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LIMITED ENGLISH-PROFICIENT STUDENTS: ANALYSIS OF SUBJECTIVE EXPERIENCES

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ABSTRACT

Background. Many long-term adolescent and adult learners experience persistent academic underachievement in English in spite of many years of schooling. Students pertaining A2 level can be classified as Limited English-Proficient Learners who have not acquired English proficiency as required by the university, state and European guidelines. Research aim was to analyse the perceptions of underachieving students of reasons of their failure to gain English language proficiency of the required level aiming at increasing the knowledge on the problem and providing possible solutions for improvement.

Methods. Participants' perceptions of their underachievement reasons were elicited through individual unstructured in-depth interviews. Data analysis occurred concurrently with data collection using grounded theory as a method for analysing the data. Member checks with several research participants, reflexive journaling and peer debriefing were also utilized to ensure trustworthiness of the study.

Results. The examination of interview transcripts revealed two big themes concerning the students' underachievement in the English language: internal and external causes for being limited English-proficient learner. External causes were conditions for learning English at school and at the university: poor learning in primary grades, underestimated value of knowing and learning English at school, inadequate conditions for informal learning, and poor organization of English lessons. University factors mentioned were too few contact hours for English classes, inconvenient time-table, and lack of time due to other activities. Internal factors were fear to look unacceptable (resulting in the inactivity in the classes), lack of self-confidence, too much self-criticism, laziness, procrastination, finding faults with others, inadequate perception of the course, poor attitudes towards the course, lack of internal motivation, rating the module of English as a second-rate course, not knowing how to learn the language, and, what is most important, absence of self-study skills.

Conclusions. Internal factors conditioning underachievement in the English language proved to be much more important than the external ones. Poor self-esteem, lack of motivation and poor attitudes towards the course suggest the need of the individualization of teaching/learning and psychological counselling. Lack of self-study skills can predict poor academic achievements in other university courses, which could result in drop-outs. This suggests the need of coaching students in learning skills. The collected data show that the teacher also plays a crucial role in language learning, however, the wider societal, cultural and psychological context should be articulated in further possible research as well. Study programmes at tertiary level should be designed to encourage both internal and external motivation of students to study foreign languages as an indispensable factor for developing a full-rate personality.

Keywords: limited English – proficient learners, qualitative research, underachievement.

INTRODUCTION

Many long-term adolescent and adult learners experience persistent academic underachievement in English in spite of many years of schooling. Underachievers exhibit a severe discrepancy between expected achievement (as measured by standardized achievement scores or cognitive as well as intellectual ability assessment) and actual achievement (as measured by class grades and teacher evaluations) (Reis & McCoach, 2002). At the college level, underachievement stems from either underprepared students or students who do not perform to expected standards (Bailey, Hughes, & Karp, 2003; Nelson, 1998). Haycock and Huang (2001) found that nearly 50% of college students were not academically prepared.

Students pertaining A2 level can be classified as Limited English-Proficient Learners (Won & Shernaz, 2014) who have not acquired English proficiency as required by the university, state and European guidelines. In the countries where students cannot use their own language to study university subjects academic underachievement in the English language usually results in undesirable educational outcomes, including low engagement, high retention and drop-out rates.

The academic achievements of Limited English-Proficient (LEP) students have long been a major educational concern in many countries because students in many non-English speaking countries have to be able to use English as a tool for learning subject matter at school or university. In the countries that English is not spoken as the mother tongue, programs in university education are targeted for foreign language learning (FLL) – which involves learning the target language in academic settings without regularly interacting with the target language community (typical European FLL environment). Hashemi (2011) suggests that students' weakness in English language learning is due to the differences of social contexts as well as cultural environments in different countries. Often, LEP students become proficient in communication skills; however, they encounter difficulties understanding and completing tasks in the more cognitively-demanding English language needed for successful performance in academic subjects (Lewelling, 1991).

Little research has been conducted on the issues relating to underachieving students' academic challenges. Although learners are the focus of the improvement of the study quality, their opinions are insufficiently taken into consideration. Students' academic performance may be closely related to how they perceive their studies and difficulties they encounter. Our understanding of the problem can be increased by students' educational experiences. Thus, our ***research question*** was as follows: what are underachieving students' perceptions of reasons of their failure to gain English language proficiency of the required level? ***Research aim*** was to analyse the perceptions of underachieving students of reasons of their failure to gain English language proficiency of the required level aiming at increasing the knowledge on the problem and providing possible solutions for improvement.

METHODS

Data collection. Data were collected in the spring semester of 2015. Participants' perceptions of their underachievement reasons were elicited through individual unstructured in-depth interviews. After explaining the purpose of the study and receiving the students' agreement to participate in the research, students were asked to reflect on the question: *Why don't I succeed in learning English?* Students were given no orientating questions; they were only encouraged to expand on the topic by short stimulating phrases (*OK, anything else,* etc.)

Research participants were students from two Lithuanian universities specializing in sport, physical fitness, health sciences and law. They were selected using the *Criterion sampling strategy* (participants were chosen because they had the particular features, characteristics and specific experiences). All in all, 54 participants were interviewed. The general principle that guided the sample size was the saturation of data, i.e. the redundancy of the further data obtained. Each interview lasted from five to 15 minutes. Contextual influences were considered as well.

Research participants were allowed to speak in their native (Lithuanian) language so that they did not have difficulties in providing genuine thoughts. The translation of the participants' responses and its linguistic validation were carried out by all the authors of the present research paper. The linguistic validation process consisted of three phases: forward translation (form Lithuanian into English), backward translation (from English to Lithuanian), and the preparation of the English version of transcripts (comparisons of both Lithuanian variants making the necessary amendments in the English version of the interview transcripts).

Data processing. Data analysis occurred concurrently with data collection using grounded theory as a method for analysing the data (Mills, Bonner, & Francis, 2006; Pitney & Parker, 2009).

Transcribed data were divided into meaningful units with descriptive labels or categories, and categories that emerged from data were clustered into themes. Categories and themes were adjusted as data continued to be gathered and analysed.

Triangulation was used to ensure that the findings accurately reflected the situation. Member checks with several research participants, reflexive journaling and peer debriefing (with seven randomly chosen English language teachers from four Lithuanian universities, who were also given the same question) were also utilized to ensure trustworthiness of the study (Pitney & Parker, 2009).

RESULTS

The initial examination of interview transcripts revealed two big themes concerning the students' underachievement in the English language: internal and external causes for being limited English-proficient learner. Internal causes are certain personal qualities that might have affected students' learning achievements (poor self-esteem, motivation attitudes, self-discipline, etc.). External causes mentioned were conditions for learning English at school and at the university. The categories and subcategories which emerged from the data together with examples from the transcripts as illustrations are given in Tables 1 and 2.

Table 1. **Internal causes of underachievement in English**

Category	Subcategory	Illustrations
Poor self-esteem	Fear to look unacceptable	*"I am afraid to say a word not to look stupid"* *"my pronunciation is bad, and I am afraid to speak because I don't want to be humiliated"* *"I become nervous and stressed when I have to show my knowledge, so I fail"*
	Lack of self-confidence	*"I have very poor memory and I will never be able to memorize things"* *"I am not good at many other courses"* *"I don't have a talent for languages"* *"I don't have the fundamentals of the language"* *"I am afraid to speak in front of the class because I think I will fail"* *"I can understand something in the classroom, but I don't understand anything when I have to do my homework"*
	Too much self-criticism	*"I am very self-critical and always unhappy with my learning outcomes"* *"I believe I have very poor memory"* *"I feel discomfort because I am always worse than others"* *"I am not good at all languages, including Lithuanian"*
Poor self-discipline	Laziness	*"I learnt to be lazy at school and I am still lazy now"* *"all students are lazy including me"* *"I cheated during English tests"* *"I didn't learn the language at school and now I have no will-power to change the situation for the better"*
	Procrastination	*"I always delay learning English because I want to do what is more interesting to me"* *"learning English takes too much time, so often I don't even start doing the homework"* *"first I spend my time learning more important subjects, then there remains no time for English"*
	Finding faults with others	*"at school I had a very bad teacher who did not know how to teach"* *"our teacher at school was rather permissive"* *"I was learning English in a village school"* *"I wasn't made to learn seriously, so I did not learn"* *"my English teacher used to laugh at me whenever I made mistakes"* *"the teacher at school did not help us improve"* *"our teacher at school paid attention only to those who succeeded, others could do whatever they wanted"* *"life has been unfair to me: no strict parents, brothers or sisters who could push me"* *"Our psychology teacher has told us that a person cannot be good at all things. I have a talent for other things. Not knowing English is in my genes"* *"nobody has invented the most effective way how to achieve the necessary level of English"*

table 1 continued

Category	Subcategory	Illustrations
Unfavourable personal attitudes	Inadequate perception of the course	*"English is a very difficult language with too many tenses and complicated constructions"* *"too much learning by heart"* *"learning English means memorizing many things, which is very hard"* *"it is impossible to learn English without hiring a tutor"*
	Poor attitudes towards the course	*"I have hated English since the elementary grades"* *"I don't have any wish to communicate in that language"* *"I don't see chances to get interested in the English language"* *"learning English is a waste of time, I need time for more serious courses"* *"inappropriate attitude is the biggest obstacle"* *"Students, including me, simply don't understand the purpose of self-study hours. They think that at that time they are free, and usually they find jobs"*
Poor motivation	Lack of internal motivation	*"I don't need to know English at B2 level, I will never go abroad"* *" I am sure I will not need English in my speciality, and I won't need writing for sure"* *"I don't have motivation to learn and I don't understand how to become motivated"*
	Rating the module of English as a second-rate course	*"at the university I am concentrated on the speciality courses, and English is among the second-rate subjects"*
Poor learning skills	Not knowing how to learn the language	*"I never know what is not clear to me and that is why I always make silly mistakes"* *"I cannot understand what teachers want from me"* *"I try to work hard in many ways (learning by heart, watching films, etc.), but I feel that I am not improving"*
	Absence of self-study skills	*"at school nobody taught us how to work independently"* *"So what that we have 80 percent of time for independent work. We don't know how to use this time."*

Table 2. **External causes of underachievement in English**

Category	Subcategory	Illustrations
Conditions for learning English at school	Poor learning in primary grades	*"I primary grades English was taught by unqualified teachers who were not specialists"* *"while I was in primary school, we had eight teachers in the period of three years"*
	Underestimated value of knowing and learning English at school	*"English received very little attention at school"* *"teachers changed often, and they did not feel any responsibility for us"* *"we had a good teacher at school who allowed us not to learn English, but watch films or do something else"* *"those who didn't plan to take an exam in English were allowed to do nothing in the classroom"*
	Inadequate conditions for informal learning	*"in Lithuania there are no or very few opportunities to use the language outside school or university"*
	Poor organization of English lessons	*"our English teacher was our class mistress, so English lessons were intended for class matters, different problems in general, but not for learning English"* *"our teachers didn't come to English lessons or let us go"* *"we never had any oral tasks, we only wrote exercises form the sixth till the twelfth grade"* *"the teacher spoke much in the classroom, and there was no time for us to utter a word in English"*
Conditions for learning English at the university	Too few contact hours	*"it is impossible to reach B2 level in two semesters with so little contact time"* *"two hours a week is not enough"*
	Inconvenient time-table	*"English classes are early in the morning, other lectures are in the middle of the day, so sometimes we simply do not get up and go to English"*
	Lack of time	*"many students have jobs"* *"sport takes too much time"* *"too much time is planned for self-study, and in reality we don't have it"* *"too many assignments in much more important study courses"* *"I have to participate in extra-curricular activities"*

Teachers' opinions:

- Poor learning skills, especially self-study skills.
- Inadequate attitudes and disposition.
- Poor motivation to learn English.
- Lack of self-confidence, "programming oneself for failure".
- Poor memory.
- Lack of communication skills.
- Poor writing skills.

DISCUSSION

Research results show that students' answers revealed two big groups of reasons to be limited English-proficient learners: internal and external. Internal causes are certain personal qualities that might have affected students' learning achievements (poor self-esteem, motivation attitudes, self-discipline, etc.).

External causes fall into two categories – conditions for learning English at school and at the university. The most often mentioned school factors were poor learning in primary grades, underestimated value of knowing and learning English at school, inadequate conditions for informal learning, and poor organization of English lessons. University factors mentioned were too few contact hours for English classes, inconvenient time-table (for training sessions, great gaps in the timetable, and too early to get up in the morning), and lack of time due to other activities.

Discussions with English language teachers have shown that in Lithuanian universities, there are practically about one-fifth of students (in other fields than English Philology) underachieving in the English language, i.e. with A2 level of proficiency in the English language. It means that the majority of students who are successful in learning English have had the same favourable and unfavourable conditions at school and university: timetables, turnover of teachers, teachers' personality traits and teaching skills, etc. On the other hand, university teachers interviewed have not mentioned any external conditions (both at school and university) interfering with learning. Though research findings suggest that lack of motivation provided by teachers at school could have a negative impact on children's performance (Sousa, 2002), still it can be concluded that external causes are not of primary importance for the underachievement in the subject; at least they are not decisive.

Internal factors conditioning underachievement in the English language which were mentioned by students were fear to look unacceptable (resulting in the inactivity in the classes), lack of self-confidence, too much self-criticism, laziness, procrastination, finding faults with others, inadequate perception of the course, poor attitudes towards the course, lack of internal motivation, rating the module of English as a second-rate course, not knowing how to learn the language, and, what is most important, absence of self-study skills.

Chang (2010) indicated that reasons causing students' weakness for English language learning derived from learners' laziness, lack of efficiency of the school, and insufficient parents' promotions. Moreover, a survey into the internal causes of English language learning in students also found that students felt anxiety, they were afraid of making mistakes in the classes, failing in task accomplishment, as well as were ashamed of their pronunciation skills, which, consequently, caused the poor performance in learning languages (Khattak, Jamshed, Ahmad, & Baig, 2011). In addition, the lack of practice outside the classroom (typical European FLL environment) leads to resulting low proficiency and failure of the majority of A2 level students, so that they did not feel they had as of yet mastered any aspect of the language.

If students are strongly motivated, they will enjoy learning the language; will need to learn the language and attempt to learn the language (Sakiroglu & Dikilitas, 2012). At the university level emphasis should be put on designing study programmes of professional English or ESP (English for Special Purposes) which would motivate students to study English in their chosen field and the knowledge of which could help them become more competitive in a demanding labour market. Moreover, motivation has usually been considered to be the key concept in the learning of foreign language (Klimova, 2011). Therefore, students should eliminate the internal hindrances in their motivation as well as teachers have to help them improve the motivational beliefs and language learning strategies in order to find ways that reach to their academic achievement.

The modern university is a complex social organization. In today's world, universities, in particular those in the West, have increasingly become networked, informationalized, and commercialized, and tend to operate on a clock or chronologic time like a business or corporation, though their demands on individuals are often in real or chronoscopic time terms. Scheduled time gives people on a modern university campus their rhythm of life (Liao et al., 2013). In this context lack of skills for independent learning should be given much consideration. The benefits of knowing the English language are much more than just linguistic ones. There are social, psychological and cognitive advantages to being proficient in foreign language (Dewaele & Thirtle, 2009). Knowing more languages has been linked to lower levels of communicative anxiety in different languages (Dewaele, Petrides, & Furnham, 2008). It has also been linked to higher levels of creativity (Karkhurin, 2007) and a higher level of metalinguistic awareness (Kemp, 2007). Clearly, in today's globalised world it is, thus, an imperative for educators and teachers to address the issue of uptake of the English language urgently, and with the attention it deserves.

The results of the study show that there is no shortcut to the development of cognitive academic English language proficiency and to academic achievement in other subjects concurrently. It is a long-term process that initiates in even pre-school activities when a human personality starts to develop.

The limitation of the study is that the results are related to the contexts in which the study was carried out. Thus the transferability of the findings might be limited to similar settings, students or institutions of education. Absence of some factors causing low English language proficiency may suggest that they are not significant, or only that they were not mentioned and recorded at the time of the interviews. Certainly, the study is limited in time and space as it was conducted in one city of Lithuania. Besides, there are constant changes in the system of higher education in response to which some of the findings might be different as well.

For future research, the focus may be put on the differences in students' English proficiency before and after graduation from the university to measure progress in students' English proficiency and the efficacy of study programmes at the universities.

CONCLUSIONS

1. Internal factors conditioning underachievement in the English language proved to be much more important than the external ones.
2. Poor self-esteem, lack of motivation and poor attitudes towards the course suggest the need of the individualization of teaching/learning and psychological counselling.
3. Lack of self-study skills can predict poor academic achievements in other university courses, which could result in drop-outs. This suggests the need of coaching students in learning skills.
4. The collected data show that the teacher also plays a crucial role in language learning, however, the wider societal, cultural and psychological context should be articulated in further possible research as well.
5. Study programmes at tertiary level should be designed to encourage both internal and external motivation of students to study foreign languages as an indispensable factor for developing a full-rate personality.

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CORRELATION BETWEEN EMOTIONAL INTELLIGENCE OF YOUNG PEOPLE AND THEIR ACADEMIC ACHIEVEMENT: EMPIRICAL PROOF

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ABSTRACT

Background. A scientific problem concerning factors which are important for academic achievement of students is analysed in the paper. Questions whether emotional intelligence level is related to academic achievement and whether correlation between academic achievement in a specific area (science, languages) and EI expression exists, whether emotional intelligence of young people with low education differs from that of young people with higher education, etc. are raised.

Methods. Research participants were 1430 students aged between 17 and 27 years. The survey was performed using EI-DARL V2 test. The following factors were assessed: "Perception of one's own emotions"; "Control of one's own emotions"; "Perception of emotions of other people"; "Control of emotions of other people", and "Manipulations". Also, such aspects as ability of recognizing emotions in facial pictures and ability of emotional situation solving were assessed.

Results. The combined EI scale scores in all factors were the highest of those subjects who are or were excellent students, the lowest – of those who were poor students. Those subjects who were equally poor both at languages and sciences were the least capable of perception of their own emotions and those of others people, they also were the least capable of controlling their own emotions. Highly educated young people were of higher emotional intelligence. Furthermore, emotional situation solving and emotion recognition in pictures was better in the group of highly educated students.

Conclusion. Positive correlation between academic achievement and emotional intelligence was established. Mathematics and language skills proved to be significant indexes of emotional intelligence: it was established that those subjects who were more successful in sciences were the best at understanding and controlling their own emotions, while individuals who were better in languages were more efficient in understanding and controlling emotions of other people.

Keywords: academic achievement, educational level, emotional intelligence.

INTRODUCTION

Numerous studies are performed in the world aimed at naming factors important for academic achievement. The need for such studies is understandable: having identified and corrected both internal personality and external environment factors it would be possible to expect higher academic achievement and later – professional success. In this context, for example, Lillydahl (1990) examined social and economic factors; Bjarnason (2000) explored the importance of relations with peers, etc. Studies that aimed at searching correlations between emotional intelligence (EI) and academic achievement may also be attributed to the said category. The question is raised whether EI improves individual performance (including academic). Scientists are not unanimous on this issue; independent, systemic proof is lacking. Some researchers present data that

EI is not related or very weakly related to results of cognitive origin (Mavroveli, Petrides, Sangareau, & Furnham, 2009; Mavroveli & Sánchez-Ruiz, 2011; Petrides, 2011; Radford, 2011; Suliman, 2010). Supporters of the other view maintain that EI does have influence on academic achievements, especially when the level of academic assignments exceeds cognitive resources of the personality and when high academic results have to be demonstrated in stressful situations (Fallahzadeh, 2011; Ferrando et al., 2010). This view is substantiated by the fact that individuals with highly developed EI are able to identify and control their own emotions and those of other people, they are less affected by fear and other negative emotions – all factors that negatively affect individual and team performance (Seipp, 1991). Therefore, heterogeneous results show that there is a need to continue such research while taking into account methodological aspects of studies.

The purpose of the present article is to reveal correlation between emotional intelligence and academic achievement of young people. The following tasks were solved in the research: 1) correlations between school knowledge subjectively assessed by the subjects and EI factors were determined, 2) possible correlation between achievement in a certain study field and EI factor expression was looked for, 3) existence of differences between EI factor expression of young people of low and high education level was sought.

METHODS

Subjects. A total of 1430 subjects were interviewed. The study involved young studying, employed people, also the unemployed, involved in various community and political organizations and even imprisoned individuals. The target group was young people from 17 to 27 years of age (M = 19.7, SD = 3.29); 43.2% of men and 55.5% of women participated in the survey (1.3% did specify their gender). A total of 1092 subjects who were studying were surveyed: secondary school and gymnasium students of 11–12 grades (n = 371), vocational school (n = 384), college (n = 158) and university (n = 399) students. Other interviewed persons were the unemployed (n = 15); imprisoned young people (n = 54), representatives of some unions and social movements: young liberals (n = 11), scouts (n = 7) and others.

Instruments. The survey questionnaire consists of two parts. The first part is dedicated to assessment of personality EI level applying EI-DARL V2 methodology (Antinienė & Lekavičienė, 2014; Lekavičienė & Antinienė, 2014). Assessments are made in the following scales: "Perception of one's own emotions"; "Control of one's own emotions; "Perception of emotions of other people"; "Control of emotions of other people" and "Manipulations". The statements of the manipulation scale are aimed at detecting the person's ability to control the behaviour of people around them by using their emotions, discovering their weaknesses. In addition to the said scales such EI expression aspects as ability to recognize emotions in pictures (the identification scale of facial expressions) and ability to solve emotionally loaded social situations (the scale of emotional-social and interpersonal situations) were assessed. The psychometric quality of the instrument is sufficient.

In the second part of the questionnaire questions regarding demographical and psychosocial characteristics of the subject: age, sex, socio-economic status, present occupation, etc. were presented. Questions about academic achievement of young people were also presented in this part of the questionnaire.

RESULTS

Correlation between subjectively assessed their own school knowledge and EI factors of subjects. Subjects were asked to assign themselves to a group of excellent, good, average, and poor students by grades that they received at school. The results of study showed that emotional intelligence (i.e., combined in all factor scales) was the highest of those subjects who were excellent students, while the lowest – of poor students (χ^2 = 11.53, $p \leq .01$). High emotional intelligence also statistically significantly correlated with excellent or good academic achievement in the following scales: "Control of one's own emotions" (χ^2 = 11.82; $p \leq .01$), "Understanding of emotions of other people" (χ^2 = 25.57; $p \leq .0001$), and "Control of emotions of other people" (χ^2 = 15.91; $p \leq .001$). Table 1 shows relation between academic achievement and EI level in more detail.

Analogous results were obtained in emotional-social situations and face recognition scales. Excellent at present or in the past students were the best in situation solving (Mean Rank = 503.28), poor students (at present or in the past) showed the worst results (Mean Rank = 251.00) (χ^2 = 87.17,

Assessment of Academic Achievement \ EI Scales	Combined EI scale	"Control of one's own emotions"	"Understanding emotions of other people"	"Control of emotions of other people"
Excellent student (used to get grades 10-9)	499.67	643.14	644.73	675.25
Good student (grade 8 was predominant, sometimes would get 7)	488.43	571.52	676.27	690.10
Average student (mostly would get 7 and 6)	434.08	557.69	561.43	599.98
Poor student (mostly would get 5, 4 and lower)	394.17	541.90	554.79	595.41

Table 1. **Duplex model of subjective assessment of one's own academic achievement and emotional intelligence factors. Kruskal-Wallis Test mean ranks**

Areas of Study \ EI Scales	"Understanding one's own emotions"	"Control of one's own emotions"	"Understanding emotions of other people"	"Control of emotions of other people"
I was better at sciences in school	623.61	611.11	579.06	587.69
I was better at languages in school	580.26	560.15	682.38	711.70
I was equally successful in both areas in school	604.18	596.94	612.53	651.18
I was equally poor in both areas in school	464.62	485.30	559.26	598.74

Table 2. **Duplex model of components of academic achievement in a specific area assessment and emotional intelligence. Kruskal-Wallis Test mean ranks**

$p \leq .0001$). Similarly, excellent students were the most successful in emotional state recognition in faces (pictures) (Mean Rank = 359.54) while poor students showed the worst results (Mean Rank = 279.74, $\chi^2 = 20.47$, $p \leq .0001$).

Correlation between academic achievement of subjects in a specific area and EI factors. In the questionnaire subjects were also asked to specify in what areas of studies – sciences (mathematics, physics, IT, etc.) or languages (native, foreign) – they were more successful; furthermore, two additional choices were presented – "I was equally successful in both areas" and "I was equally unsuccessful in both areas".

It was established that those who were better at sciences were best at understanding and controlling their own emotions: understanding score $\chi^2 = 87.17$ ($p \leq .0001$), controlling score $\chi^2 = 87.17$ ($p \leq .0001$), whereas individuals who were more successful at languages were more efficient in understanding and controlling emotions of other people: understanding score $\chi^2 = 87.17$ ($p \leq .0001$), controlling score $\chi^2 = 87.17$ ($p \leq .0001$). Table 2 shows the relation of academic achievement in a specific area with EI level in more detail.

Table 2 shows that those subjects who were equally poor both at sciences and languages were the worst in understanding their own emotions and those of other people. However, it is interesting to note that those subjects who were excellent at sciences were the worst in controlling emotions of other people.

Expression of EI factors of young people of low and high education level. Subjects hypothetically formally were allotted into two levels by the type of their activity: vocational school students, jobless, and imprisoned subjects were assigned to the low education group; gymnasium seniors, college and university students, and active young people working in various youth organizations were assigned to the high education group.

Cumulative percentage frequency probability distribution was applied to group comparison. Cumulative frequency curves show group differences in an informative and telling way (see Figure 1). Analogous statistically significant differences were also obtained by individual EI scales.

It has to be noted that particularly big differences between different educational level groups were observed in social-emotional situation solving (see Figure 2); statistically significant differences were also recorded in facial emotion recognition (see Figure 3).

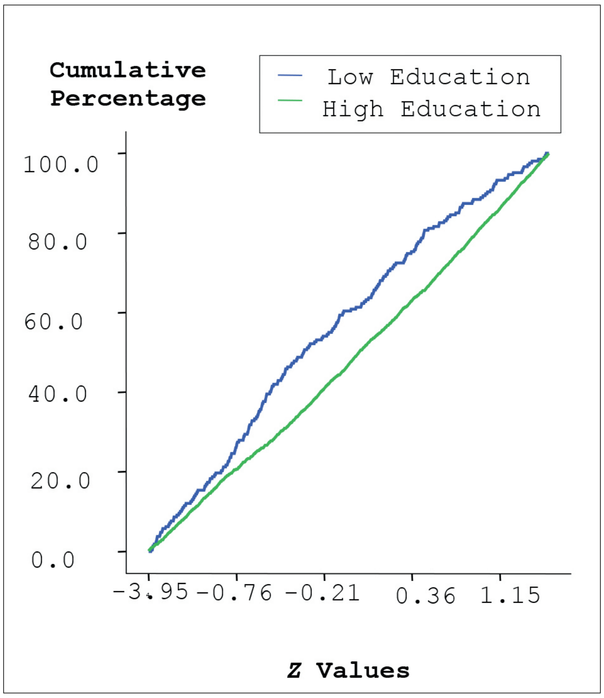

Figure 1. **Comparison of Combined EI Scale and scores of low and high education subjects**

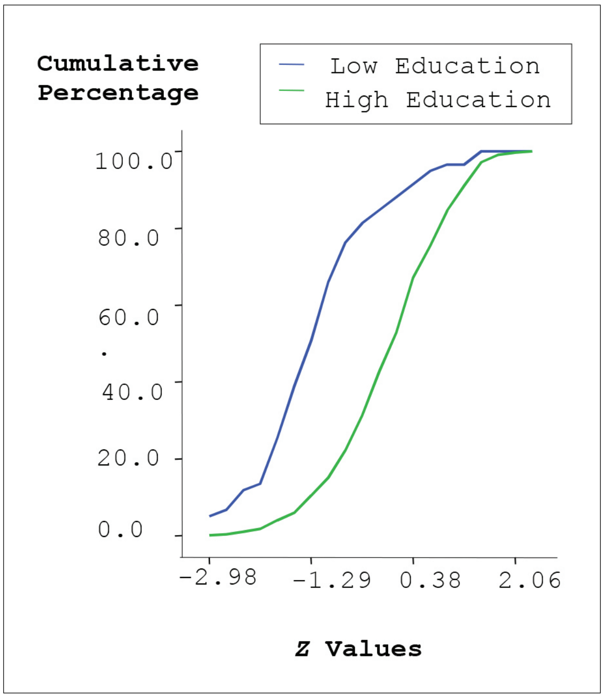

Figure 2. **Comparison of low and high education subject scores in Social-Emotional Situation Solution Scale**

Calculation of Mann-Whitney criterion *U* showed that statistical solutions satisfied very strict reliability condition $p \leq .0001$.

It was established that young highly educated people were of higher emotional intelligence ("Combined EI Scale") (Mean Rank = 474.46) than poorly educated (Mean Rank = 395.32).

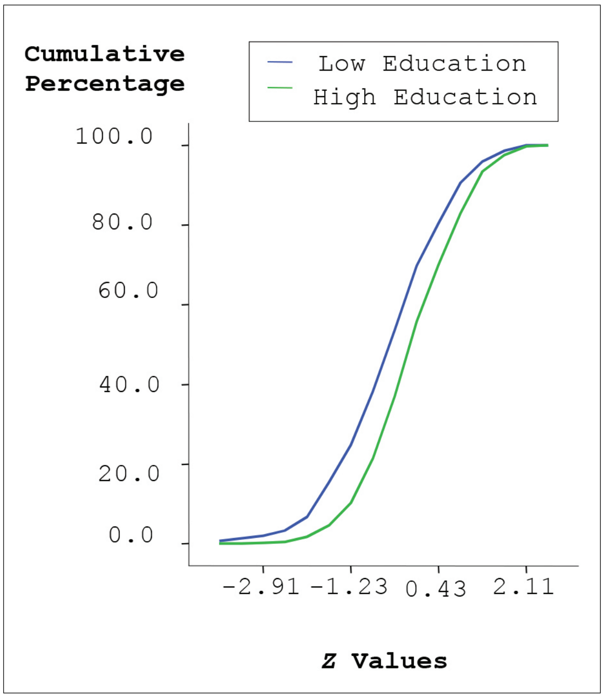

Figure 3. **Comparison of Facial Emotion Recognition (in pictures) Scores of low and high education subjects**

Individuals of higher education were better at understanding and control emotions of other people (understanding Mean Rank = 530.85, control Mean Rank = 553.39). The same applies to understanding and control of their own emotions: high education (understanding Mean Rank = 573.88, control Mean Rank = 553.39), low education – understanding Mean Rank = 510.96, control Mean Rank = 493.85.

It was also established that solutions of social-emotional situations were better in the group of people with higher education (Mean Rank = 419.40 and Mean Rank = 410.73 in the first and the second cases correspondingly) than in the group of people with lower education (Mean Rank = 175.06 and Mean Rank = 201.07 in the first and the second cases correspondingly). Emotion recognition in faces (pictures) was also more successful in the group of people with higher education, Mean Rank = 322.06, while in the group of people with low education it was less successful – Mean Rank = 250.39. In this case, it was the same as in social situation solution, $p \leq .0001$.

DISCUSSION

The obtained research results have confirmed existence of positive correlation between EI level and academic achievement. They concur with correlation between EI and academic achievement confirmed by foreign scientists (Barchard, 2003; Codier & Odell, 2014; Fallahzadeh, 2011; Ferrando et al., 2010; Lam & Kirby, 2002; Petrides, Frederickson, Furnham, 2004; Zins, Weissberg, Wang, Walberg, 2004, and other). Review of articles of this type has shown that determined correlation between EI and academic achievement usually range between 0.20 and 0.30, however, sometimes more impressive data may be found, e.g. Fayombo (2011), having surveyed 151 students ($M = 23.0$, $SD = 7.6$) determined very firm correlation between EI and academic achievement ($r = .439$, $p < .05$). Meta-analysis of empirical studies of this type performed in 1998–2012 by Perera and DiGiacomo (2013) is even of greater value than individual studies. Studies, in which academic achievement was assessed objectively (grade average, standardized academic test scores, knowledge of subjects) or subjectively (by self-evaluation), were selected. Analysis of 48 independent cases encompassing approximately 8700 survey subjects revealed that correlation between EI and academic achievement had reached $r = .30$. Furthermore, an important observation has been made that correlation between EI and academic achievement is more obvious in primary school ($r = .28$, $p < .05$) and less obvious at university level ($r = .18$, $p < .05$). How could analogous results presented in the article and obtained by other authors be used practically?

As the evidence that higher EI should be related with higher individual cognitive achievement increases, this should encourage the creation and implementation of EI development programs in educational facilities. Scientists not only maintain that such correlation exists, but also try to explain the very correlation mechanism theoretically and empirically. Mount, Barrick, and Srauss (1999) claim that individuals with high EI have a clear goal, are achievement oriented, and that allows them to define academic goals that would provide for higher results. Furthermore, individuals with high EI are prone to decisiveness and persistence, and this may stipulate greater commitment towards the said academic goals (Barrick, Mount, & Strauss, 1993; Tepper, Duffy, & Shaw, 2001). It is possible that the said self-motivation traits have an influence not just to apply more effort, but also constantly maintain the said efforts in pursuit of academic achievement (Barrick et al., 1993). Individuals with high EI are prone to put off short-term pleasures and concentrate on set goals (Petrides, 2009). They are also characterized by great self-control and can dissociate from tempting stimuli to pursue higher objectives (Fishbach & Shah, 2006; Trope & Fishbach, 2005). This is also applicable to pursuit academic achievement. Theoretically it is likely that individuals with high EI are up-front inclined to regulate their own emotions, therefore they are less controlled by negative emotions in the context of academic studies, and this may incite better academic performance (Goetz, Frenzel, Pekrun, & Hall, 2005; Petrides, 2011).

CONCLUSIONS

Results of the study importantly show that correlation between academic achievement and emotional intelligence exists. The highest emotional intelligence is of those subjects who are/were excellent students, while the lowest – of poor students. Mathematical and language abilities turned out to be significant indexes of emotional intelligence: it has been determined that subjects who are better at sciences are best at understanding and control of their own emotions, while individuals who are better at languages are more efficient in understanding and control of emotions of other people.

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EFFECT OF THE APPLICATION OF CONSTRAINT-INDUCED MOVEMENT THERAPY ON THE RECOVERY OF AFFECTED HAND FUNCTION AFTER STROKE

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ABSTRACT

Background. Research aim was to evaluate the effect of the application of constraint-induced movement therapy on the recovery of affected hand function after stroke. Research hypothesis: The application of constraint-induced movement therapy on the recovery of affected hand function after stroke would be more effective than the application of conventional physiotherapy.

Methods. The study employed the Mini Mental State Examination (MMSE), Lovett's test, Modified Movement Assessment Scale (MMAS) hydraulic dynamometer, and Wolf Motor Function Test.

Results. Results showed that constraint – induced movement therapy for patients after stroke helps to recover injured hand movement more effectively ($p < .05$), enhances performance of functional tasks ($p < .05$) and also increases muscle strength ($p < .05$) compared to conventional physiotherapy.

Conclusions. After the application of the conventional physiotherapy for patients after stroke affected hand movements and functional task performance improved and the hand grip strength increased statistically significantly. Applying the constraint-induced movement therapy for patients after stroke affected hand movements and functional task performance improved and the hand grip strength increased statistically significantly. The application of constraint-induced movement therapy for patients after stroke statistically significantly more improved the affected hand function than the application of conventional physiotherapy.

Keywords: constraint-induced movement therapy, stroke, hand function, rehabilitation, physiotherapy.

INTRODUCTION

Brain damage is one of the most common and serious injuries, and the elimination of its effects is a long, complex and expensive process (Bižokaitė & Daratienė, 2011). According to the research data, 20% of patients die from stroke, more than 50% of stroke survivors remain temporarily or permanently disabled, only 20% of working-age people return to work, and about 10% of patients are in need of nursing (Jamontaitė & Puzara, 2011).

Approximately 43 to 69% of patients who have suffered a stroke, have problems with their hand movements, and four years after the disease, impaired hand function and its restriction remains a major problem in patients (Siebers, Öberg, & Skargren, 2010). The most common consequence of stroke is paralysis which disrupts movements. There are two broad types of paralysis: hemiparesis and hemiplegia. Statistics show that after stroke hemiplegia occurs in 11.2%, severe hemiparesis – in 11.1%, and mild hemiparesis – in 58.9% of patients (Dewey, Chambers, & Donna, 2004).

Hands function is one of the most important components of the quality of life. Hands can help us manipulate with objects in different environments, so the arm function recovery is of great importance. There are many scientific articles that explore the upper extremity disorders and its restoration after stroke. There are a variety of physical therapy techniques, the latest technology tools which speed up the recovery of the affected arm. One of the techniques applied is training movements using various computer programmes (Cameirao, Bermundez, & Verschure, 2008), creating a "virtual reality" model (Subramanian et al., 2007) and electrical muscle stimulation (Lindquist et al., 2007).

Most physiotherapy methodologies used in patients after stroke tend to compensate the impaired function and ensure the recovery of independence in daily life. Patients are taught to use the undamaged hand and various compensatory measures, while the purpose of constraint-induced movement therapy is maximum return of hand functions or improvement of existing functions in damaged hands (Dromeric, Edwards, & Hahn, 2000).

Constraint-induced therapy is a neurorehabilitation technique that improves motor function in the affected arm after stroke (Alberts, Butler, & Wolf, 2004). Traditional constraint-induced therapy programme consists of intensive motor training, repetitive and adaptive tasks for the affected limb, while the healthy arm is constrained by a glove or a special splint.

Timely and proactive rehabilitation measures improve prognosis of the disease, help restore damaged functions, prevent complications, and give the patient a chance to adapt in daily activities (Šapogienė, Strukčinskienė, Raistenskis, Griškonis, & Stasiuvienė, 2011). Physiotherapy plays an important role in rehabilitation of patients after stroke (Kwakkel, 2006). Studies comparing the early and late start of rehabilitation have shown that a better prognosis is provided by the therapy which starts within 20–30 days (Jatužis & Kasiulevičius, 2010). Therefore, the early start of rehabilitation is an essential component of treatment in a specialized stroke section.

Research hypothesis poses that the application of constraint-induced movement therapy is more efficient than conventional physiotherapy aiming at recovering the function of the affected hand after stroke. **Research aim** was to evaluate the effect of the application of constraint-induced movement therapy on the recovery of affected hand function after stroke.

METHODS

Subjects. Research was carried out in PI Palanga Rehabilitation Hospital, Department of Neurology in 2013. The patients participated in the research voluntarily. They were acquainted with the research aims, procedures and possible inconveniences. The study was conducted in accordance with the principles of the Declaration of Helsinki dealing with the ethics of the experiments with human beings.

The study involved 20 patients (11 men and 9 women). All persons selected were after the ischemic stroke regardless of the damaged left or right hand. Inclusion criteria were as follows:

- No more than six months after strike;
- Muscle strength of the damaged hand according to Lovett's 5-point scale is no less than 2 points;
- Ability to understand orders and the essence of training is no less than 11 points in the Mini Mental State Examination (MMSE);
- Ability to stretch the hand at the elbow joint at least 20°, and the fingers of the hand – 10° (goniometry);
- Muscle spasticity according to Ashworth scale 0–1 points.

Patients subjects with underlying medical conditions that could affect the test results (e.g. amputations, muscular atrophy) were not included in the study.

Subjects were randomly assigned to experimental and control groups with 10 patients in each of them. The experimental group included 5 men and 5 women, the control group had 6 men and 4 women. Their characteristics are given in the Table. Patients in the experimental group underwent constraint-induced movement therapy, and those in the control group – conventional physiotherapy.

Table. **Characteristics of subjects (mean ± *SD*)**

Characteristics	**Subjects**	
	Control group	**Experimental group**
Age *(m)*	68.90 ± 2.81	68.7 ± 2.95
Height *(cm)*	168.50 ± 5.68	166.20 ± 4.96
Weight *(kg)*	75.20 ± 5.27	73.40 ± 5.15
Duration of the disease *(years)*	3.44 ± 1.07	3.20 ± 1.03

Methods applied. First the patients took the *Mini Mental State Examination*, (MMSE), a structured method to test cognitive (cognitive) function which is widely used in clinical practice (Mungas, 1991).The minimal score is 0, maximal – 30. Less than 20 points means deterioration of cognitive function (Folstein, Folstein, & McHugh, 1975). Lovett's test was used to assess muscle strength from 0 – absence of muscle contraction, to 5 – active movement overcoming constraint (Krutulytė, 1999). Hand function was assessed using *Modified Movement Assessment Scale* – MMAS) (Carr & Shepard, 2003). The present study employed a modified version of the scale which aimed at evaluating changes related to the recovery of function and the reliability of the method applied (Williams, Galea, & Winter, 2001). Muscle strength of the damaged hand was measured using hydraulic dynamometer. This device shows the maximum grip strength (0–90 kg).

The effect of constraint-induced movement therapy is most often assessed using *Wolf Motor Function Test* (Wolf et al., 2006). It is also one of the most commonly used assessment methods in rehabilitation of patients following a stroke. The test establishes the possibilities of the upper limb movements within a certain period of time, measuring movements in one or more joints and functional task performance (Fritz et al., 2006). It starts with easy tasks such as laying hands on the table, and then the tasks become more difficult, such as turning over pictures or picking up paper clips. The tasks should be carried out in no less than 120 s. The maximal score in the test is 75, the minimal score is 0.

Organization. All subjects were tested before and after rehabilitation procedures and the results obtained were compared. During the procedures, the patients were motivated to try to achieve better results. The control group underwent conventional physiotherapy five times a week, 30–45 min a day. Every patient attended 10 physiotherapy sessions. The experimental group had constraint-induced movement therapy. A special glove was used to restrain the healthy arm movements so that the upper arm and the forearm could not participate in the activities. The patients had to wear this device 6 hours a day during the most active hours, regardless of the patients' condition and well-being. The total workout lasted for 2 weeks, 5 days a week. Every hour the patients had a 10–15 min break when they could take off the glove. Training involved the exercises to restore the function only of the affected hand constraining the healthy hand.

During the session various movements were carried out: reaching, grabbing, pinching, lifting, putting, pushing (e.g. laying out pins, hanging rings, picking up small items), physical exercise, work and daily activities, etc. Task difficulty was gradually increased: in the beginning the patients only had to perform the movement, but then they had to reach further, lift higher, or repeat more times (Figure 1).

Figure 1. **A task in constraint-induced movement therapy**

Mathematical statistics. Research data were processed using *Microsoft ® Excel 2003* programme package. We calculated the mean values ($\bar{x}$) and standard deviations (*SD*) of the investigated indices. The significance of differences of the results for functional movements of the affected hand and hand muscle strength before and after the application of constraint-induced movement therapy was calculated using Students t test for paired samples. The significance level was set at $p < .05$.

RESULTS

Analysis of the results of the Modified Movement Assessment Scale. During the first testing of patients, i.e. before physiotherapy, hand movements in the control group were assessed by 27.87 ± 0.8 points, and in the experimental group – 27.95 ± 0.83 points. During the retest after two weeks it was found that the mean value of task performance in the control group was 32.55 ± 0.69 points; in the experimental group it was 34.65 ± 0.82 points. The maximum score in the Modified Movement Assessment Scale is 72 points. After treatment (conventional physiotherapy and constraint-induced movement therapy) there was a statistically significant recovery of hand movements. Comparing the two methods of treatment we suggest patients who received constraint-induced movement therapy showed better results (Figure 2).

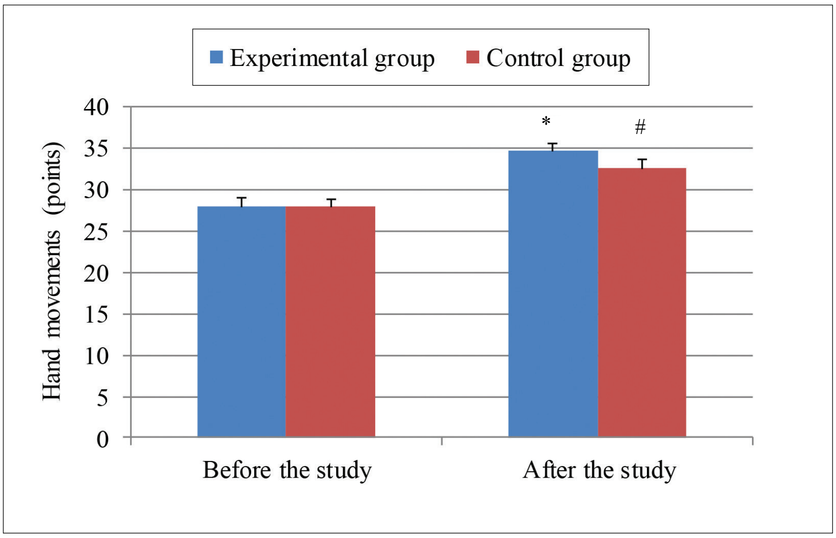
Analysing the mean values of hand movements in a complex task we did not find significant differences in both groups before physiotherapy: in the control group it was 20.88 ± 1.71 points, in the experimental group – 20.95 ± 1.3 points. After the repeated assessment of subjects after physiotherapy it was established that the mean value in the control group increased to 23.86 ± 1.1 points, and in the experimental group – 31.1 ± 1.02 points (Figure 3). Complex hand movements improved statistically significantly.

Comparing the Modified Movement Assessment Scale (MMAS) results after the application of two different physiotherapy methods we see that for patients who had constraint-induced movement therapy hand recovery increased from 48.90 ± 2.07 to 65.77 ± 1.35 points, and for those who had conventional physiotherapy – from 48.75 ± 1.66 to 57.21 ± 1.40 points (Figure 5). The evaluation of the effect of both physiotherapy methods on hand movement recovery revealed statistically significant differences.

Comparison of the results of Wolf Motor Function Test. Before the programme applied the results for patients were similar: in the control group – 49.4 ± 1.30 points, in the experimental group – 49.1 ± 1.90 points. Research results showed that in the experimental group the score in Wolf Motor Function Test after the constraint-induced movement therapy increased to 69.70 ± 1.1 points, and in the control group which had conventional physiotherapy – to 61.2 ± 2.00 (Figure 5). The difference between the results of those two physiotherapy methods was statistically significant.

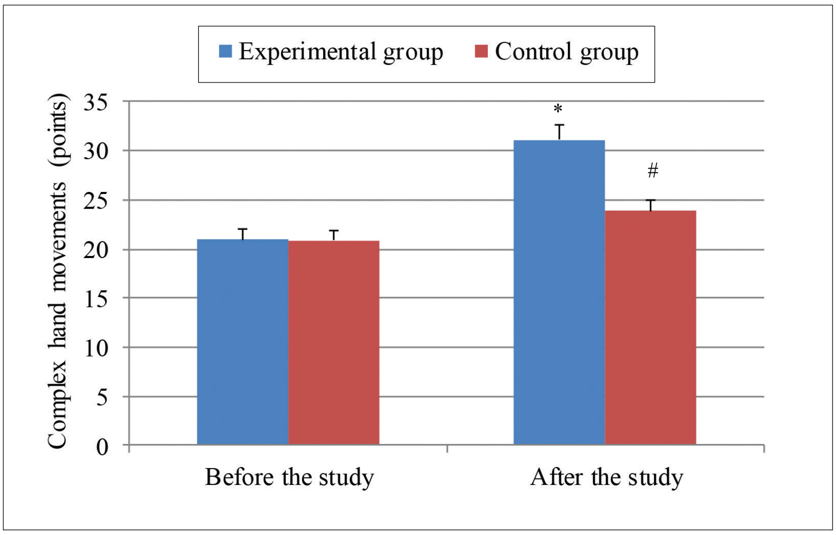
Analysis of hand-grip strength results. In the experimental group the mean value of hand-grip strength before the application of constraint-induced

Figure 2. **Changes in hand movements (according to Modified Movement Assessment Scale) before and after the study**



Notes. * – significance of mean differences ($p < .05$) comparing the values before and after the study; # – significance of mean differences ($p < .05$) comparing the values in the control and experimental groups after the study.

Figure 3. **Changes in complex hand movements (according to Modified Movement Assessment Scale) before and after the study**



Notes. * – significance of mean differences ($p < .05$) comparing the values before and after the study; # – significance of mean differences ($p < .05$) comparing the values in the control and experimental groups after the study.

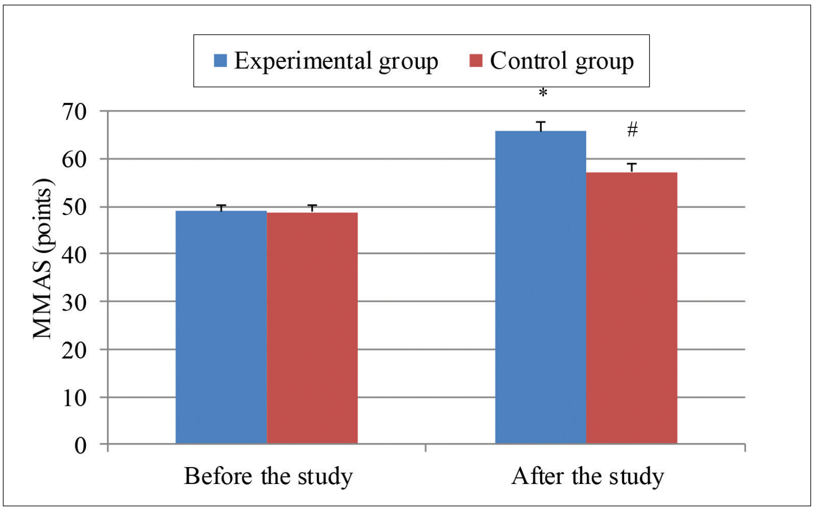


Figure 4. **Changes in Modified Movement Assessment Scale (MMAS) results before and after the study**

Notes. * – significance of mean differences ($p < .05$) comparing the values before and after the study; # – significance of mean differences ($p < .05$) comparing the values in the control and experimental groups after the study.

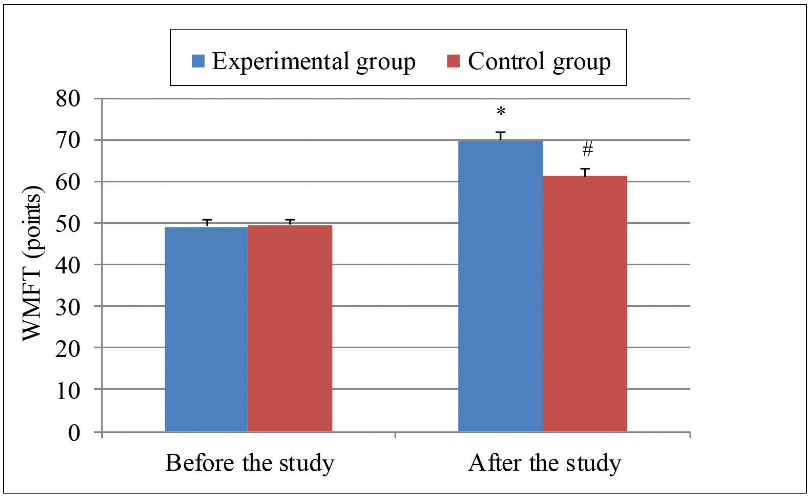


Figure 5. **Comparison in changes in Wolf Motor Function Test (WMFT) results after the application of constraint-induced movement therapy in the experimental group and conventional therapy in the control group**

Notes. * – significance of mean differences ($p < .05$) comparing the values before and after the study; # – significance of mean differences ($p < .05$) comparing the values in the control and experimental groups after the study.

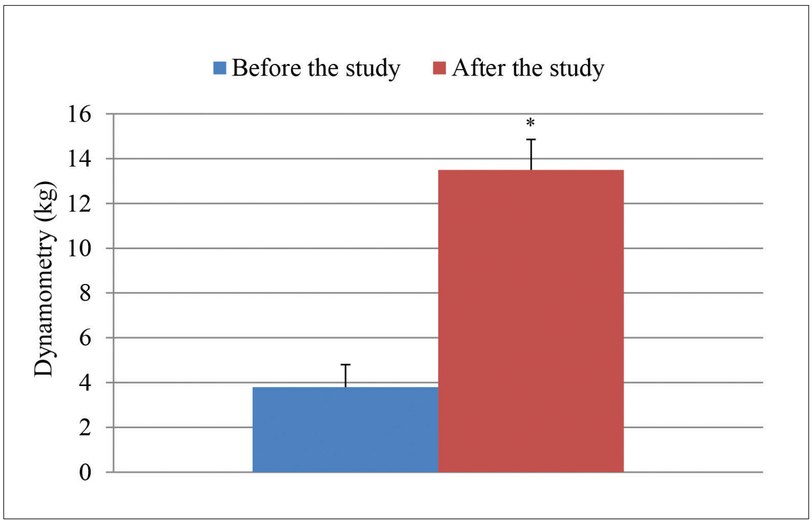


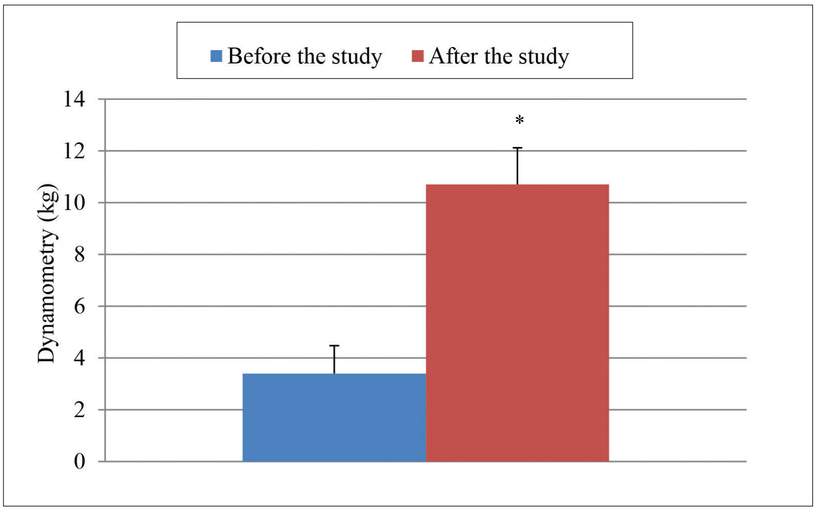
Figure 6. **Changes in hand-grip strength for patients before and after constraint-induced movement therapy**

Note. * $p < .05$, comparing the values before and after constraint-induced movement therapy.

movement therapy was 3.8 ± 1.32 kg. after the therapy the strength of hand muscles increased by 9.1 kg (13.5 ± 1.35) ($p < .05$) (Figure 6).

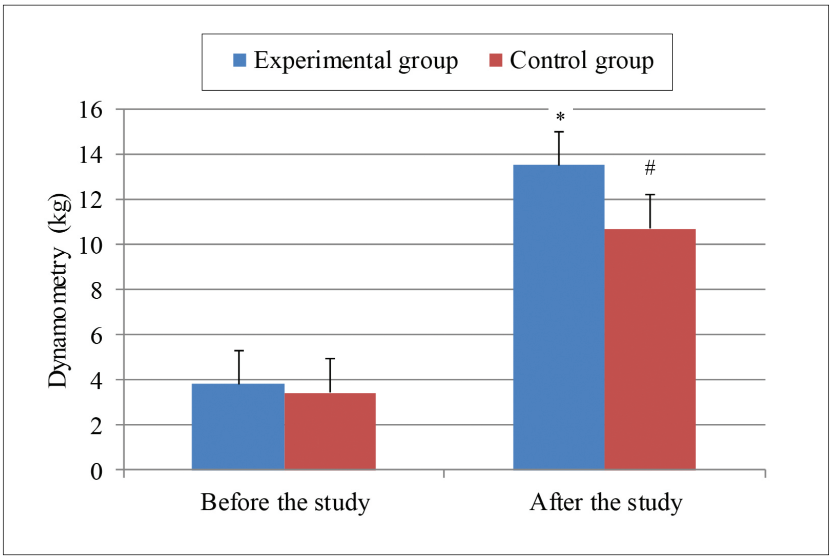
In the control group, hand grip strength before the conventional physiotherapy was 3.4 ± 1.07 kg. After the repeated assessment after exercising, the strength of hand muscles increased by 7 kg on average (10.7 ± 1.42) ($p < .05$) (Figure 7). Patients who had constraint-induced movement therapy increased their hand muscle strength by 2.8 kg more than those who had conventional physiotherapy ($p < .05$) (Figure 8).

Figure 7. **Changes in hand-grip strength for patients before and after conventional physiotherapy**



Note. *$p < .05$, comparing the values before and after conventional physiotherapy.

Figure 8. **Changes in hand-grip strength after the application of constraint-induced movement therapy and conventional physiotherapy**



Notes. * – significance of mean differences ($p < .05$) comparing the values before and after the study; # – significance of mean differences ($p < .05$) comparing the values in the control and experimental groups after the study.

DISCUSSION

Research aim was to compare the efficiency of physiotherapies (constraint-induced and conventional) on the recovery of impaired hand function. It has been established that constraint-induced movement therapy produced better results than conventional physiotherapy. Similar results were obtained by Alberts et al. (2004), who found that a two-week constraint-induced movement therapy for patients who had stroke 3–9 months before produced significant improvement of hand function. Besides, improved hand function remains about one year after therapy (Wolf et al., 2006).

Constraint-induced movement therapy more improves impaired hand function for patients after stroke, which is very important for their independence (Miklaševičienė, Jamontaitė, & Raistenskis, 2012). Similar statistically significant results were obtained by Brogardh and Sjolund (2006), who found that a two-week constraint-induced movement therapy can help patients restore their hand function even in the late period after stroke.

Comparing the constraint-induced movement therapy with conventional physiotherapy we suggest that the first one is more effective than alternative therapies for patients after stroke. Research by Williams, Colton, Fregni, Leone-Pascual, and Alexander (2009) came to the same conclusion. Constraint-induced movement therapy is an effective method for treating long-term hand function impairment.

Azab et al. (2009) showed that a four-week constraint-induced movement therapy together with traditional therapies for patients after stroke produced a statistically significant improvement. It remained after even six months, as it was shown by the testing results. It has proved once again that constraint-induced movement therapy is a perspective and efficient method of rehabilitation for long-term movement function impairment after stroke.

Similar results were obtained by Wang, Zhao, Zhu, Li, & Meng (2011). They compared conventional, intensive conventional and constraint-induced movement therapies. After two weeks of treatment, Wolf Motor Function Test results showed the greater efficiency of intensive conventional and constraint-induced movement therapies. However, Wang et al. suggest that constraint-induced therapy is the most effective comparing all three methods because the application of it produced strong, systemic and statistically significant relations between the initial values and those obtained after two – four weeks of treatment.

The essence of constraint-induced movement therapy is the performance of complex and accurate movements, which requires hand muscle strength. Siebers et al. (2010) found significant improvement in the hand-grip strength in their research. Porter and Lords (2004) found different results in the application of Modified Movement Assessment Scale, but the differences can be explained by the duration of treatment: in our study the treatment was one week longer compared to that in the study of aforementioned researchers.

Our research has confirmed the hypothesis that that the application of constraint-induced movement therapy is more efficient than conventional physiotherapy aiming at recovering the function of the affected hand after stroke.

CONCLUSIONS

1. The application of conventional physiotherapy for patients after stroke significantly improves hand movements and the performance of functional tasks, and increases the hand-grip strength of the affected hand.
2. The application of constrained-induced movement therapy for patients after stroke significantly improves hand movements and the performance of functional tasks, and increases the hand-grip strength of the affected hand.
3. Constrained-induced movement therapy is more effective for patients after stroke, and it more improves the function of the affected hand compared to conventional physiotherapy.

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RETICULOCYTES AS A MARKER OF OXYGEN TRANSPORT SYSTEM ADAPTATION TO PHYSICAL ACTIVITY IN ENDURANCE SPORTS

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ABSTRACT

Backgraund. Peripheral blood reticulocytes and aging of the activity of these cells are markers of erythropoiesis activity. The purpose of this study was to examine changes of reticulocytes in blood formation of elite athletes in endurance sports during the preparation and the competitive periods.

Methods. Reticulocytes and IRF content was examined in blood of 305 elite athletes aged 20-26 years that specialized in swimming, biathlon, cross-country skiing, kayaking and canoeing, rowing and cycling. At various stages of preparation 459 blood tests were performed and processed. Capillary blood was analysed using a haematology analyser SYSMEX XT 2000i.

Results. Differences in reticulocytes depending on sport, gender and qualification were not found. Increase in reticulocytes was marked for male athletes in the age aspect, for females, reduction was observed. A tendency of average reticulocytes group data in peripheral blood at various stages of the annual preparation cycle was found: reduction of the amount of reticulocytes in competition period. This pattern was found regardless of gender. Similar evidence was found concerning the dynamics of IRF at the stages of the annual training.

Conclusion. The effect of training activity on reticulocyte indices in the annual training cycle is related to the direction, duration and intensity of physical activity in different periods of training. Changes in reticulocytic indices may be due to effects such as hemoconcentration and hemodilution appearing after exercise in the corresponding areas of energy supply.

Keywords: reticulocytes, erythropoiesis, elite athletes, training loads.

INTRODUCTION

A leading role in energy supply of physical activity in endurance sports belongs to aerobic processes, where the intensity of muscular activity depends significantly on oxygen circulatory function of blood. Oxygen circulation depends on erythropoiesis activity, the rate of which can identify early tiredness symptoms.

Peripheral blood reticulocytes and aging of the activity of these cells are markers of erythropoiesis activity. The amount of blood reticulocytes and their sub-populations of different age reflect the regenerative ability of bone marrow and is an important marker for monitoring training (Asshenden, Lacoste, Orhant, Audran, & Sharpe, 2004; Banfi, 2008; Fallon & Bishop, 2002; Lombardi, Colombini, Lanteri, & Banfi, 2013; Nadarajan, Ooi, Sthaneshwar, & Thompson, 2009).

Reticulocytes content in ribonucleic acids remain, mitochondria and other cell organelles are destroyed as they age, and the cells are transformed into mature red blood cells. Oxygen transfer efficiency of younger cells is slightly lower compared to mature erythrocytes.

Athletes' biological passport model includes parameters of peripheral blood reticulocytes, which promoted interest in studying the influence of training and competition on reticulocytes. Relatively little information is published in specialized periodicals concerning behaviour of reticulocytes depending on training and competitive physical activity. Some studies suggest that a change in reticulocytes depends on sport specifics as well as seasonal factors related to training process and schedule of events. Certain studies mark fluctuations in reticulocytes during the season from 5 to 21% (Lombardi at al., 2013; Banfi, Lundby, Robach, & Lippi, 2011).

The results of reticulocytes studies in different periods of training show a tendency to decrease the amount of reticulocytes from preparatory to competitive period (Banfi, 2008). The amount of reticulocytes in different sports can vary, but in most cases there is either a decrease of this parameter before a competition period, or the absence of any dynamics (Banfi & Del Fabbro, 2007). Immature reticulocyte fraction (IRF) does not undergo significant fluctuations in different periods of the training cycle. There is evidence of an increase of IRF for cyclic sport athletes during the competitive season. In general, available literature describes multidirectional dynamics of reticulocytes under the influence of intense muscular activity. A study of changes in reticulocytes under the influence of the training process has both scientific and practical interest.

The purpose of this study was to examine changes in reticulocytes in blood formation of elite athletes in endurance sports during the preparation and the competitive periods.

METHODS

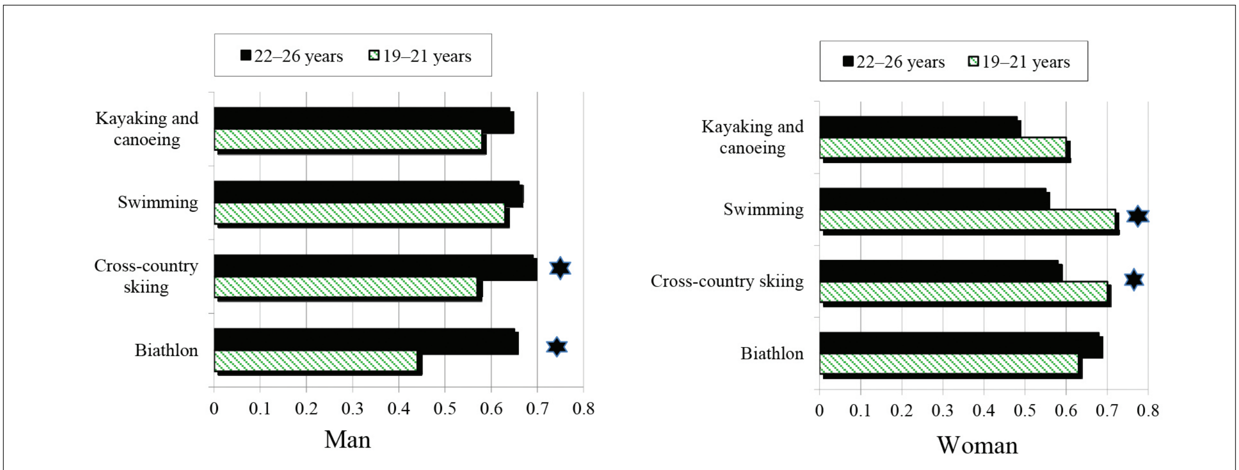
Reticulocytes and IRF content were examined in blood of 305 elite athletes aged 19–26 years that specialized in swimming, biathlon, cross-country skiing, kayaking and canoeing, rowing and cycling. At various stages of preparation 459 blood tests were performed and processed. Capillary blood testing was carried out using a haematology analyser SYSMEX XT 2000i. The data were tested for Gaussian distribution using the Kolmogorov-Smirnov test. The Mann-Whitney test for non-parametric distribution was used to determine the differences between groups.

RESULTS

Table 1 shows the ranges of reticulocytes and their fractions of immature forms in endurance sports. As the data show, no statistically significant differences in the studied parameters depending on sport as well as gender and qualification were revealed.

Table 1. **Reticulocytes (%) and IRF in peripheral blood of elite athletes in cyclic sports ($X \pm \sigma$)**

Cyclic sport	Men			Women		
	n	Reticulocytes (%)	IRF	*n*	Reticulocytes (%)	IRF
Biathlon	12	0.60 ± 0.20	3.28 ± 1.74	19	0.64 ± 0.31	2.10 ± 1.68
Cross-country skiing	48	0.51 ± 0.23	2.83 ± 1.59	18	0.58 ± 0.16	1.77 ± 1.36
Swimming	56	0.64 ± 0.21	3.98 ± 2.32	92	0.61 ± 0.23	3.06 ± 2.07
Rowing	63	0.62 ± 0.23	2.54 ± 2.02	28	0.60 ± 0.20	3.42 ± 2.07
Kayaking and canoeing	43	0.61 ± 0.20	6.21 ± 2.78	32	0.58 ± 0.21	3.76 ± 2.59
Cycling	41	0.61 ± 0.22	2.61 ± 1.78	7	0.64 ± 0.21	3.53 ± 2.08



Note. * – $p < .05$.

Figure 1. **The mean group data of reticulocytes in cyclic sports athletes in the aspect of age and gender**

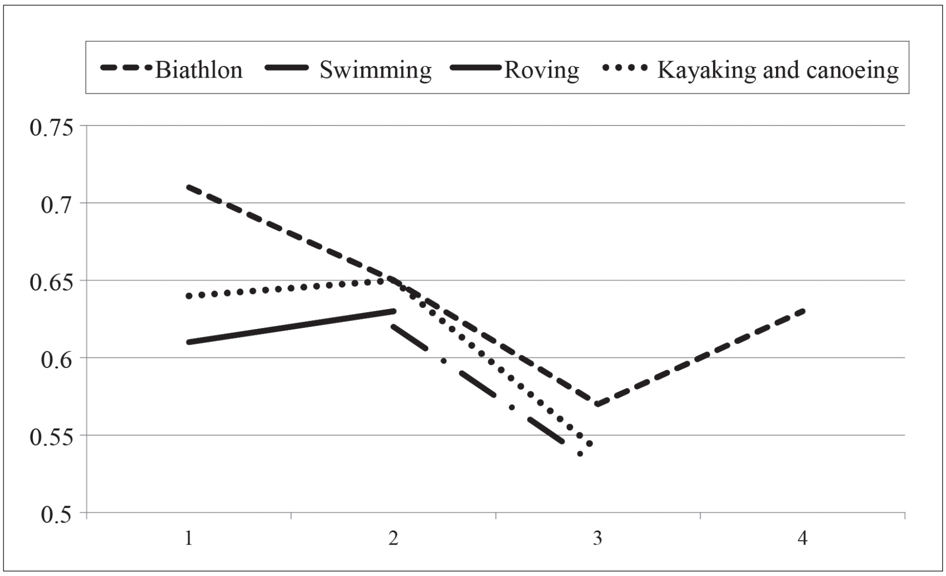


Figure 2. **The dynamics of reticulocytes amount at stages in cyclic sports annual preparation cycle for males**

Note. 1 – generalized stage of preparatory period, 2 – specialized stage of preparatory period, 3 – competitive, 4 – recovery.

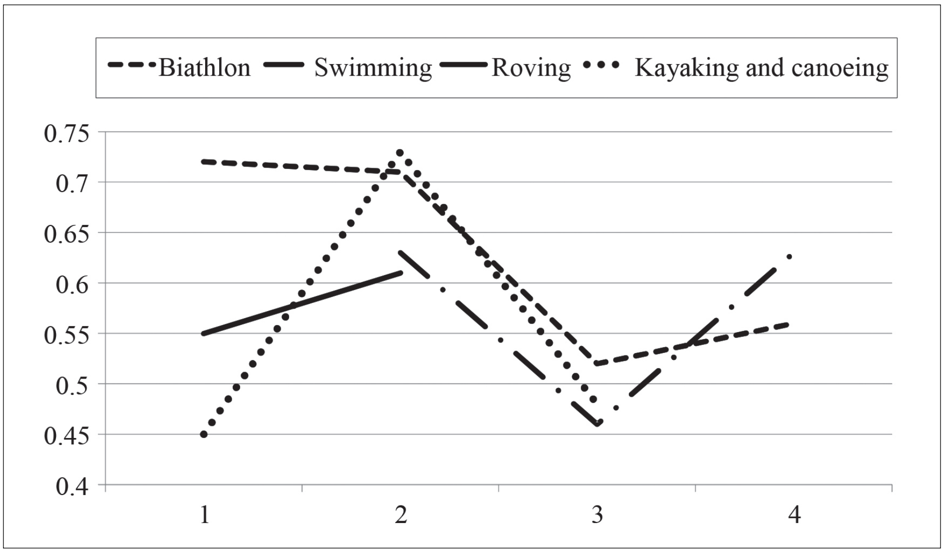


Figure 3. **The dynamics of changes in reticulocytes amount at stages in cyclic sports annual preparation cycle for females**

Note. 1 – generalized stage of preparatory period, 2 – specialized stage of preparatory period, 3 – competitive, 4 – recovery.

Figure 1 shows multidirectional trend of reticulocytes amount regarding the aspect of age for male and female athletes.

Figures 2–3 present the trend line of average reticulocytes group data in peripheral blood at various stages of the annual preparation cycle.

DISCUSSION

The amount of reticulocytes may be affected by the number of factors including individual metabolism features, circadian rhythms, seasonality, physiological activity of athletes' organisms, athletes' gender and age and many others depending on muscle activity in each sport. Studies in reticulocytes amount are an important marker for detecting early signs of oxygen decrease in blood and timely pharmacological and non-drug correction of training in order to improve its efficiency (Fallon & Bishop, 2002).

Increase in reticulocytes is marked for male athletes in the age aspect; for females, reduction is observed. This phenomenon seems to be due to differences in the dynamics of activation and inhibition of erythropoiesis in different gender groups with increasing age. Leading factor of erythropoiesis stimulation is the synthesis of erythropoietin hormone that occurs as a result of hypoxic condition.

In addition, sex hormones have a significant effect on erythropoiesis. Female sex hormones oestrogens cause inhibition of erythropoiesis. Products of metabolism of male sex hormones androgens have positive impact on erythropoiesis activation, which contributes to sensitivity increase of bone marrow to erythropoietin. The activity of erythropoiesis changes with the increasing production of sex hormones in the age aspect due to the multidirectional impact on erythropoietic function of oestrogens and androgens.

The trend of reticulocytes amount change during the season in different sports differs, but what causes obvious interest is the common to all sports pattern of reducing the amount of reticulocytes in competition period, which is characterized by the high level of exertion of all athletes' body functioning systems including oxygen transport. This pattern is seen regardless of gender. The dynamics of IRF at the stages of the annual training is similar.

Reduction of reticulocytes amount and IRF in competitive period may be due to accelerated ageing of red blood cells and slowing of erythropoietic activity. Acceleration of red blood cell ageing may be the result of adaptation aimed at the improvement of oxygen transport by aged erythroid cells.

On the other hand, the reduction in hemopoietic system's capacity at the start of competitive period may be a consequence of large training loads during generalized and specialized stages of preparatory period. As a result of intensive muscular exertion proliferative activity of bone marrow decreases under the influence of increasing needs of erythrocyte cell production. The cause of this phenomenon may be insufficient amount of iron and serum protein for the needs of erythropoiesis, which results in its inhibition. On the one hand, iron deficiency leads to a decrease of synthesis of iron-containing proteins, and on the other hand, the lack of proteins, such as transferrin, reduces the possibility of transporting iron for erythropoietic purposes. In addition, activation of lipid peroxidation during high-intensity physical activity may contribute to damaging cell membranes of erythrocytic class.

The tendency of reticulocytes and IRF increasing from generalized to specialized-preparatory period, apparently, is the result of performing a significant amount of training loads, aimed at endurance improvement. More intensive and longer training aimed at endurance enhancement during generalized stage of preparatory period obviously leads to prolonged stimulation of bone marrow due to the process of erythrocyte haemolysis caused by training.

CONCLUSION

Studying the reticulocytic indices dynamics from peripheral blood of cyclic sports athletes allows us to estimate the impact of training and competitive processes on erythropoiesis activity intended to compensate the hypoxic state induced by the exercise.

The effect of training activity on reticulocyte indices in the annual training cycle is related to the direction, duration and intensity of physical activity in different periods of training. Changes in the reticulocytic indices may be due to effects such as hemoconcentration and hemodilution appearing after exercise in the corresponding areas of energy supply.

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EFFICIENCY OF SNATCH TECHNIQUE IN HIGH LEVEL WEIGHTLIFTERS

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ABSTRACT

Background. Rich theoretical and experimental evidence on the biomechanics of weightlifting exercises has currently been collected (Bauman, Gross, & Quade, 1988; Garhammer, 1991; Gourgoulis, Aggelousis, & Mavromatis, 2000; Isaka, Okada, & Funato, 1996; Шалманов, Скотников, & Панин, 2012). Most of the studies were mainly carried out in laboratory settings, with long-term treatment of the obtained data. In recent years, scientists' interest has shifted to the study and evaluation of the technical mastery of athletes in the setting of the highest level competition, in the extreme conditions of sport fight. This was facilitated by the development of specialized hardware and program sets (Шалманов & Скотников, 2013; Шалманов, Скотников & Ланка, 2013), opening the possibility for biomechanical control of athletes technical and speed-strength fitness both during the technical training process and competition. One of the ways of evaluating the effectiveness of techniques is based on the idea of using motor capacity by an athlete, which is called efficiency of realization.

Methods. To register the trajectory of the bar and calculate kinematic and dynamic parameters of its movement a specialized hardware-program complex (APC) has been developed. In the APC, a photo-video camera "Canon" is included; a marker is fixed on the end of the bar as well as a computer with software. Recording was carried out during major competitions (Cup of Russia, the Russian Championship, and the XXVII World Summer Universiade) in 2012–2014. The total number of athletes surveyed was 331 people (184 men, 147 women). The paper presents the results obtained in the snatch in men.

Results. The regularities in the change of kinematic and dynamic bar movement parameter with an increase in weight category and sport result were determined. The main indicator determining sports result in a classic snatch was the absolute maximum power developed by the athlete during acceleration of the bar in the final phase of its lifting: $r = .75, p < .001$. The indicator of absolute power is the most informative to assess the level of athlete speed-strength fitness, realized due to the efficiency of sports technique and prediction of sports result.

Conclusions. The regression equation between the result in the snatch and the maximum absolute power in the final acceleration of the bar give a possibility to evaluate the technique of the effectiveness of each athlete: if it is better or worse than the average one and to what extent. This analysis gave one more possibility – to compare the set up performance with the performance that the athlete, taking into account their level of physical conditioning (maximal power), would achieve if they improve their technique.

Keywords: biomechanical control, technical and physical fitness, technique realization effectiveness.

INTRODUCTION

The effectiveness of management of training process, especially in highly qualified athletes, depends on the timeliness and completeness of the information about the condition of the athlete, the quality of their techniques, and the comparison of these data with the amount and characteristics of the training load. The main objective of biomechanical monitoring is to evaluate the motor capacities and technical skills of athletes using instrumental means. At the forefront here extends the operational and current monitoring, which is based on the testing of athlete motor abilities and the quality of the execution of any given exercise immediately after the completion of the motor exercise.

Despite the fact that numerous measuring systems are available currently (Шалманов, 2002), not all of them can be used for operational and current control. The possibilities of their application in competitive conditions are limited. The main difficulty lies in the speed of obtaining the necessary information, and, in addition, the testing procedure should not interfere with the natural course of the training process and athlete activity. One solution to this problem is the development of specialized hardware-software complexes and their introduction into the training process.

No less important is finding ways to assess athlete technical mastery. One approach to technology assessment is based on the idea of using athlete potential motor abilities, such as speed and strength. In its implementation athlete must perform two exercises. The first exercise is to assess the level of technical mastery, and the second exercise - to measure athlete's speed and strength. The technique of the execution of the second exercise should be extremely simple; the result in it should depend only on the speed and strength abilities of the athlete. Then the regression equation between the results of two exercises is calculated, and with the help of this equation the efficiency of the techniques realized is determined (regression residuals). This method was proposed by Zatsiorsky and implemented by his co-workers (Lanka & Shalmanov, 2004; Lanka, Konrad, & Shalmanov, 2005; Ланка, & Шалманов, 1982).

The aim of the research was the development of the methodology for biomechanical control of athlete speed – strength fitness and the assessment of the efficiency of athlete's technique.

METHODS

To register the trajectory of the bar, kinematic and dynamic parameters of its motion were calculated and biomechanical analysis of the athlete activity was performed as well as a methodology that could be used both in the training process, and in the conditions of competition was developed (Шалманов et al., 2012; Шалманов & Скотников, 2013). The methodology comprises a photo-camera "Canon" marker attached to the end of the neck of the bar and a computer with software. The camera is set to the side of the platform at a distance of 5.5 m from the marker at a height of 1.5 m. The optical axis is perpendicular to the camera shooting. The frequency of shooting is 50 shots per second. Recording was carried out during major competitions (Cup of Russia, the Russian Championship and the XXVII World Summer Universiade) in 2012–2014. More than 1,000 attempts in the snatch and clean and jerk in all weight categories for men and women were recorded. For further processing the best attempts of athletes having shown the results relevant to the regulations of master of sports according to

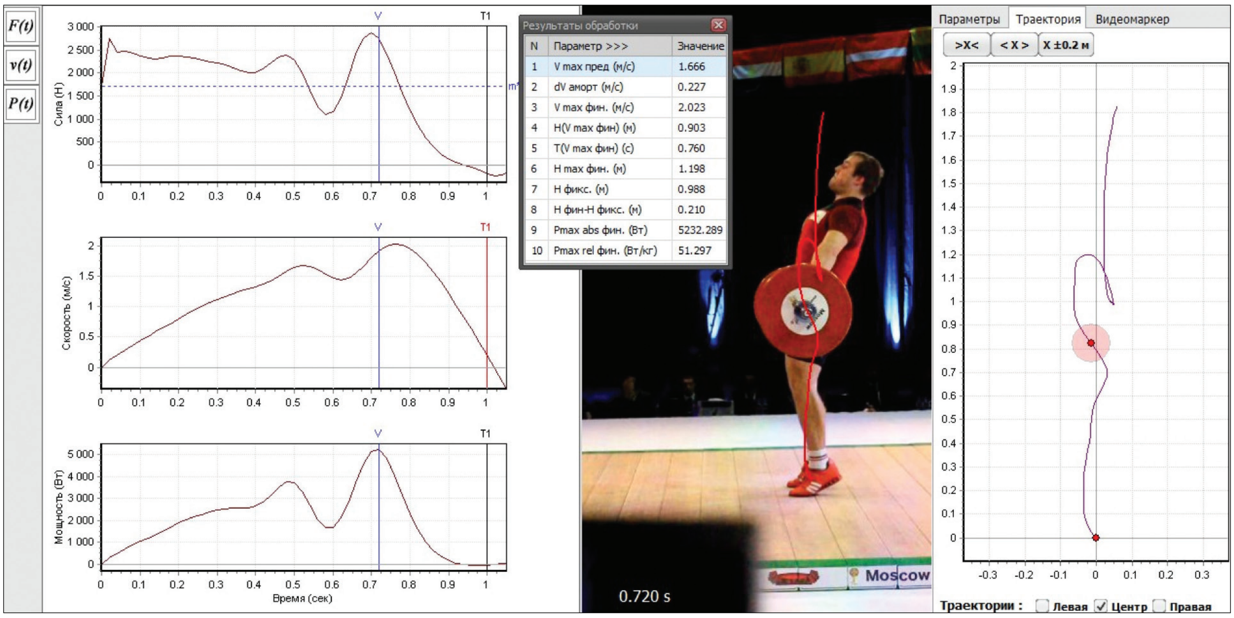


Figure 1. **Kinematic and dynamic characteristics of the movement, position of the athlete at the moment of maximum power in the final acceleration, and bar trajectory in the snatch**

the classification adopted in Russia were chosen. The total number of athletes researched was 331 people (184 men, 147 women). The paper presents the research results in the snatch in men.

The process of data collection and processing for one attempt takes less than one minute. The program displays the graphs of the change of vertical force applied to the bar, speed and power, the trajectory of the bar and the position of the athlete.

In processing the raw data, the program automatically finds the value of the selected kinematic and dynamic parameters of movement. In addition, the program provides an opportunity to measure the current value of movement characteristics listed after every 0.02 s from the beginning of raising the bar until its fixation at the end of the exercise.

RESULTS

Characteristics of the athletes and the mean values of the basic kinematic and dynamic parameters are presented in Table 1.

The data show that with increasing weight category, overall weight and height data of the athletes increased not only sport result, but it also changed most of the kinematic parameters of the motion of the bar: maximum speed of the bar in the preliminary acceleration, the height of the implement in different movement moments, the time of reaching maximum speed in the final acceleration increased.

Analysis of correlations between these parameters of bar movement and the results in the snatch showed that the main indicator determining sports result was the absolute maximum power during acceleration of the bar in the final phase of its lifting: $r = .75$. $p < .001$ (Figure 2).

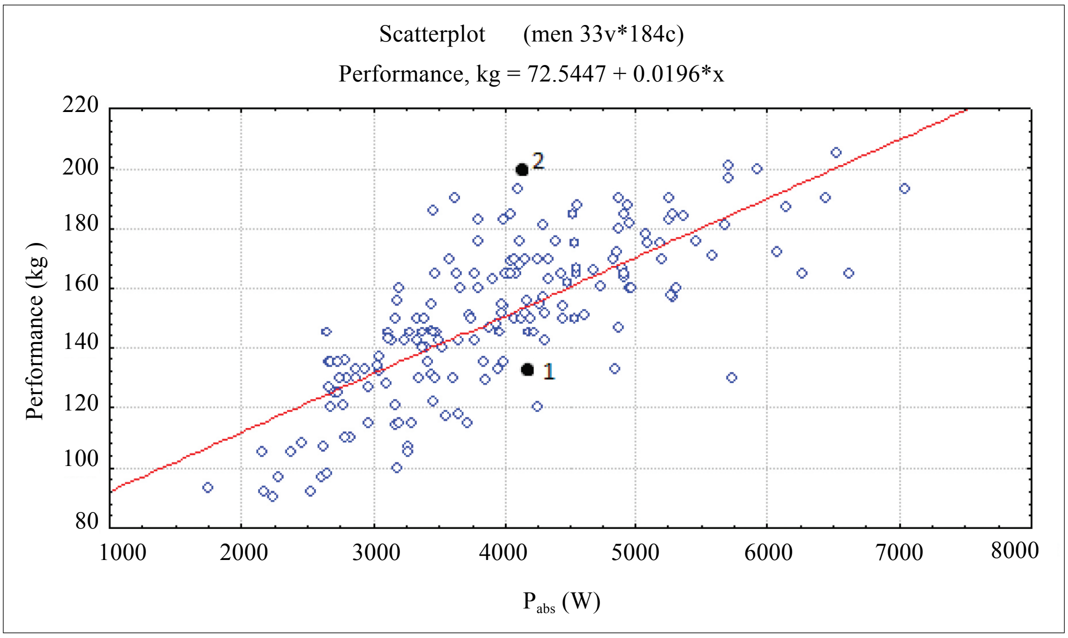
This means that approximately 50% of the result in snatch is determined by the power developed by the athletes during the acceleration of the bar. The remaining 50% are caused by other factors, one of which is the technical mastery of the athlete.

Taking the correlation between the result in the snatch and the maximum power as the basis, we tried to evaluate the effectiveness of the technique realized by the athletes, using the method of the

Table 1. **Mean values and standard deviations of the parameters of motion of the bar in the snatch in athletes of different weight categories**

No.	Indicator	Weight categories (kg)							
		56 *n* = 13	62 *n* = 17	69 *n* = 16	77 *n* = 30	85 *n* = 25	94 *n* = 31	105 *n* = 26	+105 *n* = 26
1.	Body height *(m)*	1.59 ± 0.05	1.60 ± 0.04	1.65 ± 0.03	1.72 ± 0.04	1.72 ± 0.04	1.77 ± 0.04	1.81 ± 0.04	1.85 ± 0.05
2.	Body weight *(kg)*	55.7 ± 027	61.1 ± 1.76	68.3 ± 0.88	76.1 ± 0.92	84.3 ± 0.14	92.8 ± 1.4	103.1 ± 2.0	133.3 ± 17.0
3.	Result in the snatch *(kg)*	101.2 ± 8.3	118.6 ± 11.6	137.1 ± 7.7	139.7 ± 12.4	150.3 ± 12.4	161.3 12.6	169.4 ± 15.1	178.7 ± 18.4
4.	Maximum speed in the first pull, V_1 *(m/s)*	1.25 ± 0.16	1.15 ± 0.19	1.21 ± 0.20	1.35 ± 0.18	1.34 ± 0.16	1.33 ± 0.17	1.40 ± 0.18	1.43 ± 0.17
5.	Speed reduction in amortization phase, *ΔV (m/s)*	0.08 ± 0.17	0.01 ± 0.04	0.05 ± 0.06	0.13 ± 0.17	0.08 ± 0.09	0.14 ± 0.13	0.11 ± 0.12	0.11 ± 0.11
6.	Maximum speed in the second pull, *Vmax (m/s)*	1.80 ± 0.13	1.85 ± 0.12	1.84 ± 0.12	1.82 ± 0.20	1.82 ± 0.13	1.81 ± 0.14	1.87 ± 0.17	1.86 ± 0.15
7.	Height at Vmax, *HVmax (m)*	0.70 ± 0.04	0.71 ± 0.06	0.73 ± 0.04	0.75 ± 0.07	0.77 ± 0.06	0.77 ± 0.06	0.82 ± 0.08	0.88 ± 0.07
8.	Time to Vmax, *TVmax (s)*	077 ± 0.08	0.73 ± 0.06	0.78 ± 0.07	0.74 ± 0.05	0.77 ± 0.05	0.79 ± 0.07	1.10 ± 0.07	0.84 ± 0.07
9.	Maximum height, *Hmax (m)*	0.95 ± 0.04	0.96 ± 0.07	0.98 ± 0.05	1.01 ± 0.09	1.02 ± 0.07	1.03 ± 0.08	0.93 ± 0.03	1.15 ± 0.09
10.	The height at the time of fixation, *Hfix (m)*	0.79 ± 0.04	0.80 ± 0.07	0.81 ± 0.05	0.85 ± 0.08	0.88 ± 0.06	0.86 ± 0.07	0.94 ± 0.04	0.98 ± 0.07
11.	The difference, *(Hmax-Hfix) (m)*	0.16 ± 0.04	0.16 ± 0.04	0.18 ± 0.05	0.16 ± 0.04	0.14 ± 0.05	0.17 ± 0.04	0.17 ± 0.04	0.21 ± 0.19
12.	Maximum absolute power, *Pabs (W)*	2644 ± 523	3063 ± 526	3695 ± 587	3619 ± 762	3912 ± 626	4243 ± 853	4529 ± 898	4740 ± 1096
13.	Maximum relative power, *Prel (W/ kg)*	47.5 ± 9.4	50.1 ± 8.5	54.1 ± 8.6	47.7 ± 10.0	46.3 ± 7.3	45.7 ± 8.9	43.9 ± 8.8	35.7 ± 7.7

Figure 2. **The correlation field (*r* = –.75) and the regression equation between the maximum power in the final acceleration and the result in the snatch in men (*n* = 184)**



regression residuals. Traditionally this happens by comparing the athlete's results in the movement, which he or she specializes in, with the results of the execution of a movement, which is simpler to execute, but the execution of which requires that same physical characteristics.

Unlike the approach described above, in this research both athlete's technique and motor capacity were assessed in the same exercise, i.e. during the execution of the exercise in the conditions of competition. Regression equation between the results in the snatch with indicators of the maximum power that athletes develop during the acceleration of the implement was calculated:

$$Y = 72.5447 + 0.0196 \bullet P,$$

where Y – sports performance and P – the maximum absolute power.

In this case, the power is considered as an indicator of speed - strength capabilities of the athlete. Indication of athletes technical mastery is the efficiency of the techniques that is the difference between the result in the snatch, shown in competition and the average result in this exercise, calculated from the regression equation. If the difference is positive, the technique is better than average, and if negative, then it is, respectively, worse than average. The greater the difference in absolute value, the higher or lower than average is the effectiveness of the technique.

Points located above the regression line, correspond to those of the athletes with higher efficiency of the realized techniques of the performance of the exercise regardless of the result shown. The points located below the regression line, correspond to those of athletes with lower efficiency of the techniques. For example, two athletes have maximum power in the final acceleration close to 4100 watts. One athlete showed the result of 135 kg, and the other with the same power raised the bar weighing 200 kg. Based on athlete regression equation, athletes developing maximum power of 4100 watts on average should show the result in the snatch equal to 152 kg. It can be assumed that athletes lifting more weight with the same amount of power show a more effective technique of the execution of the exercise. Thus, in this case, the coefficient of efficiency (CE) of the techniques in the first athlete is –18 kg (the technique is worse than average), while in the second athlete it is +47 kg (the technique is much better than average). Let us consider another example. In order to raise the barbell weighting 160 kg, one athlete has develops power of 3250 watts, the other almost twice as much. The given example demonstrates the basic idea of the realization of the technique criteria: effectiveness of the technique can be assessed by comparing athlete's actual result with his or her achievement, which can be predicted taking his or her physical fitness as the basis. The difference between actual and predicted result is the measure of the effectiveness of the athlete's technique.

Table 2 shows correlation coefficients between the results in the snatch (r_1), the coefficient of the realized efficiency of the techniques in the snatch (r_2), some parameters of bar movement.

Table 2. **Correlation coefficients of some parameters of movement of the bar with the result in the snatch (r_1) and the coefficient of the realized efficiency of the technique (r_2)**

No.	Indicator	r_1	r_2
1	Maximum speed in the final acceleration – V_{max}	.05	–.56
2	Maximum of the height of the lift – H_{max}	–.04	–.35
3	Relative height at the time of fixation – H_{fix}	.07	–.25
4	Maximum relative power in the final acceleration – P_{rel}	–.13	–.65

It can be seen that the maximum speed of the bar in the final acceleration, maximum relative height and the height of bar fixation significantly ($p < .05$) negatively correlates with the coefficient of the efficiency of the snatch techniques, whereas these figures do not significantly correlate with the result. This fact suggests that more technical athletes raise maximum for themselves weights at lower height, have lower "sit", accelerate the implement to less maximum speed (Figure 3), and develop smaller relative power (Figure 4), which is logical.

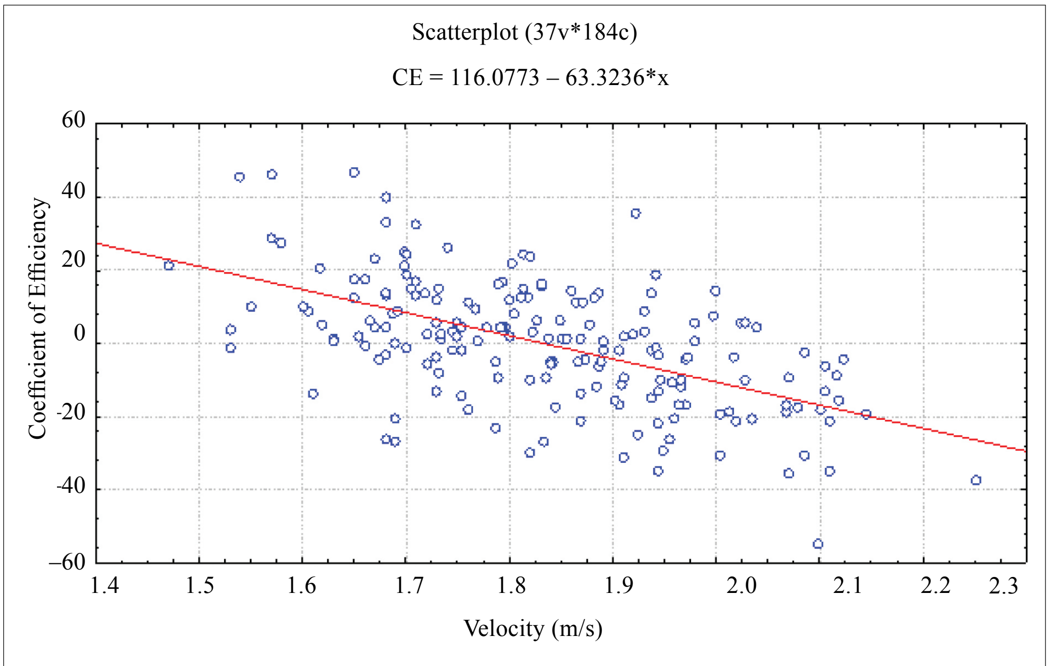


Figure 3. **The correlation field (r = –.56) and the regression equation between the maximum of the speed in the final acceleration and the coefficient of the efficiency of the techniques in the snatch in men (n = 184)**

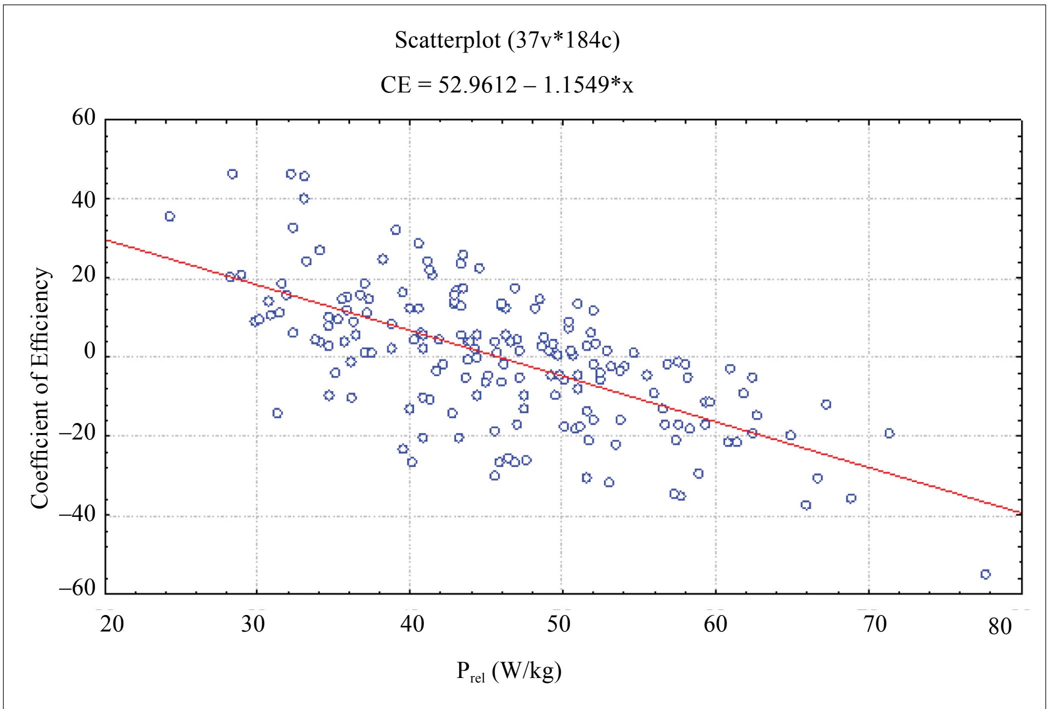


Figure 4. **The correlation field (r = –.65) and the regression equation between the maximum of the relative power and the coefficient of the efficiency of the techniques in the snatch in men (n = 184)**

DISCUSSION

The advantage of the proposed method for evaluating the effectiveness of the athlete technique is that it can be used for the registration of the necessary parameters in the extreme conditions of sport competitions. The disadvantage is that the maximum power measured in the exercise, depends not only on the physical capabilities of athletes, but also on the technique of the exercise performance. Therefore, the assumption that the maximum power measured during the competition reflects the speed-strength potential of the athlete is not quite correct. Notwithstanding this, the proposed method for evaluating the effectiveness of techniques may be useful, particularly in practical terms. It is enough to measure maximum power and the result in the classic weightlifting exercises using the proposed method and from the correlation field (Figure 2) immediately evaluate the effectiveness of techniques for subsequent action – what should be paid more attention to – the improvement of sports techniques or the development of lacking physical characteristics. It should be noted, however, that sports result depends not only on speed and power capabilities and athlete techniques, but also on other factors not accounted for.

Wide application of the regression method to solve sports problems is restricted by several conditions (Lanka & Shalmanov, 2004; Lanka et al., 2005; Lanka, Shalmanov & Medvedjev, 2012; Шалманов, 2002). Firstly, in case the research does not involve a great number of individuals, the precision of the regression equation is not high. Secondly, variable marks that are included in regression equations, may in an intrinsic way mutually correlate and the signs of plus or minus that stand before the equation's members may not correspond to the real situation. Thirdly, the regression equities with two and more variables are difficult to be applied in practice due to data obtaining, as well as – the selection of the necessary information is becoming more and more difficult. Multifactor regression equities may be applied in practice only if the variables they contain mutually do not correlate, but they correlate closely with the dependent variable – sports performance (Шалманов, 2002). In this case the variables depict those various factors that the sports result depends on, they show the importance of the factors and their investment in sport result. In the event there is a mutual correlation between the variables that enter the regression equity, it means that they depict the influence of some common factor. In this case we speak about co-linearity of factors: the factors correlate mutually, as well as they correlate with the sports result, however, those factors may have no logical causes – coherence of consequences with the result (Lanka et al., 2005).

The regression residuals method can be used to work out technique's model-indices, as well as movements' statistic models (Lanka et al., 2012). The method allows evaluating the efficiency of athlete technique, comparing them, though it fails to provide answer to the question in general and in particular to what determines these differences. The usage of the regression remnant method becomes more useful in case it is applied alongside with the biomechanical analyses (Lanka, 2004; Lanka, 2007; Шалманов et al., 2013).

CONCLUSIONS

1. Indicators of absolute power developed during acceleration of the bar in the snatch, are the most informative in assessing the level of physical fitness of athletes and the prediction of sports results. At the same level of athlete technical mastery the increase of power by 50 watt will increase the result in the snatch per 1 kg on average.
2. The regression equation between the result in the snatch and the maximum absolute power in the final acceleration of the bar gives a possibility to evaluate the technique of the effectiveness of each athlete: if it is better or worse than the average one and to what extent. This analysis gave one more possibility – to compare the set up performance with the performance that the athlete, taking into account their level of physical conditioning (maximal power), they would achieve if they improved their technique.
3. Regularities of the change in kinematic and dynamic parameters of movement of the bar with the growth of sports results and the mean values of the indicators registered in the conditions of competition in highly qualified athletes can be used as model characteristics of technical and speed-strength fitness and serve as a guide in the preparation of the athletes of lower qualification.

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PHYSICAL EXERTION MONITORING: ELITE ATHLETES MODIFY THEIR COACH'S TASK

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ABSTRACT

Background. The objective of this study was to establish how accurately elite athletes carried out the task of a coach to perform an exercise at a given intensity.

Methods. Cardiovascular indices were registered and analysed during a two-step research process. Two groups including six well-trained long-distance runners and 21 healthy non-athletes performed graded stress exercise up to the inability to continue the task. Runners took part in the second study in which heart rate and running pace were recorded during an aerobic training session.

Results. Research findings showed that athletes demonstrated higher physical performance, but the maximum heart rate values achieved in the last fatigue phase did not differ significantly between the groups. No ischemic events were observed in elite athlete group during the entire physical test. Relatively stable heart rate indices in the maximal physical load step were observed in both groups, but heart rate indices were significantly lower during all physical load steps in the group of elite runners.

Conclusions. Elite athletes carried out the coach's task only in the first phase of running and further modified the task by maintaining the stability of the cardiovascular system.

Keywords: training, cardiovascular system, functional state, heart rate.

INTRODUCTION

The complex system approach is based on the understanding that the human body is a self-regulating system, and many factors determine the behaviour of the entire system. The cardiovascular system is a vital part of the body, and its complexity and interrelationship with all body systems allow the monitoring of cardiovascular parameters as feedback of applied influences.

It is generally accepted that various factors determine training effects. A quantified dose-response relationship for the continuum of training intensities, frequencies, and volumes was identified for fans of healthy lifestyle populations, but this relationship has not been identified for elite athletes (Peterson, Rhea, & Alvar, 2004; Seiler & Kjerland, 2006). Sports training is the process of adaptation, the efficiency of which can be increased by manipulating training loads. Therefore, the precise workload parameters while exercising are one of the essential components of effective training (Gaudino et al., 2013).

Functional status of fans of healthy lifestyles and high-performance athletes changes during exercise, and the mechanisms of these changes are partially different and individualized. Additional monitoring and recording of internal and external load parameters can improve the quality of health observations and also provide better knowledge of the optimal dose of training load during exercise (Shephard & Blady, 1999; Weiner et al., 2011).

Aerobic-type exercise triggers many short-term and long-term adaptive changes. Cardiovascular changes in athletes depend on the nature of the activity, the length of training and other factors (B. J. Nainmark, A. Naimark, Tate, Sigurdsson, & Axelsson, 1996). Scientists assign long-distance runners as typical aerobic endurance training athletes, who have one of the largest hearts, to calculate mass and other parameters for each kilogram of their body weight (Fagard, 1997; Fagard et al., 1983; Urhausen, Monz, & Kindermenn, 1997). Some authors consider the heart rate response measurement as a convenient non-invasive evaluation tool to monitor and analyse individual workouts (Dellal et al., 2012; Hettinga, Monden, van Meeteren, & Daanen, 2014; Jeukendrup & VanDiemen, 1998). Various types of heart rate monitors were widely used in endurance sports for over 30 years (Achten & Jeukendrup, 2003). Optimum performance level depends on the development of body responses through training. Therefore, one important task of physiological research is to effectively evaluate and monitor the training schedule (Alexandre et al., 2012; Ghosh, 2004).

The task of a training session is the infliction of internal body changes. A coach must first consider the type of internal body changes and the proper approach to provoke the planned changes in athlete's body during the planning of physical loads. Continuous methods are widely used in endurance training. It is important to continue task performance under fatigue by increasing the conditions that trigger long-term adaptation mechanisms. One of the important questions in training methodology is how accurately athletes perform the given task or how they modulate the given task of a training session. Therefore, the accurate accomplishment of the task given by the coach is very important. This study assessed how accurately elite athletes carried the task of their coach to "run 12 km at a steady speed".

METHODS

Internal body changes are a trigger for long-term adaptation. The purpose of each training session is to make appropriate internal body changes, and the coach's task is to plan the mode of exercise. However, internal body changes at the onset of exercising depend on individual features of the athletes, and the monitoring of the body's response during exercising is one manner to obtain feedback.

There are two ways to monitor the external performance of tasks, such as the dynamics of running speed or the dynamics of HR changes during exercise. Both parameters are important in our approach because they can reveal important features of the essence of the training session.

Subjects. Two groups of participants were involved in the study. The first group consisted of elite endurance runners (age 20.9 ± 1.21, body mass index 22.3 ± 0.38; $n = 6$). The second group consisted of healthy male non-athletes (age 23 ± 1.8 years, body mass index 24.4 ± 1.3; $n = 21$). All subjects provided their written informed consent before participation in the study.

Procedures. *The first study* was designed to compare the functional abilities of the two groups in this study. All participants performed bicycle ergometry, i.e., a graded exercise test up to the inability to continue the task. A 12-lead electrocardiogram provided continuously recording during exercise and the first three minutes of recovery.

The second study was designed to study exercise task accuracy accomplishment**.** A group of elite runners performed a task to run a 12-km distance at a steady running speed in an aerobic zone. The heart rate monitor Polar-S810 monitored heart rate changes (instantaneous heart rate values, average heart rate (HR avg.), values of the selected section (each 1000 m), and optional sections of running time (t) (every 1000 m running time).

Statistical analysis. The arithmetic mean (x) and standard deviation (s) and the arithmetic mean of the error (s_x) were calculated. A two-way independent samples Student's *t*-test was used to determine the reliability of the mean difference in performance indicator results. A significant difference between the compared values was indicated when the error did not exceed 5% ($p < .05$).

RESULTS

The results obtained during the first study showed a significant difference between groups in physical working capacity. The healthy male non-athletes continued exercising up to 250 W, and the elite athletes continued exercising up to 350 W. The mobilization of cardiovascular function during the workload was described using HR changes (Figure 1). A significant increase in HR was observed in both groups during the graded exercise test up to inability to continue the task, and this increase continued according to the increasing workload. The endurance runners' HR was significantly lower at rest and during the entire test than non-athletes (before the load at rest – 87.6 ± 2.8 in the group of non-athletes and 71.7 ± 2.5 in the group of endurance runners; on the last minute load– 172.3 ± 3.0 in the group of non-athletes and 170.7 ± 0.8 in the endurance runners' group). The investigation established that athletes had higher physical performance but maximum HR values in both groups when the full fatigue phase was achieved, but these values did not differ significantly. Faster HR recovery was observed in the group of endurance runners during the recovery time.

The ST-segment depression increased with each step of increasing workload in the group of non-athletes. These types of changes were not observed in elite runners' group. The results indicate that ischemic episodes were observed in the group of non-athletes, and there were no ischemic episodes in the group of elite runners. ST-segment depression changes (Figure 2) show that the workload reached its maximum values during the highest physical test loads in both groups (in the non-athletes' group it was recorded at 250 W, ST-segment depression – 0.53 ± 0.13 mV; in the runners' group – at 350 W – 0.17 ± 0.02 mV ST-segment depression).

The second study was designed to assess how accurately elite athletes carried out the task of their coach to "run 12 km at a steady speed". The results

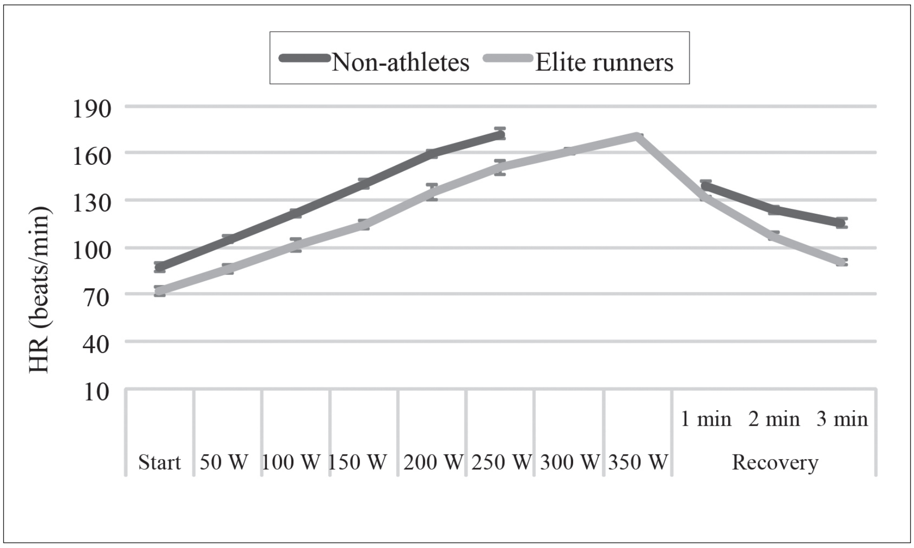

Figure 1. **The heart rate (HR) changes in male elite runners and non-athletes every minute in steps during incremental cycling exercise testing**

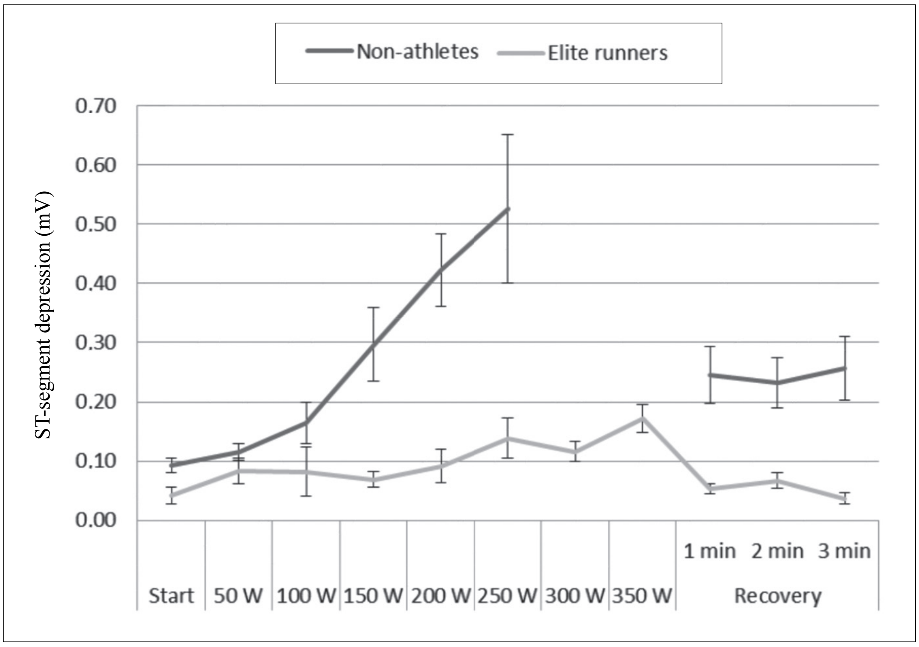

Figure 2. **ST-segment depression changes in male elite runners and non-athletes during the performance of graded exercise tests to maximal efforts**

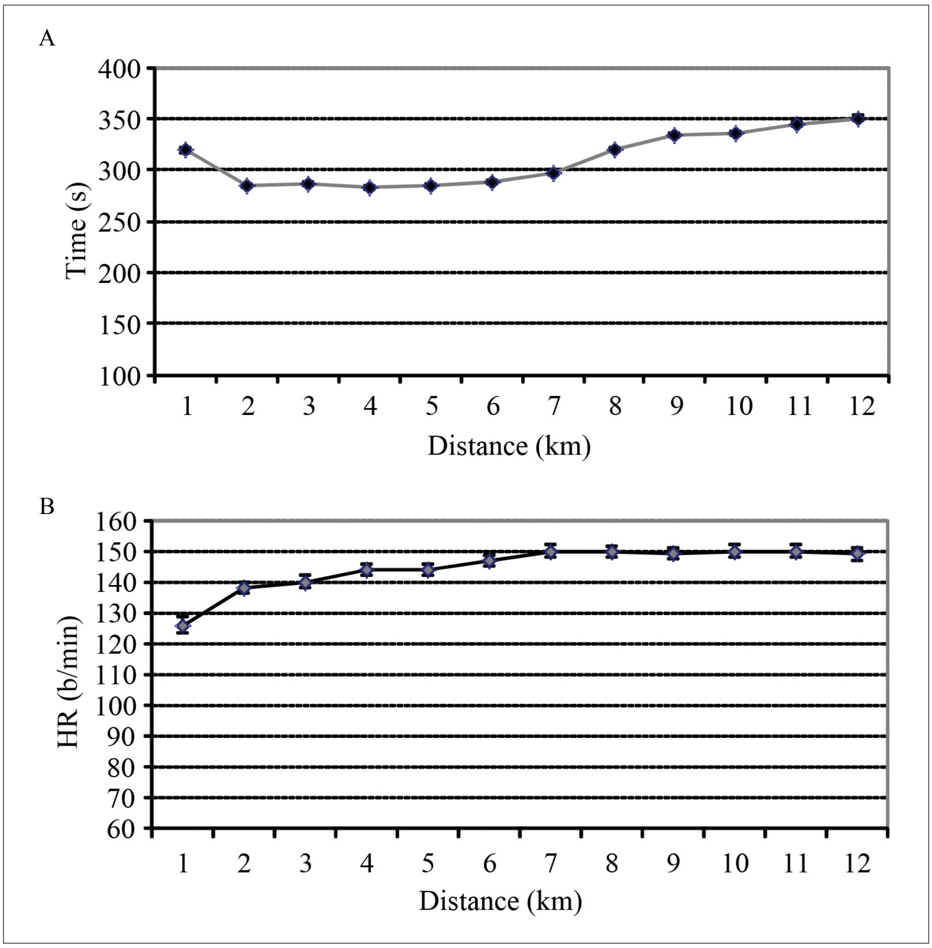

Figure 3. **Indices characterizing external and internal physical loads during the task "run 12 km at a steady speed". A – dynamics of time of running 1 km. B – dynamics of HR**

showed that running time change was 319.8 ± 4.8 in the first kilometre in the endurance runners' group, and the change in the last kilometre was 350.7 ± 3.4. A fairly equal rising segment speed was maintained during the middle distance (Figure 3 A).

HR dynamics (Figure 3 B) during the run in the first kilometre revealed an average HR of 126.0 ± 2.6 beats/min and 149.0 ± 2.0 beats/min in the final kilometre. The submitted change in HR curve during the second half of the running task, i.e., from the 7th kilometre of running, revealed no significant HR variations, i.e., the task to run was performed without changes in HR.

DISCUSSION

Exercise is one of the most powerful non-pharmacological strategies that affects most cells and organs in the body (Shalaby, Saad, Akar, Reda, & Shalgham, 2012). Regular aerobic exercise has a positive long-term impact on the cardiovascular system, which is a vital part of the body because it is a biologically complex adaptive system that is characterized by a variety of complex reactions to training loads (Alex et al., 2013; Ellison, Waring, Vicinanza, & Torella, 2012; Gibala, Little, MacDonald, & Hawley, 2012).

Biological systems consist of numerous different components that are linked together to form a complex system characterized by non-linear dynamics (Pinsky, 2010). However, a system of self-regulation that leads to a single factor within the system does not exist because it determines the entire system. The complexity of this regulation cannot be appreciated if the body is studied as a collection of disconnected components, which is the usual approach in modern exercise sciences (Noakes, 2011).

External and internal physical loads have been identified. Most previous authors note that the internal side of exercising is very important in the training of physical abilities (Issurin, 2013; O'Keefe et al., 2012). Therefore, the accuracy of elite athletes' accomplishment of a task of their coach is essential for the management of the training process. The essence of the coach's planned task for a training session with a specified external workload, usually measured in SI units, is the internal body changes to be achieved by the performance of the assigned workloads. Notably, an internal exercise control and evaluation are the essence of individualization. HR is one of the cardiovascular functional status indicators evaluating the inner half of physical exertion. HR is also used to describe the body's common condition changes.

Advances in technology have provided athletes, coaches, and scientific as well as medical staff with mobile and easy to use heart rate monitors (Weippert et al., 2010). These monitors are widely used by elite athletes and people who exercise for health promotion. HR monitors can help a coach assess the accuracy of an athlete's performance of a given task during training, but not all of the HR monitor indicators are accurate and suitable for evaluations of high-performance athletes.

There are various methods of measuring the body reactions to exercise and physical exertion, but their applicability and value are widely discussed and analysed (Boettger et al., 2010). Doubts of an optimality index are associated with cardiovascular parameters with synergic interaction features. Increases in the severity of exercise lead to increases in HR until it reaches its maximum, which is relatively constant in a particular person. This observation was confirmed in our first study. The results of the first study showed that athletes (first group) differed from the healthy group with better cardiovascular reactions to incremental exercise stress. There were no ischemic episodes during exercising, but the lower HR values at each step of workload indicated better functional abilities that were obtained by training. This comparison showed that the participants in the elite runners group exhibited better functional readiness; the increasing workload HR values were significantly lower in elite runners than in the group of non-athletes. HR monitors can be used during highly trained runners' workout sessions to control the quality or task accuracy of the session. The results of this study showed that the runners modified the coach's designated exercise task to "run 12 km at a steady speed". More than half of the current distance runners maintained a steady running speed, which resulted in a gradual increase in HR, and a stable HR was maintained during the rest of the running distance; HR did not increase and running speed decreased.

Running time showed few changes during the distance when the runners performed a measured workload, which was performed in a particular operating region. The runners turned to training activity during the first kilometre, and only after the second section they began to maintain the goal of the task. A constant running speed was maintained until the middle distance, and then it declined. These results suggest that the runners began to maintain the trained zone regardless of the distance. Subsequent HR changes during the distance run were low. An HR change increased by the seventh kilometre, and HR was maintained at the same level from midway of the distance to exceed the prescribed training mode.

Measures of an athlete's heart rate have shown potential for use in the prescription of individual training. However, little data exists on elite athletes who are regularly exposed to intense training loads (Plews, Laursen, Kilding, & Buchheit, 2012; Wallén, Hasson, Theorell, Canlon, & Osika, 2012). Measures of heart rate cannot provide data on all aspects of wellness, fatigue, and performance. Therefore, the use of HR in combination with daily training logs, psychometric questionnaires and non-invasive, cost-effective performance tests, such as a countermovement jump, may offer a complete solution to monitor the training status of athletes participating in aerobic-oriented sports (Buchheit, 2014). Our data also confirmed the results obtained by other researchers, who observed a lower degree of functional ischemic events in cardiac muscle in a group of trained athletes (Gademan et al., 2012; Poderys, Buliuolis, Poderytė, & Sadzevičienė, 2005).

CONCLUSION

Monitoring is an important part of the management of training processes. The monitoring of running pace and internal body changes during a training session will allow the control of how accurately athletes perform a given task. Even well-trained athletes carried out the coach's task only in the first part of running and further modified a given task for training sessions by adapting themselves to internal feelings and decreasing their running pace accordingly.

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THE EFFECTIVENESS OF NON-FORMAL PHYSICAL EDUCATION CURRICULUM FOR THE PHYSICAL DEVELOPMENT OF 11-13-YEAR-OLD CHILDREN

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ABSTRACT

Background. This study aims to develop and implement a curriculum of non-formal physical education in school and assess its effectiveness for the physical development of 11−13-year-old children.

Methods. The research was conducted in two stages. In the first stage 51 fifth grade children (M_{age} = 11.3 years) participated in a quasi-experiment for two years. The children were organized into two groups: E and C. Both groups shared the duration (1 hour) and frequency (twice a week) but were different in their education curriculum. In the second stage (after four years) 72 sixth graders (M_{age} = 13.0) participated from the same comprehensive schools. The focus groups underwent anthropometric (height, weight, BMI) and physiometric (VC, right and left handgrip strength) measurements. Dependent *t* test indicated that over two years E and C group girls' and boys' height, weight, right and left handgrip strength indices increased significantly, $p < .05$.

Results. E group girls' and boys' BMI and C group girls' VC indices did not change significantly, $p > .05$. Independent *t* test indicated that in the second research stage differences in anthropometric and physiometric measurements of groups were not significant, $p > .05$.

Conclusion. The developed and implemented curriculum of non-formal education in the schools had the biggest positive effect on the decrease of 11−13-year-old children's levels of BMI and the increase in the VC levels.

Keywords: 11−13-year-old children, non-formal physical education, physical development.

INTRODUCTION

Physical development is the process of continuous change that occurs in the body, starting with conception and continuing through adulthood (Wilmore & Costill, 2004). The general postnatal biological development is very similar, however big differences dominate between individual morphological and functional indices, which are influenced by many factors – biological (genetic, sex, health condition), cultural, geographical position, environmental, etc., though the most important are genetic and environmental (Abernethy et al., 2013; McArdle, Katch, F. I., & Katch, V. L., 2009; Machado, Filho, & Fernandes, 2008). One of the environmental factors is education (formal and non-formal) process. Some physical development indices are more determined by environment, the other by genetic factors.

The genetic determinism of the human organism particularly manifests through morphogenesis. In the research of twins, parents and brothers and sisters, the big impact of genetic factors for height indices was ascertained. According to the data of Malina, Bouchard, and Bar-Oro (2004), about 60% or more height indices are related with genotype. The research of height of children engaged and not engaged in sport and the obtained results prove that physical activity has minimal or does not have any influence to changes in height (Baxter-Jones, Eisenmann, Mirwald, Faulkner, &Bailey, 2008; Erlandson, Sherar, Mirwald, Maffulli, & Baxter-Jones, 2008). Very tight interaction of genetic and environment factors burden the estimation of their influence on body weight (McArdle et al., 2009). It is a negotiable question how genetic factors affect weight indices. The scientists carrying out research in genetics (Haberstick, et al., 2010; Maes et al., 2009; Malina et al., 2004) point out that this index is hereditary from 30 to 70%. However, the body weight varies more because of the lifestyle habits and social, economic, cultural and other factors (Bouchard & Katzmarzyk, 2010; California Department of Education, 2009).

Analyzing the factors that influence physiological indices it was determined that lung vital capacity is more conditioned by genetic factors, though muscle power – by environment factors (Malina et al., 2004; McArdle et al., 2009).

The empirical research suggests that 11−13-year-old children's physical development indices frequently do not match the development standards established for children at this age. In their longitudinal research Julia, Van Weissenbruch, Prawirohartono, Surjono and Delemarre-van de Waal (2008) and Roustorp (2010) estimated that the weight of children at this age increased during the last years. According to Gao, Oh and Shehg (2011), a fifth (20.5%) of 11-year-old children were overweight, though 23.7% – obese. Tutkuvienė (2005) has been investigating children's development for many years. The scientist determined that during the last decades the indices of 11−13-year-old Lithuanian children's power and lung vital capacity increased largely. The aforementioned facts encourage searching for the means which would motivate the harmonious physical development of children at this age.

One of the ways to solve the problem is the education of harmonious physical development in a non-formal way. Through non-formal physical education (NFPE) in school pedagogues have the power to make daily physical activity accessible and engaging for every child and to help all youths in after school programs to discover the benefits and joys of physical activity. NFPE in school programs give children the opportunity to develop further the skills taught during the regular school day. As some children do not receive daily physical education during the regular school day, after school programs may be the only place where the students can regularly engage in physical activity and to seek balanced physical development (California Department of Education, 2009)

Research by Carrel et al. (2011), Da Silva, Fisberg, de Sousa Pires, Nassar, and Sottovia (2013) demonstrates that NFPE curriculum in school can improve body composition. Drake et al. (2012) conducted telephone surveys with 1718 high school students and their parents. The scientists estimated that team sport participation had the strongest and most consistent inverse association with weight status. Vajda et al. (2007) carried out research during which 10-year-old obese boys not only participated in physical education lessons, but also took part in three NFPE sessions of 60 min time in the afternoon, on Mondays (swimming and water games), Wednesdays (folk dance) and Fridays (soccer). Anthropometric and physiometric data were collected. Relative body fat content and BMI did not increase during the observation period in contrast to the significant increase in the control group. Peak minute ventilation, aerobic power, oxygen pulse increased in the study group and did not change in the control group.

In present study the following research question was formulated: What curriculum of NFPE in school can positively affect physical the development of 11−13-year-old children?

The aim of this study was to develop and implement a curriculum of non-formal physical education in school and assess its effectiveness for the physical development of 11−13-year-old children.

Research hypothesis: training 11−13-year-old children's physical development, when the individualized non-formal education curriculum is implemented combining and integrally developing knowledge, abilities, attitudes and using the methods and forms that activate the child, has a positive effect on their physical development.

METHODS

Participants. The research was conducted in two stages. In the first stage (academic years 2007−2009), 51 fifth grade children (M_{age} = 11.3 years, SD = 0.26, 50.2% boys), who took part in NFPE in school for the first year, from four Klaipėda city (Lithuania) schools were selected to participate in a quasi-experiment. They were assigned to one of two groups. Criterion assignment strategy was used: children from two schools were assigned to the experimental group (E, *n* = 29.0% boys) and children from two other schools were assigned to the control group (C, *n* = 22.0% boys) and they participated in NFPE permanently for two years.

In the second stage (academic year 2012–2013) the participants were 72 sixth graders (M_{age} = 13.00 years, *SD* = 0.33; 52.4% boys) who took part in NFPE in school for the second year, and they were from the same schools who participated in the quasi-experiment (Group I – *n* = 46, Group II – n = 26) (see Figure 1).

Written voluntary informed consent was provided by all of the children and their parents and/or foster parents. Department of Physical Education (Klaipėda University) approved the study.

Instruments. In the first stage at the beginning (2007-10), in the middle (2008-05) and at the end (2009-05) of the quasi – experiment the focus groups conducted anthropometric and physiometric measurements.

Anthropometric measurements. Height was measured using roller height meter (Seca, model 206, Germany). The height meter was mounted on the wall and the participants stood erect, barefooted, and looked straight ahead. Before being measured or weighed, children were asked to remove their shoes and outer clothing, such as jackets. Students were asked to stand with their backs and heels against a wall that had a measuring tape attached. A measuring triangle was placed on the children's head, forming a right angle with the wall. Height was measured to the nearest half centimetre from the lower edge of the triangle. Weight was measured to the nearest 0.1 kilogram using a calibrated scale (Seca, model 709, Germany) that was zero balanced before each student was weighed. Body mass index of the participants were calculated from their respective height and weight using the relation = Weight/Height^2.

Physiometric measurements. Vital capacity was defined as the volume of air delivered during expiration starting from full inspiration and completed while the children were as relaxed as possible while completing the expiration. Vital capacity was measured using a portable spirometer (Spirotest, model Rudolf Riester GmbH). The maximal handgrip strength was measured using a hydraulic hand *dynamometer* (Seahan, model SH5001). All participants were examined in a standardized position (Skernevičius, Raslanas, & Dadelienė, 2004): the subject holds the dynamometer in the hand to be tested, with the arm at right angles and the elbow by the side of the body. The width of the handle is adjusted for the participant's hand size. When ready, the subject squeezes the dynamometer with maximum isometric effort, which is maintained for about 5 seconds. No other body movement is allowed. The best result of the right and left hands was chosen for the analysis. The presented scores are expressed in kilos force.

During the second stage the children of six grades performed the same measurements as their colleagues four years ago.

After applying document analysis method, the average of children age was determined. The age average was 11.3 years during study I, 11.9 years during study II, 12.9 years during study III and 13.0 years during research in stage II. Evaluating the young adolescents' physical development, we compared the averages of anthropometric and physiometric indices with the average means of the same age children's anthropometric and physiometric indices given by Tutkuvienė (1995) and Tutkuvienė and Jakimavičienė (2004). We compared the study I physical development indices with 11-year-old children's indices, study II indices with 12-year-olds' indices, and study III indices with 13-year-olds' indices. The II stage research

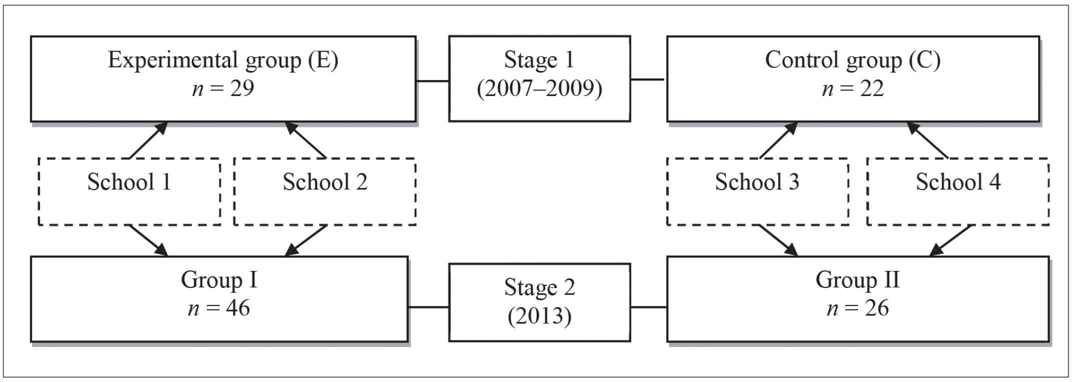


Figure 1. **Distribution of children who participated in the research**

Table 1. **Content and its percentage distribution of the experimental and control groups' NFPE at school**

Experimental group	Control group
1. Knowledge (10%) 2. Cooperative games (40%) 3. Sports games (10%) 4. Athletics (8%) 5. Gymnastics (10%) 6. Fun outdoor activities (7%) 7. Sport and wellness activities (15%)	1. Knowledge (4%) 2. Technical and tactical skill development for game "Quadrate" (30%) 3. Technical and tactical skill development for relay race "Brave, strong, quick" (30%) 4. Athletics, "Triathlon" (20%) 5. General physical fitness and relay race (10%) 6. Competitions (6%)

results were compared to average values of 13-year-old Lithuanian children.

Procedures. After being informed about the nature and steps of the study and agreeing to participate, the young adolescents were invited to attend the two-year quasi-experiment. NFPE in school were held at the end of formal education. Both experimental and control groups shared the duration (1 hour) and frequency (twice a week) but were different in their education programs.

Experimental group (E) worked under the program developed by us. 85% of NFPE content was formed of sessions and 15% – sport and wellness events. The principles that were followed were voluntarism, individuality, accessibility, relevance, and individualization; different person activating methods (discussions, case analysis, "Mind hedgehog", arguments "Pros and cons", "Brainstorm", learning in groups) were applied as well.

Control group (C) worked according to NFPE programs prepared by teachers and approved by the school principal and school methodical group (see Table 1)

Priorities of the Experimental group were:

- Integral knowledge, training abilities and attitudes.
- Integration of 11–13-year-old children with lower health and physical fitness levels.
- Content that corresponds to 11–13-year-old children's needs, abilities, physical and functional powers.
- Methods and forms that activate and train individual development process.
- Priorities of the Control group were:
- Motor learning and development.
- Training physical skills.
- Training most physically capable children.
- Education content oriented to preparation for competitions (Game "Quadrate", relay race "Brave, strong, quick"; athletics; "Tetrathlon").

In the second stage (academic year 2012–2013) the young adolescents from the same four Klaipėda city comprehensive schools participated in the research. After implementing quasi – experiment in schools, where experimental educational programme was practiced, the curriculum was modified:

- The educational content was oriented towards preparation for competitions. The content only partly corresponded to 11–13-year-old children's needs, abilities, physical and functional powers.
- The content was oriented towards physical skill development. Knowledge transfer and formation of physical abilities were implemented episodically.
- The traditional physical education methods usually applied were classes, group work, team work.

In the control group (C) teachers worked with NFE programme, where the part of activities and given time essentially did not differ from those which were carried out during the quasi-experiment (Table 1).

Data analysis. The data was analysed using the Statistical Package for Social Sciences (SPSS) version 20.0. Descriptive statistics indices were calculated (including means (*M*) and standard deviation (*SD*) for each physical development component. Depended *t* test was used to determine whether the means of two related groups were significantly different. Independent *t* test was used to examine test differences between two (E and C), (Group I and Group II) groups. For all the tests, statistical significance was set at $p < .05$.

RESULTS

The descriptive results are shown in Table 2 and Table 3. Tables provide the means, standard deviation and average values of corresponding age Lithuanian children's physical development. As it can be seen in Table 2, in studies I, II and III the anthropometric indices of the experimental and the control group girls and boys were higher than the average values for Lithuanian schoolchildren. Girls' left handgrip strength in study III and Vital capacity (VC) in all the studies (except group C in study I), and physiometric indices for both groups boys were lower than the average values for Lithuanian boys in the analysed age groups.

During the second research stage (Table 3) the anthropometrical indices of all of the researched children were higher than the average values for Lithuanian children. Analysing physiometric indices it was determined that group I girls' right handgrip strength and boys' right and left handgrip strength in both groups did not reach the average values in the country.

After study I it was identified that the average results of physical development of male and female groups E and C did not reveal significant differences, i.e. groups were homogeneous and met the essential condition - experiment reliability.

Dependent *t* test indicated that over two academic years E group girls' height, $t(10) = -6.799$,

Table 2. **Physical development indices for 11−13-year-old children of stage I research in the experimental and control groups**

Variable	Study	Girls				Boys			
		E group		C group				C group	
		M	CD	M	CD	M	CD	M	CD
Height	Study 1	150.59	8.84	149.79	6.31	148.86	6.90	150.73	6.51
	Study 2	153.41	8.54	153.00	6.50	152.25	7.11	154.55	8.18
	Study 3	159.64	7.55	158.55	7.05	158.78	8.73	161.55	8.17
Weight	Study 1	45.05	6.47	40.36	6.50	44.02	16.32	39.50	7.41
	Study 2	46.38	6.84	42.55	7.09	47.56	16.79	42.77	8.63
	Study 3	50.91	5.59	49.09	7.23	50.66	19.33	47.05	8.57
BMI	Study 1	19.90	2.65	17.93	2.07	19.51	5.06	17.32	2.10
	Study 2	19.69	2.22	18.11	2.35	20.20	5.05	17.75	2.14
	Study 3	20.01	2.12	19.56	2.94	19.78	5.56	19.90	1.89
RHS	Study 1	19.77	4.59	19.38	4.06	19.92	3.68	20.27	3.64
	Study 2	21.64	2.50	24.41	3.88	22.39	3.81	23.32	4.93
	Study 3	26.45	4.34	25.82	4.90	26.83	4.53	25.55	5.15
LHS	Study 1	17.86	4.01	18.55	5.07	18.00	3.64	19.27	3.55
	Study 2	20.09	3.92	22.82	3.97	21.61	3.55	21.45	4.63
	Study 3	23.55	3.53	23.36	5.20	24.78	4.82	24.18	4.42
VC	Study 1	1990.91	359.04	2018.18	314.84	2044.44	329.39	2022.73	371.73
	Study 2	2077.27	386.24	2050.00	357.07	2130.56	416.26	2213.64	331.73
	Study 3	2309.09	359.04	2090.91	383.29	2438.89	548.94	2227.27	485.99

Note. RHS = right handgrip strength; LHS = left handgrip strength; VC = vital capacity.

Table 3. **Physical development indices for 13-year-old children in stage II research in groups I and II**

Variable	Girls				Boys			
	Group I		Group II		Group I		Group II	
	M	CD	M	CD	M	CD	M	CD
Height	162.15	6.87	165.08	8.43	160.85	8.55	163.12	9.48
Weight	52.90	10.75	52.58	13.31	50.84	9.43	49.21	9.52
BMI	20.06	3.48	19.07	3.58	19.57	2.65	18.33	2,61
RHS	24.58	4.07	25.58	4.10	27.17	6.79	22.33	3.20
LHS	23.32	4.07	25.08	6.24	24.08	5.85	20.56	3.09
VC	2907.89	456.51	2695.83	807.76	3145.83	694.06	2711.11	878.13

Note. RHS – right handgrip strength; LHS – Left handgrip strength; VC– vital capacity.

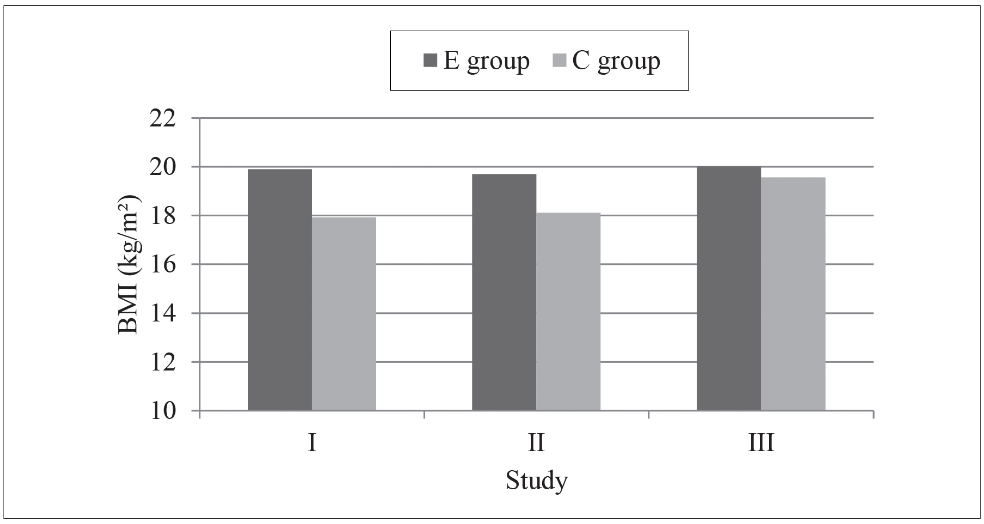
p = .000; weight, *t*(10) = −11.474, *p* = .000; right handgrip strength, *t*(10) = −8.751, *p* = .000; left handgrip strength, *t*(10) = −5.285, *p* = .000 and vital capacity, *t*(10) = −5.590, *p* = .000 indices increased significantly. The difference between the pre-test (study I) and post-test (study III) BMI was not significant, *t*(10) = − 0.302, *p* = .769. It should be noted that at the beginning of the research E group girls' BMI rates on average were higher by 2.92 kg/m^2 than the average values of Lithuanian girls of this age. However, during two school years, BMI of this group young adolescents varied occasionally and at the end of research this difference decreased till 1.31 kg/m^2, i.e. height and weight ratio of girls who participated in non-formal physical education in school became more proportional (Figure 2).

Over two academic years indices of C group girls' height, *t*(10) = −9.936, *p* = .000; weight, *t*(10) = −6.906, *p* = .000; BMI, *t*(10) = −3.228, *p* = .009; right handgrip strength, *t*(10) = −7.636, *p* = .000 and left handgrip strength, *t*(10) = −4.783, *p* = .001, differed significant. The results of vital capacity, *t*(10) = −0.561, *p* = .587 did not change significantly.

Independent *t* test indicated that in study III children's height in groups E and C, *t*(20) = 0.350, *p* = .730; weight, *t*(20) = 0.660, *p* = .517; BMI, *t*(20) = 0.416, *p* = .682; right handgrip strength, *t*(20) = 0.322, *p* = .750; left handgrip strength, *t*(20) = 0.096, *p* = .925 did not differ significantly.

Dependent *t* tests indicated that the difference in height between E group boys the pre-test

Figure 2. **The alternation of E and C group girls' BMI indices during two academic years**



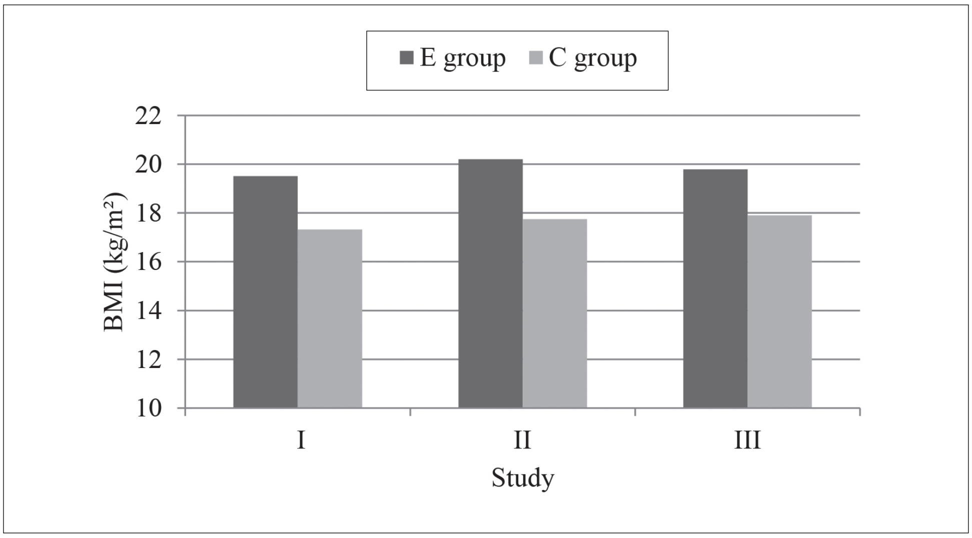


Figure 3. **The alternation of E and C group boys BMI indices during two academic years**

and post-test, $t(17) = -11.386$, $p = .000$; weight, $t(17) = -5.030$, $p = .000$; right handgrip strength, $t(17) = -10.276$, $p = .000$; left handgrip strength, $t(17) = -7.161$, $p = .000$; vital capacity, $t(17) = -3.864$, $p = .001$ was significant. E group boys', as well as girls' BMI ($t(17) = -0.572$, $p = .575$) did not change significantly.

C groups boys' all tests – height, $t(10) = -8.250$, $p = .000$; weight, $t(10) = -7.965$, $p = .000$; BMI, $t(10) = -2.308$, $p = .044$; right handgrip strength, $t(10) = -4.810$, $p = .001$; left handgrip strength, $t(10) = -4.034$, $p = .002$ and vital capacity, $t(10) = -3.042$, $p = .012$ – indices changed significantly.

Independent *t* test indicated that in study III differences between E and C group boys' height, $t(27) = -0.848$, $p = .404$; weight, $t(27) = 0.582$, $p = .497$; BMI, $t(27) = 1.076$, $p = .565$; right handgrip strength, $t(27) = 0.706$, $p = .486$; left handgrip strength, $t(27) = 0.333$, $p = .742$ and vital capacity, $t(27) = 1.050$, $p = .303$ were not significant.

Independent *t* test revealed that in the research implemented in 2013 group I girls' height, $t(29) = -0.858$, $p = .398$; weight $t(29) = 0.257$, $p = .799$; BMI, $t(29) = 0.889$, $p = .381$; right handgrip strength, $t(29) = -0.438$, $p = .665$; left handgrip strength, $t(29) = -0.926$, $p = .363$ and vital capacity, $t(29) = 0.913$, $p = .369$ did not differ significantly from the values of group II girls.

Group I and group II boys' height, $t(37) = -0.868$, $p = .391$; weight, $t(37) = 0.347$, $p = .730$; BMI, $t(37) = 1.363$, $p = .181$; left handgrip strength, $t(36) = 1.712$, $p =.097$ and vital capacity, $t(36) = 1.486$, $p = .147$ results were also similar. Right handgrip strength in group I was significantly better than that in group II, $t(36) = 2.0314$, $p = .027$.

DISCUSSION

This study was conducted to investigate the effect of interventions of non-formal physical education curriculum on physical fitness of 11–13-year-old children. Tutkuvienė (1995) suggests that from all structural and functional condition indicators height is mostly determined by genetic factors. Our research results show that experimental education programme had no influence on children's growth alternation indices: there were no statistically significant differences between the groups, i.e. the rate of growth in all the groups was similar. Baxter-Jones et al. (2008), Erlandson, Sherar, Mirwald, Maffulli, & Baxter-Jones (2008) also established that the format and the extent of physical activity had no effect on growth rate.

In the analysis of the indices of height alternation, their quantitative changes are very important in particular years because during the period of rapid growth rate, which is called pubertal growth spurt, the intensive structural and functional changes happen in organs and tissues. The scientists (Armonaitė-Engelmanienė, 2008; Tutkuvienė, 2007) point out that Lithuanian girls' pubertal growth spurt is at the age of 11–14 years, that of boys' – at 13–16 years of age, though the height spurt summit, according to the data of Grinienė and Vaitkevičius (2009), for girls is at the age of 11.4–12.2, for boys – 13.4–14.4.

The research revealed that the height changes of both sexes were bigger in the second year of the research (age 12−13 years): in the sixth grade girls' height averagely increased by 6.26 cm, boys' – 6.99 cm. The results of our research were close to the data proposed by Volbekienė and Kavaliauskas (2002), where statistically significant difference ($p < .001$) was determined between the height of 12 and 13-year-old pupils and of both sexes it is equal – 6 centimetres.

The other indicator of development – the weight – is much more labile than height and varies more because of the impact of various factors. The scientists (Cora et al., 2009; Julia et al., 2008; Lowry et al., 2007) emphasize that every year increasingly bigger part of adolescents' weight do not correspond to recommendatory standards. World Health Organization (WHO, 2014) announces that more than 40 million children aged more than five years are overweight or obese, and children's overweight and obesity indices have achieved epidemic extent in many industrial counties.

Analysing the weight indices of young adolescents who participated in the quasi-experiment it was ascertained that experimental and control groups' weight changes in two academic years were statistically significant ($p < .001$). The weight of group E girls in two years increased by 5.9 kg, though C – 8.7 kg, for the boys – E – 6.6 kg, C – 7.6 kilograms. After analysing the results, the assumption that participation in NFPE in school had a positive influence to group E girls' weight control can be made: at the beginning of the research the girls' average weight in this group was significantly bigger than the values of country's average weight indices, though at the end of the research they were close to country's average (Tutkuvienė, 1995; Volbekienė & Kavaliauskas, 2002).

It was determined, that weight changes of young adolescents of both sexes, just like the changes of height, in the sixth grade (12−13 years old) were bigger than in the fifth grade (11−12 years old). At the end of the research the weight indices of subjects were close or slightly exceeded the optimum limits, however it should be noted that the indices of height were also bigger than the country's average indices. Analysing the weight indices it is purposeful to follow BMI which helps to evaluate whether weight matches the height. Tutkuvienė and Jakimavičienė (2004) suggest that BMI of 11−12-year-old boys fluctuate a little, though the bigger change occurs at the age of 12−13 years. Girls' BMI similarly grows in the first and second years. BMI alternation curves (WHO, 2007) of 5−19-year-old children, offered by WHO, indicate that BMI of 11−13-year-old children gradually increases. Our research shows that during two academic years BMI increased only for group E girls and boys, these differences in C group were significant ($p < .05$). The bigger changes of girls' BMI were determined in the second research year, though this index for boys mediates both in the first and the second years.

Carrying out the research after four years, it was determined that BMI indices of subjects were very similar to those in the research performed in 2009. Comparing the results of the first and second groups, statistically significant differences did not show up, $p > .05$.

Physical development in the early adolescence was evaluated by the functional parameters, i.e. VC and static arm strength. VC index is increasing while a kid grows up (Armonaitė-Engelmanienė, 2008; Malina et al., 2004; Skirius, 2007). This has also been proved by our research data: VC indices of all the young adolescent groups improved. However, these changes were not similar in all the groups and that highlighted the alternation of the effect of the applied measures on VC indices during the pedagogical experiment. For E group girls and both (E and C) group boys significant ($p < .05$) changes were determined in two academic years, but these changes in E group boys were bigger than in group C: in two experimental years VC indices of E group boys increased averagely by 394.45 cm^3, though in C group – 204.54 cm^3.

Four years later the repeated research also estimated that the VC indices of first group both sexes were better than those of the second group young adolescents. Considering the scientists' (Malina et al., 2004; Šiupšinskas, Vitaraitė & Berškienė, 2007; Tutkuvienė, 1995) propositions that this index reflects the physical activity impact on the organism, the assumption can be made that systematically doing aerobic exercises, which were used considering the capacity of individual functional systems, had a positive effect on the alternation of first group's VC indices.

It was ascertained that during the quasi-experiment the static arm strength changes were significant ($p < .01$) in all the groups. The differences between E and C group young adolescents, who constantly participated in NFPE in school, were slight. After repeating the research in four years, significant differences of static arm strength indices between the first and the second groups were not determined, $p > .05$. Following the received data, we draw a conclusion that experimental educational programme had no influence on static arm strength changes.

The research has some limitations. First of all, the educational institutions, from which the 11−13-year-old children participated in the quasi-experiment, were selected not at random, but following some criteria. Besides, only a small part of pupils participated in NFPE in school, therefore the samples of groups E and C, Group I and Group II were little. Despite all these limitations, our research revealed that qualitative characteristics of non-formal physical education curriculum are a very important factor for 11−13-year-old children's balanced physical development.

CONCLUSION

Non-formal physical education curriculum to meet children's hobbies, needs, abilities, physical and functional powers was developed and implemented. It encompassed and integrally developed knowledge, abilities and attitudes; child activating learning methods and forms were applied – all these factors had a positive effect on decreasing 11−13-year-old children's levels of BMI and increasing the levels of VC. These findings provide evidence for the development of effective and feasible curriculum of non-formal physical education at school.

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