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PHYSICAL FITNESS OF RHYTHMIC GYMNASTS DEPENDING ON AGE AND LEVEL OF SPORTS ACHIEVEMENTS

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A. Study design/planning
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Abstract:

Aim. The aim of this study was to compare the indices of physical development, frequency and time duration of training, and the results of physical fitness tests depending on age and level of sports achievements among rhythmic gymnasts.

Materials and methods. The study comprised 36 rhythmic gymnasts: Gr1 (n=13, 9.0±1.0 years), Gr2 (n=11, 11.36±0.5 years), Gr3 (n=12, 14.27±0.7 years). After standardised sports interview, the groups with lower level of sports achievements (LSL) (n=20) and higher level of sports achievements (HSL) (n=16) were defined. Measurements of body height and mass were performed. The study participants performed the broad jump test, Unipedal Stance Test with Eyes Open (UPST-EO) and Eyes Closed (EC), and the rhythmic gymnastics specific coordinative test with a hoop.

Results. The number of training sessions per week and their duration did not depend on age. The results of the broad jump were significantly different for groups Gr1, Gr2 and Gr3 ($F=27.02$, $p<0.01$). The average results for the 3 trials of UPST-EO in Gr2 and Gr3 were better than in Gr1 ($F=5.51$, $p=0.008$). The average result of UPST-EC for Gr3 was also significantly better than for Gr1 ($W=9.53$, $p=0.008$). The hoop test showed differences for all age groups Gr1<Gr3<Gr2 ($F=11.55$, $p<0.001$). HSL athletes were significantly different from LSL in frequency and duration of training, average results from 3 trials of UPST-EO, UPST-EC and the best result of UPST-EC ($p<0.05$).

Conclusions. Differences between groups in physical fitness tests results depended on gymnasts' age and showed their usefulness in the control of training at a particular stage of sports development. HSL gymnasts predominated over LSL in results of the one-leg standing position postural balance test with eyes opened and closed. The detected differences can be useful for coaches in identifying and developing gymnastic talent.

Introduction

Rhythmic gymnastics is a female sports discipline that has been permanently included in the programme of the Summer Olympics since 1984 [1]. The competitions are carried out in individual and group exercises. Individual competitors perform routines with 4 out of 5 apparatus, i.e. a rope (except for the senior category), a hoop, a ball, clubs and a ribbon, on a floor area measuring 13x13 meters. The judges score: 1) difficulty and 2) execution of the presented exercises. The first category includes: body difficulties (jump/leaps, balances, rotations), combinations of dance steps, dynamic elements with rotation, and apparatus difficulty. However, judges assessing the execution require aesthetics, artistry and technical perfection as well as a harmonious combination of the type of exercises presented with the pace and nature of the background music, and in the case of group exercises, synchronisation, collaboration and a smooth exchange of the apparatus between the athletes [2].

The training and competition requirements in rhythmic gymnastics are very high. Girls who want to practice this sport professionally, from an early age are subjected to many hours of exercises aimed at shaping flexibility, a sense of rhythm, movement expression and technical manipulation of the used apparatus [3]. Vigorous training is conducted during childhood and adolescence. The participation of girls below the age of 20 is observed in competitions of the highest world rank [4,5,6].

Many authors have dealt with determining the factors which influence the achievement of success in rhythmic gymnastics. Douda et al. [7] assigned a percentage share to selected anthropometric features (45%), flexibility (12.1%), explosive strength (9.2%), aerobic capacity (7.4%), body dimensions (6.8%), anaerobic abilities (4.6%) concerning their meaning as factors explaining success in rhythmic gymnastics. Researchers emphasize that achieving a high sports level is conditioned by having an appropriate, slender body structure, characterised by low body fat, with a simultaneous high percentage of lean body mass [8,9,10]. Long-term sports training causes adaptive changes, which in girls aged 13-17, are manifested in the lateralisation of the lower limbs in the form of an increased circumference of the dominant leg and an increased calf circumference of the supporting leg. These one-sided, specific changes are related to the exercises performed, in which there is asymmetric work of the lower limbs, i.e. balance exercises, turns, jumps [11]. Santos et al. [12], however, did not find a functional disproportion in the explosive power of the dominant and non-dominant limb during performance of stag and cossack jumps. On the other hand, the appropriate flexibility level of the trunk and lower limbs effects the perfect technique of the performed elements and the judges' high assessment [13].

In mastering complex technical elements with the use of apparatus, a significant role is played by motor coordination abilities, i.e. kinaesthetic differentiation of movements, related to so-called "feeling the apparatus", so important in this discipline, rhythmisation, spatial orientation and combining movements, maintaining balance. The influence of training is expressed in a higher level of motor coordination abilities among girls practicing rhythmic gymnastics compared to their non-training peers [14].

A review of the research undertaken by Polish authors dealing with the issues of selection and recruitment, as well as predisposition to practicing rhythmic gymnastics, was conducted by Starosta and Podciechowska [14]. In the scientific databases, there are only a few current studies on the level of physical fitness among Polish rhythmic gymnasts, however, they do not include girls representing the national team and participating in international competitions. In the available research, somatic structure and the ability to maintain dynamic balance [15, 16], jumping ability and motor coordination are discussed [17, 14].

The aim of this study is to compare the indices of physical development, frequency and time duration of training, and the results of physical fitness tests depending on age and level of sports achievements among rhythmic gymnasts.

Materials and methods

Study group

The study comprised 36 rhythmic gymnasts, who were further divided into 3 groups: Gr1 (n=13, 9.0±1.0 years), Gr2 (n=11, 11.36±0.5 years), Gr3 (n=12, 14.27±0.7 years), corresponding to the 3rd, 2nd and 1st sports classes [18]. All girls practiced rhythmic gymnastics competitively. At the time of carrying out research, 33 of them were training at the "Sokół" Kraków Polish Gymnastic Society, and 3 at the OLIMPIA Kraków Association of Rhythmic and Artistic Gymnastics. The gymnasts took part in national, European and world competitions. Among the subjects, there were 8 athletes belonging to the Polish national team.

A standardised sports interview was conducted with regard to training method. Each competitor answered the questions about: date of birth, training experience, number of training sessions per week, duration of a single training unit and her greatest sports achievements. The dominant leg was defined by the gymnast performing a piqué (pirouette). Girls who had had muscle or joint injuries within the 3 months preceding the study were excluded from the measurements. The research was carried out in the starting period, with the participation of coaches and after obtaining consent from the girls' parents. The study was in compliance with the provisions proposed in the Declaration of Helsinki [19].

After detailed analysis of the girls' (from all age categories) sports achievements, the criterion for qualifying the female athletes to the group with higher sports level (HSL) (n=16) was, for G1 and G2: winning 1st-3rd place during the Polish Championships in the individual all-around, or group all-around, or finals classification, or 1st place at regional (voivodeship) competition, or 1st place in an international tournament during the year preceding the research, while for G3: achieving 1st-3rd place at the Polish Championships in the individual all-around, or group all-around, or finals classification in the year preceding the examination. The remaining competitors who did not meet the above criterion were qualified to the lower sports level (LSL) (n=20). There were no statistically significant differences in age between the HSL and LSL groups (t=1.36, p=0.183).

Anthropometric measurements

Body height (cm) was measured with an anthropometer (Siber Hegner, Switzerland), while body mass was calculated on a Beurer BG20 electronic scale (Germany) [20]. BMI (kg/m^2) was computed [21].

Standing long jump

The standing long jump was performed according to the EUROFIT instructions [22]. Before beginning the test, the gymnasts were instructed on the optimal method of rebound [23]. The girls performed 2 trials, of which the better result was used for further analysis. Results were read in meters using a tape measure attached to the floor.

Balance test

The Unipedal Stance Test (UPST) was performed similarly as in previous studies [24, 25, 26]. The duration of maintaining balance on one leg, with arms crossed over the chest, was measured. The test was performed on the dominant leg. The measurement was read in seconds using a stopwatch. The foot of the free leg was kept in contact with the medial ankle of the supporting leg. Timing was stopped when the athlete changed position of the arms or the foot of the free leg lost contact with the supporting leg. Each participant performed 3 attempts of the UPST-EO eyes open and UPST-EC eyes closed test. Arithmetic means were calculated from 3 measurements and the best results were determined for EO and EC [27].

Special fitness test with hoop

In order to determine the ability to perform movements quickly and precisely in a specific time frame, a test based on performing skipping through a spinning hoop was used. The gymnasts started the test positioned with the hoop held in front of them with both hands. The number of successful skips within 15 seconds was measured (time measured using a stopwatch). Only correctly performed jumps were recorded [3].

Statistical calculations

Descriptive statistics were calculated. Normality of distribution was verified and it was assumed that the values of kurtosis and skewness ranging from -2 to 2 indicate a distribution close to the norm. Additionally, the Bartlett test allowed to confirm equality of variance in individual groups Gr1-Gr3. After examining normality of distribution in individual groups, ANOVA or the non-parametric Kruskal-Wallis test were performed. The age factor (3 levels) was an independent variable. The set of age-dependent variables included physical development indices (height, mass, BMI), sports training characteristics (training experience, number of training units per week, duration of training), results of physical fitness tests (standing long jump, balance test with open and closed eyes, special fitness test with hoop). For pairwise comparisons, 95.0 percent Bonferroni intervals were used. Statistical significance was assumed at $p=0.017$ (Bonferroni correction). The η^2 effect size was calculated assuming the interpretation: 0.01: small effect; 0.06: medium effect; 0.14: large effect [28]. Comparisons by sport level, after checking the normality of distribution, were carried out using the Student's *t* or Mann-Whitney tests. The values in the tables are presented as mean±standard deviation or median and interquartile ranges (25% to 75%).

Results

The characteristics of the basic physical development and BMI indices for female gymnasts are presented in Table 1.

Body height varied between all of the age groups. Body mass naturally increased in successive age groups. Significant differences were in: Gr1<Gr3, Gr2<Gr3. Groups Gr1 and Gr2 demonstrated similar levels of body mass. For BMI, there was a similar system of median values, Gr3 athletes were characterised by significantly higher values of this index than Gr1 or Gr2, which were similar.

The characteristics of training experience, frequency and time duration of training of the rhythmic gymnasts are presented in Table 2.

The female gymnasts from individual age groups differed significantly in training experience. The duration of training and the number of training sessions per week did not differ significantly between the groups.

Table 1. Physical development indices of rhythmic gymnasts.

	Total (n=36)	Gr1 (n=13)	Gr2 (n=11)	Gr3 (n=12)	Statistics
Body height (cm)	142,3±13,92	129,9±8,97[a]	141,0±7,89[b]	156,99±7,46[c]	F=34,42, p<0,001, η^2=0,68
Body mass (kg)	29,35 (26,0;36,25)	25,2 (20,5;26,8)	29,5[b] (27,6;31,2)	41,85[c] (35,95;49,85)	W=23,4, p<0,001, η^2=0,67
BMI (kg/m^2)	15,35 (13,96;16,2)	14,01 (13,64;15,31)	15,0 (14,3;15,8)	17,02[c] (15,82;18,85)	W=13,37, p<0,001, η^2=0,38

a=different from Gr2 and Gr3; b=different from Gr1 and Gr3; c=different from Gr1 and Gr2

Table 2. Experience and training characteristics of rhythmic gymnasts.

	Total (n=36)	Gr1 (n=13)	Gr2 (n=11)	Gr3 (n=12)	Statistics
Experience (years)	6,13±2,32	4,16±1,13[a]	6,0±1,36[b]	8,45±1,79[c]	F=25,97, p<0,001, η^2=0,62
Frequency of training per week (count)	6,0 (6,0;6,0)	6,0 (6,0;6,0)	6,0 (5,0;6,0)	6,0 (6,0;6,0)	W=5,36, p=0,069, η^2=0,15
Duration of training session (hours)	3,5 (3,5;3,5)	3,5 (3,0;3,5)	3,5 (3,5;3,5	3,5 (3,5;3,5)	W=7,62, p=0,022, η^2=0,22

a=different from Gr2 and Gr3; b=different from Gr1 and Gr3; c=different from Gr1 and Gr2

Table 3. Comparison of rhythmic gymnastics athletes motor fitness results in three age categories.

	Total (n=36)	Gr1 (n=13)	Gr2 (n=11)	Gr3 (n=12)	Statistics
Standing long jump (m)	1.71±0.24	1.51±0.17[a]	1.69±0.14[b]	1.95±0.13[c]	F=27.02, p<0.001, η^2=0.62
UPST-EO best result (s)	45,0 (42,05;45,0)	44,8 (33,4;45,0)	45,0 (42,0;45,0)	45,0 (43,0;45,0)	W=2,23, p=0,327, η^2=0,06
UPST-EO mean (s)	33,98±6,44	29,76±7,1[a]	36,05±5,03	36,64±4,56	F=5,51, p=0,008, η^2=0,25
UPST-EC best result (s)	21,7 (15,25;27,85)	11,2 (7,3;21,7)	21,8 (18,2;28,9)	26,4 (20,75;30,3)	W=7,63, p=0,022, η^2=0,22
UPST-EC mean (s)	15,73 (10,08;17,34)	6,33[d] (4,47;15,43)	13,97 (11,7;16,9)	16,8 (16,22;19,9)	W=9,53, p=0,008, η^2=0,27
Test with hoop (count)	30,64±6,37	26,0±6,11[a]	35,9±4,76[b]	30,83±3,83[c]	F=11,55, p<0,001, η^2=0,41

a=different from Gr2 and Gr3; b=different from Gr1 and Gr3; c=different from Gr1 and Gr2; d=different from Gr3

Table 4. Physical development indices, experience, training characteristics, motor fitness results of lower (LSL) and higher (HSL) level of sports achievements rhythmic gymnasts.

	LSL (n=20)	HSL (n=16)	Statistics
Body hight(cm)	140±13,6	145±14,4	t=0,923, p=0,363
Body weight (kg)	30,6±8,86	34,0±10,7	t=1,040, p=0,305
BMI (kg/m²)	15,3±1,83	15,8±1,87	t=0,757, p=0,454
Experience (years)	5,65±2,07	6,72±2,55	t=1,39, p=0,174
Frequency of training per week (count)	6,0 (5,0;6,0)	6,0 (6,0;6,0)	U=112, p=0,019*
Duration of training session (hours)	3,5 (3,0;3,5)	3,5 (3,5;3,5)	U=114, p=0,044*
Standing long jump (m)	1,67±0,225	1,77±0,248	t=1,17, p=0,251
UPST-EO best result (s)	44 (37,5;45,0)	45 (44,9;45,0)	U=117, p=0,119
UPST-EO mean result (s)	31,8±6,17	36,7±5,82	t=2,45, p=0,019*
UPST-EC best result (s)	17,6±8,62	25,5±9,72	t=2,59, p=0,014*
UPST-EC mean result (s)	12,9±5,93	18,0±8,0	t=2,19, p=0,035*
Test with hoop (count)	30,4±7,46	30,9±4,92	t=0,248, p=0,806

*p<0,05

In Table 3, the results of physical fitness tests for the rhythmic gymnasts are presented.

The standing long jump results differed significantly between all groups. For the best UPST-EO result, there were no significant intergroup differences. The average UPST-EO score significantly differed G1 from G2 and G3. Gr1 had a significantly worse result than the others. For the best UPST-EC result, no significant differences between the groups were shown. The average UPST-EC result achieved by Gr1 athletes was significantly weaker than the Gr3 time. The hoop test results differed significantly between all age groups. Gr2 athletes performed the greatest number of jumps in 15 seconds.

In Table 4, indices of physical development are shown, as well as the characteristics of the training method and the results of fitness tests for LSL and HSL athletes. There were no intergroup differences in body height, body mass, BMI or training experience. Statistical analysis allowed to indicate significant differences in the frequency and duration of training in favour of HSL gymnasts. In all of the physical fitness tests, athletes from the group with higher sports level pre-dominated. Statistically significant differences concerned the average result from 3 UPST-EO trials and the best and average UPST-EC result.

Discussion

Analysis of the research results made it possible to compare the indices of physical development, experience, frequency and time duration of training, and the results of selected general and special fitness tests among female gymnasts, depending on age category and level of sports achievements.

The examined athletes were characterised by low body mass index (BMI). Values for the girls from Gr1-Gr3 were at the level of the 10th percentile according to the percentile grids proposed by WHO, that is at the lower limit of the norm [29]. BMI was higher in the groups of girls from Serbia aged 9.67±0.49 (n=28), 11.83±0.64 (n=20), 14.8±1.74 (n=6), and totalled 17.48±2.11 kg/m^2, 18.82±2.71 kg/m^2, 20.47±1.87 kg/m^2, respectively [30]. Similarly, higher values were found in the group of Polish gymnasts aged 8-11 (n=19), which amounted to 15.32 kg/m^2 [15]. A slender physique is highly desirable in this sport and is an important criterion when selecting girls for rhythmic gymnastics [31]. Therefore, it should be important to constantly monitor the health of female athletes in order to avoid eating disorders while maintaining low body mass [32, 33].

Training experience depended on the age of the participants. The frequency of training during the week and the duration of a single training unit did not differentiate the 3 groups of gymnasts. The duration of training among the studied girls was similar to Portuguese, high-level athletes (13.60±0.2 years) and those at a national level (13.76±0.2 years), but the higher-level gymnasts trained 7 times a week [12]. Longer training sessions concerned female competitors (n=255) aged 14.73±2.12 (from the age of 11 to 23) who practised 6.82±1.92 hours daily [34].

A predisposition determining the result of the standing long jump is maximal anaerobic power, related to the level of somatic development [35]. The conducted research revealed a natural increase in distance for the standing long jump in subsequent age groups. Explosive strength of the lower limbs is mentioned as one of the factors determining sports success in rhythmic gymnastics [7]. This ability manifests itself during the performance of jumps included in the routines presented during the competition. The introduction of a 12-month exercise programme, based on employing the plyometric method into traditional gymnastics training, resulted in improvement of results for the standing long jump by 20.3% [36].

An ecological test was used to measure balance, i.e. it does not require specialised measuring equipment, difficult to access for club trainers. In the studied group of female athletes, an extension of the time maintaining balance while standing on 1 leg was observed in subsequent age groups. The average results of the 3 UPST-EO and EC trials revealed significant differences in static balance depending on the age of the girls. Nonetheless, juniors (n=34, 14.3±2.15 years) and seniors (n=19, 21.3±2.62 years) training artistic gymnastics at national and international sports levels did not differ in the average and best UPST-EC results, maintaining balance while standing with eyes closed for approximately the same duration [26]. Quantitative analysis of "body difficulties" in gymnastics routines for 40 Olympic finalists in London, which consisted of exercises with a hoop, ball, clubs and ribbon, indicated that the elements of balance were performed most frequently. Their diversity, however, was smaller than in the elements of rotation. The exercises performed less frequently included elements of flexibility and body waves [37]. Therefore, balance is an important component in the motor preparation of rhythmic gymnasts due to the significant share of such elements in the composition of routines. In sports training, it is additionally shaped by girls' participation in classical dance exercises, where apart from shaping proper figure, aesthetics, expression of movement and balance exercises constitute an important part of the classes [31].

The performed hoop test requires performing as many skips as possible through the rotating hoop within 15 seconds. The hoop diameter is not specified in the test description [3], thus, the requirements of the Polish

Table 5. Results of test with hoop in age groups in comparison to normative values.

	Excellent 25 and more	Good 18-24	Fair 11-17	Poor 1-10	Unsuccessful 0
	N	N	N	N	N
G1 (n=13)	8	4	1	-	-
G2 (n=11)	11	-	-	-	-
G3 (n=12)	11	1	-	-	-
Total (n=36)	30	5	1	-	-

N-number of gymnasts in range of evaluation

Gymnastic Association were adopted, which determines the dimensions of the inner diameter as follows: youth class and class 3, without measurement, class 2 min. 75 cm, class 1, 80-90 cm [18]. The results of the test significantly differed with regard to the age of the female gymnasts under study, with large effect size ($\eta^2=0.41$). In this trial, the G2 athlete achieved the best results. The better results of girls from Gr2 than Gr3 may indicate greater importance of specific coordination abilities in the early stage of sports development. This pattern of results could have also been influenced by body proportions that were not taken into account in this study. Comparison of the results obtained in this research with standards is presented in Table 5 [3].

Purenović-Ivanović et al. [38] conducted testing of specific coordination with apparatus (including a hoop) among a group of female rhythmic gymnasts (n=106) representing various levels of advancement and sports achievements. A very good result in the hoop test was achieved by 83.47% of the subjects, 7.78% good, 5.51% average. As in our research, none of the girls fell into the range of poor or very poor performance.

Rhythmic gymnastics athletes qualified to groups with lower and higher levels of sports achievements did not differ in age, body height, body mass or BMI. However, significant influence of the frequency and duration of training on the sports result was noted. HSL competitors trained more often and their training sessions were longer than LSL.

Among the performed tests, significant differences depending on the sports level were found in the average results of the 3 UPST-EO and EC tests, and the best UPST-EC result was in favour of female athletes with higher sports performance. Balance elements in rhythmic gymnastics are mostly carried out standing on 1 leg, additionally, performing the so-called *relevé*.

Purenović-Ivanović et al. [38] used multiple regression analysis to indicate which of the selected tests conducted with apparatus: ball, rope, hoop or clubs [3] were most strongly associated with sports success. They found significant impact of the hoop and ball test results on the scores obtained in the competition. In this study, such a correlation was not confirmed. The athletes representing a higher sports level performed more jumps through the hoop in a specific time frame than those of the lower level of sports achievements, however, this difference was small and not did not reach the level of statistical significance.

Conclusions

Despite the fact that rhythmic gymnastics is an early specialization sport, the number of training session per week and their duration, did not differ depending on the age of the participants.

The performed tests revealed intergroup differences in the level of physical fitness among the gymnasts from 3 age categories, indicating the advisability of their use in training control at individual stages of sports development.

Significant differences were found in the frequency and duration of training in favour of higher-level gymnasts compared to girls representing the lower level of sports achievements.

Athletes with higher sports achievements also dominated with regard to the results of balance tests performed standing on 1 leg with open and closed eyes. The detected differences may be useful for rhythmic gymnastics coaches in identifying and developing sports talent.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Ethics Committee

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