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CHANGES IN BODY COMPOSITION AND PHYSICAL FITNESS OF 7-YEAR-OLD GIRLS AFTER COMPLETING A 12-MONTH ARTISTIC GYMNASTICS TRAINING PROGRAM

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ABSTRACT

Purpose. The aim of the study was to evaluate changes in body composition and physical fitness in girls aged 7 years before and after a 12-month macrocycle artistic gymnastics training program. **Methods.** The study involved 32 girls attending the first grade at a sports-focused primary school with a specialization in artistic gymnastics. The study was conducted at the beginning and after an annual training cycle. Measures of body height, body mass, and body composition were performed. Physical fitness was assessed using the Eurofit physical fitness test battery. **Results.** The results showed average body composition and a high initial level and later dynamic increase in the physical fitness of the participants. **Conclusions.** The dynamic increase in the results of six Eurofit tests and the overall high level of results in seven of the tests after completing the annual training cycle is evidence of the high effectiveness of the applied training program in improving the physical fitness of the tested girls. The reasons for the lack of significant progress in one of the tests measuring agility (10 × 5 m shuttle run) are unclear, requiring more in-depth analysis of the training process used by trainers with focus on the applied methods, means, and training load volumes. The Eurofit test battery proved to be a precise tool to assess changes in the physical fitness of the tested girls after completing the annual training cycle and is therefore worth recommending at early training stage in gymnastics. The results provide useful information in optimizing the training loads of artistic gymnasts at the initial training stage.

Key words: girls aged 7–8 years, artistic gymnastics, body composition, physical fitness, Eurofit

Introduction

Contemporarily, it is believed that in order to achieve a high degree of complex motor performance in many sports disciplines training needs to begin in early childhood. This is in part the result of modern competitive sport being characterized by an ever-continuing increase in performance levels [1, 2]. This development is the result of growing knowledge on the human body's adaptation to exercise, improved athlete recruitment and selection methods, and more efficient training exercises and programs [2–4].

The particular importance of the training process at its initial stage is due to the role it plays in the development of athletic motor skills. Nonetheless, a high level of wide-ranging physical fitness provides a foundation on which specific motor abilities and skills can later be developed.

The basis for assessing the training process in sports involves a systematic examination of training effects. Such an evaluation requires the use of objective, quantitative, and qualitative criteria for assessing motor skill level, the body's response to training loads, the characteristics of pertinent mental processes, and the level of athletic technical and tactical preparation. All of these factors are then interpreted so as to optimize the training process. However, this optimization process requires coaches and educators to continually monitor the training effects for each athlete to allow for the individualization of training loads [1–8].

The above-mentioned factors combine to form an 'optimal fitness structure', which is particularly important in sports such as artistic gymnastics where a great deal of significance is attributed to motor abilities and particularly coordination [1, 5]. Artistic gymnastics, due to its physical structure, athletic demands, and physiological profile, belongs to a group of coordinative difficult aesthetic and technical disciplines whose energy demands are met mainly by the anaerobic glycolytic system. Potop et al. [10] highlighted the importance of using specific training loads to elicit peak improvements in women's artistic gymnastics by highlighting the importance of an optimum relationship between workload and technical-physical training level. Increased performance requires the combination of an athlete's individual fitness levels and coordination skills to be in mutual harmony with suitable training techniques and workouts at different difficulties [11, 12]. It needs to be stressed that the effectiveness of the training process in gymnastics depends on the individual abilities of athletes and what useful indicators on performance can be gained across training stages. This also relates to the importance that is attributed to the recruitment/selection stage, as it aims to identify talented individuals and determine their developmental potential [1, 4].

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Many experts have emphasized the crucial importance of possessing a broad level of physical fitness in the athletic development of artistic gymnastics [1, 5, 8, 11–16]. For these reasons, the aim of the present study was to evaluate the anthropometric characteristics, body composition, and selected components of physical fitness of 7 year-old girls beginning an introductory level of gymnastics and after the completion of a full (12-month) training macrocycle.

Material and methods

A quasi-experimental, longitudinal (pre- and post-test) design was adopted to examine the effects of gymnastics training on the individual components of body composition and physical fitness in 32 pre-pubertal girls (mean chronological age 7.72 ± 0.30 years) attending the first grade at the No. 23 Primary School of Sports Championship in Olsztyn, Poland. The girls were attending the school with a specialization in artistic gymnastics and were admitted based on a set of performance tests.

The subjects participated in one daily training unit (4 h) six days every week in a specialized gym. Each training unit contained two training phases: routine development (RD) and strength-technical conditioning (STC). Each of phases lasted 2 h. The RD phase started with a 30-min warm-up which included 8 to 10 min of slow running and a 20-min set of athletic exercises (skipping, hand walking, etc.). One and a half hours was devoted to choreographic-ballet elements and active stretching of the upper and lower limb muscle groups. The STC phase consisted of general and technical-strength development performed on gymnastic apparatuses such as the high bar, parallel bars, etc. Training impact (loads) were primarily administered on four gymnastics apparatuses (30 min on each): (1) gymnastics table – vaulting; (2) parallel bars – standing, turnovers, turnstiles, drop jumps; (3) balance beam – choreographic elements, ballet jumps; and (4) free exercises – acrobatics, handsprings on one and two lower limbs, forward and backward somersaults, etc. Examples of the duration of specific exercises per standard training unit were, for example, an average of 18–20 min of static support loading on the hands/wrists or an average of 3.5 min swinging on the bars.

Heart rate was monitored during chosen training units. It was estimated that about 63% of total training time was devoted to rest or recovery. Mean heart rate was 139 beats per minute (bpm) although varied depending on apparatus and training phase and approached 60% to 65% of participants' maximum heart rate.

Testing was conducted twice at the Central Research Laboratory of the Joseph Rusiecki Olsztyn University in the morning (08:00–11:00). Baseline tests (pre-test) were completed at the beginning of the participants' training program and a post-test was administered after 12 months of them regularly training. The period between pre- and post-tests constituted a complete annual macrocycle. Participants had to attend at least 90% of the training units to be included in data analysis and attend both pre- and post-tests. Prior to testing parental consent and child assent were obtained, and the study received the approval of the local ethics committee.

Participants' body height was measured with a calibrated WB-150 medical weight/stadiometer (ZPU Tryb-Wag, Poland) with an accuracy of 0.1 cm. Body mass (with an accuracy of 0.1 kg) and body fat content (with an accuracy of 0.1%) were measured using a BC 418 MA electronic body composition analyzer (Tanita, Japan) using bioelectric impedance analysis (BIA). During measurement participants were barefoot wearing underwear only. All anthropometric measurements were performed by the same certified investigator and in accordance with international standard procedures.

Physical fitness was determined by administering eight tests included in the Eurofit physical fitness battery [17]. Due to the research task, an assessment of cardio-respiratory endurance was not performed. As gymnasts regularly train barefoot, the flamingo balance test (FLB) was performed without footwear. To allow for a more detailed interpretation of participants' physical fitness, an additional variable was introduced – relative hand strength (HGR) in relation to body mass (N/kg). Body height and mass, body mass index, and the results of the Eurofit tests were evaluated by percentile ranks and point scores according to national norm score tables and percentile charts [18, 19].

Following data collection, descriptive statistics (means and standard deviations) were calculated. Minimal and maximal values and the coefficient of variation (CV) for each variable were presented. The significance of differences between the results of measurements carried out at pre- and post-test was assessed using Student's *t* test for dependent samples (paired *t* tests). Tables show the *t* values and the *p* values. The alpha-level for significance was set to 0.05. Statistical analysis was performed using the StatisticaPL v. 10 software package (StatSoft, USA).

Results

Table 1 shows the results of the basic anthropometric characteristics of tested gymnasts in both trials (pre- and post-), the significance of differences between the variables, and biological (physical) development based on norms for the age-specific general population (scaled scores and percentile ranks) [18, 19].

The participants were below the norms for body height and mass at pre- and post-test in comparison with the general population of Polish girls in this age group [18], scoring 46–48 points in the 34.5–42.1 percentiles, respectively. Nonetheless, there was a significant increase ($p = 0.0000$) in body height and mass after the one-year period as the obvious result of biological development. It should be noted that an increase in body

Table 1. Basic anthropometric characteristics of the artistic gymnasts (N = 32)

	Variables	Age (years)	BM (kg)	BH (cm)	BF (%)	FM (kg)	FFM (kg)	FM/FFM (%)	BMI (kg/m²)
Pre-test	M (*SD*)	7.23 (0.28)	23.22 (2.76)	122.55 (3.78)	18.11 (3.51)	4.25 (1.18)	18.97 (1.96)	22.33 (5.25)	15.42 (1.28)
	Min-Max	6.60–7.50	18.50–29.20	116.5–130.0	10.60–24.90	2.23–7.27	15.17–22.99	11.86–33.16	13.12–17.89
	CV	3.87	11.88	3.09	19.40	27.71	10.33	23.52	8.29
	c./pts.		38.2/47	38.2/47					38.2/47
Post-test	M (*SD*)	8.21 (0.31)	25.71 (2.94)	128.81 (4.10)	19.16 (2.51)	4.95 (0.99)	20.76 (2.26)	23.81 (3.86)	15.45 (1.20)
	Min-Max	7.60–8.53	19.60–31.80	121.1–139.5	13.60–24.10	3.37–6.86	16.01–25.32	15.74–31.75	13.39–18.25
	CV	3.74	11.43	3.18	13.12	20.03	10.87	16.22	7.78
	c./pts.		34.5/46	42.1/48					30.9/46
Difference (%)		13.83	10.73	5.11	5.80	11.65	9.43	6.62	0.22
t			–21.55	–19.59	1.80	–4.683	–12.549	–1.719	–0.372
p			0.0000	0.0000	0.0816	0.0000	0.0000	0.0957	0.7121

BM – body mass, BH – body height, BF – body fat, FM – fat mass, FFM – fat-free mass, FM/FFM – ratio of fat mass and fat free mass, BMI – body mass index, M – mean value, SD – standard deviation, Min – minimal value, Max – maximal value, CV – coefficient of variation, c. – percentile, pts. – points, t – t value in Student's t test, p – value based on the Student's t test

Table 2. Results of the Eurofit physical fitness tests of the artistic gymnasts (N = 32)

	Variables	FLB (n)	PLT (s)	SAR (cm)	SBJ (cm)	HGR (N)	HGR (N/kg)	SUP (n)	BAH (s)	SHR (s)
Pre-test	M (*SD*)	18.78 (6.33)	18.57 (2.62)	9.69 (4.91)	119.1 (11.2)	104.8 (20.4)	4.51 (0.69)	20.63 (4.71)	13.87 (9.01)	24.56 (2.17)
	Min–Max	5–31	13.92–25.72	0–21	100–140	71–142	2.81–6.24	7–29	1.80–36.22	21.15–30.58
	CV	33.72	14.10	50.67	9.27	19.42	15.30	22.83	65.00	8.82
	c./pts.	*6.7/35*	72.6/56	84.1/60	86.4/61	57.9/52		90.3/63	90.3/63	72.6/56
Post-test	M (*SD*)	11.88 (4.35)	15.81 (1.88)	13.91 (4.37)	128.3 (9.7)	130.0 (21.9)	5.06 (0.61)	26.50 (3.72)	34.16 (17.53)	24.46 (2.33)
	Min–Max	5-22	12.26–19.85	4–23	110–145	91–178	3.91–6.48	20–36	9.87–82.62	21.00–29.78
	CV	36.60	11.87	31.44	7.59	16.82	12.12	14.02	51.31	9.53
	c./pts.	*18.4/41*	86.4/61	95.5/67	86.4/61	65.5/54		98.6/72	99.8/79	61.8/53
Difference (%)		36.77	–14.83	43.55	7.74	24.11	12.10	28.48	146.28	–0.38
t		6.81	7.45	–6.88	–6.08	–9.20	–5.21	–7.91	–7.68	0.21
p		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.8341

FLB – flamingo balance test, PLT – plate tapping, SAR – sit-and-reach test, SBJ – standing broad jump, HGR – hand grip test, SUP – Sit-ups, BAH – bent arm hang, SHR – 10 × 5 m shuttle run, M – mean value, SD – standard deviation, Min – minimal value, Max – maximal value, CV – coefficient of variation, c. – percentile, pts. – points, t – t value in Student's t test; p – value based on the Student's t test; values in italics denote estimated percentile ranks and point scores mass can negatively influence performance in aesthetic sports and in those which a high power to body mass ratio is important. Body mass index (BMI) in both trials was also below the general population norms of Polish girls (47–46 pts. and 38.2–30.9 c., respectively).

Body fat percentage (BF) was at the same level in both trials. However, due to natural biological growth and increases in body size (body height and mass), fat mass (FM) increased significantly ($p = 0.0000$). It should be noted that the size of the coefficient of variation (CV) of the percentage of body fat (BF) and fat mass (FM) strongly decreased in the post-test. This reflects a decrease of inter-individual diversity in the tested group.

Fat-free mass increased since fat mass and body mass either remained constant or decreased. The ratio of fat mass to fat-free mass (FM/FFM) is important for physical fitness especially in exercises where the whole body is rapidly lifted (running, jumping). As there are elements of running, jumping, or lifting the body in each gymnastics exercise on different apparatuses, the importance of the FM/FFM ratio is significant. In the present study, this ratio did not change significantly in the group during the observed period ($p = 0.0957$).

Table 2 shows the participants results in the eight Eurofit tests [16], which were evaluated with respect to national norms [see 19 for a reference sample] based on research conducted in the 2009/2010 school year on a representative group of Polish girls ($N = 23704$) from all regions of Poland.

The results of the six physical tests performed at baseline (pre-test) were at a high and very high level (ranging from 57.9–90.3 c. and 53–63 pts.) according to the score tables. This indicates the high level of physical fitness of the tested participants at the beginning of their training. The percentile and point scores in seven of the Eurofit tests (PLT, SAR, SBJ, HGR, SUP, BAH, SHR) were summed in order to assess the impact of the annual training cycle on the results of applied tests. Subsequently, the mean values were calculated and amounted to 79.17 c. and 58.85 pts. at baseline (pre-test) and 84.86 c. and 63.86 pts. at post-test, improving by 7.18% and 8.51%, respectively.

The static balance test results (flamingo balance test – FLB) could not be directly estimated from the percentile charts and point tables due to the used methodology to modify performance. This test was performed without footwear, which undoubtedly made it more difficult to maintain balance and therefore allowed for greater differentiation of the results. However, the participants significantly improved in this test (36.77%, $p = 0.0000$). An ad hoc assessment on the basis of the score tables showed they increased from 6.7 c. and 36 pts. to 18.4 c. and 41 pts.

The results of the test measuring the speed of upper limb movement (plate tapping test – PLT) were already at a high level at baseline based on the score tables (72.6 c. and 56 pts.) and significantly improved (14.83%, $p = 0.0000$) at post-test (86.4 c. and 61 pts.).

The results of the test measuring flexibility of the sciatic-tibial muscles and lower back (sit-and-reach test – SAR) were at a very high level at baseline (84.1 c. and 60 pts.). The participants' results improved after the 12-month gymnastics training program by 43.55% ($p = 0.0000$), obtaining 95.5 c. and 67 pts. At the same time, the differences between the results of the individual participants, as evidenced by significantly lower coefficients of variation (50.67% at pre-test and 31.44% at post-test), decreased significantly.

The test results of lower limb explosive power (standing broad jump – SBJ) improved relatively little (7.74%), but the increase was statistically significant ($p = 0.0000$). An evaluation of the results based on the score tables showed the same scores in both trials (86.4 c. and 61 pts.), suggesting no effects of training.

The results of the hand grip test (HGR) showed a significant increase after 12 months of gymnastics training (24.11%, $p = 0.0000$). Additionally, the relative strength of the hand to body mass increased significantly during the observation period although the increase was relatively lower (12.10%, $p = 0.0000$). An evaluation of the results based on the percentile charts showed this motor skill was performed with greater success (from 57.9 to 65.5 c.).

A very high level of performance at baseline (90.3 c. and 62 pts.) was found in the test measuring abdominal muscular and hip flexor endurance (sit-ups test – SUP) and a significant improvement was noted at post-test (28.48%, $p = 0.0000$). An evaluation of the results based on the score tables also showed substantial progress (98.6 c and 72 pts.).

Very high performance (90.3 c. and 63 pts.) was observed in the test of arm and shoulder muscular endurance (bent-arm hang test – BAH), showing the highest (of all tests) progress at post-test (146.28%; $p = 0.0000$). An evaluation of the test results based on the score tables also showed very high results (99.8 c. and 79 pts.). Out of all the Eurofit tests, this test also showed the largest variability between the participants and the relatively largest range of decrease in these differences post-test as evidenced by the size of the coefficient of variation (65.31% at pre-test and 51.31% at post-test).

There were no statistically significant improvements after 12 months of gymnastic training only in the speed-agility test (10 × 5 m shuttle run – SHR). An evaluation of the test results showed a decline from 72.6 c. and 56 pts. to 61.8 c. and 53 pts. based on the score tables. Overall, the level of physical fitness of the participants improved significantly in seven of the Eurofit motor fitness tests.

Discussion

Significant increases in physical fitness and the comprehensive and the harmonious development of the body constitute some of the key objectives in gymnastics and are closely linked to the development of motor abilities (strength, speed, endurance, agility, flexibility, coordination and others) [20, 21].

The specialized literature emphasizes the importance of somatic build and body composition in gymnastics [1, 5, 12, 14]. Di Cagno et al. [12] pointed out the significant influence of somatic build, body tissue composition, and jumping abilities on results in gymnastics and recommended using measurements of these factors to identify the predispositions of children during the selection process. A study conducted by Fjørtoft [22] that included 75 children in Norway (37 girls) aged 5–7 years showed a strong correlation between the results of the Eurofit test battery and age. However, this author found that basic somatic parameters (body height and mass) had no significant effect on individual physical fitness variables in this studied age group.

In the present study, lower values of the girls' body height and mass were recorded than what is considered to be the population norm for Polish girls [18]. Body height and mass were located at the 38th percentile at baseline (pre-test), suggesting that mostly short and slim girls were selected. Coaches confirmed that taller and heavier girls have more difficulties in performing technically difficult exercises. According to Malina et al. [23], gymnasts as a group demonstrated patterns of growth and maturation similar to those observed among early-, normal-, and late-maturing individuals who were not athletes. Given the significant impact of biological age on body size and physical fitness, this suggests the need to identify the biological age of girls at the recruiting and selection process in gymnastics. This can facilitate the identification of athletes with the most beneficial features and somatic build proportions as well as provide an objective assessment of physical fitness. Specialists dealing with the issues surrounding gymnastics training emphasize that sports results at the highest level require comprehensive physical and mental preparation [1, 5, 8, 11, 14, 16, 21, 24–26]. Sawczyn [25] underlined the importance of physical fitness in gymnastics, showing systematically increasing differences over time between gymnasts and non-trained subjects aged 10–15 years in flexibility, speed, strength, agility and endurance tests. However, some researchers [27, 28] have stated that it is not currently possible to establish a cause-effect relationship between training and performance in gymnastics due to limitations in the available data, inadequate descriptions of the training processes, failure to consider other factors affecting growth and maturation, and failure to address epidemiological causation criteria. Attempts to isolate the effects of gymnastics training on physical fitness took into account covariates such as age, body size, and physical maturity. Kochanowicz [5] proposed a complex set of indicators to assess motor preparation at the initial stage of training in gymnasts aged 6–7 years. These included an evaluation of balance function, agility, and special technical skills. The basis for selecting these indicators was the results of earlier studies on the physical fitness of gymnasts by the author [14, 15].

The findings discussed above suggest the importance of systematically monitoring comprehensive, targeted, and specific indicators of physical fitness during the gymnastics training process. Currently different motor tests are used to assess physical fitness at the initial stage of training. One of the most developed and recommended by the Council of Europe is the Eurofit physical fitness test battery [17]. Mahoney and Boreham [29] found the Eurofit test battery to be accurate and reliable in the assessment of comprehensive physical fitness in school children. The Eurofit test battery has been previously applied in the analysis of the biological and motor development of children and youth in Poland. A nationwide reference in the form of percentiles charts was developed in a 1999 study conducted on a population of more than 73000 children and adolescents (including more than 35000 girls) attending various schools in Poland [30]. Additional studies were performed in the 2009–2010 school year to update national norms by analyzing a population of 49612 youths (including 23704 girls) [31]. Research was also undertaken to determine the relationship between physical fitness levels estimated by the Eurofit test battery and health levels in 615 adolescents aged 11–16 years [32].

The use of the Eurofit test battery to study the effects of training on physical performance has also been undertaken in many scientific studies. Baquet et al. [33] conducted an experiment to evaluate the effects of a 7-week interval training program on the physical fitness of children (girls and boys aged 8–11 years). The experiment showed that high-intensity speed interval training influenced a significant improvement in explosive strength (standing broad jump) and agility (10 × 5 m shuttle run). It is also known that physical fitness improves with age during childhood and adolescence, although this development may not be equal for all motor skills [34]. This fact was confirmed by the test results of the examined gymnasts in the present study.

Taking into account the findings of the above-cited works, the high and very high levels of performance in the six Eurofit tests at the beginning of training program confirm the accurate selection of the girls to the gymnastics program. However, the physical fitness test results in the group of gymnasts were highly varied, from a –0.38% decrease in the agility test (SHR) to a 146.28% increase in the test of muscular endurance of upper limbs and shoulder girdle (BAH). Nonetheless, a considerable statistically significant improvement ($p < 0.0000$) was recorded in seven out of the eight administered motor tests. In addition, evaluation of the results of six tests after the participants had completed the 12-month training program found significant increases in the percentile ranks and point scores based on the national norms charts and scales. The large increases in the results of six tests as well as the very high level of performance point to the high effectiveness of the adopted training program in comprehensively shaping the physical fitness levels of the tested participants.

The largest improvement (146.3%) was observed in the test of muscular endurance of the upper limbs and shoulder girdle (BAH) out of all the eight tests. Significant improvements (28.48%) were also seen in the test of abdominal muscular and hip flexors endurance (SUP). The results of both of these tests are determined to a large extent by muscular endurance, a core focus in gymnastics training.

The second largest improvement among the tested group was noted in the test measuring flexibility of the sciatic-tibial muscles and lower back (SAR). The participants scored very high at baseline (84.1 c. and 60 pts.) and after 12 months of gymnastics training they performed exceptionally well (pre-test: 95.5 c. and 67 pts.). Such dynamic progress in this test was undoubtedly the result of training aimed at increasing joint mobility and skeletal muscle length due to its particular importance in the effective performance of gymnastic exercises. This improvement is even more impressive when considering the results of Malina et al. [35], who found that girls aged 5 and 11 years show relatively stable results in the Eurofit's flexibility test (SAR) and only after 14 years of age does performance increase.

The speed and frequency of movements is known to develop the most intensively between 7 and 12 years of age [35]. The processes in charge of maintaining optimal body position mature around 6 years of age and the ability to maintain body balance improves together with age [35]. The results of physical fitness tests in the present study confirm these observations. A significant improvement was observed in the static balance test (FLB), which probably was the result of intense proprioceptive training and vestibular stimulation. These in concert resulted in the rapid improvement of the balance system's functioning.

In studies on young elite gymnasts in three age groups (9–10, 11–12, and 13–15 years), increasing age and competitive level was correlated with improved motor abilities both in regards to fitness level and coordination ability [1, 25, 36]. Particularly high levels were demonstrated in such abilities as: overall coordination, static and dynamic balance, kinesthetic skills differentiating movement, endurance, eye-hand coordination, and simple and complex reaction times. The results presented in the present study are consistent with the cited authors. The tested gymnasts featured large improvements in the static balance test (FLB), which was previously mentioned to be most likely due to a strong stimulation of various systems (proprioception and vestibular systems) that constitute the balance system.

One of the most puzzling issues in the present study was the lack of significant progress in the agility test (10 × 5 m shuttle run – SHR). According to Malina et al. [35] the results of the standing broad jump (SBJ), shuttle run (SHR), and bent arm hang (BAH) increase linearly with age in both sexes until they reach adolescence. The reasons for the lack of substantial progress in the shuttle run are unclear considering the gymnastics training the participants performed every day with a large proportion of the exercises aimed at shaping agility. This points to the need for more in-depth analysis of the training process used by trainers with focus on the applied methods, means, and training load volumes.

The findings of the authors presented above show the importance of establishing the level of physical fitness preparation both at the recruitment and selection stages as well as throughout the training process. At the same time, researchers have pointed out that only certain psychophysical and functional features are modified, and to a relatively small extent, during long-term training [1, 15, 37]. Hence, these findings underline the need to seek candidates with high predispositions in those motor skills essential in gymnastics at the recruitment and selection stages.

Zaporozhanov et al. [16] investigated the gymnastic predispositions of seven girls aged 7.7 years and eleven girls aged 9.3 years. Based on the size of the differences in each of the skills assessed by the Eurofit test battery, they distinguished four tests as the most accurate and reliable indicators of gymnastic predisposition: the speed of the upper limb movement (PLT), jumping ability (SBJ), agility (SHR), and relative hand strength (HGR). The authors stated that the results of these four tests differentiated the groups of gymnasts to the smallest extent and, in their opinion, provided evidence of the strong determination of genetic abilities that influence the results in the selected tests. The authors postulated that research be performed throughout the training process, as it could identify the improvement dynamics of individual motor abilities and the impact of these abilities on gymnasts' performance level. These four tests were also distinguished in another study on twelve gymnasts aged 6.9 years and twelve aged 10.0 years. [11]. In a similar vein, Hutchison et al. stressed the importance of continually monitoring jumping abilities in elite gymnastics training [13].

The results of the present study are in line with the findings reported previously. The smallest increases among the Eurofit tests after a year's worth of gymnastics training were observed in the tests measuring agility (SHR), jumping ability (SBJ), relative hand strength (HGR), and the speed of upper limb movement (PLT). This demonstrates the strong genetic determination of the abilities that determine the results of these tests. Simultaneously, this points to the usefulness of these tests in diagnosing the predispositions of girls at the selection stage in artistic gymnastics.

In light of the above-discussed findings and the results presented in this study, it appears that the Eurofit battery of tests provides reliable and useful data in assessing the physical fitness levels of children and adolescents involved in physical education and sport [38]. Additionally, the results obtained in the present study may provide useful information in optimizing the training loads of artistic gymnasts at the initial training stage.

Conclusions

In light of the significant influence of biological age on body size and physical fitness, it is suggested to determine the biological age of girl at the recruitment and selection stage in artistic gymnastics. This may facilitate the identification of athletes with the most advantageous somatic features and proportions and allow for an objective assessment of physical fitness.

The high level of results obtained by participants in six Eurofit physical fitness tests at baseline (pre-test) is testament to the accuracy of the selection process applied in participants' school.

The dynamic increase in the results of six Eurofit physical fitness tests and the concurrent increase in the percentile ranks based on national norms after completing the annual training cycle is evidence of the high effectiveness of the applied training program in improving the physical fitness of the tested girls.

The reasons for the lack of significant progress in the agility test (10 × 5 m shuttle run) are unclear. This points to the need for more in-depth analysis of the training process used by trainers with focus on the applied methods, means, and training load volumes.

The Eurofit test battery proved to be a precise tool to assess changes in the physical fitness of the tested girls after completing the annual training cycle and is therefore worth recommending at early training stage in gymnastics.

The results obtained in the present study provide useful information in optimizing the training loads of artistic gymnasts at the initial training stage.

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