 25 to 20 June 2016. In the following 6 months, that is from 1 July to 31 December 2016, the injuries sustained by the studied individuals were noted.

The anthropometric characteristics of the studied players and their training history are presented in Table 1. The players were additionally divided into a group of players who were injured and a group of injury-free players.

Table 1. Anthropometric characteristics and training history of the studied players of KKS Lech Poznań (Junior A,B)

Variable	Height (cm)	Weight (kg)	BMI	Training history (years)
	X ± δ	X ± δ	X ± δ	X ± δ
All players, N = 102	176.37	67.65	21.76	9.35
	0.61	7,354.87	325.69	94.64
Injured players, N = 79	176.82	67.96	21.74	9.41
	0.43	5,450.89	241.79	70.20
Injury-free players, N = 23	174.70	66.61	21.83	9.15
	0.16	1,871.48	83.81	23.23

Study methods

Functional Movement Screen (FMS)

The study group underwent the Functional Movement Screen test using a ready "FMS Kit" in the period from 25 to 30 June 2016. Each individual performed seven motor tests assessing the quality of basic movement patterns, stability, joint mobility, and neuromuscular control. Additionally, three pain-provocation tests were performed. The activities were analyzed in two planes of movement (frontal and sagittal). The studied individuals had three attempts for each basic test and the best result was recorded. In asymmetric tests, assessing the left and right side separately, the side with the lower number of points was recorded in the overall FMS test results. Each movement pattern was assessed in the four-degree scale from 0 to 3 points according to the generally accepted principles:

3 points – for correct performance of the functional pattern;

2 points – for the ability to perform the functional pattern with some compensation;

2 point – if the individual was unable to perform the pattern;

0 points – if the individual reported pain at any point of the test.

The highest possible score to be achieved by the study group in the whole FMS test was 21 points. In case of an individual reporting pain in additional pain-provocation tests 0 points were scored for a given movement pattern.

FMS test battery consists of:

Test 1 Deep Squat

Test 2 Hurdle Step

Test 3 In-line Lunge

Test 4 Shoulder Mobility

+ pain-provocation test – irritation, impingment syndrome

Test 5 Active Straight Leg Rise

Test 6 Trunk Stability Push-up

+ pain-provocation test – active extension of lumbar spine

Test 7 Rotational Stability

+ pain-provocation test – global stretch in quadruped position (Adamczyk et al., 2012; Lemiesz et al., 2013; Rzepka et al., 2009).

The FMS test was followed by a six month period (1 July to 31 December 2016) when players' health was monitored and injuries were recorded in detail in special research cards.

Statistical methods

All statistical analyses were performed using STATISTICA 10.0 for Windows Version (SPSS Inc., Chicago, Il, USA). The following descriptive statistics were calculated for all studied individuals and for all subgroups: arithmetic mean, standard deviation, minimum and maximum. For all studied parameters the consistency with normal distribution was assessed using Shapiro-Wilk test. Relations between the studied FMS parameters and the number of injuries were assessed using the correlation coefficient. For variables with normal distribution the analysis was performed using Pearson's correlation coefficient. If one of the variables did not meet the criteria for normality, Spearman's correlation coefficient was used. In order to determine the probability of injury in players in individual

groups (so called lower range, FMS score of 14–17 and the upper range, FMS score of 18–21) univariate regression model was used and a forest plot for this model. The level of statistical significance was defined as $p < 0.05$.

Results

Overall FMS results

Table 2 shows mean scores in individual tests, mean total FMS score and mean number of injuries of players for all participants.

Table 2. Descriptive statistics for all participants (n = 102)

Variable	Mean	Minimum	Maximum	Standard deviation
Deep Squat	2.19	1	3	0.502
Hurdle Step L	2.39	2	3	0.491
Hurdle Step R	2.58	2	3	0.496
In-line Lunge L	2.76	2	3	0.432
In-line Lunge R	2.82	2	3	0.383
Shoulder Mobility L	2.96	2	3	0.195
Shoulder Mobility R	2.98	2	3	0.139
ASLR L	2.47	1	3	0.609
ASLR R	2.54	1	3	0.520
Trunk Stability Push-up	2.77	1	3	0.491
Rotational Stability L	2.47	2	3	0.502
Rotational Stability R	2.28	2	3	0.453
Total	17.70	14	21	1.756
Number of injuries	1.28	0	3	0.948

In the analysis of the Functional Movement Screen scores for the whole study group the lowest values were noted in the Deep Squat. The mean score in the Deep Squat for all participants was 2.19 points. The highest values were noted in the Shoulder Mobility test. In the Shoulder Mobility test mean scores of 2.96 and 2.98 were noted for the left and right sides, respectively. In the Deep Squat, Trunk Stability Push-up and ASLR tests for both sides, some players were noted to score 1 point, which indicates incorrect performance of the movement task. For other tests the players scored at least 2 points. The mean score for the whole test for the group was 17.7 points. and the mean number of injuries per one player was 1.28.

Table 3 presents mean scores in individual tests, mean total FMS score and mean number of injuries of players of the lower range (14–17 points).

In the analysis of the FMS scores of the group of players in the lower range (with the score of 14–17 points) it can be noted that the Deep Squat test featured the lowest scores. Mean score in the Deep Squat test of the analyzed group was 1.93 points. The group had highest scores in the Shoulder Mobility tests. In the Shoulder Mobility tests mean scores of 2.91 and 2.96 points were noted for the left and right sides, respectively. For the Deep Squat, Trunk Stability Push-up and ASLR tests for both sides, some players had a score of 1 point which indicates incorrect performance of the movement pattern. For other tests movement patterns performed by the representatives of the

lower range were given a score of at least 2 points. The mean score for the whole test for the participants in the lower range was 16.07 points and the mean number of injuries per one player within the analyzed group was 1.27.

Table 3. Descriptive statistics of the group of players in the lower range (14–17 points, n = 45)

Variable	Mean	Minimum	Maximum	Standard deviation
Deep Squat	1.93	1	3	0.393
Hurdle Step L	2.07	2	3	0.252
Hurdle Step R	2.29	2	3	0.458
In-line Lunge L	2.53	2	3	0.505
In-line Lunge R	2.6	2	3	0.495
Shoulder Mobility L	2.91	2	3	0.288
Shoulder Mobility R	2.96	2	3	0.208
ASLR L	2.07	1	3	0.580
ASLR R	2.27	1	3	0.495
Trunk Stability Push-up	2.56	1	3	0.624
Rotational Stability L	2.27	2	3	0.447
Rotational Stability R	2.09	2	3	0.288
Total	16.07	14	17	1.075
Number of injuries	1.27	0	3	0.889

Table 4 shows mean scores for individual tests, mean total FMS score and mean number of injuries in the group of upper range players (18–21 points)

Table 4. Descriptive statistics of the players in the upper range (18–21 pts, n = 57)

Variable	Mean	Minimum	Maximum	Standard deviation
Deep Squat	2.39	2	3	0.491
Hurdle Step L	2.65	2	3	0.482
Hurdle Step R	2.81	2	3	0.398
In-line Lunge L	2.93	2	3	0.258
In-line Lunge R	3.00	3	3	0.000
Shoulder Mobility L	3.00	3	3	0.000
Shoulder Mobility R	3.00	3	3	0.000
ASLR L	2.79	2	3	0.411
ASLR R	2.75	2	3	0.434
Trunk Stability Push-up	2.93	2	3	0.258
Rotational Stability L	2.63	2	3	0.487
Rotational Stability R	2.44	2	3	0.501
Total	18.98	18	21	0.916
Number of injuries	1.30	0	3	0.999

The analysis of the FMS scores in the group of the upper range players (with the score of 18–21 points) shows that the lowest scores were noted in the Deep Squat test. The mean score in the Deep Squat test of the analyzed

group was 2.39 points. The highest scores were noted in the Shoulder Mobility tests and In-line Lunge tests. In the Shoulder Mobility test mean values of 3 points for both sides were noted, which indicates faultless performance of the movement pattern by the analyzed group of upper range players. In the In-line Lunge test mean value of 3 and 2.93 points were noted for the right and left sides, respectively. The analyzed group of players had a mean score for the whole test of 18.98 points, and the mean number of injuries sustained per one player was 1.3.

Correlations between the FMS test scores and the number of injuries

Table 5 presents the results of Spearman's rank correlation test taking into account the total FMS score and the number of injuries.

Table 5. Spearman's rank correlation for FMS test scores and the number of injuries

Pair of variables	Size of group	Spearman's R correlation coefficient	t test	Value of p
FMS vs. number of injuries (all)[a]	102	0.05	0.47	0.6404
FMS vs. number of injuries (players with the score of 14–17 pts.)[b]	45	–0.10	–0.66	0.5161
FMS vs. number of injuries (players with the score of 18–21 pts.)[c]	57	0.18	1.37	0.1770

Statistically significant $p < 0.05$.
[a] Spearman's rank correlation between the total FMS score of all players and the number of injuries.
[b] Spearman's rank correlation between the total FMS score of lower range players (14–17 points) and the number of injuries.
[c] Spearman's rank correlation between the total FMS score of the upper range players (18–21 points) and the number of injuries.

In the analysis of the results of testing pairs of variables no statistically significant correlation was noted for the total score in the FMS tests and the number of injuries. For the whole group (n = 102) the correlation coefficient was 0.05 and was not statistically significant (p = 0.6404). For the group of lower range players (with scores of 14–17 points) the correlation coefficient was –0.10 and did not show statistically significant correlations, either (p = 0.5161). For the participants in the upper range (with scores of 18–21 points) the correlation coefficient was 0.18 which also shows no statistical significance (p = 0.1770).

Table 6 shows the results of Spearman's rank correlation test taking into consideration the number of points scored in individual tests and the number of injuries for all participants.

The analysis of correlations between the number of injuries and 12 tests was performed. The analysis was performed using Spearman's rank correlation for the whole group (n = 102) without the division. The number of injuries was statistically significantly correlated only for the Shoulder Mobility test for the right side. The value of the correlation coefficient was r = 0.20 and statistically significantly p = 0.0451. The positive value of the correlation coefficient indicates a relation between the increase in the value of one variable and the increase in the other variable. In the analysis of the strength of this relation a weak, but statistically significant relation was noted. For other tests no statistically significant variation with the number of injuries was noted.

Table 6. Spearman's rank correlation between individual tests and the number of injuries for all participants (n = 102)

Variable	Spearman's R correlation coefficient	t test	Value of p
1. Deep Squad & the number of injuries	0.120	1.20	0.2331
2. Hurdle Step L & the number of injuries	–0.040	–0.40	0.6896
3. Hurdle Step R & the number of injuries	–0.050	–0.54	0.5919
4. In-line Lunge L & the number of injuries	–0.150	–1.47	0.1453
5. In-line Lunge R & the number of injuries	–0.060	–0.59	0.5555
6. Shoulder Mobility L & the number of injuries	0.060	0.61	0.5417
7. Shoulder Mobility R & the number of injuries	0.200	2.03	0.0451*
8. ASLR L & the number of injuries	0.030	0.31	0.7580
9. ASLR R & the number of injuries	0.120	1.24	0.2189
10. Trunk Stability Push-up & the number of injuries	–0.010	–0.09	0.9264
11. Rotational Stability L & the number of injuries	–0.004	–0.04	0.9666
12. Rotational Stability R & the number of injuries	0.040	0.38	0.7024

* Statistically significant $p < 0.05$.

Table 7 presents the results of Spearman's rank correlation test taking into account the number of points scored in individual tests and the number of injuries of the lower range players (14–17 points).

Table 7. Spearman's rank correlation between individual tests and the number of injuries of players in the lower range (14–17 points, n = 45)

Variable	Spearman's R correlation coefficient	t test	Value of p
1. Deep Squad & the number of injuries	–0.0008	–0.006	0.9957
2. Hurdle Step L & the number of injuries	–0.3900	–2.800	0.0077*
3. Hurdle Step R & the number of injuries	–0.2400	–1.620	0.1126
4. In-line Lunge L & the number of injuries	–0.0800	–0.500	0.6186
5. In-line Lunge R & the number of injuries	–0.1200	–0.810	0.4246
6. Shoulder Mobility L & the number of injuries	0.1000	0.670	0.5056
7. Shoulder Mobility R & the number of injuries	0.3200	2.190	0.0342*
8. ASLR L & the number of injuries	–0.1100	–0.710	0.4842
9. ASLR R & the number of injuries	0.0200	0.140	0.8896
10. Trunk Stability Push-up & the number of injuries	–0.0700	–0.440	0.6601
11. Rotational Stability L & the number of injuries	0.0400	0.280	0.7791
12. Rotational Stability R & the number of injuries	0.0500	0.360	0.7241

* $p < 0.05$ statistically significant.

The analysis of relationship between the number of injuries and the 12 analyzed tests was performed using Spearman's rank correlation for the players of the lower range (with the score of 14–17 points). The number of injuries correlated significantly statistically within pairs of variables of the Hurdle Step of the left side and the Shoulder Mobility test of the right side. The analysis of the Hurdle Step of the left side indicated that the value of correlation

was r = –0.39 and statistically significant p = 0.0077. The negative value of the correlation coefficient indicates the relation between the decrease in the value of one variable and the increase in the other variable. The analysis of the strength of the above relation moderate relation was noted. In Shoulder Mobility test of the right side it was noted that the value of correlation was r = 0.32 and statistically significant p = 0.0342. The positive value of the correlations coefficient indicates the relation between the increase in one variable and the increase in the other variable. In the analysis of the strength of the above relation moderate dependence was noted. No statistically significant variation with the number of injuries was noted for other tests. In spite of the lack of statistical significance in the correlation between the number of injuries and the Hurdle Step test of the left side, a trend towards significance was noted. The negative value of the correlation coefficient (r = –0.24) informs about the decrease in the value of one variable with the increase in value of the other variable.

Table 8 presents the results of Spearman's rank correlation test taking into account the number of points scored in individual tests and the number of injuries of players in the upper range (18–21 points).

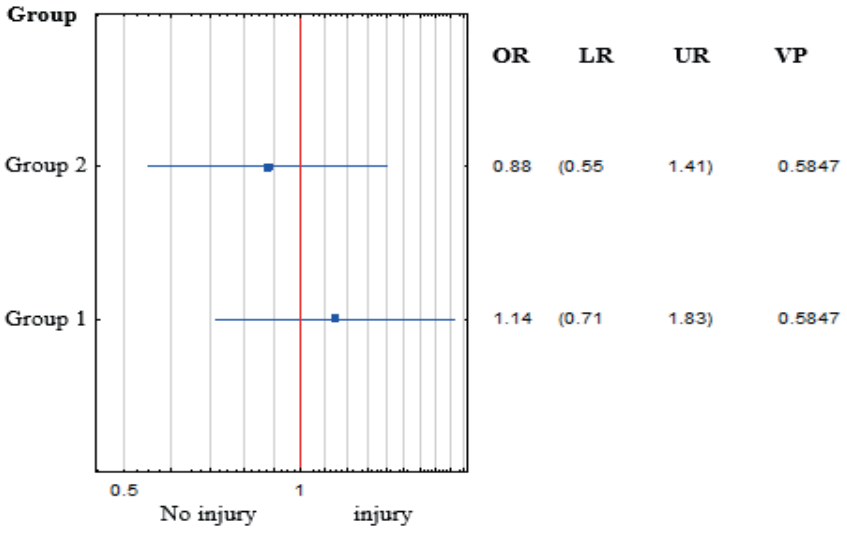
Table 8. Spearman's rank correlation between individual tests and the number of injuries for players in the upper range (18–21 points, n = 57)

Variable	Spearman's R correlation coefficient	t test	Value of p
1. Deep Squad & the number of injuries	0.18	1.33	0.1881
2. Hurdle Step L & the number of injuries	0.07	0.51	0.6117
3. Hurdle Step R & the number of injuries	0.07	0.52	0.6029
4. In-line Lunge L & the number of injuries	–0.33	–2.56	0.0133*
5. In-line Lunge R & the number of injuries			
6. Shoulder Mobility L & the number of injuries			
7. Shoulder Mobility R & the number of injuries			
8. ASLR L & the number of injuries	0.10	0.72	0.4741
9. ASLR R & the number of injuries	0.20	1.53	0.1307
10. Trunk Stability Push-up & the number of injuries	0.08	0.57	0.5736
11. Rotational Stability L & the number of injuries	–0.04	–0.31	0.7595
12. Rotational Stability R & the number of injuries	0.03	0.21	0.8363

* Statistically significant p < 0.05.

The analysis of relations between the number of injuries and 12 tests was performed using Spearman's rank correlation for the players of the upper range (with scores of 18–21 points). The number of injuries correlated statistically significantly only for the In-line Lunge test of the left side. The correlation coefficient was r = –0.33 and statistically significant p = 0.0133. The negative value of the correlation coefficient indicates the relation between the increase in one variable and the decrease in the other variable. The analysis of the strength of the above relations moderate dependence was noted. For other tests no statistically significant variation was noted.

Logistic regression drawings



OR – odds ratio; LR – lower range; UP – upper range; VP – value of p

Figure 1. Forest diagram for injuries and groups

The results of univariate logistic regression showed than injuries more often occurred in group 1. Forest diagram indicates the direction of increased chance of injury in players in the lower range of scores: OR = 1.14 (95% CL; 0.71 : 1.83).

Discussion

It is undisputable that physical activity creates a number of health benefits, however it also carries some risks. An increased risk to health and life usually takes place in competitive sport where trauma and body injury are nothing unusual. A constantly growing number of scientific studies analyzing the risk of sports injuries in soccer players shows the essence of the problem. A continuous progress in motor and technical preparation of players is a result of adaptation to the growing dynamics of the game. As a consequence systematic the need to shorten the reaction time of a player with the ball can be observed which is conducive to a further increase in the number of injuries reported by the players in soccer clubs. With the awareness that the analysis of motor abilities as an isolated approach provides insufficient feedback on the condition of players, the search began for other methods assessing the fitness of the motor system as a cohesive whole. FMS is a screen test which analyses the quality of basic movement patterns which are the necessary foundations for normal movement of body in space. The FMS test battery consists of seven movement screens and three additional clearing tests which are assessed in the four-degree scale from 0 to 3 points. An additional advantage of the tests is the possibility of observing deficiencies and asymmetries within the whole biokinematic chain of a studied person, as well as the ability to estimate the risk

of injury. During movement activities analyzed body parts co-operate together, creating favorable conditions for observation of the musculoskeletal system as a cohesive whole (Bangsbo et al., 2006; Hadała et al., 2006; Kiesel et al., 2011).

A review of the currently available literature brings out a large number of studies focusing on the Functional Movement Screen. However, the vast majority of the publications analyze the effect of the FMS test results on the progress of mobility, stability, quality of movement patterns, and modification of training units. There are still relatively few studies confirming the ability of the FMS test to identify individuals with a potentially higher risk of injury in soccer. J.C. Tee et al. (2016) in their study noted significantly lower results of the test in players who sustained a serious injury compared to the healthy group. It was noted that the above phenomenon occurred as a result of significant differences in assessment within the In-line Lunge (ILL) and Active Straight Leg Raise (ASLR) tests. According to the authors, the ASLR test is characterized by the highest sensitivity as an injury risk indicator (Tee, Klingbiel, Collins, Lambert, Coopoo, 2016). In the study of D. Zalai et al. (2015) carried out on a group of 20 professional soccer players it was noted that the mean number of injuries per one player was 1.5. In the analysis of the Hurdle Step and Deep Squat tests the authors noted a statistically significant correlation with injury proneness. In the analysis of the Hurdle Step test statistical significance was noted between the results of the movement pattern and injuries within the ankle joint. Similarly, statistically significant correlation was noted between the results of the Deep Squat test and injuries of the knee and hip joints (Zalai et al., 2015).

Another study was performed on a group of 100 physically active students in order to identify relations between the FMS test results and the injury history. In the analysis of the results reported by the authors it can be noted that for persons in the lower range (range of points ≤17, n = 46) the risk of a light injury is 4.7 times higher than persons in the upper range (range of points >17, n = 54). In the analysis of the group of players in the lower range it can be noted that 22 persons were injured and for the other 24 participants no injuries within the motor system were noted. In the group of players in the upper range it can be noted that a definitely greater number of people (n = 34) did not sustain injuries (Shojaedin et al., 2014).

Our study included 102 players regularly training in a sport soccer club KKS Lech Poznan. In the analysis of the results of test of all players it was noted that the mean score in FMS test was 17.7 points and the mean number of injuries per one player was 1.28. The lowest scores were noted in the Deep Squat test where the mean was 2.19 points. After dividing the participants into two groups where the criterion was sustaining injury or not, it was noted that the vast majority, i.e. 77.45% of participants sustained an injury in the six months of the study. In the analysis of the results of the group of players in the lower range (with FMS scores of 14–17, n = 45) it was noted that the lowest values were noted in the Deep Squat test where the mean was 1.93 points. The mean score for the whole test for persons in the lower range was 16.07 points and the mean number of injuries per one player in this group was 1.27. In the group of upper range players (with the FMS score of 18–21 points, n = 57) it was also noted that the lowest scores were in the Deep Squat test. The mean score in the Deep Squat test of the analyzed group was 2.39 points. The analyzed group of players had a mean total score of 18.98 points and the mean number of injuries per one player was 1.3.

The adopted research hypothesis was not confirmed within the analyzed group of players. In the analysis of Spearman's rank correlation between the total FMS score and the number of injuries, statistical significance was not noted in the analyzed groups. In the next stage, the analysis of Spearman's rank correlation between the scores in individual tests and the number of injuries was performed. Within the whole study group (n = 102) it was noted that

the number of injuries correlated statistically significantly only in case of the Shoulder Mobility test of the right side. The value of the correlation coefficient was r = 0.20 and statistically significant p = 0.0451. For players in the lower range (with the score of 14–17 points, n = 45) the number of injuries correlated statistically significantly within pairs of variables of the Hurdle Step test of the left side and Shoulder Mobility test of the right side. In the analysis of the Hurdle Step test of the left side it was noted that the value of correlation was r = –0.39 and statistically significant p = 0.0077. For the Shoulder Mobility test of the right side the value of correlation was r = 0.32 and statistically significant p = 0.0342. For players in the upper range (with the score of 18–21 points, n = 57) it was noted that the number of injuries was statistically significantly correlated only for the In-line Lunge test of the left side. The value of the correlation coefficient was r = –0.33 and statistically significant p = 0.0133. For other tests no statistically significant variation was noted. The analysis of the results of univariate logistic regression showed that injuries occurred more often in the group of lower range players. The forest diagram shows the direction of an increased risk of injury in players of the lower range of score: OR = 1.14 (95% CL; 0.71 : 1.83).

Conclusions

1. On the basis of the performed tests it was noted that 77.45% of the studied players sustained a sports injury in a six month period. The mean number of injuries per one player within the whole study group was 1.28 injuries/person. It was noted that the mean number of injures, taking into account the division of players into the upper and lower ranges, was 1.3 and 1.27 injuries/person, respectively. The situation could have been caused by the fact that the players of upper range representing the higher sport level took a larger share in the match units.
2. No statistical significance was noted between the total FMS score and the number of injuries.
3. Statistically significant correlation was found between the number of injuries and the scores in the Hurdle Step test of the left side for the group of lower range players and the In-line Lunge test of the left side for the group of upper range players. The negative value of correlation coefficients suggests that with the increase in the score in the Hurdle Step test of the left side for the lower range players and the In-Lunge test of the left side for the upper range players the number of injuries decreased.
4. The forest diagram indicates the direction of increased risk of injury in the players of the lower score range.

References

Adamczyk, G. (2005). Injuries in football. *Forum Trenera*, *1*, 36–39.

Adamczyk, J.G., Pepłowski, M., Boguszewski, D., Białoszewski, D. (2012). Functional evaluation of athletes practicing weightlifting using the functional movement screen test. *Medycyna sportowa*, *28* (4), 267–276.

Bangsbo, J., Mohr, M., Krustru, P. (2006). Physical and metabolic demands of training and match-play in the elite football player. *Journal of Sports Sciences*, *24* (7), 665–674.

Główny Urząd Statystyczny (GUS) (2017). Physical Culture in Poland in 2016. Retrieved from: https://stat.gov.pl/obszary-tematyczne/kultura-turystyka-sport/sport/kultura-fizyczna-w-polsce-w-2016-r-,12,1.html.

Grygorowicz, M., Głowacka, A., Wiernicka, M. (2010). Comprehensive physiotherapeutic assessment as the basis for the primary prevention of sports injuries. *Nowiny lekarskie*, *79* (3), 240–244.

Hadała, M., Bieganowski, K., Wierzbowska, C., de Bernardo Tajedor, N., Snela, S. (2006). Traumatism among football players and methods of work of the medical team in selected Polish and Spanish football clubs. *Medycyna sportowa*, *22* (5), 272–276.

Kiesel, K., Plisky, P., Butler, R. (2011). Functional movement test scores improve following a standardized off-season intervention program in professional football players. *Scandinavian Journal of Medicine & Science in Sports*, *21* (2).

Kiesel, K., Plisky, P.J., Voight, M.L. (2007). Can serious Injury in Professional Football be Predicted by a Preseason Functional Movement Screen? *North American Journal of Sports Physical Therapy*, *2* (3).

Lemiesz, G., Iwańczyk, K., Biernat, R., Godlewski, J., Szymański, M., Biernat, U., Tajchman, L., Sieklucka, E. (2013). Application of the Functional Assessment test in practice. *Praktyczna fizjoterapia i rehabilitacja*, *39*, 4–11.

Minick, K., Kiesel, K.B., Burton, L., Taylor, A., Plisky, P., Butler, R.J. (2010). Interrater Reliability of the Functional Movement Screen. *Journal of Strength Conditioning Research*, *24* (2).

Rzepka, R. (2009). Functional training and the possibilities of its use in training footballers. In: T. Grzybczak, R. Więcek, A. Stuła (eds), *Theoretical and practical aspects of modern football* (209–244). Opole: Politechnika Opolska.

Shojaedin, S.S., Letafatkar, A., Hadadnezhad, M., Dehkhoda, M.R. (2014). Relationship between functional movement screening score and history of injury and identifying the predictive value of the FMS for injury. *International Journal of Injury Control and Safety Promotion*, *21* (4), 355–360.

Tee, J.C., Klingbiel, J.F., Collins, R., Lambert, M.I., Coopoo, Y. (2016). Preseason Functional Movement Screen Component Tests Predict Severe Contact Injuries in Professional Rugby Union Players. *J Strength Conditioning Research*, *30* (11), 3194–3203.

Zalai, D., Panics, G., Bobak, P., Csáki, I., Hamar. P. (2015). Quality of functional movement patterns and injury examination in elite-level male professional football players. *Acta Physiologica Hungarica*, *102* (1), 34–42

Żołnowski, B., Wrona-Żołnowska, L., Gębska, M., Wojciechowska, A., Żyżniewska-Banaszak, E. (2013). Traumatism of youth practicing football at the age of 15–19. *Rocznik Pomorskiej Akademii Medycznej w Szczecinie*, *59* (1), 120–123.

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EVOLUTION OF RECEPTION EFFICACY AND EXECUTION IN WOMEN'S VOLLEYBALL ACCORDING TO LEVEL OF COMPETITION – A DESCRIPTIVE STUDY AGED FROM 14-YEAR-OLD TO ADULT PROFESSIONAL PLAYERS

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Abstract The aim of this study was to determine the technical performance profile of service reception with regard to execution and efficacy level according to level of competition in women's volleyball. The sample of the study was composed of a total of 6,311 game phases from 187 sets in 48 matches played during season 2005–2006 by the following divisions: under-14, under-16, under-18, 2nd national senior division, 1st national senior division, and international senior division. The design of the study was a descriptive and inter- and intra-group correlational one. The variables studied included level of competition, technique used to serve, technique used to receive, zone where the reception was executed, and efficacy of reception. The results indicated that at higher levels of competition: a) there is higher efficacy in reception; b) number of errors decreases; and c) proportion of receptions that allow one or more attacking options for the receiving team increases. As level of competition increases, the effect of service on reception decreases, and receiving zones are more diverse. This study establishes the technical and tactical service-reception profiles in women's volleyball, compares them, and establishes the dependence between variables to understand how the action changes throughout the levels of competition.

Key words team sport, sport performance, match analysis, developmental stage

Introduction

Athletes improve their performance all over their learning process (Stamm et al., 2003). This improvement comes from gaining skills, experience (Elferink-Gemser, Visscher, Lemmink, Mulder, 2007; Grgantov, Katic, Jankovic, 2006; Rikberg, Raudsepp, 2011; Viviani, 2004) and changes in physical maturation (e.g. gains of weight

and height) (Malina, Eisenmann, Cumming, Ribeiro, Aros, 2004). In team sports, performance in-game actions is the result of the interaction between players of both teams. In volleyball, these interactions are affected by the height of the net that separates both teams on the court, and the number of ball contacts allowed in a rally. The team with the ball tries to send it over the net in such a way that it touches the opponent's court floor or in a way that the opponents cannot control (Selinger, Ackermann-Blount, 1985). On the other hand, the opponent team tries, with its arrangement and actions, to neutralize the ball and build an offensive movement (Federation Internationale de Volleyball [FIVB], 2016). These interactions should change, as well as the characteristics of players along their training process (technical proficiency, physical abilities, aging expertise, etc.).

In volleyball, the game begins with the serve-reception sequence. Receivers try to neutralize the serve and pass the ball as best as possible to the setter (João, Carvalho, Sattler, Mota, 2007; Palao, Ahrabi-Fard, 2014; Silva, Lacerda, João, 2014b; Zetou, Moustakidis, Tsigilis, Komninakidou, 2007). If the passing action achieves its goal, chances of success in the rally increase significantly (Bergeles, Barzouka, Nikolaidou, 2009; Costa et al., 2011; Laios, Kountouris, 2005; Palao, Santos, Ureña, 2006). Reception performance is linked to serving performance (Afonso, Moraes, Mesquita, Marcelino, Duarte, 2009; Stamm et al., 2003; Ureña, León, González, 2013), and throughout the whole developmental process of players arise imbalances between both performances (García-Alcaraz, Palao, Ortega, 2014). In youth women's volleyball, serving is more relevant than passing in rally success (Grgantov et al., 2006), though passing improves its performance over the years of player development (Inkinen, Häyrinen, Linnamo, 2013; Zadraznik, Marelic, Resetar, 2009). In the developmental stages, there are a few issues that affect passing performance, such us height of the net (FIVB, 2016), type of serving techniques (Gil, Moreno, Moreno, García, Del Villar, 2011), physical condition (Stamm et al., 2003), own technical performance of the receivers (Zadraznik et al., 2009), or team's tactics (Dávila-Romero, García-Hermoso, 2012).

As age increases, there is an increase in serving performance, regardless of serving technique, in women's volleyball (García-Alcaraz et al., 2014). The changes in physical condition (Costa, Afonso, Brant, Mesquita, 2012), serving techniques (Gil et al., 2011), and height of the net (FIVB, 2016) may alter the serve-receive sequence. Understanding techniques of reception, zones where it is made, tactics in reception or the reference values of efficiency on every competition level could enhance the knowledge about the developmental process of female volleyball players. The aim of the study was to know the technical profile of performance in reception according to the competition level in women's volleyball.

Methodology

The sample included 6,311 receptions played in 187 sets, corresponding to 48 volleyball matches, eight matches of each level of competition (U-14, U-16, U-18, 2nd national division, 1st national division, and international level), during season 2005–2006. It was an incidental sample (Pereda, 1987). The distribution of the sample is described in Table 1. The study project was pre-approved by the ethics commission of the principal researcher, in compliance with the principles of Helsinki's Declaration.

The design of the study was descriptive punctual, nomothetic, multidimensional, inter- and intra-group correlational (Anguera, 2003). The variables discussed in the study were: level of competition (Spanish national U-14 championship, Spanish national U-16 championship, Spanish national U-18 championship, Spanish senior 2nd national division, Spanish senior 1st national division, and senior international level (World Championship)), serve technique (standing serve, float-jump serve, and power-jump serve), reception technique (forearm, overhead, and

others), reception efficacy (on a scale from 0 to 3), and reception zone (6 zones). The variables registered are part of the observation instrument (Observation Instrument of Techniques and Efficacy in Volleyball) that was designed and validated by J. Palao and P. Manzanares (2009) and J. Palao, P. Manzanares and E. Ortega (2015), respectively.

Table 1. Distribution of the sample for the different age groups and levels of competition (women volleyball)

Sample	Levels						Total
	U-14	U-16	U-18	2nd national	1st national	international	
Matches	8	8	8	8	8	8	48
Sets	29	35	32	27	31	33	187
Sequences	1,142	1,036	922	1,136	1,118	957	6,311

Reception efficacy was evaluated in relation to the success of the action and the options it gave to the offense of the team. The following four levels of efficacy were differentiated: error, no attack options, limited attack options, and maximum attack options (Palao et al., 2015). For the categories of reception performance, an efficacy coefficient (sum of attempts per category multiplied by value of the level and divided by total attempts (0–3)), a point-to-error ratio, and an efficiency value (points or perfect actions minus errors) were calculated.

All recordings were made in public sporting events without any influence in the game. All of them were official matches recorded with a video camera in live performance by the researchers or coaches. The observation was made by a single observer. He had a Sport Science university degree, had the highest coaching certification in Spain, and had more than five years of experience as a coach and volleyball analyst. The observer was previously trained in the TEVOL observation instrument (Palao, Manzanares, 2009). After the training period, inter- and intra-observer reliability were calculated (Cronbach's Alpha). To calculate the intra-observer reliability, another researcher's conclusions were used as a reference. This researcher also held a Sport Science degree, had the highest coaching certification in Spain, and had more than ten years of experience. The results showed 0.82 in inter-observer reliability and 0.96 in intra-observer reliability.

A TEVOL observation sheet was generated for each match of the sample. In those sheets were the descriptive variables of the match: level, teams, player line-up, position, and starting rotation. After that, all observation sheets were joined in a single Excel spreadsheet and then it was transferred to the statistical software SPSS 21.

A descriptive analysis (occurrence, occurrence percentage, arithmetic mean, standard deviation of the mean and coefficient of performance values) and an inferential analysis was made. The Kolmogorov-Smirnov test was used to analyze the normality of the sample. The chi-square test was used to study the differences in each category. The U of Mann-Whitney was used to analyze the differences between categories. The analysis was made with the SPSS 21 software. The level of significance was established by $p < 0.05$.

Results

There were no significant differences between levels of competition in the frequency of the use of the forearm technique (Table 2). In the use of the overhand technique there was a significant lower use from the U-16 category to U-18 and senior levels. The 'errors' had significantly higher occurrence in U-14 level and significantly lower in international level. Comparing efficiency between levels in both techniques, there was noted a significantly higher

coefficient of efficacy, percentage of efficacy and efficiency, which increased with every next level (from younger to senior levels). The percentage of errors was significantly higher in U-14 and U-16 than U-18 and the senior levels.

Table 2. Efficacy of service reception technique according to levels of competition (women volleyball)

Service reception technique	U-14		U-16		U-18		2nd national		1st national		International	
	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
Forearm contact												
Coefficient	1.53^{cdef}	0.04	1.75^{cdef}	0.02	1.94^{abdef}	0.06	2.17^{abce}	0.05	2.26^{abcd}	0.02	2.29^{abc}	0.11
Efficacy (%)	7.57^{bdfe}	1.68	15.3^{adef}	1.30	19.62^{def}	8.97	34.56^{abce}	7.46	40.04^{abcd}	3.61	38.86^{abc}	6.17
Error (%)	17.38^{def}	2.27	13.8^{def}	1.99	17.25	17.79	4.92^{ab}	1.77	2.98^{ab}	0.82	2.82^{ab}	1.95
Efficiency	–9.8^{bdef}	3.20	1.5^{adef}	3.19	2.38^{def}	14.82	29.64^{abc}	8.05	37.06^{abc}	3.11	36.04^{abc}	8.07
Ratio	1 : –1.11^{bdef}	2.29	1 : 8.4^{adef}	2.22	1 : 11^{def}	8.42	1 : 32.1^{abc}	7.71	38.55^{abc}	3.34	1 : 37.45^{abc}	7.12
Occurrence	958		973		884		1,089		1,072		914	
Frecuency (%)	88.1		91.1		93.9		94.0		93.8		94.3	
Underhand contact												
Coefficient	1.46	0.06	1.66^{de}	0.25	1.97^{de}	0.10	2.15^{ab}	0.14	2.27^{abc}	0.15	2.41	0.47
Efficacy (%)	2.6^{f}	3.09	12.9	9.90	14.6	10.49	20.6	13.96	28.28	16.35	20.4^{a}	9.50
Error (%)	16.82^{cdef}	6.54	15.9	12.61	3.62^{a}	4.27	1.66^{a}	3.71	–	–	2.07^{a}	4.15
Efficiency	–14.22^{cdef}	6.73	–3	19.10	10.98^{a}	8.58	18.94^{a}	12.48	28.28^{a}	16.35	18.32^{a}	11.31
Ratio	1 : –5.81^{cdef}	4.09	1 : 4.95	13.85	1 : 12.79^{a}	9.34	1 : 19.77^{a}	13.11	1 : 28.28^{a}	16.35	1 : 19.36^{a}	10.23
Occurrence	89^{+}		58		36		38$^{–}$		45		40	
Frecuency (%)	8.2		5.4		3.8		3.3		3.9		4.1	
Other technique												
Coefficient	–	–	1.41	0.96	–	–	0.69	0.94	0.75	1.5	1.25	0.96
Efficacy (%)	–	–	–	–	–	–	31.25	52.04	–	–	–	–
Error (%)	–	–	–	–	25	0	12.5	28.87	–	–	–	–
Efficiency	–	–	–	–	–25	50	18.75	62.5	–	–	–	–
Ratio	–	–	–	–	1 : –12.5	25	1 : 25	54	–	–	–	–
Occurrence	–		5		2		9^{+}		1		3	
Frecuency (%)	–		0.5		0.2		0.8		0.1		0.3	
No contact												
Occurrence	40^{+}		32		19		23		25		12$^{–}$	
Frecuency (%)	3.7		3.0		2.0		2.0		2.2		1.2	

Note. $^{a}p < .05$ in U-14; $^{b}p < 0.05$ in U-16; $^{c}p < 0.05$ in U-18; $^{d}p < 0.05$ in 2nd national division; $^{e}p < 0.05$ in 1st national division; $^{f}p < 0.05$ in international, – o + statistical significance of .05 (chi square test); – o + relationship found (positive or negative).

In reception performance (Table 3), forearm and overhand techniques was noted with a statistically significant decrease in percentage of errors and receptions that limit attack options, from the lower level of competition to the highest. Receptions that allow all options in attacking had a significantly higher increase from the lower levels to the U-18 and the senior levels. With respect to areas of service reception (Table 4), both forearm and overhand techniques had a higher number of zones used at professional levels than at the lower levels of competition.

Table 3. Performance of service reception technique according to levels of competition (women volleyball)

Service reception technique	U-14		U-16		U-18		2nd national		1st national		International	
	n	%	n	%	n	%	n	%	n	%	n	%
Forearm contact												
Error	168^{+}	17.5	133^{+}	13.7	62	7.0	55^{-}	5.1	29^{-}	2.7	34^{-}	3.7
No attack	193^{+}	20.1	161^{+}	16.5	100	11.3	98^{-}	9.0	87^{-}	8.1	40^{-}	4.4
Limit attack	524	54.7	530	54.5	544^{+}	61.5	586	53.8	542^{-}	50.6	509	55.7
All attacks allowed	73^{-}	7.6	149^{-}	15.3	178^{-}	20.1	350^{+}	32.1	414^{+}	38.6	331^{+}	36.2
Underhand contact												
Error	14^{+}	15.7	10^{+}	17.2	2	5.6	1	2.7	–	–	1	2.5
No attack	22^{+}	24.7	8	13.8	4	11.1	1	2.7	1^{-}	2.2	–	–
Limit attack	50	56.2	32	55.2	23	63.9	26	70.3	28	62.2	31	77.5
All attacks allowed	3^{-}	3.4	8	13.8	7	19.4	9	24.3	16^{+}	35.6	8	20.0
Other technique												
Error	–	–	2	100.0	3^{+}	33.3	–	–	–	–	–	–
No attack	1	20.0	–	–	2	22.2	–	–	1	33.3	1	20.0
Limit attack	4	80.0	–	–	3	33.3	1	100.0	2	66.7	4	80.0
All attacks allowed	–	–	–	–	1	11.1	–	–	–	–	–	–

Note. – o + statistical significance of $p < 0.05$ (chi square test); – o + relationship found (positive or negative).

Table 4. Efficacy of service reception technique according to performing area and levels of competition (women volleyball)

Performing area	U-14		U-16		U-18		2nd national		1st national		International	
	n	coefficient	n	coefficient	n	coefficient	n	coefficient	n	coefficient	n	coefficient
1	2	3	4	5	6	7	8	9	10	11	12	13
Forearm contact												
Zone 1	140^{-}	1.64^{bcdef}	147^{-}	1.65^{acdef}	168	1.88^{abdef}	250^{+}	2.05^{abc}	230	2.21^{abc}	225^{+}	2.24^{abc}
Zone 2	3	1.67^{bdef}	3	1.33^{af}	4	2.00^{f}	5	2.20^{a}	10^{+}	2.00^{a}	5	1.80^{af}
Zone 3	3^{-}	1.00^{cdf}	12	1.25	10	1.80^{a}	16	1.94^{a}	18	2.61	6	2.00^{a}
Zone 4	3	2.33^{df}	8	1.88^{e}	6	1.17	1^{-}	2.00^{a}	14^{-}	2.57^{b}	6	2.17^{a}
Zone 5	221^{-}	1.56^{f}	246	1.74	280^{+}	1.89	310	2.11	356^{+}	2.21	247	2.26^{a}
Zone 6	588^{+}	1.48	557^{+}	1.73	416	2.03	507	2.19	444^{-}	2.28	425	2.25
Total in frontrow	9	1.67^{cdef}	23	1.49^{def}	20	1.66^{adef}	22	2.02^{abc}	42	2.39^{abc}	17	1.99^{abc}
Total in backrow	949	1.56^{cdef}	950	1.71^{def}	864	1.93^{a}	1,067	2.12^{ab}	1,030	2.23^{ab}	897	2.25^{ab}
Underhand contact												
Zone 1	8^{-}	1.88^{def}	10	1.60^{def}	5	1.80	11	2.27^{ab}	15	2.53^{ab}	16^{+}	2.06^{ab}
Zone 2	–	–	–	–	–	–	1	2.00	1	2.00	–	–
Zone 3	–	–	–	–	2	1.80	1	3.00	2	2.50	–	–
Zone 4	1	1.00	–	–	–	–	–	–	–	–	–	–
Zone 5	22	1.23	17	1.76	12	1.75	12	1.92	16	2.25	15	2.27
Zone 6	58^{+}	1.52	31	1.61	17	2.29	12	2.25	11^{-}	2.18	9^{-}	2.11
Total in frontrow	1	1.00	0	–	2	1.80	2	2.50	3	2.25	0	–
Total in backrow	88	1.54^{def}	58	1.66^{def}	34	1.95	35	2.15^{ab}	42	2.42^{ab}	40	2.15^{ab}
Other tecnique												
Zone 1	–	–	1	2.00	–	–	–	–	1	1.00	3	1.25
Zone 2	–	–	–	–	–	–	1	0.00	–	–	–	–
Zone 3	–	–	–	–	–	–	1	0.00	–	–	–	–
Zone 4	–	–	–	–	–	–	2	1.00	–	–	–	–

1	2	3	4	5	6	7	8	9	10	11	12	13
Zone 5	–	–	–	–	1	0.00	1	2.00	–	–	–	–
Zone 6	–	–	4	1.75	1	0.00	4	1.75	–	–	–	–
Total in frontrow	–	–	–	–	–	–	4	0.33	–	–	–	–
Total in backrow	–	–	5	2.87	2	0.00	5	1.87	1	1.00	3	1.25

Note. [a] $p < 0.05$ in U-14; [b] $p < 0.05$ in U-14; [c] $p < 0.05$ in U-14; [d] $p < 0.05$ in 2nd national division; [e] $p < 0.05$ in 1st national division; [f] $p < 0.05$ in international, – o + statistical significance of $p < 0.05$ (chi square test); – o + relationship found (positive or negative).

In the reception performance according to serve technique (Table 5), there was a significant decrease of errors and receptions that did not allow attack options for the standing serves and the jump-float serves from the younger levels of competition to the U-18 and the senior levels. Passes that allowed all offense options from the standing serves, and the jump-float serves had a significantly higher increase from U-14 and U-16 levels to international level. Efficacy in reception that allowed all attack options in a game-sequence rose significantly from the U-14 and U-16 levels to the 1st national division level.

Table 5. Performance of service reception according to serving technique and levels of competition (women volleyball)

Performance	U-14		U-16		U-18		2nd national		1st national		International	
	n	%	n	%	n	%	n	%	n	%	n	%
Reception of standing serve												
Error	203^{+}	20.04	124^{+}	13.84	58	8.61	48^{-}	6.10	21^{-}	3.08	22^{-}	4.19
No attack	195^{+}	19.25	143^{+}	15.96	72	10.68	69^{-}	8.77	57^{-}	8.37	17^{-}	3.24
Limit attack	539	53.21	486	54.24	396	58.75	422	53.62	321	47.14	280	53.33
All attacks allowed	76^{-}	7.50	143^{-}	15.96	148	21.96	248^{+}	31.51	282^{+}	41.41	206^{+}	39.24
Reception of power-jump serve												
Error	14^{+}	19.72	26^{+}	37.14	3	15.79	18	10.78	14^{-}	6.70	14^{-}	6.36
No attack	20^{+}	28.17	13	18.57	2	10.53	18	10.78	16	7.66	17	7.73
Limit attack	35	49.30	25^{-}	35.71	10	52.63	80	47.90	105	50.24	134^{+}	60.91
All attacks allowed	2^{-}	2.82	6^{-}	8.57	4	21.05	51	30.54	74^{+}	35.41	55	25.00
Reception of jump-float serve												
Error	–	–	19^{+}	20.00	24	9.84	11	5.56	17	6.85	10	4.63
No attack	–	–	18^{+}	18.95	29^{+}	11.89	12	6.06	15	6.05	6^{-}	2.78
Limit attack	–	–	52	54.74	158	64.75	108	54.55	141	56.85	124	57.41
All attacks allowed	–	–	6^{-}	6.32	33^{-}	13.52	67^{+}	33.84	75	30.24	76^{+}	35.19

Note. – o + statistical significance of $p < 0.05$ (chi square test); – o + relationship found (positive or negative).

Table 6. Efficacy of service reception according to serving technique and levels of competition (women service)

Reception's technique	U-14		U-16		U-18		2nd national		1st national		International	
	n	coefficient	n	coefficient	n	coefficient	n	coefficient	n	coefficient	n	coefficient
1	2	3	4	5	6	7	8	9	10	11	12	13
Reception of standing serve												
Forearm	894	1.53^{bcdef}	825	1.76^{a}	635	1.97^{adef}	743	2.17^{ac}	638	2.26^{ac}	498	2.34^{ac}
Underhand	84	1.49^{def}	48	1.8^{def}	26	1.99	29	2.12^{ab}	33	2.28^{ab}	25	2.09^{ab}
Reception of power-jump serve												
Forearm	64	1.45^{def}	59	1.27^{def}	16	2.22	156	2.08^{ab}	198	2.28^{ab}	211	2.14^{ab}
Underhand	7	1.33	–	–	2	2.00	–	–	3	2.25	–	–

1	2	3	4	5	6	7	8	9	10	11	12	13
Reception of jump-float serve												
Forearm	–	–	86	1.52[cdef]	233	1.85[bdef]	189	2.17[bc]	233	2.21[bc]	219	2.29[bc]
Underhand	–	–	6	1.22	8	1.83	7	2.27	8	2.29	13	2.29

Note. [a] $p < 0.05$ in U-14; [b] $p < 0.05$ in U-14; [c] $p < 0.05$ in U-14; [d] $p < 0.05$ in 2nd national division; [e] $p < 0.05$ in 1st national division; [f] $p < 0.05$ in international.

In the reception efficacy according to reception technique (Table 6), the forearm technique had a significantly higher coefficient of efficacy from lower levels to senior levels. The overhand technique significantly increased its efficiency of standing services from lower levels to senior levels.

Discussion

The results show the evolution of reception execution and its performance throughout the different levels of competition in women's volleyball. The results showed that forearm technique was the most employed in all levels. The significantly higher occurrence of error in the lowest level studied, U-14, showed the importance of experience and practice during the early stages of training. The tactical reception system needs time to develop, in addition to the development of technical abilities (Dávila-Romero, García-Hermoso, 2012), knowledge of its organization and the right decision of what is needed (Grgantov et al., 2006; Rikberg, Raudsepp, 2011). The occurrence of these errors in early stages could be related to a problem of the player's ability to estimate the ball's trajectory, a wrong choice of the place where it could be played or a mistake in the decision making (miscommunication among players). All of these issues are related to the lack of experience and maturity in early stages of training (Elferink-Gemser et al., 2007; Malina et al., 2004).

The results of reception performance showed that a higher level of competition, there is higher performance in reception. These results coincide with other studies about the evolution of service reception in different levels (Elferink-Gemser et al., 2007; García-Alcaraz et al., 2014; Grgantov et al., 2006; Inkinen et al., 2013). It is confirmed that the experience and maturity does influence the execution of this action and the decision making involved (Araujo, Afonso, Mesquita, 2011; Berry, Abernethy, 2009; Malina et al., 2004). The improvement in reception is so significant that it becomes a predictor of success in the final score of competitions at high levels (Afonso et al., 2009; Silva et al., 2014a; Zetou et al., 2007). All of this is related to the prior action in a game, the service. The authors of this study analyzed the performance of reception according to serving technique. All serving techniques produced a significantly lower reception performance at U-14 and U-16, and higher at U-18 and senior levels. This could be possible due to the improvement in a technique's capacity and the decreased imbalance between serving and reception as observed in U-14 and U-16 (Ureña et al., 2013).

Regarding zones of reception, U-14 showed a low level of performance in four out of six zones compared to higher levels of competition. These findings support the observations done previously about the lower efficacy in reception in early stages of training and the imbalance between service and reception (Selinger, Ackermann-Blount, 1985; Ureña et al., 2013). The results showed that reception done in different zones had the same efficiency. In early stages, zone 6 was the one that had the highest occurrence of receptions. This data may be related to the fact that in early stages of training the servers do not have the intention or the skill to serve to certain zones, trying to hinder the opponent's reception (McGown, Fronske, Moser, 2001; Selinger, Ackermann-Blount, 1985). That could be explained by the conscious decision of trying to prevent any mistakes hitting the ball out, rather than trying a more successful but risky option (Ureña, Santos, Martínez, Calvo, Oña, 2000). There is a connection between

the evolution of serve and reception. The reception is influenced by the power or the hit height in which the serve is made (MacKenzie, Kortegaard, LeVangie, Barro, 2012). Mastery in service technique is required if the players want to broaden the options in opposing zones, as seen in high level of competition.

The information about the zones of reception is helpful comparing the performance in both front row and back row zones in the field. Reception in front-row zones had a significantly lower performance in U-14 and U-16 than the rest of the levels. The reason why it is this way could be connected with the speed and mobility of the player. To do this as well as possible, the players need to have a good physical condition, reaction capacity and technical ability (Elferink-Gemser et al., 2007; Grgantov et al., 2006; Stamm et al., 2003; Ureña et al., 2000). Because of that, coaches in early stages often make use of tactics with more players involved in reception (Selinger, Ackermann-Blount, 1985), and those tactics become more complex and involve less players every time they improve their technique and increase both their ability to move and their decision making.

Conclusions

The results of this study show the performance profile of service reception in women's volleyball, from the lowest to the highest level of competition. The most used reception technique in all analyzed levels was the forearm, regardless of the serving technique. As competition level increases, higher performance of reception is presented. The receptions in front row zones are less efficient in the early stages than at higher levels. Nevertheless, the serving technique has less influence on reception as the level of competition increases. With the level of competition, reception deals with more destination zones of the services.

This information provides insight into the long-term development of this technical skill for female players. This information could help coaches to analyze and evaluate this game action of their players in order to design a working plan adapted to the level of competition. More information is needed about the relationship of this action with other parts of the performance through different developmental stages, such as: tactical variables (efficiency of receiving techniques according to reception systems and the number of players involved), physical condition (of specialist players in reception or of players who need to be added to the attack options), or psychological indicators (performance of reception in the final points of a set or match).

References

Afonso, J., Moraes, J. C., Mesquita, I., Marcelino, R., Duarte, T.C. (2009). Relationship between reception effect, attack type and tempo with performance level in high-level men's volleyball. *Journal of Sports Sciences*, *27*, 128.

Anguera, M.T. (2003). Observational methods (general). In: R. Fernandez-Ballesteros (ed.), *Encyclopedia of psychological assessment* (vol. 2, pp. 632–637). London: Sage.

Araujo, R., Afonso, J., Mesquita, I. (2011). Procedural knowledge, decision-making and game performance analysis in female volleyball's attack according to the player's experience and competitive success. *International Journal of Performance Analysis in Sport*, *11* (1), 1–13.

Bergeles, N., Barzouca, K., Nikolaidou, M.E. (2009). Performance of female setters and attackers on Olympic-level volleyball teams. *International Journal of Performance Analysis of Sport*, *9* (1), 141–148.

Berry, J., Abernethy, B. (2009). Developmental influences on the acquisition of tactical decision-making expertise. *International Journal of Sport Psychology*, *40* (4), 525–545.

Costa, G., Afonso, J., Brant, E., Mesquita, I. (2012). Differences in game patterns between male and female youth volleyball. *Kinesiology*, *44* (1), 60–66.

Costa, G., Caetano, R., Ferrerira, N., Junqueira, G., Afonso, J., Costa, P., Mesquita, I. (2011). Determinants of attack tactics in youth male elite volleyball. *International Journal of Performance Analysis in Sport*, *11*, 96–104.

Dávila-Romero, C., García-Hermoso, A. (2012). Acciones finales discriminantes de voleibol en categorías de formación masculina: importancia del saque en los partidos igualados. *International Journal of Sport Science*, *8* (28), 151–160.

Elferink-Gemser, M.T., Visscher, C., Lemmink, K.O.P.M., Mulder, T. (2007). Multidimensional performance characteristics and standard of performance in talented youth field hockey players: A longitudinal study. *Journal of Sports Sciences*, *25* (4), 481–489.

Fédération Internationale de Volleyball (2016). Official Volleyball Rules 2017-2020. Retrieved from: http://www.fivb.org/EN/Refereeing-Rules/documents/FIVB-Volleyball_Rules_2017-2020-EN-v06.pdf (21.04.2016).

García-Alcaraz, A., Palao, J.M., Ortega, E. (2014). Technical-tactical performance profile of reception according to competition category in men volleyball. *Kronos*, *13* (1). Retrieved from: http://g-se.com/es/journals/kronos/articulos/perfil-de-rendimiento-tecnico-tactico-de-la-recepcion-en-funcion-de-la-categoria-de-competicion-en-voleibol-masculino-1706 (2015).

Gil, A., Moreno, M.P., Moreno, A., García, L., Del Villar, F. (2011). Estudio del saque en jóvenes jugadores/as de voleibol, considerando la eficacia y función en juego. *Retos. Nuevas tendencias en Educación Física, Deporte y Recreación*, *19*, 19–24.

Grgantov, Z., Katic, R., Jankovic, V. (2006). Morphological characteristics, technical and situation efficacy of young female volleyball players. *Collegium Antropologicum*, *30* (1), 87–96.

Inkinen, V., Häyrinen, M., Linnamo, V. (2013). Technical and tactical analysis of women's volleyball. *Biomedical Human Kinetics*, *5*, 43–50.

João, P.V., Carvalho, J, Sattler, T., Mota, M.P. (2007). *Attack organization in-system and off-system by the setter, in volleyball team of Castelo Da Maia Ginásio*. Paper presented at the XII Annual Congress of the ECSS, Jyväskylä, Finland.

Laios, Y., Kountouris, P. (2005). Evolution in men's volleyball skills and tactics as evidence in the Athens 2004 Olympic Games. *International Journal of Performance Analysis in Sport*, *5* (2), 1–8.

MacKenzie, S., Kortegaard, K., LeVangie, M., Barro, B. (2012). Evaluation of two methods of the jump float serve in volleyball. *Journal of Applied Biomechanics*, *28*, 579–586.

Malina, R.M., Eisenmann, J.C., Cumming, S.P., Ribeiro, B., Aroso, J. (2004). Maturity-associated in the growth and functional capacities of youth football (soccer) players 13-15 years. *European Journal of Applied Physiology*, *91*, 555–562.

McGown, C., Fronske, H., Moser, L. (2001). *Coaching volleyball: building a winning team*. Needham Heights: Allyn & Bacon.

Palao, J.M., Ahrabi-Fard, I. (2014). Effect of jump set usage on side-out phase in women's college volleyball. *Journal of Sport Human Performance*, *2* (3), 1–10.

Palao, J.M., Manzanares, P. (2009). *Manual for observation instrument of techniques and efficacy in volleyball*. Spain: Murcia.

Palao, J.M., Manzanares, P., Ortega, E. (2015). Design, validation, and reliability of an observation instrument for technical and tactical actions in indoor volleyball. *European Journal of Human Movement*, *34*, 75–95.

Palao, J.M., Santos, J.A., Ureña, A. (2006). Effect of reception and dig efficacy on spike performance and manner of execution in volleyball. *Journal of Human Movement Studies*, *51* (4), 221–238.

Pereda, S. (1987). *Psicología experimental*. Madrid: Pirámide.

Rikberg, A., Raudsepp, L. (2011). Multidimensional performance characteristics in talented male youth volleyball players. *Pediatric Exercise Science*, *23* (4), 537–548.

Selinger, A., Ackermann-Blount, J. (1985). *Arie Selinger's power volleyball*. New York: St. Martin Press.

Silva, M., Lacerda, D., João, P.V. (2014a). Game-related volleyball skills that influence victory. *Journal of Human Kinetics*, *41* (1), 173–179.

Silva, M., Lacerda, D., João, P.V. (2014b). Match analysis of discrimination skills according to the setter defense zone position in high level volleyball. *International Journal of Performance Analysis in Sport*, *14* (2), 463–472.

Stamm, R., Veldre, G., Stamm, M., Thomson, K., Kaarma, H., Loko, J., Koskel, S. (2003). Dependence of young female volleyballers' performance on their body build, physical abilities, and psycho-physiological properties. *The Journal of Sports Medicine and Physical Fitness*, *43* (3), 291–299.

Ureña, A., León, J., González, M. (2013). Study about game continuity in children's volleyball. *Revista Internacional de Medicina y Ciencias de la Actividad Física y el Deporte*, *13* (49), 149–162.

Ureña, A., Santos, J.A., Martínez, M., Calvo, R., Oña, A. (2000). Defensive facilitation through serving in high level female volleyball. *Revista Motricidad*, *6*, 175–189.

Vivinai, F. (2004). The somatotype of "amateur" Italian male volleyball-players. *Papers on Anthropology*, *13*, 286–293.

Zadraznik, M., Marelic, N., Resetar, T. (2009). Differences in rotations between the winning and losing teams at the youth European volleyball championships for girls. *Acta Universitatis Palackianae Olomucensis Gymnica*, *39* (4), 33–40.

Zetou, E., Moustakidis, A., Tsigilis, N., Komninakidou, A. (2007). Does effectiveness of skill in complex I predict win in men's Olympic volleyball games? *Journal of Quantitative Analysis in Sport*, *3* (4), 1–11.

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GRADUATES OF THE UNIVERSITY OF SZCZECIN IN THE GROUP OF TRAINERS WHO STAND AS A CANDIDATE FOR THE POLISH REPRESENTATION OF THE 32ND OLYMPICS OR THE 16TH TOKYO PARALYMPICS 2020

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Abstract Club coaches, national team coaches, as well as Olympic or Paralympic team coaches are those trainers who use their knowledge, professionalism and experience to lead their trainees to achieve sports results that satisfy athletes as well as coaches and authorities of Polish associations of various sports disciplines practiced by the athletes. A good trainer is the most important person in the coaching team, as they supervise the whole participation of their Olympians or Paralympians. Among the graduates of the Szczecin University's Physical Education, there are many trainers of various sports disciplines. They are club coaches, national team coaches and they also hold coaching functions at the Summer Olympic and Paralympic Games.
The aim of this paper is to: present the university (student) characteristics of the analyzed coaches and a physiotherapist who stand among the potential candidates to be appointed for the coaching and medical staff of their trainees (including the football team) who will fight for qualification standards guaranteeing them participation in the 32nd Summer Olympics or 16th Paralympic Games Tokyo 2020; showing the current coaching activity of the trainers and a physiotherapist in question; presenting the criteria and eligibility rules which the athletes of the coaches and the physiotherapist need to obtain to take part in the Tokyo Olympic or Paralympic competition. The research material consists of six graduates of the University of Szczecin, who majored in Physical Education, and who currently work primarily in the coaching team (Tomasz Kaźmierczak, Jacek Kostrzeba, Tomasz Lewandowski, Grzegorz Musztafaga, Miłosz Stępiński) and the medical/therapeutic team (Beata Buryta). All of the analyzed graduates of the University of Szczecin are among the trainers and physiotherapists who are candidates for the Polish national team for the 32nd Olympic Games or the 16th Paralympics Games Tokyo 2020. Tomasz Kaźmierczak – he will definitely be present for the fourth time at the Summer Games Tokyo 2020 as a coach for disabled rowers (previous participations in 2008, 2012, and 2016). The trainees of the coaches in question (except for the football team) can be included into the Polish team participating in the Summer Games Tokyo 2020 and at least compete in finals during the Olympic or Paralympic competition.

Key words graduates, trainers, coaches, games: Olympic Games, Paralympic Games, University of Szczecin, Faculty of Physical Culture and Health Promotion

Introduction

Each athlete hopes to be drafted for the national team and represent their country at competitions of various international ranks. Only few – the very best athletes – meet the qualification standards that guarantee a spot in the Polish national team that participates in the Summer Olympic or Paralympic Games. Every participant of this biggest sporting event held every fourth year strives to achieve the best possible result to secure a place in the finals and win the coveted medal.

Club coaches, national team coaches, as well as Olympic or Paralympic team coaches are those trainers who use their knowledge, professionalism and experience to lead their trainees to achieve sports results that satisfy athletes as well as coaches and authorities of Polish associations of various sports disciplines practiced by the athletes. A good trainer is the most important person in the coaching team, as they supervise the whole participation of their Olympians or Paralympians.

It must be emphasized that the Polish national team for the Summer Olympic or Paralympic Games includes not only the athletes, but also (-Iwaniszewska, 2012):

- the team management (e.g. President of the Polish Olympic Committee – President of the Polish Olympic Team, President of the Polish Paralympic Committee),
- Olympic mission (e.g. Head of Mission, press attaché),
- medical mission (e.g. Head of Mission, doctors, physiotherapy coordinator, psychologist coordinator),
- team guests (e.g. Minister of Sport and Tourism).

The national team also includes coaches: club trainers, national team trainers, as well as trainers of particular sports association. For example, rowing is one of Olympic disciplines with many athletes taking part in a number of competitions. For this reason, the Polish Association of Rowing Societies appoints several trainers, doctors and physiotherapists (www.olimpijski.pl).

Among the graduates of the Szczecin University, Faculty of Physical Education, there are many trainers of various sports disciplines (Buryta, Stefanik, 2010; Eider, 2005; Florkiewicz, Fogtman, 2004; Iwińska, Iwiński, Wesołowska, 2014; Kotarska, 2006; Krupecki, 2006; Stefanik, 2006, 2014). They are club coaches, national team coaches and they also hold coaching functions at the Summer Olympic and Paralympic Games. So far, the greatest coaching achievements may be attributed to dr Krzysztof Krupecki, a graduate of the Faculty of Physical Education of the Pedagogical University in Szczecin (in 1976), who "... in 1990–2012 was a coach of Marek Kolbowicz, 5-time Olympian (Atlanta 1996, Sydney 2000, Athens 2004, Beijing 2008, London 2012), gold medalist of the Beijing Olympic Games, four-time world champion (Gifu 2005, Eton 2006, Munich 2007, Poznań 2009) and European champion (Montemor–o–Velho 2010)..." (Eider, Eider, 2017, p. 76). Krupiecki, as a trainer/coordinator of disabled rowers, led them to scored rank at the Paralympic Games, as well as to winning many medals at the world championships held on the rowing ergometer. Details of the coaching achievements of Krzysztof Krupecki are presented in other studies (Eider, 2005; Eider, Eider, 2017).

Among the current employees of the Faculty of Physical Culture and Health Promotion of the University of Szczecin (WKFiPZ US) and graduates of the university's Institute of Physical Culture are club coaches, national team coaches, and a physiotherapist, who are among the candidates for the Polish team for the 32nd Olympic Games or the 16th Paralympic Games Tokyo 2020.

The purpose of this paper is:

1. To present the university (student) characteristics of the analyzed coaches and physiotherapists who stand among the potential candidates to appoint to be appointed for the coaching and medical staff of their trainees (including the football team) who fight for qualification standards guaranteeing them participation in the 32nd Summer Olympics or 16th Paralympic Games Tokyo 2020.
2. To show the current coaching activity of the trainers and physiotherapist in question.
3. To present the criteria and eligibility rules which the athletes of the coaches and the physiotherapist need to obtain to take part in the Tokyo Olympic or Paralympic competition.
4. To continue research in the field of broadly defined Olympism and Paralympism, including the participation of graduates of the University of Szczecin's Physical Education in the Summer Olympic or Paralympic Games.

Materials and methods

The research material consists of six graduates of the University of Szczecin, who majored in Physical Education, and who currently work primarily in the coaching team (Tomasz Kaźmierczak, Jacek Kostrzeba, Tomasz Lewandowski, Grzegorz Musztafaga, Miłosz Stępiński) and the medical/therapeutic team (Beata Buryta) (Table 1). Except for Jacek Kostrzeba, all of them are graduates of the Institute of Physical Culture of the Faculty of Natural Sciences of the University of Szczecin (IKF WNP US), which was transformed into the Faculty of Physical Culture and Health Promotion in 2011 (Eider, 2017). Trainer Jacek Kostrzeba is a graduate of the Institute of Physical Culture of the University of Szczecin, which operated as a faculty until 1992 (from October 1, 1992 it was included into structures of the WNP). It must be noted that dr Miłosz Stępiński i mgr Beata Buryta are researchers and teachers employed by Faculty of Physical Culture and Health Promotion at the University of Szczecin (Dokumentacja, 2019). Master's theses of the discussed trainers are closely related to the sports discipline they train, as well as to physiotherapy (Beata Buryta) (Table 1).

Table 1. Research material – coaching team, medical team (training supervisors), as of 31 May 2019

First name and surname	Age	Sports discipline	A graduate of which university unit	Year of graduation	Subject of the defended Master's thesis
Tomasz Kaźmierczak	42	Rowing (disabled)	IKF WNP US	2002	Dynamics of rowers' performance indicators in the annual training cycle
Jacek Kostrzeba	53	Athletics	IKF US	1990	Athletes' maximum oxygen consumption depending on age and sport preparation in medium distance competitions
Tomasz Lewandowski	38	Athletics	IKF WNP US	2005	Optimization of physical loads in boys aged 16–17 in middle-distance running
Grzegorz Musztafaga	46	Swimming (disabled)	IKF WNP US	2004	An attempt to use the Cooper test to assess physical performance of junior competitive swimmers
Miłosz Stępiński	44	Football	IKF WNP US	1999	The impact of initial training on the development of motor skills and the effectiveness of football technique teaching in boys aged 11–13
Beata Buryta	44	Rowing (disabled)	IKF WNP US	2000	Comparison of motor skills of children with posture defects and mental retardation against healthy children in the Połczyn Zdrój spa

Source: Dokumentacja (2019).

The analyzed research material was obtained primarily from the archival documentation of WKFiPZ US, written and oral reports by the analyzed trainers and the physiotherapist, from author's (co-author's) reviews of the author of this publication and www.wikipedia.pl, www.olimpijski.pl, www.paralympic.org.pl, www.pzla.pl.

The collection of materials for this study was completed on May 31, 2019. The author is aware of the fact that this study may not include other graduates of Szczecin University Physical Education faculty, who may perform various functions in coaching, medical and other teams, and are among the candidates for the Summer Olympic or Paralympic Games Tokyo 2020. It may solely be caused by incomplete knowledge of the author of this article.

Results

The discussed group includes trainers with qualifications in four sport disciplines: athletics, football, swimming, and rowing (Table 2). The highest coaching class is held by: Tomasz Lewandowski – Masters Class, and dr Miłosz Stępiński – UEFA PRO. Among the analyzed trainers, three of them – Jacek Kostrzeba, Tomasz Lewandowski and Miłosz Stępiński – are trainers of Olympic disciplines (athletics, men's and women's football). The other two trainers – Tomasz Kaźmierczak and Grzegorz Musztafaga – work with disabled athletes in Paralympic disciplines (rowing, sports swimming). All the trainers listed in Table 2 were or are coaches of: the national team, the Olympic/ Paralympic Polish team in their sports disciplines (competitions) (Kaźmierczak, 2019a; Krupecki, 2019; Kostrzeba, 2019; Musztafaga, 2019; Stępiński, 2019a).

Tomasz Kaźmierczak was the main coach of the Polish national team of disabled rowers at the Summer Games in Beijing 2008, London 2012, and Rio de Janeiro 2016 (Table 3). Rowing has been a Paralympic discipline since 2008, and it is practiced in Poland, e.g. at the Klub Sportowy Inwalidów START in Szczecin. Kaźmierczak's trainees have also won many medals at the World and European Championships on a rowing ergometer (Kaźmierczak, 2019a).

Tomasz Lewandowski is the second trainer in terms of participation in the Summer Games so far (Table 3). He is the older brother and trainer of Marcin Lewandowski – a titled athlete in the 800 m and 1,500 m run (Lewandowski, 2019a, 2019b; Przegląd, 2016). He participated in 30th and 31st Olympic Games in London 2012 and Rio de Janeiro 2016. He coached endurance run athletes, including Marcin Lewandowski. It should be noted that Tomasz Lewandowski did not participate in the Olympic Games in Beijing 2008, but was preparing his brother Marcin for the Olympic start in the 800 m race (Lewandowski, 2019b).

Table 2. Trainers' characteristics

First and last name	Sports discipline	Currently held coaching class	Year of obtaining that coaching class	Current sports club	National team coach; representation coach
Tomasz Kaźmierczak	Rowing	second	2010	KSI "Start" Szczecin	National team coach; Paralympic team
Jacek Kostrzeba	Athletics	second	2002	UKS Barnim Goleniów	National team in cross-country running; Olympic representation in cross-country running
Tomasz Lewandowski	Athletics	Master	2013	–	National team: youth, juniors, seniors; Olympic team in endurance runs
Grzegorz Musztafaga	Swimming	second	2004	KSI "Start" Szczecin	–
Miłosz Stępiński	Football	First, UEFA A, UEFA PRO	2008, 2012, 2018	–	U19 team coach; Polish women A team coach;

Source: Kaźmierczak (2019a, 2019b); Kostrzeba (2019); Lewandowski (2019a, 2019b); Musztafaga (2019); Stępiński (2019a, 2019b).

Table 3. Participation of trainers and a physiotherapist in the Summer Olympic and Paralympic Games – sports achievements of their trainees

First and last name	Discipline of trainees	Beijing 2008			London 2012			Rio de Janerio 2016		
		name of trainee(s)	sport competition	rank	name of trainee(s)	sport competition	rank	name of trainee(s)	sport competition	rank
Tomasz Kaźmierczak	Rowing (disabled)	Jolanta Pawlak, Piotr Majka Martyna Snopek	TA2x ASW1x	6th 10th	Jolanta Pawlak, Piotr Majka Martyna Snopek	TAMix2x ASW1x	10th 9th	Jolanta Majka Michał Gadowski	TAMix2x	6th
Jacek Kostrzeba	Athletics	–	–	–	–	–	–	Krystian Zalewski	3,000-meter steeplechase	27th
Tomasz Lewandowski	Athletics	–	–	–	Marcin Lewandowski	800 m	9th	Marcin Lewandowski	800 m	6th
Grzegorz Musztafaga	Swimming (disabled)	–	–	–	Paulina Woźniak	100 m butterfly stroke 100 m breaststroke	6th 3rd	–	–	–
Miłosz Stępiński	Football, men, women	–	–	–	–	–	–	–	–	–
Beata Buryta	Rowing (disabled)	–	–	–	–	–	–	Jolanta Majka Michał Gadowski	TAMix2x	6th

Source: Kaźmierczak (2019a, 2019b); Lewandowski (2019a); Maniak-Iwaniszewska (2012); Musztafaga (2019); Stępiński (2019b); Woźniak (2019b); www.wikipedia.pl.

The 31st Olympic Games in Rio de Janeiro 2016 were also attended by Jacek Kostrzeba, who was the coach of the Polish national team of cross-country runners. One of them was Krystian Zalewski from UKS Barnim Goleniów, who took the 27th place in the 3,000-meter steeplechase (www.olimpijski.pl; Kostrzeba, 2019).

Among the remaining coaches, only Grzegorz Musztafaga participated in the Summer Games London 2012 (Table 3). His trainee, swimmer from the KSI "Start" Szczecin, Paulina Woźniak won a bronze medal in the 100 m breaststroke competition. As a club coach, Grzegorz Musztafaga prepared Paulina Woźniak for the Paralympic competitions in Beijing 2008 and Rio de Janeiro 2016. In Beijing, she won a silver medal, also in the 100 m breaststroke competition (Musztafaga, 2019; Woźniak, 2019a).

One of the discussed coaches, Miłosz Stępiński, has not participated in any Summer Olympic Games as a coach. He has played various training roles, such as a coach of the Polish U19–U21 national teams. From December 2018, he has worked as an analyst coach in the staff of the U21 men's Polish national team. He will participate in the U21 European Championships, which will take place in June 16–30, 2019 in Italy and San Marino. These championships serve also as qualifications (for teams ranked 1–4) for the Olympic Games in Tokyo. It should be particularly noted that since 2016 Miłosz Stępiński has also been the first coach of the Polish A women's national team (Stępiński, 2019a).

Beata Buryta has been cooperating since 2010 "...with disabled athletes from KSI "Start" Szczecin as a physiotherapist and masseuse" (Eider, Eider, 2017, p. 68). She worked in this capacity with disabled rowers at the 15th Paralympics in Rio de Janeiro 2016 (Buryta, 2019).

Discussion

A good trainer is one who has significant professional achievements. Their trainees get appointed to the national team, Olympic or Paralympic team. They win medals at Olympic Games, World Championships, European Championships, national championships, etc. A good trainer constantly improves their coaching qualifications through e.g. participation in various domestic and international workshops. A good coach actively participates in specialist conferences and scientific symposia. S/he gets acquainted with professional literature on modern teaching methods in their discipline/sports competition. A good coach uses the knowledge and advice of scientists involved in research, including motor, physiological, and biochemical studies. Their trainees undergo specific tests in scientific and research institutions. The obtained results – measurements, parameters, quantities, etc. – are analyzed and used to modify the training and starting process of the trained athletes.

An example of a research unit which serves athletes is the Human Structural and Functional Research Center (CBSFC) at the Faculty of Physical Culture and Health Promotion of the University of Szczecin. It includes four laboratories: biochemistry, physiology, genetics and kinesiology. They are all "...equipped with modern research equipment and devices that help conduct specialized scientific research in the field of physical culture, health and medical sciences" (Eider, 2017, p. 54). Many Szczecin coaches, including the national team of able-bodied and disabled athletes (e.g. Tomasz Lewandowski, Tomasz Kaźmierczak) use CBSFC research equipment and devices. Research and teaching staff of the Center work on e.g. specialized research on athletes trained by the discussed coaches.

All of the analyzed trainers and the physiotherapist are among candidates for the 32nd Olympic Games or the 16th Paralympics Games Tokyo 2020. Their trainees and the football team must obtain certain qualification standards (Table 4) to compete in the largest sporting event, which are the Tokyo Games in 2020. The athletes

listed in Table 4 are bound to reach qualifying standards in their respective disciplines and will become the Polish national team members for the Tokyo Summer Games. The qualification standards are quite challenging, but feasible because the athletes represent a high level of Olympic or Paralympic disciplines.

Men's football team (U21) is in a quite difficult qualifying position. In June, during European Championships 2019, they will compete with the often victorious teams of Spain, Italy and Belgium. Only the semi-finalists are guaranteed to participate in the Tokyo Olympic Games. On June 22, 2019 it will be decided whether Polish football team has obtained qualification standards for the Japanese Games, and trainer Miłosz Stępiński will be on the coaching staff of Czesław Michniewicz – the first U21 trainer (Stępiński, 2019b).

Table 4. Qualifying standards for athletes (trainees)

First and last name of the trainer	First and last name of the athlete	Athlete's sports club	Sports discipline	Competition	Qualification standard
Tomasz Kaźmierczak	Jolanta Majka Michał Gadowski	KSI "Start" Szczecin	Rowing (disabled)	TAMix2x (mixed doubles)	World Cup in 2019 – ranks 1–8 Continental qualifications in 2020 – the first two teams
Jacek Kostrzeba	Krystian Zalewski Michał Rozmys	UKS Barnim Goleniów	Athletics	3,000-meter steeplechase 800 m	8:22.00 1:45.20
Tomasz Lewandowski	Marcin Lewandowski	WKS Zawisza Bydgoszcz	Athletics	1,500 m	3:35.00
Grzegorz Musztafaga	Paulina Woźniak	KSI "Start" Szczecin	Swimming (disabled)	100 m breaststroke	High ranking at the world list from certain competitions and a limit of places awarded to Poland by IPC Swimming
Miłosz Stępiński	Polish National Team U21	Polish National Team U21	Men's football	–	European Championship in 2019 – ranks 1–4

Source: Kaźmierczak (2019a, 2019b); Woźniak (2019a, 2019b); Stępiński (2019a); www.pzla.pl.

To become a coach, a member of a coaching or medical staff in the Olympic or Paralympic team (including a role of a coach of a trainee/-s), certain requirements must be met, which are set by the boards of Polish sports associations; they are approved by the Polish Olympic Committee or the Polish Paralympic Committee (www.olimpijski.pl; www.paralympic.org.pl; www.pzla.pl).

Conclusions

1. All of the analyzed graduates of the University of Szczecin are among the trainers (Tomasz Kaźmierczak, Jacek Kostrzeba, Tomasz Lewandowski, Grzegorz Musztafaga, Miłosz Stępiński) and a physiotherapist (Beata Buryta), who are candidates for the Polish national team for the 32nd Olympic Games or the 16th Paralympics Games Tokyo 2020.
2. Tomasz Kaźmierczak – he will definitely be present for the fourth time at the Summer Games Tokyo 2020 as a coach for disabled rowers (previous participations in 2008, 2012, and 2016).
3. The trainees of the coaches in question (except for the football team) can be included into the Polish team participating in the Summer Games Tokyo 2020 and at least compete in finals during the Olympic or Paralympic competition.

References

Archives

Archival documentation of WKFiPZ US (dean's office, secretary office) (2019). The Faculty of Physical Culture and Health Promotion at the University of Szczecin.

Printed sources

Buryta, R., Stefanik, R. (2010). Piłka nożna kobiet w Szczecinie w latach 1957–2007. *Zeszyty Naukowe Uniwersytetu Szczecińskiego*, *570. Prace Instytutu Kultury Fizycznej*, *25*, 103–119.

Eider, J. (2005). *Sportowcy, trenerzy szczecińscy absolwenci studiów magisterskich. Kierunek wychowanie fizyczne*. Szczecin: Wydawnictwo Naukowe Uniwersytetu Szczecińskiego.

Eider, J. (2017). *Wydział Kultury Fizycznej i Promocji Zdrowia Uniwersytetu Szczecińskiego w latach 2011–2016*. Szczecin: Wydawnictwo Naukowe Uniwersytetu Szczecińskiego.

Eider, J., Eider, P. (2017). *Problematyka olimpijska i paraolimpijska w działalności Wydziału Kultury Fizycznej i Promocji Zdrowia Uniwersytetu Szczecińskiego*. Szczecin: Wydawnictwo Naukowe Uniwersytetu Szczecińskiego.

Florkiewicz, B., Fogtman, S. (2004). Największe osiągnięcia sekcji piłki ręcznej mężczyzn MKS "Pogoń" Szczecin. In: J. Eider (ed.), *50 lat piłki ręcznej na Pomorzu Zachodnim* (pp. 166–176). Szczecin: Wydawnictwo Naukowe Uniwersytetu Szczecińskiego.

Iwińska, A., Iwiński, J., Wesołowska, J. (2014). Lekkoatleci, absolwenci studiów magisterskich i licencjackich Wydziału Wychowania Fizycznego Wyższej Szkoły Pedagogicznej oraz Instytutu Kultury Fizycznej Uniwersytetu Szczecińskiego. In: J. Eider (ed.), *60 lat kształcenia nauczycieli wychowania fizycznego w Szczecinie* (pp. 129–146). Szczecin: Wydawnictwo Naukowe Uniwersytetu Szczecińskiego.

Kotarska, K. (2006). Absolwenci Wydziału Wychowania Fizycznego Wyższej Szkoły Pedagogicznej w Szczecinie i Instytutu Kultury Fizycznej Uniwersytetu Szczecińskiego – pracownikami kierunków studiów wychowania fizycznego w Szczecinie. In: J. Eider (ed.), *Magisterskie studia z wychowania fizycznego w Szczecinie* (pp. 149–160). Szczecin: Wydawnictwo Naukowe Uniwersytetu Szczecińskiego.

Krupecki, K. (2006). Trenerzy olimpijczyków w sportach wodnych Pomorza Zachodniego. In: J. Eider (ed.), *Ruch olimpijski na Pomorzu Zachodnim* (pp. 135–138). Szczecin: Wydawnictwo Naukowe Uniwersytetu Szczecińskiego.

Maniak-Iwaniszewska, M. (2012). *Polska Reprezentacja Paraolimpijska Londyn 2012*. Elbląg: Wydawnictwo Uran, Marzena Bracka-Kondracka.

Przegląd Sportowy (2016). Reprezentacja Polski, Skarb Kibica, Igrzyska XXXI Olimpiady – Rio de Janeiro 2016. Wydawnictwo Ringler Axel Springer Polska Sp. z o.o., 52–75.

Stefanik, R. (2006). Piłka nożna w środowisku szkolnym na Pomorzu Zachodnim w latach 1945–2006. In: J. Eider (ed.), *Piłka nożna na Pomorzu Zachodnim w latach 1945–2006* (pp. 229–249). Szczecin: Wydawnictwo Naukowe Uniwersytetu Szczecińskiego.

Stefanik, R. (2014). Studia nauczycielskie w Szczecinie i idea kształcenia nauczycieli o dodatkowych kwalifikacjach zawodowych. In: J. Eider (ed.), *60 lat kształcenia nauczycieli wychowania fizycznego w Szczecinie* (pp. 107–128). Szczecin: Wydawnictwo Naukowe Uniwersytetu Szczecińskiego.

Written accounts

Kaźmierczak Tomasz, Szczecin, 2019a.

Lewandowski Tomasz, Szczecin, 2019a.

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Woźniak Paulina, Szczecin, 2019a.

Oral accounts

Buryta Beata, Szczecin, 2019.

Kaźmierczak Tomasz, Szczecin, 2019b.

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Krupecki Krzysztof, Szczecin, 2019.

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Musztafaga Grzegorz, Szczecin, 2019.
Stępiński Miłosz, Szczecin, 2019b.
Woźniak Paulina, Szczecin, 2019b.

Internet sources
www.wikipedia.pl.
www.olimpijski.pl.
www.paralympic.org.pl.
www.pzla.pl.

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ULTRASOUND ELASTOGRAPHY IN CLINICAL DIAGNOSTICS AND IN SCIENTIFIC RESEARCH ON MUSCLES

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Abstract Ultrasound elastography is a revolutionary medical imaging technique, enabling a quantitative and qualitative evaluation of tissue stiffness. This paper presents, based on published evidence, a wide range of possibilities for this method in clinical trials and scientific research. The use of dynamic elastography avoids the undesired influence of force applied to the tissue by the elastograph probe on the information content of the obtained image. In clinical practice, elastography is used to identify and examine the pathological condition of soft tissues (including cancer lesions and tendonitis) and to diagnose neuromuscular diseases. It is also used in scientific investigations as a non-invasive method to study the structure of skeletal muscle, including muscle thickness, fiber length and pennation angle using standard ultrasonography mode; it is also possible to obtain information about physical properties such as stiffness. Ultrasound elastography could also be a useful tool for physiotherapists monitoring the rehabilitation process. Based on the results of these studies, advances in elastographic imaging technology, and progress in biomedical diagnostic methods, elastography is expected to become a common method used in clinical diagnostics and scientific research.

Key words diagnostic imaging, stiffness, skeletal muscles, neoplasm

Introduction

Palpation is a basic diagnostic method. The earliest documented mentions of palpation are found in the Elebra Papyrus and the Edwin Smith Papyrus, from 1500 BC. In ancient Greece, Hippocrates was a main propagator of palpation. Nowadays, it is one of the basic examination methods used in medical practice (e.g. palpation of the abdomen and lymph nodes), in physiotherapy practice (e.g. palpation of muscle, ligaments, and bone structures), as well as by patients themselves (e.g. breast cancer prevention). During palpation, the investigator senses the position of organs, their ability to displace and their stiffness by applying pressure to the examined part of the

body. One should emphasize that this method has its limitations, i.e. it is subjective and requires an experienced investigator. Not all organs are suitable for palpation, e.g. the kidneys, and in addition the quality of examination depends on body constitution and body mass. Whereas massive and on the advanced stage pathological changes can already be quite well palpable, in many cases, small changes are impossible to examine. Taking the above limitations into consideration, ultrasonography (USG) is now routinely applied in medical practice. This method of imaging is based on phenomena associated with the propagation of mechanical waves with ultrasound frequency through tissues, which allows the examiner to observe very small structures. Initially, USG was used exclusively for the detection of defects in metals, but since the 1970s, it has been popular in clinical diagnosis. However, USG images do not contain any information about tissue properties such as stiffness, defined as displacement caused by an external force (Hooke's law). In medical practice, information about tissue properties could be helpful in cancer diagnosis. To address this problem, ultrasound elastography (UE) was developed the 1980s and 1990s as a USG method with the ability to map tissue stiffness (Wells, Liang, 2011; Gennisson, Deffieux, Fink, Tanter, 2013).

Imaging by ultrasound elastography

Measuring stiffness by UE is based on Young's modulus, which defines the relationship between stress and deformation in a material. There are many advantages of UE, such as more precise detection of changes even at an initial stage of progression, which can lead to earlier implementation of a treatment. UE has become a valid tool in clinical practice, and is often called 'palpation imaging'. The main advantage of UE over palpation is its repeatability and the ability to examine deeper structures (Gennisson et al., 2013; Drakonaki, 2012).

Methods

Assessment of stiffness is obtained as a result of the analysis of deformation caused by the impact of an external force of probe (the quasi-static method) or an internal force generated by a shear wave (the dynamic method) inside tissue.

The quasi-static method

In the quasi-static method, often called strain imaging, Young's modulus is estimated based on deformation before pressure applied by the probe (pre-compression image) and after (post-compression image) (Szabo, 2004). In practice, the value of the force is unknown, which means that the result is not precise, so this method is mainly used for preliminary estimation (Gennisson et al., 2013; Ophir et al., 1999).

In contrast, the dynamic method utilizes forces, variable over time, that are generated in tissues as a result of the influence of ultrasound. In diagnostic practice, two kinds of waves are applied: shear waves and compression waves. Compression waves propagate very quickly at high frequencies while shear waves propagate slowly and at lower frequencies. The speed depends on the relationship between deformation and force, which is described by the shear modulus (Kirchhoff modulus). For most of human tissues, the value of Young's modulus is approximately three times greater than the shear modulus (Gennisson et al., 2013). The fundamentals of shear wave imaging (SWEI) that utilizes shear waves in clinical practice are described by Saravzyan and co-authors (Saravzyan, Rudenko, Swanson, Fowlkes, Emelianov, 1998). The main advantage of the dynamic method is that the results do not depending on the pressure of the probe.

In comparison to the quasi-static method, using shear waves allows for quantified measurements. However, imaging with both compressional and shear waves can cause interference waves as a result of simultaneous influences on tissues. Based on these restrictions, transient elastography depends on force generated in the form of an aperiodic impulse that reduces interference (Gennisson et al., 2013; Franchi-Abella, Eloe, Correas, 2013).

Dynamic techniques used in ultrasound elastography

In contrast to the quasi-static method that is performed only one way, the dynamic method encompasses several techniques. Vibro-acoustography, invented by Fatemi and Greenleaf (Fatemi, Greenleaf, 1998; 1999) is an extraordinarily sensitive high-definition imaging technique using low frequencies. It exploits two confocal waves that differ in frequency. Interference between these two waves causes the deformation of tissues. Based on the response of tissues to the vibration evoked by ultrasound and recorded by a hydrophone, images are created that show the amplitude of deformation. This highly sensitive technique can even detect microcalcifications of the carotid artery (Gennisson et al., 2013; Szabo, 2004).

Acoustic radiation force impulse imaging (AFRI) was developed by Nightingale and co-authors in 2001 (Nightingale, Palmeri, Nightingale, Trahey, 2001). In contrast to the vibro-acoustography, AFRI uses only one focal wave. The force of the radiation slightly displaces tissue around a focal spot and simultaneously with known, programmed time intervals images are recorded. Definitive images showing deformation of the examined area consists of particular images. This technique is similar to the quasi-static method, but it is more precise. Unfortunately, only assessing stiffness exclusively near a focal spot is possible (Gennisson et al., 2013; Szabo, 2004).

Transient elastography consists of generating impulses in tissues and registering shear wave propagation using a custom-constructed probe. This probe, the 1D transient elastography probe, was constructed at Institute Langevin in 1995 (Catheline, Thomas, Wu, Fink, 1999). This technique is becoming widely used in assessing chronic diseases of the liver and for quantifying hepatic or splenic fibrosis, reducing the number of biopsies by more than 50%. Since 2001, Echosens Co. has commercialized this technique and given it a trade name, FibroScan (Gennisson et al., 2013).

Supersonic Shear Imaging was also developed at Institute Langevin. The idea of analyzing shear wave acoustic radiation arose based on SWEI assumptions. This technique merges acoustic radiation and ultrafast ultrasound imaging. In clinical practice, it is used for the diagnosis of different organs, most commonly for breast examination (Gennisson et al., 2013; Szabo, 2004).

Ultrasound elastography in clinical diagnosis

The application of ultrasound elastography allows for detecting changes in the stiffness of tissue, a sign of many diseases including neoplasia and fibrosis. This imaging technique facilitates diagnosis as well as the monitoring of disease and treatment course. Primarily, UE has been used in breast cancer prevention and to assess the progression of hepatic fibrosis. Currently, research is being conducted into the utility of UE in the assessment other tissues like the muscles, thyroid gland, or kidneys. In the case of breast examination, this technique is extremely useful, especially after detecting abnormalities during regular ultrasound examination (Balleyguier et al., 2012). The main mass of benign tumors is more able to deform in comparison to malignant tumors. Often, when examining a benign tumor, the lesion can be identified as a false positive, e.g. a fibrous fibroadenoma or scar tissue. Thus, UE is not an appropriate tool to monitor the recurrence of a tumor after treatment, since scar tissue

often develops after surgery or radiotherapy. In addition, complications can occur after breast implant surgery, such as capsular contracture, i.e. the formation of a capsule of scar tissue around the implants, so using UE may be difficult (Rzymski, Kubasik, Opala, 2011). In other cases, the results might be identified as a false negative, e.g. in the case of mucinous cancer, cancer with an inflammatory stoma, or lesions smaller than 5 mm in diameter. During the diagnostic process for cancer with an inflammatory stoma, ordinary USG is recommended, because the morphology can indicate the malignant characteristics of lesions. Examination with both USG and UE makes the diagnosis more reliable, since the methods are complementary. The advantage of using UE is the fact that it shows the local extension of cancer, which is not always seen in USG. The image received using UE is similar to size of changes in tissue confirmed histologically (Barr et al., 2012). In the case of breast cancer, it is important to determine whether the cancer has spread to the axillary lymph nodes. Metastatic axillary lymph nodes, considering their rich vascularization, have the tendency to be more resistant to deformation in comparison to inflammatory lymph nodes (Choi et al., 2011).

Another important benefit of UE is in the diagnosis, monitoring, and treatment of chronic liver diseases that lead to fibrosis, e.g. hepatitis B virus (HBV), hepatitis C virus (HCV), or human immunodeficiency virus (HIV) infection, metabolic disease, autoimmune disease, and toxin exposure (e.g. alcohol). Comparatively 20 to 30% of patients with chronic liver disease evolve into cirrhosis. The degree of cirrhosis is described by the METAVIR score, developed by Bedossa and co-authors, members of the French METAVIR Cooperative Study Group (Bedossa et al., 1994). Until recently, liver biopsies have been the gold standard tool to assess liver disease, but now testing for blood serum markers using Fibrotest and UE assessments have become more common (Castera, 2012; Frulio, Trilluad, 2013).

During the UE examination, the patient is supine with the right arm in maximum abduction, in order to expand the intercostal spaces. One of techniques used is transient elastography. It has been described several times for liver diagnosis as it provides excellent repeatability and reproducibility (Fraquelli et al., 2007). It is recommended by the European Association for the Study of the Liver (EASL) (EASL, 2011). However, it has its limitations i.e. absence of ultrasound imaging, difficulties with examining obese people or people with narrow intercostal spaces (Frulio, Trilluad, 2013; Fraquelli et al., 2007). Another commonly used technique is ARFI. Unlike transient elastography, it allows for USG imaging of examined structures. Another advantage is the possibility of adjusting the wavelength depending on the position of the organs. Major drawbacks of ARFI include the very small measurement region and the lack of extensive validation (Karlas et al., 2011). The quasi-static method can be useful in assessing the liver in patients with ascites, but it is a non-quantitative and operator-dependent technique (Frulio, Trilluad, 2013). There has also been some research concerning the use of UE in the evaluation kidney fibrosis in chronic disease. However, due to the complicated morphology of the kidneys and their position, the analysis of the results can be more complicated in contrast to the liver, indicating the need for further research (Grenier, Gennisson, Cornelis, Le Bras, Couzi, 2013).

Ultrasound elastography in scientific research on muscles

UE can be applied in scientific research on the muscles. This paper discusses published research on humans as well as animals, performed for the quantitative evaluation of muscle stiffness. Different methods are used to assess muscle stiffness, but they have some restrictions. They are often based on a qualitative not quantitative evaluation, and most measure the stiffness of a group of muscles responsible for movement at a joint, not individual muscles. Myotonometry can be used to assess the stiffness of individual muscle. The most common device for

this purpose is the Myoton (the most recent version is the MyotonPRO). It is a hand-held device that enables the examiner to perform a non-invasive measurement of the properties of muscles, tendons, and ligaments including stiffness, elasticity, muscle tone, creep, and relaxation time. It records the responses of tissues due to deformation caused by the movement of a small probe. Based on the dynamic function of muscle, it is important to perform the examination in real-time, providing a quantitative evaluation. Shear wave elastography seems to fulfill these conditions and has become a useful tool for diagnostic purposes.

In order to validate UE for assessing of skeletal muscle stiffness, studies have been conducted on the brachialis muscle dissected from female swine (Eby et al., 2013). The specimens were positioned in a material testing machine (model 312; MTS Minneapolis, MN) for tensile testing and UE. During testing, the force was measured by a load cell (model 3397; Lebow Products; Troy, MI) and deformation of muscle was assessed on the basis of changes in the cross-sectional area (CSA). Then, using Young's modulus, muscle stiffness was evaluated. Measurements were also conducted using the SWEI technique. The probe was placed in three positions according to the long axis: parallel, perpendicularly and at a 45° angle. There was correlation between the results obtained from Young's modulus and SWEI with the probe parallel to the long axis. The results showed an increase in muscle stiffness with a higher tensile load. The results obtained perpendicularly and at a 45° probe position were apparently different from Young's modulus. This was related to the fact that shear waves propagate more efficiently along muscle fibers in comparison to propagation across fibers. For this reason, it is important to investigate muscle morphology by USG before using shear wave elastography.

Another study (Takashima, Arai, Kawamura, Hayashi, Takagi, 2017) on use of UE assessed muscle stiffness caused by a disease or disorder of the joints or muscle system. It included people suffering from temporomandibular disorders (TMD) which manifest as myofascial pain and the appearance of trigger points sensitive during palpation. The diagnostic process of TMD is not objective, because it is based on a subjective assessment by the patient and the investigator. The masticatory muscles, including the masseter muscle, were examined by researchers in Japan with use of SWEI. They examined a group of women suffering from bilateral masseter pain and compared the results to a healthy, pain-free control group of women. It was found that women with TMD were characterized by two-times greater stiffness of the masseter muscle in comparison to the healthy group. These findings indicate the usefulness UE in masseter muscle evaluations.

In order to establish the optimal force applied during massage, muscle stiffness was also examined. TMD therapy can include massage, acupuncture, manual techniques used by physiotherapists, even meditation. Additionally, therapists use oral splints and occlusal adjustments. Information about masticatory muscle stiffness might facilitate the application of force during massage and assess therapeutic progress observed as a decrease in muscle stiffness compared to the initial examination. To obtain this information, a study was conducted by Y. Ariji et al. (2009), it was performed on a healthy group of volunteers (men and women) and group of women with TMD. Measurements were taken by the same investigator, who placed the probe on the masseter muscle perpendicular to the ramus, 15 mm above the inferior border of body of the mandible. There were two measurement regions: the masseter muscle (region A; 100–125 mm^2) and the subcutaneous fat covering the masseter muscle (region B; 20 mm^2). The masseter stiffness index (MSI) was calculated. Temporomandibular joint therapy was conducted with the use of a specially constructed robot, i.e. the Waseda-Asahi Oral Rehabilitation Robot No. 1. (WAO 1). Massage was performed at different pressure forces: 1–2 N, 6–8 N, and 10 N. It was observed that patients with the lowest MSI chose most comfortable massage with 1–2 N of pressure, while those with a higher MSI chose 6–8 N and

patients with the highest MSI selected 10 N of pressure. The results showed that the evaluation of muscle stiffness by UE might help choose the optimal massage pressure and be useful in the estimation of therapeutic progress.

Another group of scientists from Korea (Park, Kwon, Kwon, 2018) evaluated the utility of UE in the examination of shortening or contraction of the sternocleidomastoid muscle (SCM) in infants with congenital muscular torticollis (CMT). Based on SCM thickness, participants were divided into two groups. Infants with an SCM thicker than 10 mm (group 1) were subdivided into two subgroups based on limitations in the passive range of motion (PROM) of neck rotation: 1S with severe and 1M with moderate limitation. Group 2 contained infants with an SCM thickness less than 10 mm. Measurements of SCM stiffness were conducted bilaterally with the ARFI technique. In group 1, the stiffness of the affected SCM was much higher compared to the unaffected one. The results showed greater stiffness of the SCM in group 1S in contrast to group 1M, with a positive correlation between muscle stiffness and PROM limitation. Furthermore, SCM stiffness in group 1 was higher than in group 2. These findings indicate that UE can be used to evaluate SCM stiffness in infants with CMT.

Although most studies use dynamic UE methods, a group from the USA (Gao et al., 2018) decided to conduct a study using strain imaging to estimate post-stroke spasticity in the biceps brachii muscle in healthy volunteers and stroke survivors. Changes in muscle length were induced by passive elbow extension (from 90° to 0° in healthy volunteers and maximally extended in stroke survivors without causing pain) and flexion, with the probe placed on the muscle belly. As an external force to deform the muscle, a 1 kg sandbag was attached to the probe. The results showed higher muscle stiffness in spastic muscles compared to non-spastic and healthy muscles. Moreover, impaired biceps brachii displacement was observed during passive extension of the elbow in spastic muscles in contrast with healthy and non-spastic muscles. This study provides evidence for the feasibility of strain imaging for estimating biceps brachii stiffness.

A recent report provided a comparison of two methods used to measure muscle stiffness, i.e. UE and myotonometry (Kelly et al., 2018). The study was conducted on three different muscles: the infraspinatus, erector spinae and gastrocnemius in healthy volunteers. Measurements were taken with the use of shear wave UE and MyotonPRO. The UE probe was placed parallel to the muscle fibers, and the MyotonPRO probe was placed in the center of the outline for the UE probe. Muscle stiffness was measured under three conditions: relaxed, 40% and 80% of maximum voluntary isometric contraction (MVIC) at a specific position for each muscle. The force of contraction was measured by a hand-held dynamometer (HHD, microFET2). In order to perform at the proper percentage of MVIC, participants observed their force biofeedback on a monitor. UE showed statistically significant differences between a contracted and relaxed erector spinae, but no significant difference between 40 and 80% of MVIC. Considering all conditions, there were no differences in the infraspinatus and gastrocnemius muscles. However, all measurements taken with MyotonPRO were significantly different. Despite the fact that the measurements were carried out by three different therapists, the intrarater reliability was good to excellent for all MyotonPRO measurements, in contrast to UE where it was generally lower. It is worth emphasizing that, in each studied muscle across all conditions, the scatter plots showed a positive correlation between UE and MyotonPRO.

Conclusions

UE is a modern medical imaging technique that can provide a quantitative and qualitative evaluation of tissue stiffness. Although it is now routinely used in medical practice, further scientific studies are needed to provide evidence for the accuracy and reliability of this technique in assessing the properties of tissue as well as structures

and organs. Initially UE, was used as a diagnostic tool in the liver, kidney and breast, but it can now be utilized to estimate muscle stiffness.

References

Ariji, Y., Katsumata, A., Hiraiwa ,Y., Izumi, M., Iida, Y., Goto, M., Sakuma, S., Ogi, N., Kurita, K., Ariji, E. (2009). Use of sonographic elastography of the masseter muscles for optimizing massage pressure: a preliminary study. *Journal of Oral Rehabilitation*, *36*, 627–635.

Balleyguier, C., Ciolovan, L., Ammari, S., Canale, S., Sethom, S., Rouhbane, R., Vielh, P., Dromain, C. (2012). Breast elastography: The technical process and its applications. *Diagnostic and Interventional Imaging*, *94*, 503–513.

Bedossa, P., Bioulac-Sage, P., Callard, P., Chevallier, M., Degott, C., Deugnier, Y., Fabre, M., Reynés, M., Voigt, J., Zafrani, E. (1994). Intraobserver and interobserver variations in liver biopsy interpretation in patients with chronic hepatitis C. *Hepatology*, *20*, 15–20.

Barr, R.G., Destounis, S., Lackey, L.B., Svensson, W.E., Balleyguier, C., Smith, C. (2012). Evaluation of breast lesions using sonographic elasticity imaging. *Journal of ultrasound in medicine*, *31*, 281–287.

Castera, L. (2012). Non-invasive methods to assess liver disease in patients with hepatitis B or C. *Gastroenterology*, *142*, 1293–1302.

Catheline, S., Thomas, J., Wu, F., Fink, M. (1999). Diffraction field of a low frequency vibrator in soft tissues using transient elastography. *IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control*, *46*, 1013–1019.

Choi, J.J., Kang, B.J., Kim, S.H., Lee, J.H., Jeong, S.H., Yim, H.W. (2011). Role of sonographic elastography in the differential diagnosis of axillary lymph nodes in breast cancer. *Journal of ultrasound in medicine*, *30*, 429–436.

Drakonaki, E. (2012). Ultrasound elastography for imaging tendons and muscles. *Journal of Ultrasound*, *12*, 214–225.

European Association for the Study of the Liver (EASL) (2011). EASL clinical practice guidelines: management of hepatitis C virus infection. *Journal of Hepatology*, *55*, 245–264.

Eby, S., Song, P., Chen, S., Chen, Q., Greenleaf, J., An, K.N. (2013). Validation of shear wave elastography in skeletal muscle. *Journal of Biomechanics*, *46*, 2381–2387.

Fatemi, M., Greenleaf, J.F. (1998). Ultrasound- stimulated vibroacustic spectrography. *Science*, *280*, 82–85.

Fatemi, M., Greenleaf, J.F. (1999). Vibro-acoustography: An imaging modality based on ultrasound- stimulated acoustic emission. *Proceedings of the national Academy of Sciences of the USA*, *96*, 6603–6608.

Franchi-Abella, S., Eloe, C., Correas, J.M. (2013). Ultrasound elastography: Advantages, limitations and artefacts of the different techniques from a study on a phantom. *Diagnostic and Interventional Imaging*, *94*, 497–501.

Fraquelli, M., Rigamonti, C., Casazza, G., Conte, D., Donato, M.F., Ronchi, G., Colombo, M. (2007). Reproducibility of transient elastography in the evaluation of liver fibrosis in patients with chronic liver disease. *Gut*, *56*, 968–973.

Frulio, N., Trilluad, H. (2013). Ultrasound elastography in liver. *Diagnostic and Interventional Imaging*, *94*, 515–534.

Gao, J., Chen, J., O'Dell, M., Li, P.C., He, W., Du, L.J., Rubin, J., Weitzel, W., Min, R. (2018). Ultrasound strain imaging to assess the biceps brachii muscle in chronic poststroke spasticity. *Journal of Ultrasound in Medicine*, *37*, 2043–2052.

Gennisson, J.L., Deffieux, T., Fink, M., Tanter, M. (2013). Ultrasound elastography: Principles and techniques. *Diagnostic and Interventional Imaging*, *94*, 487–495.

Grenier, N., Gennisson, J.L., Cornelis, Y., Le Bras, Y., Couzi, L. (2013). Renal ultrasound elastography. *Diagnostic and Interventional Imaging*, *94*, 545–550.

Karlas, T., Pfrepper, C., Wiegand, J., Wittekind, C., Neuschulz, M., Mossner, J., Berg, T., Tröltzsch, M., Keim, V. (2011). Acoustic radiation force impulse imaging (ARFI) for non-invasive detection of liver fibrosis: examination standards and evaluation of interlobe differences in healthy subjects and chronic liver disease. *Scandinavian Journal of Gastroenterology*, *46*, 1458–1467.

Kelly, J.P., Koppenhaver, S.L., Michener, L.A., Proulx, L., Bisagni, F., Cleland, J.A. (2018). Characterization of tissue stiffness of the infraspinatus, erector spinae, and gastrocnemius muscle using ultrasound shear wave elastography and superficial mechanical deformation. *Journal of Electromyography and Kinesiology*, 38, 73–80.

Nightingale, K.R., Palmeri, M.L., Nightingale, R.W., Trahey, G.E. (2001). On the feasibility of remote palpation using acoustic radiation force. *The Journal of the Acoustical Society of America*, 110, 625–634.

Ophir, J., Alam, S.K., Garra, B., Kallel, F., Konofagou, E., Krouskop, T. (1999). Elastography: Ultrasonic estimation and imaging of the elastic properties of tissues. *Proceedings of the Institute of Mechanical Engeineers*, *213*, 203–233.

Park, G.Y., Kwon, D.R., Kwon, D.G. (2018). Shear wave sonoelastography in infants with congenital muscular torticollis. *Medicine (Baltimore)*, *97*. DOI: 10.1097/MD.0000000000009818.

Rzymski, P., Kubasik, M., Opala, T. (2011). Use of shear wave sonoelastography in capsular contracture before and after secondary surgery: report of two cases. *Journal of Plastic, Reconstructive and Aesthetic Surgery*, *64*, 309–312.

Saravzyan, A.P., Rudenko, O., Swanson, S., Fowlkes, J., Emelianov, S. (1998). Shear wave elasticity imaging: A new ultrasonic technology of medical diagnostics. *Ultrasound in Medicine and Biology,* 24, 1419-1435.

Szabo, T.L. (2004). *Diagnostic ultrasound imaging inside out.* Elsevier Academic Press, 277–283.

Takashima, M., Arai, Y., Kawamura, A., Hayashi, T., Takagi, R. (2017). Quantitative evaluation of masseter muscle stiffness in patients with temporomandibular disorders using shear wave elastography. *Journal of Prosthodontic Research*, *61*, 432–438.

Wells, P.N.T., Liang, H.D. (2011). Medical ultrasound: imaging of soft tissue strain and elasticity. *Journal of the Royal Society Interface*, *8*, 1521–1549.

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SELF-ESTEEM OF PEOPLE WHO PRACTICE SPORT IN RELATION TO THEIR EXPERIENCING THE FLOW STATE AND THEIR STYLE OF COPING WITH STRESS

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Abstract The purpose of this work was to ascertain the association of the level of athletes' self-esteem with their stress management and experiencing the *flow* state. The study included 56 men and 18 women, aged 19 to 25, who practiced sport and lived in Gorzów Wielkopolski and its vicinity. The following tools were employed: the Rosenberg Self-Esteem Scale, N.S. Endler and J.D. Parker's Coping Inventory for Stressful Situations (CISS), and S. Jackson and D. Eklund's Flow State Scale – 2. For the analysis of variables descriptive statistics, correlation measures (Pearson's *r*) and regression analysis were used. It was found that there is a positive correlation at the level of 0.05 between high self-esteem and the task-oriented style of coping with stressful situations, and a significant negative correlation at the level of 0.01 between self-esteem and the emotion-oriented style of stress management. The level of self-esteem also correlates with experiencing the *flow* state. Self-esteem is an important predictor of the method of coping with stressful situations and experiencing the *flow* state. People with higher self-esteem achieve the state of a kind of felicity, an autotelic experience. They are aware of their own abilities, have the feeling that they effortlessly control their situation and themselves, and can distance themselves from the surrounding environment. In a stressful situation, they focus on the problem.

Key words self-evaluation, *flow*, stress, style of coping, athletes

Introduction

One of the ways good life is expressed is through a sense of successful coping with all adversities that are an integral part of human existence. It is connected with the willingness to experience satisfaction with actions taken on the one hand, and with the ability to cope with difficult situations on the other.

The flow state indicates optimal engagement, elation associated with the state of mind in a situation of taking actions in which the challenges correspond to the skills, and where the objective is not the result but the action itself.

One of the main assumptions of the flow experience is that the challenges must match the skills (Csikszentmihalyi, 2005).

An individual style of coping with difficulties (Endler, Parker, James, 1994) means putting emphasis on a certain general and more abstract way of taking action, superior to the choice of strategy, manifested in longer time perspectives, and in the assessment of distant consequences, concerning e.g. health, social functioning or sport achievements. This kind of approach offers the basis for the search for people's individual preferences in coping with stress, also in the field of sport.

Out of many personality characteristics, self-esteem and self-evaluation seem to be especially significant determinants of the way people function in the physical, social and mental spheres. For example, children who successfully cope with school requirements become convinced of their own competences. The kind of feedback received and the way it is interpreted has a very strong influence on a person's self-image (Harter, Whitesell, 2003).

Self-esteem is a conviction of the positivity and importance of one's self, which is strongly connected with the level of one's self-evaluation, defined as the anticipation of one's own capacity, depending on the tasks and circumstances (Epstein, 1992). Self-esteem denotes subjective experiencing of oneself as a value, and its indicator is a comprehensive self-evaluation, being a subjectively experienced overall evaluation of oneself (Rosenberg, Schooler, Schoenbach, Rosenberg, 1995). M. Rosenberg and psychologists of social learning treated the sense of personal value or valuableness as a relatively permanent trait of personality, measured by self-evaluation, being a measure of a person's well-being.

The pursuit of a high self-esteem plays an important role in human life. People seek to achieve success in areas which are important for them, thus satisfying, as some researchers argue, one of the primary needs. A high self-esteem can also be instrumental, as it brings several benefits, such as a sense of security in social relations, which eliminates rejection and exclusion, or a diminished fear of death (Pyszczyński's concept of anxiety control) (Solomon, Greenberg, Pyszczyński, 1991). It is also an important determinant of efficiency and the feeling of satisfaction with the work done (Kuster, Orth, Meier, 2013). Such benefits stemming from a high self-esteem can determine the way a person functions. They can, for example, be inclined to experience positive emotions, look upon themselves and the world optimistically, and have confidence as to the effectiveness of their own actions.

It is therefore to be expected that individuals with a high self-esteem will exhibit the characteristics of an autotelic personality, inclined to experience elation only when that self-esteem is based on real and authentic inner qualities, and not on the conviction that it is conditioned by personal achievements. The aspiration to put continually increasing demands upon oneself and, most of all, the striving for recognition of other people, are the basis of a high self-esteem, but can also be a source of stress. Seeking external gratification will be an obstacle to achieving optimal engagement and satisfaction with actions taken. The constant search for confirmation of one's greatness is connected with an exaggerated sense of self-magnitude in narcissistic people (Brummelman, Thomaes, Sedikides, 2016; Leckelt, Küfner, Nestler, Back, 2015).

Self-esteem is significantly related to stress. On the one hand, it influences the way stressogenic stimuli are treated and the choice of strategies for coping with them, and on the other hand, the experience of stress can lead to a lower self-esteem and contribute to a greater sense of insecurity, and non-adaptive responses (Doyle, Slaven, 2004). Most studies show that people with a high self-esteem are strong, mentally resilient and able to cope with threats and challenges. They treat challenges as new opportunities, stimulating and motivating them to take action, inspiring them to pursue new achievements and to draw satisfaction from them. People with a low

self-esteem, in turn, are less resistant to difficult situations, lack confidence in their own abilities. As a result, depressive behaviors may occur (Lee, Hankin, 2009) and sometimes antisocial behaviors such as aggression and crime (Donnellan, Trzesniewski, Robins, Moffitt, Caspi, 2005). The study of volleyball players, by Terelak (2008), indicates that self-evaluation influences the style of coping with stress. A higher level of self-evaluation correlates with the task-oriented style. The lower the self-evaluation, the more likely volleyball players (both female and male) are to use the style that focuses on emotions.

People who practice sports are characterized by an optimistic attitude, self-esteem, self-reliance, and desire to overcome obstacles and win. They feel that everything depends on their own strength, skills and abilities, as well as their self-discipline and strong belief in their own effectiveness, resilience and perseverance (Laborde, Guillén, Mosley, 2016).

The aim of the present work was to ascertain the relationship of self-evaluation with coping with stress and experiencing the flow. From the point of view of psychologists and pedagogues, these variables are crucial for educational interactions, which enable young people to successfully cope with the requirements of their environment and make it possible to achieve satisfaction with their lives.

The following hypotheses were made:

1. There is a relationship between self-esteem of people who practice sport and their experiencing the flow phenomenon.
2. There is also a relationship between athletes' self-esteem and their style of coping with stressful situations.

Material and methods

In the study purposeful sampling was used, involving the selection of subjects who had a defined (desirable) property or experience relevant to the purpose of the study. The study embraced 74 people practicing sports at a competitive level, ranging in age from 19 to 25, including 18 women and 56 men. The subjects were mostly athletes studying at the Faculty of Physical Culture in Gorzów Wielkopolski, being a branch of the University School of Physical Education in Poznań, as well as people training in sports clubs in the Gorzów region.

The average length of sports practiced by the respondents is 9.39± years. Most athletes (60.8%) practiced team sports such as football, volleyball or handball. They represented teams that had been oscillating between the first and the third leagues in recent years. Individual sports were practiced by 39.2% of the athletes, among whom canoeists were at a particularly high level.

In the operationalization of variables, M. Rosenberg's *Self-Esteem Scale* was used (Laguna, Lachowicz-Tabaczek, Dzwonkowska, 2007), as well as N.S. Endler and J.D.A. Parker's *Coping Inventory for Stressful Situations* (CISS) (Strelau, Jaworowska, Wrześniewski, Szczepaniak, 2005), and S. Jackson and D. Eklund's *Flow State Scale – 2*.

The self-esteem questionnaire is a tool that makes it possible to determine the level of general self-esteem, regarded as a relatively constant disposition to take a conscious attitude – positive or negative – toward Self. The scale consists of 10 diagnostic statements that have a high internal consistency of most scales (Cronbach's *alpha* coefficients for different age groups range from 0.81 to 0.83). The range of results obtained during the questionnaire survey is between 10 and 40. The higher score a person gets on a scale, the higher self-esteem level they have.

Endler and Parker developed a questionnaire that ascertains one's style of coping with stress. The questionnaire has a high internal consistency of particular scales, as Cronbach's *alpha* coefficients range from 0.78 to 0.90 (Szczepaniak, Strelau, Wrześniewski, 1996).

Flow State Scale – 2 is a tool developed by Jackson and Eklund to measure optimum involvement in a group of athletes. The questionnaire consists of 36 statements, and individuals can score between 36 and 180 points. The overall score consists of 9 dimensions: challenge-skill balance, action-awareness merging, setting clear goals, receiving feedback, concentration on the task at hand, paradoxical loss of control, loss of self-consciousness, time transformation, and one of the main and necessary conditions, namely the autotelic experience. The questionnaire is a tool that has a high internal consistency in the nine subscales and the general *flow* scale, as indicated by Cronbach's *alpha* coefficients ranging from 0.80 to 0.90 (Koehn, 2007).

The *Flow State Scale – 2* questionnaire was adapted for the purpose of this study. The translation of the original version was carried out by three independent people. Out of the options offered, the convergent ones were chosen, and they were further modified so that they both sound correct in the Polish language and accurately render the essence and content of each scale. Following the survey, information concerning comprehensibility and clarity of the set statements was collected. In the present study, Cronbach's *alpha* coefficients were lower and ranged from 0.58 to 0.78.

The results presented in this paper are part of research carried out since 2014 in Gorzów Wielkopolski at the Faculty of Physical Culture of the University School of Physical Education in Poznań into psychological determinants of competitive sport, including the formation of athletes' self-esteem.

The research was carried out in a correlation-regression model, which in the case of analyzing the relationship between self-esteem and optimal engagement and stress coping style, becomes the one-variable – multi-variable variant. In the analysis of the variables, descriptive statistics, correlation measures (Pearson's *r*) and regression analysis were used.

Results

The average self-evaluation score obtained by the subjects was 28.64 points (Table 1). Half of the subjects scored 29 points or fewer, and half scored 29 or more, which indicates a fairly high level of self-evaluation among the respondents, but lower than in the comparable 19–24 age group (Laguna et al., 2007).

Out of the three coping styles, the task-oriented one had the highest average (57.49), which indicates its dominance among both male and female athletes who practice sports at a competitive level. The level of the emotion-oriented style of coping with difficulties was slightly lower: this was caused by the difference in the results between the genders. As expected, women were characterized by a higher level of the emotion-oriented coping style.

The average score for the flow state experience amounted to 130.28 points. The examined athletes declared a fairly good ability to experience optimal engagement. The score obtained by the greatest number of the subjects was 124. Clear goals and willingness to derive pleasure from sport and rivalry were the most commonly chosen flow dimensions. Autotelic experience is an action that is an end in itself, performed not for reward, but for the sole pleasure of doing it. According to Csikszentmihalyi (2005), it transfers a person to a higher level, justifying life in the present, bringing freedom from the necessity of attaining future goals. The athletes had the greatest difficulty with

getting rid of self-consciousness, which is expressed in being somewhat carried away, not thinking about oneself or the people watching, thereby expanding the boundaries of one's own being.

Table 1. Descriptive statistics for the subscales of the Coping Inventory for Stressful Situations (CISS), the Flow State Scale – 2 and the SES

Scale	Subscale	Min	Max	Average $\bar{x}$	Standard deviation
SES		21	39	28.64	3.61
CISS	Task-oriented style	40	74	57.49	7.03
	Emotion-oriented style	27	69	50.14	7.98
	Avoidance	21	44	33.32	5.54
	Distraction	11	31	23.55	4.55
	Social Diversion	7	25	17.69	3.46
Flow State Scale – 2	Flow	89	175	130.28	18.81
	Clear goals	10	20	15.91	2.40
	Challenge-skill balance	7	20	14.89	2.69
	Concentration on task	7	20	14.08	2.49
	Paradox of control	4	20	14.72	3.16
	Unambiguous feedback	9	20	14.19	2.51
	Action-awareness merging	7	20	13.66	2.70
	Time transformation	7	20	13.92	2.56
	Loss of self-consciousness	4	20	13.31	4.73
	Autotelic experience	8	20	15.61	2.97

The correlation results shown in Table 2 a significant positive correlation at the 0.05 level. It points to interconnections between the level of optimal engagement and the level of self-evaluation.

Table 2. Results of Pearson's *r* correlation between self-esteem and the *flow* scales

Flow scales	Self-esteem scale
Flow	0.24*
Clear goals	0.19
Challenge-skill balance	0.34**
Concentration on task	0.09
Paradox of control	0.37**
Unambiguous feedback	0.23
Action-awareness merging	–0.22
Time transformation	–0.06
Loss of self-consciousness	0.25*
Autotelic experience	0.28*

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

As far as the scales which make up the overall flow result are concerned, significant positive correlations could be observed at the 0.01 level in the challenge-skill balance scale, and in the control paradox scale. Athletes with

a high level of self-evaluation were aware of their own competencies, and therefore could meet the demands of the situation and control their thoughts, emotions and behavior. Significant positive correlations at the 0.05 level occurred between the self-evaluation level and the loss of self-consciousness and the autotelic experience. Individuals with a high self-evaluation do not pay attention to surrounding people, to how they are judged or perceived by others, seeking positive experiences and satisfaction in each occurrence.

Table 3. Results of Pearson's *r* correlation between self-esteem and the stress coping style

Styles	Self-esteem scale
Task-oriented style	0.30*
Emotion-oriented style	–0.52**
Avoidance style	–0.15
Distraction	0.08
Social Diversion	–0.04

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

Table 3 contains the correlation results which verify the hypothesis. There was a positive correlation at the 0.05 level, indicating interconnections between a high self-esteem and the task-oriented style of coping with a stressful situation. It is self-esteem and confidence in one's own competences and ability to perform tasks that prove helpful in difficult situations, resulting in a rational, task-oriented approach to the problem. The results also revealed the relationships which ascertained a significant negative correlation between self-evaluation and the emotion-oriented coping style. The determination coefficient was 0.265, so the emotion-oriented style of coping with stress in 26.5% of the competition-level sportspeople can be explained by their low self-evaluation. Based on the regression analysis (Table 4), self-esteem can be assumed to be an important predictor of the methods of coping with difficult, stressful situations, as well as experiencing the flow state.

Table 4. Significance of the full regression model

Dependent variables	R	R^2	df model	df residual	F	p
Flow	0.24	0.06	1	72	4.48	0.03
Clear goals	0.19	0.03	1	72	2.56	0.11
Challenge-skill balance	0.34	0.12	1	72	9.57	0.00
Concentration on task	0.09	0.01	1	72	0.55	0.46
Paradox of control	0.37	0.13	1	72	11.08	0.00
Unambiguous feedback	0.23	0.05	1	72	3.88	0.05
Action-awareness merging	0.22	0.05	1	72	3.53	0.06
Time transformation	0.06	0.00	1	72	0.30	0.59
Loss of self-consciousness	0.25	0.06	1	72	4.65	0.03
Autotelic experience	0.28	0.08	1	72	6.18	0.01
Task-oriented style	0.3	0.09	1	72	6.94	0.01
Emotion-oriented style	0.52	0.27	1	72	26.05	0.00
Avoidance style	0.15	0.02	1	72	1.65	0.20

R – multiple correlation coefficient; R^2 – multiple determination factor; F and p – significance of the entire regression model.

Discussion

Experiencing the flow state is a mental process that allows an individual to define precisely their body and spirit capabilities. This is difficult to achieve with low self-esteem and the emotion-oriented style of coping with stress. The experience of optimal engagement during sport rivalry seems to be possible when a person becomes self-confident and can rationally approach every situation, with the focus on resolving the problem.

An important aspect of the educational influence has been the building of high and stable self-evaluation of the athlete, which is the basis for predicting one's own capabilities. Baumeister et al., pointing to the undisputed benefits of high self-evaluation, emphasize that individuals with high self-evaluation feel that they are better and happier people and show greater initiative, also in interpersonal contacts (Baumeister, Campbell, Krueger, Vohs, 2003). High evaluation is an effective stress buffer for them. These positive aspects of high self-evaluation were confirmed in the present study. However, in his deliberations on self-evaluation Baumeister undermines the essence of high self-evaluation, and most of all the various types of impact aimed at its elevation.

A similar approach to self-evaluation is presented by Cocker and Park (2003) and Gustafsson et al., who point to the costs associated with pursuing goals whose realization is to be a confirmation of self-esteem (Gustafsson, Martinent, Isoard-Gautheur, Hassmen, Guillet-Descas, 2018). The authors believe that the pursuit of high self-evaluation interferes with making social relationships, learning, competence development, autonomy, self-regulation, and physical and mental health. According to Deci and Ryan (2000), orientation toward developing the natural need for competence, autonomy and relatedness should become the basis of our interactions in different areas of life, including sport. Realization of these needs increases internal motivation, self-regulation and well-being. The most important role in education is played by parents; their influence is stronger than that of the coach. Research shows that parents' initiating a favorable environment which is motivating for development, is a significant predictor of the levels of self-evaluation, anxiety as a quality, and autonomous regulation in future years (O'Rourke, Smith, Smoll, Cumming, 2014).

According to F.R. Baumeister et al. (2003), it is achievements that raise self-esteem, and not vice versa. Therefore, it becomes crucial that the work with athletes should be oriented toward developing perseverance and ability to pursue their own goals and ideals. Thus, self-control and self-discipline, which can be shaped and developed from an early age, are definitely more important components of one's personality. This development of self-control brings far more benefits. Higher self-control correlates with higher self-evaluation, better relationships and interpersonal skills, regulation of emotional reactions, a sense of security and decreased psychopathological behavior, as well as alcohol and food abuse (Tangney, Baumeister, Boone, 2014).

Such reformulation encourages a slightly different view on the education of a child and an athlete, with perseverance, diligence, self-discipline, composure and self-control at its core, which leads to achievements and success, and consequently to high self-esteem. Physical activity and sport develop these qualities and bring many different psychological, social and health benefits such as higher self-evaluation, improved social interactions, and decreased depressive symptoms (Eime, Young, Harvey, Charity, Payne, 2013). Physical activity improves the quality of life not only for the elderly, but also for adolescents, and the mediating factors are self-evaluation of one's physical competences and a sense of self-efficacy (Joseph, Royse, Benitez, Pekmezi, 2014; Piasecka, Kolmetz, Kotyśko, Stankiewicz, 2018). According to research (Noordstar, Van der Netb, Jakc, Heldersb, Jongmansd, 2016), physical activity and the perception of athletic competencies correlate, especially in girls, with global self-evaluation,

but this has not been confirmed for boys, who have a higher level of athletic competencies and are more physically active than girls.

It seems that physical activity may be an important preventive factor, especially in the context of research which reports that both the level of and change in self-evaluation have served as predictors for depression occurrence. Individuals who entered adolescence with low self-evaluation and/or their self-evaluation lowered in adolescence, were more likely to display symptoms of depression in adulthood (Steiger, Allemand, Robins, Fend, 2014).

Therefore, the realization of one's goals should not only be connected with the affirmation of self-esteem, but with other needs of an individual. Research shows that greater joy of practicing sports will over time result in higher self-evaluation among young people, and higher self-evaluation, in turn, increases the pleasure of practicing sports. These studies suggest that the pleasure brought by practicing sport may be more important for self-evaluation than the frequency with which young people practice (Adachi, Willoughby, 2014). Thus, the desired skill that can be developed even in young children is experiencing flow. In fact, it often comes to maintaining this skill, because small children have a natural inclination to take actions which they enjoy. It is often the adult world that expects certain results of actions taken, which are more important than the actions themselves. Therefore, one's ability to set clear goals for themselves, adjusted to their capacity, using feedback, concentrating on the task at hand, paradoxical loss of control, separating oneself from other people's judgment and the passage of time, and finally the ability to derive pleasure from what one is doing becomes a potential for experiencing a good and happy life.

Conclusions

1. An important predictor of the method of coping with stress and of experiencing the flow state by individuals who practice sport is their level of self-esteem.

2. Athletes higher self-esteem is an indicator of their achieving the state of optimal engagement, which determines how effective their actions are, as well as how much pleasure they derive from their activities. Thus, it can be assumed that people with higher self-esteem experience the state of a kind of felicity, an autotelic experience. They are aware of their own abilities, they have the feeling that they effortlessly control their situation and themselves; at the same time, they can distance themselves from the surrounding environment.

3. The results of this study show that people with high self-esteem will prefer the task-oriented style of coping with stress, while people with low self-esteem will tend to cope with problems emotionally in difficult situations.

References

Adachi, P.J.C., Willoughby, T. (2014). It's Not How Much You Play, but How Much You Enjoy the Game: The Longitudinal Associations Between Adolescents' Self-Esteem and the Frequency Versus Enjoyment of Involvement in Sports. *Journal of Youth and Adolescence*, *43* (1), 137–145. DOI: 10.1007/s10964-013-9988-3.

Baumeister, R.F., Campbell, J.D., Krueger, J.I., Vohs, K.D. (2003). Does high self-esteem cause better performance, interpersonal success, happiness, or healthier lifestyles? *Psychological Science in the Public Interest*, *4* (1), 1–44. DOI: 10.1111/1529-1006.01431.

Brummelman, E., Thomaes, S., Sedikides, C. (2016). Separating Narcissism From Self-Esteem. *Current Directions in Psychological Science*, *25* (1), 8–13. DOI: 10.1177/0963721415619737.

Crocker, J., Park, L.E. (2004). The Costly Pursuit of Self-Esteem. *Psychological Bulletin*, *130* (3), 392–414. DOI: 10.1037/0033-2909.130.3.392.

Csikszentmihalyi, M. (2005). *Flow.* Taszów: Biblioteka Moderatora.

Deci, E.L., Ryan, R.M. (2000). Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions. *Contemp Educ Psychol*., *25*, 54–67. DOI: 10.1006/ceps.1999.1020.

Donnellan, M.B., Trzesniewski, K.H., Robins, R.,W., Moffitt, T. E., Caspi, A. (2005). Low Self-Esteem Is Related to Aggression, Antisocial Behavior, and Delinquency. *Psychological Science*, *16* (4), 328–335. DOI: 10.1111/j.0956-7976.2005.01535.x.

Doyle, Ch., Slaven, G. (2004). The relationship between negative behavior in affects and unfavorable reactions for stressors. In: J. Strelau (ed.), *Personality and extreme stress* (pp. 141–166). Gdańsk: GWP.

Eime, R.M., Young, J.A., Harvey, J.T., Charity, M.J., Payne, W.R. (2013). A systematic review of the psychological and social benefits of participation in sport for children and adolescents: informing development of a conceptual model of health through sport. *International Journal of Behavioral Nutrition and Physical Activity*, *10* (1). DOI: 10.1186/1479-5868-10-98.

Endler, N.S., Parker, J.D.A., James D.A. (1994). Assessment of multidimensional coping: Task, emotion, and avoidance strategies. *Psychological Assessment*, *6* (1), 50–60. DOI: 10.1037/1040-3590.6.1.50.

Epstein, S. (1992). Coping ability, negative self-evaluation, and overgeneralization: Experiment and theory. *Journal of Personality and Social Psychology*, *62* (5), 826–836. DOI: 10.1037/0022-3514.62.5.826.

Gustafsson, H., Martinent, G., Isoard-Gautheur, S., Hassmen, P., Guillet-Descas, E. (2018). Performance based self-esteem and athlete-identity in athlete burnout: A person-centered approach. *Psychology of Sport and Exercise*, *38*, 56–60. DOI: 10.1016/j.psychsport.2018.05.017.

Harter, S., Whitesell, N.R. (2003). Beyond the Debate: Why Some Adolescents Report Stable Self-Worth Over Time and Situation, Whereas Others Report Changes in Self-Worth. *Journal of Personality*, *71* (6), 1027–1058. DOI: 10.1111/1467-6494.7106006.

Joseph, R.P., Royse, K.E., Benitez, T.J., Pekmezi. D.W. (2014). Physical activity and quality of life among university students: exploring self-efficacy, self-esteem, and affect as potential mediators. *Quality of Life Research*, *23* (2), 659–667. DOI: 10.1007/s11136-013-0492-8.

Koehn, S. (2007). Propensity and attainment of flow state. Melbourne: Victoria University.

Kuster, F., Orth, U., Meier, L.L. (2013). High self-esteem prospectively predicts better work conditions and outcomes. *Social Psychological and Personality Science*, *4* (6), 668–675. DOI:10.1177/1948550613479806.

Laborde, S., Guillén, F., Mosley, E. (2016). Positive personality-trait-like individual differences in athletes from individual- and team sports and in non-athletes. *Psychology of Sport and Exercise*, *26*, 9–13. DOI:10.1016/j.psychsport.2016.05.009.

Laguna, M., Lachowicz-Tabaczek, K., Dzwonkowska, I. (2007). The Rosenberg Self-Esteem Scale – Polish adaptation of the method. *Psychologia Społeczna*, *2* (04), 164–176.

Leckelt, M., Küfner, A.C.P., Nestler, S., Back, M.D. (2015). Behavioral processes underlying the decline of narcissists' popularity over time. *Journal of Personality and Social Psychology*, *109*, 856–871. DOI: 10.1037/pspp0000057.

Lee, A., Hankin, B.L. (2009). Insecure Attachment, Dysfunctional Attitudes, and Low Self-Esteem Predicting Prospective Symptoms of Depression and Anxiety During Adolescence. *Journal of Clinical Child & Adolescent Psychology*, *28* (2), 219–231 DOI: 0.1080/15374410802698396.

Noordstar, J.J., Van der Netb, J., Jakc, S., Heldersb, P.J.M., Jongmansd, M.J. (2016). Global self-esteem, perceived athletic competence, and physical activity in children: A longitudinal cohort study. *Psychology of Sport and Exercise*, *22*, 83–90. DOI: 10.1016/j.psychsport.2015.06.009.

O'Rourke, D.J., Smith, R.E., Smoll, F.L., Cumming, S.P. (2014). Relations of Parent-and Coach-Initiated Motivational Climates to Young Athletes' Self-Esteem, Performance Anxiety, and Autonomous Motivation: Who Is More Influential? *Journal of Applied Sport Psychology*, *26* (4), 395–408. DOI: 10.1080/10413200.2014.907838.

Piasecka, A., Kolmetz, M., Kotyśko, M., Stankiewicz, B. (2018). Subjective and objective valuation of one's physical fitness – the role of self-esteem, motivation, and the need for social approval. *Journal of Education, Health and Sport*, *8* (01), 280–293.

Rosenberg, M., Schooler, C., Schoenbach, C., Rosenberg, F. (1995). Global Self-Esteem and Specific Self-Esteem: Different Concepts, Different Outcomes. *American Sociological Review*, *60* (1), 141–156.

Solomon, S., Greenberg, J., Pyszczynski, T. (1991). A Terror Management Theory of Social Behavior: The Psychological Functions of Self-Esteem and Cultural Worldviews. *Advances in Experimental Social Psychology*, *24*, 93–159. DOI: 10.1016/S0065-2601(08)60328-7.

Steiger, A.E., Allemand, M., Robins, R.W., Fend, H.A. (2014). Low and decreasing self-esteem during adolescence predict adult depression two decades later. *Journal of Personality and Social Psychology*, *106* (2), 325–338. DOI: 10.1037/a0035133.

Strelau, J., Jaworowska, A., Wrześniewski, K., Szczepaniak, P. (2005). Coping with Stress Questionnaire. Textbook, Psychological Testing Laboratory of the Polish Psychological Association. Warszawa: Pracownia Testów Psychologicznych Polskiego Towarzystwa Psychologicznego.

Szczepaniak, P., Strelau, J., Wrześniewski, K. (1996). Diagnosis of coping styles with the use of the Polish version of Endler and Parker's CISS. *Przegląd Psychologiczny*, *39*, 113–146.

Tangney, Cz.P., Baumeister, R.F., Boone, A.L. (2014). High Self-Control Predicts Good Adjustment, Less Pathology, Better Grades, and Interpersonal Success. *Journal of Personality*, *72* (2), 271–324. DOI: 10.1111/j.0022-3506.2004.00263.x.

Terelak, J.F. (2008). *Man and stress*. Bydgoszcz-Warszawa: Oficyna wydawnicza Branta.

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