INTERACTION OF TRAINING AND PERFORMANCE OF 13–14-YEAR-OLD ATHLETES IN RHYTHMIC GYMNASTICS

Renata Rutkauskaitė, Antanas Skarbalius
Lithuanian Academy of Physical Education, Kaunas, Lithuania

ABSTRACT

Research background and hypothesis. The efficacy of athlete's sport performance depends on the targeted training in certain periods, organization, management, individual adaptation of an athlete to the loads of training and competitions.

Research aim was to determine the impact of specific training on sport performance of 13–14-year-old athletes in rhythmic gymnastics.

Research methods. The experiment resulted in modeling three different training programs and establishing the structure of the content of the training programs, as well as athletes' sport performance. The training load protocols registered the time for choreography, element mastering, competitive routines and athletic training in each training session. The efficacy of the training programs was established registering the realization of competitive activities under competitive conditions, according to the number of points received by the gymnast of each training program, according to the place won.

Research results. Training athletes in three training programs differed – their training loads were significantly different – from 10.28 to 12.91 hours a week, as well as the indices of the training days – from 5.43 to 4.17 days a week, the training content differed significantly. In the most effective training program choreographic training (35.8%) dominated. Statistically significant differences ($p < 0.05$) were found in the indices of explosive strength and muscular power, specific endurance, coordination movement abilities and the integral index of athletic fitness. At the beginning of the season and at the end of it the realization of the body movement technique performing routines with different tools was different ($p < 0.001$).

Discussion and conclusions. In the period of individual training of 13–14-year-old athletes in rhythmic gymnastics time for mastering competitive routines and integral training became more significant for the efficacy of athletes' sport performance. The indices of movement with different tools technique became more significant and the indices of difficulty of body movement technique remained stable. The most important factors influencing sports performance were explosive strength, strength endurance, coordination, and the total integral index of athletic fitness.

Keywords: rhythmic gymnastics, training, performance.

INTRODUCTION

The efficacy of athlete's sport performance depends on the targeted training in certain periods, organization, management, individual adaptation of an athlete to the loads of training and competitions (Mester, Perl, 2000; Torrents et al., 2001; Edelmann-Nusser et al., 2002). If the requirements of athlete training mentioned above are followed, there are premises for their successful participation in the most important international competitions.

While registering and analyzing competitive activities it is possible to establish the level of their interaction with different components of athlete training (Mester, Perl, 2000; Perl, 2004). Besides, registering and analyzing competitive activities enable us to foresee the tendencies of a sport, forecast

Table 1. **Anthropometric characteristics of subjects ($\bar{x} \pm SD$)**

Training groups	Age, years	Height, cm	Body mass, kg	BMI	Body Fat, %
A (n = 5)	13.0 ± 0	165.6 ± 4.36	49.4 ± 2.27	18.0 ± 0.61	12.3 ± 1.84
B (n = 5)	13.0 ± 0.71	157 ± 6.3	45.4 ± 6.69	18.1 ± 2.03	13.3 ± 3.24
C (n = 5)	12.8 ± 0.7	155.8 ± 9.9	42.14 ± 6.29	17.3 ± 0.96	11.5 ± 2.36
Average	12.9 ± 0.8	159.4 ± 8.0	45.66 ± 5.91	17.9 ± 1.34	13.3 ± 2.48
F test; p value	F = 2.7; p > 0.05	F = 2.8; p > 0.05	F = 2.2; p > 0.05	F = 0.94; p > 0.05	F = 0.61; p > 0.05

sports results and plan the trends of athlete training. Another important feature is the interaction of indices between training and sport performance (Banister et al., 1999; Edelmann-Nusser, et al., 2002; Avalos et al., 2003; Bügner, 2005; Hellard et al., 2006). J. Perl (2001, 2003, 2004) called this interaction a *Metamodel* – the theoretical interaction of training and sport performance – when we need to find an optimal model of athlete training which would allow achieving the highest level of sport performance.

Most research of this kind has been carried out in swimming (Edelmann-Nusser et al., 2002; Avalos et al., 2003; Bügner, 2005; Hellard et al., 2006) and track-and-field athletics (Banister et al., 1999). The adaptation to physical loads, intensity of training loads and competitive activities of the rhythmic gymnastics has not yet been studied.

Rhythmic gymnastics is a sport which requires early selection of athletes (Лисицкая и др., 1982; Balyi, 2001; Карпенко, 2003; Balyi, Hamilton, 2004), intensive training in the periods of childhood and adolescence (Jastrejembskaia, Titov, 1999; Карпенко, 2003) and early termination of the sports career (Стамбулова, 1999). The trends in the changes of training high performance athletes (Balyi, 2001; Balyi, Hamilton, 2004), specific features of the developments of rhythmic gymnastics (Krug, 1996; Jastrejembskaia, Titov, 1999; Knoll et al., 2000; Медведева, 2001; Карпенко, 2003), as well as the upturn of sports results motivate us to look for new, scientifically grounded sports technologies, methods and forms of training. That is why the **aim** of this study was to determine the impact of specific training on sport performance of 13–14-year-old athletes in rhythmic gymnastics.

RESEARCH METHODS

Subjects and experiment design. The research involved the training of 13–14-year-old athletes (n = 15) in rhythmic gymnastics from the National and Kaunas city teams (Lithuania) (Table 1). The experiment resulted in modeling three (A, B, and C) different training programs (5 gymnasts in each training program) and establishing the structure of the content of the training programs for the whole macrocycle, as well as athletes' sport performance. The training loads protocols registered the time for choreography, element learning, competitive routines and athletic training in each training session (Лисицкая и др., 1982; Jastrjembskaia, Titov, 1999).

The efficacy of the training programs was established registering the realization of competitive activities under competitive conditions, according to the number of points received by the gymnast of each training program, and according to the place won (the points awarded in the descending order). Participation of gymnasts in competitions was different because not all of them succeeded in winning the right to participate in more important competitions – national and international.

Research hypothesis (H_0) was that different training programs (Tables 2 and 3) would have the same impact on sports performance. The alternative hypothesis was that different training programs would have different impact on sport performance (H_1). Independent variables were the duration, content, volume, intensity of training loads, and the dependent variable was athletes' sport performance.

The following **research methods** were used in this research:

- **Anthropometry.** The values of height in the standing position and body mass components (body mass, body mass index BMI, subcutaneous body fat layer in percent (%), and kilograms (kg)) (TANITA BODY ANALYSER TBF-300) were taken.
- **Physical fitness.** Athletic fitness of female athletes was estimated applying tests of flexibility (tests of "bridge" and "splits"),

complex abilities of flexibility and balance (test of "leg keeping"), muscular endurance (push–ups, sit-ups and lifting legs), specific endurance (test of "jumping into rope with double turns"), coordination abilities ("10 seconds running into the rope") and explosive strength (standing long jump on both feet). Research presented absolute values of estimation of movement abilities, and the values estimated in points. The integral index estimating athletic fitness was received summing up the points of each test (Лисицкая и др., 1982; Jetrejambskaja, Titov, 1999; Говорова, Плешкань, 2001; Карпенко, 2003).

- Changes in gymnasts' **technical fitness** were registered during competitions according to the declared and realized coefficients of technical fitness – Difficult values and Artistic values (Abbruzini, 2004).

Methods of mathematical statistics. In order to compare the data the means ($\bar{x}$) and standard deviations (SD) were calculated. One-way analysis of variance – ANOVA (generalizing Student criterion for several independent samples was used to evaluate the differences and the reliability of value differences. The following reliability levels of statistical conclusions were used: $p < 0.05$ – reliable; $p < 0.01$ – very reliable; $p < 0.001$ – absolutely reliable conclusion. Causal relations were determined applying correlation analysis (Pearson's correlation coefficient r). The significance of training and fitness factors was established by factor analysis (principal factor analysis – communalities = multiple r^2). All calculations were performed using computer programs MS Excel and STATISTICA. Experimental data were described using 44 variables, 43 of which were the aspects of training and fitness (X) and one was the final indicator of the efficacy of competitive activities (the mean of the points achieved by each gymnast) – Y. The principal factor analysis (communalities = r squares) was performed to estimate the interaction of the structure, the content and the volume of the complicated training process and fitness.

RESEARCH RESULTS

Training. Training athletes in three training programs differed – their training loads were significantly different ($p < 0.01$) – from 10.28 to 12.91 hours a week, as well as the indices of the training days – from 5.43 to 4.17 days a week (Table 2). 13–14-year-old athletes in rhythmic gymnastics in the most effective training program (A) in specific training in our experiment received the highest loads (283 days of training in the macro-cycle, 5.44 training sessions a week on average, all in all 674 hours of training, averagely 13.0 hours a week). Training parameters – training loads and content (Table 3) were different in the course of the whole macro-cycle and in different training periods ($p < 0.05$).

The percentage structure of the training content did not differ much in each training period. Statistically significant differences ($p < 0.05$) were found in the duration of mastering elements ($p < 0.02$) in the most effective training program (A), time for athletic training in program C ($p < 0.05$). The percentage structure of the training loads in program C did not differ statistically significantly ($p > 0.05$).

Sport performance. The most effective training program was A: 533 (points) with choreographic training dominating in it (35.8%).

Table 2. **Training loads of different training programs of 13–14-year-old athletes in rhythmic gymnastics**

Parameters of training loads	Training groups ($\bar{x}$ ± SD)			Mean ($\bar{x}$ ± SD)	Fisher's criterion, p level
	A	B	C		
Number of training sessions a year	283	213	258	225.66 ± 34.6	
Number of macro-cycle hours	674	519	593	591.33 ± 76.0	
Number of training sessions a week	5.4 ± 1.39	4.2 ± 1.09	5.3 ± 0.85	5.0 ± 1.26	F = 16.74; p < 0.001
Number of hours a week	13.0 ± 3.29	10.3 ± 2.94	11.9 ± 2.75	11.7 ± 3.19	F = 8.98; p < 0.001
Number of competitions a year (from – to, and average)	9–14 12.2 ± 2.05	10–14 12.2 ± 1.79	10–14 12.2 ± 1.79	9–14 12.2±1.74	
Number of competition days	23 days (duration of loads of competition days ~3 h)				

Table 3. **Content (%) of training loads of different training programs of 13–14-year-old athletes in rhythmic gymnastics**

Content of training loads	Training groups ($\bar{x}$ ± SD)			Mean ($\bar{x}$ ± SD)	Fisher's criterion, p level
	A	B	C		
Choreography	29.32 ± 7.09	31.59 ± 7.86	**33.93 ± 5.84**	31.56 ± 7.19	**F = 5.06; p < 0.01**
Elements	20.79 ± 6.96	**38.67 ± 11.13**	22.82 ± 4.58	27.31 ± 11.30	**F = 67.78; p < 0.001**
Competition routines	**33.57 ± 12.04**	16.56 ± 9.15	19.56 ± 6.52	23.86 ± 12.43	**F = 48.05; p < 0.001**
Athletic training	14.40 ± 5.00	11.62 ± 8.26	21.02 ± 5.02	15.65 ± 7.34	**F = 26.80; p < 0.001**

The least effective program was B (240 points), where each gymnast collected 48.0 points on average. The integral index of gymnasts' athletic fitness was different at the beginning of the season ($p < 0.05$). The differences between the muscular test results diminished, too (evaluation of "press-ups" in times and points, "sit–ups" in points), but there appeared a difference between the indices of coordination abilities ("10 seconds running into the rope" in points) ($p < 0.05$). Though there were positive alterations in the indices of all movement abilities, no statistically significant differences were established between the indices of athletic fitness in different training groups before the experiment and after it ($p > 0.05$).

At the beginning of the season ($F = 5.56$; $p < 0.001$) and at the end of it ($F = 9.06$; $p < 0.001$) the realization of the body movement technique performing routines with different tools was different (Table 4). Such tendency remained after the experiment.

Coefficients of different routines with tools did not differ significantly ($p > 0.05$) (from 4.18 to 3.52). In different training programs indices of movements with tools before the season ($F = 9.93$; $p < 0.001$) and at the end of the season ($F = 14.32$; $p < 0.001$) were different. The average coefficients of difficulty of technique were the lowest in training program C (2.09 ± 0.60), and the highest – in training program A (3.03 ± 0.94). At the end of

Table 4. **Body movement technique coefficients of difficulty with different tools in different rhythmic gymnastics training programs for 13–14-year-old athletes**

Before experiment (at the beginning of the season) ($\bar{x}$ ± SD)				
Training Progamm / Tools	A (n = 5)	B (n = 5)	C (n = 5)	Average
Rope	4.21 ± 0.46	2.81 ± 0.81	3.24 ± 0.60	3.32 ± 0.89
Ball	3.70 ± 0.41	3.41 ± 0.34	3.56 ± 0.32	3.58 ± 0.35
Clubs	4.02 ± 0.66	2.73 ± 0.85	3.25 ± 0.26	3.44 ± 0.78
Ribon	3.07 ± 0.94	1.99 ± 0.80	2.58 ±0.68	2.72 ± 0.92
The average coefficients of difficulty	**3.61 ± 0.83**	**2.57 ± 0.89**	**3.18 ± 0.57**	**3.19 ± 0.86 F = 4.09; p < 0.001**
After experiment (at the end of the season) ($\bar{x}$ ± SD)				
Training Progamm / Tools	A (n = 5)	B (n = 5)	C (n = 5)	Average
Rope	3.34 ± 0.66	2.93 ± 0.35	3.16 ± 0.70	3.14 ± 0.60
Hoop	3.23 ± 0.75	2.77 ± 0.67	3.15 ± 0.74	2.95 ± 0.73
Clubs	3.20 ± 0.62	3.18 ± 0.16	3.26 ± 0.21	2.93 ± 0.72
Ribbon	3.35 ± 0.57	2.46 ± 0.91	3.0 ± 0.59	2.84 ± 0.78
The average coefficients of difficulty	**3.23 ± 0.64**	**2.60 ± 0.71**	**3.16 ± 0.57**	**2.97 ± 0.70 F = 3.41; p < 0.001**

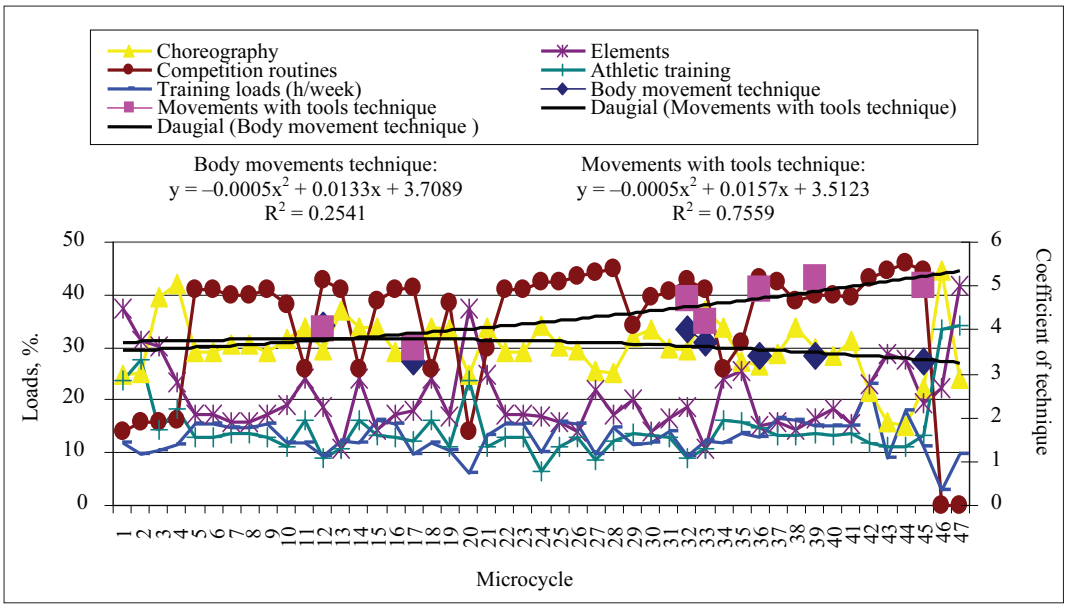

Figure. **Changes in the volume of training loads (%) and complexity of the content and technique in the most effective training program in the experiment for 13–14-year-old athletes in rhythmic gymnastics during the macro-cycle**

the season the coefficient of movement with tools technique ranged form 2.33 (ribbon) to 3.36 (clubs). At the end on the season the highest coefficients of difficulty were demonstrated by athletes in training program A (3.03 ± 0.94) and C (3.16 ± 1.02).

The subjective evaluations of ones own sport performance (self-confidence before the competition) between various groups were not statistically significantly different ($p > 0.05$).

Interaction of training and sport performance. In the most effective training program correlations between body movement techniques and program training loads were $r = –0.514$; polynomial interdependence: $y = –0.0003 \times 2 + 0.0008x + 0.0369$; $r^2 = 0.4553$; and between movement with tools techniques and training loads: $r = 0.658$; and polynomial interdependence: $y = 0.0006 \times 2 – 0.0186x + 0.0894$; $r^2 = 0.4069$. Effective training of athletes in program B (11–12 and 12–13 years of age) was determined by the dominance of choreographic training. At this period of training the program was distinguished by the time for the mastering of competitive routines (33.57% on average).

The most effective training program, which included choreographic training (30.3%), element mastering (19.6%), mastering of competitive routines (37.3%) and athletic training (12.8%) since the 17th micro-cycle, improved the indices of technical fitness of 13–14-year-old moderate sport performance athletes in rhythmic gymnastics: body movement technique (21.1%), tool technique (30.5%) (Figure). The achieved level of performance of movements with tools (6.35%) was improved in 14 weeks, in the training program of the following structure: 27.2% of choreographic training, 21.95% of element mastering, 40.3% of mastering competitive routines, and 13.1% of athletic training. The stable level of tool technique was maintained till the end of the season (7 micro-cycles), but body movement technique almost did not change and even diminished till 21.1% in 7 micro-cycles.

In the most effective training program the reduced time for choreography (in %) affected the changes in training and sport performance (body movements and movements with tools) – the changes in the movement techniques can be explained by the following slight positive dependence: 20% ($y = 0.0001 \times 2 + 0.0002x – 0.0197$; $r^2 = 0.2039$), and in the movement with tools technique – negative dependence of 13% ($y = –0.0003 \times 2 + 0.0123x – 0.0782$; $r^2 = 0.1398$).

DISCUSSION

Analysis of interaction of training and sport performance comparing *internal* (indices of moderately mastered body movements and movements with tools) and *external* (training loads in hours per week) (Mester, Perl, 2000) factors partly differs from what other scientists (Hartmann,

Mester, 2000) suggest, that from the standpoint of a macro-cycle the interaction between the indices of training and sport performance is neither significant nor effective. According to some researchers (Perl, 2004; Bügner, 2005), the contradictions in the management of training are natural, because due to the inner changes of an athlete the same training loads can produce different sport performance.

Adverse changes in the indices of body technique (the indices of technique in the most effective training program decreased from coefficient 4.1 to coefficient 3.3) at the end of the season confirm the supposition raised in the previous stage of the research that the increase in difficulty of body technique stabilizes – only the number of mistakes becomes less, but movements with tools are practiced and improved further on. This confirms what other researchers (Карпенко, 2003) suggest: the best age for developing coordination abilities is up to 12–13 years.

Researchers (Лисицкая и др., 1982; Jastrjembskaia, Titov, 1999; Apatow, 2001; Карпенко, 2003) suggest that *choreographic training* should be sufficient in all periods of training, but it should become more difficult, more choreographic elements should be performed without support, in all directions and with frequent turns (Лисицкая и др., 1982; Jastrjembskaia, Titov, 1999; Wolf–Cvitak et al., 2002; Карпенко, 2003; Wolf–Cvitak, 2004). It should be noted that elite gymnasts spend 45 minutes six times a week for choreography (Apatow, 2001; Карпенко, 2003). Our training programs contained 52 minutes 4.4 times a week (program A). Our research data suggest that in this period of training the influence of choreographic training on body movement and movement with tools technique is not so great. It means that more time on choreographic training should have been spent in the earlier periods of training.

In co-coordination sports training loads are presented according to the number of elements and combinations (Аркаев, Сучилин, 1997; Смолевский, Гавердовский, 1999; Медведева, 2002), but such system of registering training loads is more suitable for training management in artistic gymnastics. In this period of training in rhythmic gymnastics the value competitive activities much depends on the individual style of a gymnast, her artistry and ways of expression (Jastrejembskaia, Titov, 1999; Карпенко, 2003). Those qualities can be demonstrated only after having mastered the competitive routines. So, in the period of individualized training the importance of mastering elements for technical fitness diminished. As researchers suggest (Меканцишвили, 1991; Jastrejembskaia, Titov, 1999; Карпенко, 2003; Wolf–Cvitak, 2004), much time should be spent for competitive routines, and separate elements and parts of those routines should be practiced together with them.

After grouping the results of different factors (training and sports performance, sport performance, training), we can state that the most important factors for good results are explosive strength, strength endurance, coordination and the integral index of athletic fitness. Techniques with tools (skipping rope, ribbon, ball and average technique of all tools) were also of great importance. At this period of training the significance of training factor was not so great, thus, the significance of sports performance and technical fitness could have been conditioned by training loads applied in the earlier periods.

CONCLUSIONS AND PERSPECTIVES

In the period of individual training of 13–14-year-old athletes in rhythmic gymnastics time for mastering competitive routines ($r = 0.945$) and integral training ($r = 0.861$) became more significant for the efficacy of athletes' sports performance. The indices of movement with different tools technique became more significant ($r = 0.708 \div 0.805$), and the indices of difficulty of body movement technique remained stable. The most important factors influencing sports performance were explosive strength ($r = 0.819$), strength endurance ($r = 0.794$), coordination ($r = 0.756$), and the total integral index of athletic fitness ($r = 0.840$).

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MENINĖS GIMNASTIKOS SPORTININKIŲ (13–14 METŲ) RENGIMO IR PARENGTUMO OPTIMIZAVIMAS

Renata Rutkauskaitė, Antanas Skarbalius
Lietuvos kūno kultūros akademija, Kaunas, Lietuva

SANTRAUKA

Tyrimo pagrindimas ir hipotezė. Sportininkų ugdymo veiksmingumas priklauso nuo kryptingo rengimo vyksmo tam tikrais sportininkų rengimo etapais, valdymo, individualios sportininko adaptacijos prie pratybų ir varžybų krūvių.

Tikslas: išsiaiškinti specifinio rengimo poveikį 13–14 metų meninės gimnastikos sportininkių parengtumo optimizavimui.

Metodai. Eksperimento metu buvo modeliuota trijų skirtingų rengimo programų rengimo struktūra ir registruotas sportininkių parengtumas (atletinis, techninis ir psichinis). Krūvių registravimo protokoluose buvo registruojamas choreografijai, elementų mokymuisi, varžybiniams pratimams bei atletiniam rengimui skirtas laikas per kiekvienas pratybas. Rengimo programų veiksmingumas nustatytas registruojant varžybinės veiklos realizavimą varžybinėmis sąlygomis pagal kiekvienos rengimo programos gimnastės gaunamus taškus, pagal kiekvieną iškovotą vietą (nustatytą taškų skyrimą mažėjančia tvarka).

Rezultatai. Skirtingų programų sportininkės treniravosi nevienodai – reikšmingai skyrėsi taikomų krūvių (nuo 10,28 iki 12,91 h per savaitę) ($p < 0,001$), pratybų dienų rodikliai (nuo 5,43 iki 4,17 dienų per savaitę) ir sportininkių rengimo turinys. Statistiškai reikšmingai skyrėsi staigiosios jėgos ir jėgos ištvermės, specifinės ištvermės, koordinacijos judamųjų gebėjimų rodikliai ir atletinio parengtumo integralusis rodiklis, išreikštas balais ($p < 0,05$). Veiksmingiausioje rengimo programoje vyravo choreografinis regimas (35,8%). Kūno veiksmų ir veiksmų su įrankiais technikos realizavimas įvairiose rengimo programose sezono pradžioje ir pabagigoje buvo skirtingas ($p < 0,05$).

Aptarimas ir išvados. Sportinių rezultatų siekimo etapu išryškėjo 13–14 metų meninės gimnastikos sportininkių varžybiniams pratimams tobulinti skirto laiko ir integraliojo rengimo reikšmė sportininkių varžybinės veiklos veiksmingumui. Pastebėta veiksmų su atskirais įrankiais technikos reikšmė, o kūno judesių technikos sudėtingumo rodikliai nusistovėjo. Svarbiausi veiksniai, nusakantys geriausius rezultatus, yra staigioji jėga, jėgos ištvermė, koordinacija ir susumuotas integralusis atletinio parengtumo rodiklis.

Raktažodžiai: meninė gimnastika, rengimas, parengtumas.

Gauta 2011 m. liepos 23 d.
Received on July 23, 2011

Priimta 2011 m. rugsėjo 9 d.
Accepted on September 9, 2011

Corresponding author **Renata Rutkauskaitė**
Lithuanian Academy of Physical Education
Sporto str. 6, LT-44221 Kaunas
Lithuania
Tel +370 674 09104
E-mail r.rutkauskaite@lkka.lt