# ANTHROPOMETRIC AND MOTOR CHANGES AFTER ONE-YEAR AEROBIC GYMNASTICS TRAINING IN YOUNG GYMNASTS

**Anita Lamošová[1], Oľga Kyselovičová[1], Petra Tomková[2]**

[1]Comenius University in Bratislava, Faculty of Physical Education and Sports, Department of Gymnastics, Dance, Fitness and Martial Arts, Slovakia

[2]Pavol Jozef Šafárik University in Košice, Institute of Physical Education and Sports, Slovakia

*Original article, DOI:10.52165/sgj.13.2.243-251*

***Abstract***

*The purpose of this study was to investigate the effect of one-year specific aerobic gymnastics training on selected anthropometric and motor parameters in 6-11-year-old girls. 23 girls (average age in the beginning of the study was 8.04 ± 1.22 years) were involved in the study representing 2 different aerobic gymnastics sports clubs in Slovakia. The selected group completed their regular trainings and competitions for a period of one year. Measurements were taken in January 2019 and January 2020, in the middle of the preparatory period. Normality of distribution of the traits was examined using the Shapiro-Wilk test. Data were analyzed using Wilcoxon signed-rank test. Considering anthropometric parameters, there were significant changes ($p \leq 0.01$) in body height, body weight and BMI. Considering motor parameters, the mean values of straddle support hold and back extension endurance test increased significantly to the level of $p \leq 0.05$. The mean values of 4x10m shuttle run, standing long jump, modified push-ups, sit-ups in 60s increased significantly to the level of $p \leq 0.01$. No significant changes were observed in bent arm hang test or hanging knee tucks. On the other hand, the values of 1 leg stand with eyes closed and 2-min endurance shuttle run decreased insignificantly.*

***Keywords:*** *aerobic gymnastics, anthropometric changes, motor changes, motor abilities, sports training, young gymnasts.*

## INTRODUCTION

Aerobic gymnastics is one of the gymnastics types that is recognized by the International Gymnastics Federation (FIG). According to its performance structure, it is characterized as an aesthetic-technical discipline with energy coverage from the anaerobic glycolytic system. Previous investigation of aerobic gymnastics routine performance (Kyselovičová & Danielová, 2012) revealed that the values document clear anaerobic dominance and anaerobic energy metabolism. However, Kyselovičová et al. (2016) also noted, that it is rather complicated to assess the physiological and energetic demands during exercises of relatively short duration, changing intensity, and types of muscle activation.

Aerobic gymnastics' performance is characterized by its content and demonstration originating from traditional aerobics making its structure somewhat different from other types of gymnastics. The highest demands are placed on the execution and physical fitness of competitors (Hájková et al., 2006).

Athletes are required to demonstrate complex high-intensity movements to music, involving many gymnastics and dance-based skills, difficult elements and acrobatic moves, displaying the discipline's variety and creativity. Routines are evaluated by judges who consider three different aspects: difficulty, artistic value and execution (Raiola et al., 2012; FIG, 2017). The highest scores are earned by the gymnasts who perform difficult routines with high accuracy and a proper technique (Prassas et al., 2006).

In aerobic gymnastics, as well as in other sport disciplines, there is a constant demand for an ever-increasing performance level. The level of physical fitness is dependent on the innate predispositions and environmental factors, such as, for example, primarily training. It is also believed that in order to achieve a high degree of complex motor performance, the training needs to begin in early childhood as it plays an important role in the development of motor skills (Sawczyn et al., 2000; Kochanowitz et al., 2010). The success of each gymnast is highly dependent on the level of their motor abilities (Jemni et al., 2006). Therefore, a systematic examination of training effects is needed. The evaluation of the motor skill levels requires the use of objective, quantitative and qualitative criteria. There are many techniques available for measuring motor abilities and the general level of motor fitness. They serve not only to assess the current level of motor abilities, but also to monitor improvement during the process of training (motor development). However, it is necessary to continually monitor the training effects of each athlete to allow the individualization of training loads (Kochanowitz et al., 2006; Ortega et al., 2008; Zaporozhanov et al., 2012)

Many authors (Gallahue et al., 2012; Piek et al., 2012) agree that early childhood is considered to be the ideal age for the development of fundamental movement skills that become the basis for both skills needed for the daily life as well as specific movements needed for the participation in different sports and physical activities. Sports preparation, in general, positively influences children's health in terms of physical fitness, and it also improves anthropometric measurements like body weight and body composition (Fisher et al., 2005). Differences in the levels of physical fitness and motor coordination in children who are actively involved in sports can partly be explained by the number of hours spent doing their chosen sport (Opstoel et al., 2015). Physical activity during the period of growth results in significant changes in anaerobic strength and aerobic capacity. It has also a beneficial impact on aerobic and muscular strength, coordination and muscular endurance (Ortega et al., 2008). On the other hand, gymnastics is one of the key sports that play an important role in the development of children as it offers a wide range of locomotive, stability and body control movements such as transitions from dynamic to static elements and frequent changes of the body position in space (Culjak et al., 2003; Bressel et al., 2007; Pajek et al., 2010). Regular gymnastics training contributes to the development of coordination, strength, muscular endurance, flexibility and balance (Bencke et al., 2002; Werner et al., 2012). According to Douda et al. (2008), important factors for the execution of gymnastics seem to be anthropometric characteristics, flexibility, aerobic capacity, and anaerobic power.

There have been a few studies researching the effects of a long-term gymnastics training on both anthropometric and motor parameters (Tibenská et al., 2010; Živčić et al., 2012; Mertashl et al., 2015; Mlsnová, 2016). However, the amount of research, especially in aerobic gymnastics, is insufficient and we felt the need to expand the knowledge in this field. The aim of our study was to discover the changes in the selected anthropometric and motor

parameters after one-year specific aerobic gymnastics training of 6-11-year-old girls.

## METHODS

The examined sample consisted of 23 girls involved in aerobic gymnastics. Their average age in the beginning of the study was 8.04 ± 1.22 years, the average sport age was 3.07 ± 1.35 years, height 130.21 ± 9.21 cm and mass 26.88 ± 6.10 kg. Girls were attending aerobic gymnastics classes in two different sports clubs and completed regular trainings and competitions for a period of one year. They trained on average 5.02 ± 0.68 hours a week (except during summer and winter holidays) and participated in on average 4.26 ± 2.36 competitions in Slovakia and the Czech Republic. In general, our training program included general physical preparation, learning and performing routines and difficult elements, and specific gymnastics preparation. Each training session also included warm-up and cool-down exercises. The trainings' content followed the one-year training cycle (Table 1.)

Measurements were taken in January 2019 and January 2020 in the middle of the preparatory period (lasting from the beginning of December till the end of February). They consisted of anthropometry tests (body height, body mass, BMI) and 10 standardized tests picked from the test battery used by the Slovak Gymnastics Federation for the selection of the national team (SGF 2018). The test battery included the following tests: 1. one leg stand with eyes closed, 2. 4x10m shuttle run, 3. standing long jump, 4. bent arm hang, 5. straddle support hold, 6. back extension endurance test, 7. hanging knee tucks, 8. modified push-ups, 9. sit-ups in 60s, 10. 2min endurance shuttle run (7m).

Normality of distribution of the traits was examined using the Shapiro-Wilk test. Results pointed out that the variables were not normally distributed, therefore, the Wilcoxon signed-rank test was used for all the variables. Significance levels for all statistical analyzes were considered as $p \leq 0.05$ and $p \leq 0.01$.

## RESULTS

After the one-year aerobic gymnastics training, we noted significant changes in selected anthropometric parameters. The mean value of body height increased by 4.3 % ($p \leq 0.01$), body weight increased by 12.7 % ($p \leq 0.01$) and BMI increased by 4.5 % ($p \leq 0.01$). Detailed data of all anthropometric parameter are presented in Table 2.

Table 1
*Approximate trainings' content during the one-year training cycle of the examined group.*

| Phase | Preparatory 1 | Competitive 1 | Transition 1 | Preparatory 2 | Competitive 2 | Transition 2 |
|---|---|---|---|---|---|---|
| Month | Jan Feb | Mar Apr May | Jun Jul | Aug Sep | Oct Nov | Dec |
| Content | routine construction | routine perfection | acrobatics | routine construction | routine perfection | acrobatics |
| | new elements | technical prep. | transitions | new elements | technical prep. | transitions |
| | conditioning | psychological preparation | new elements | conditioning | psychological preparation | new elements |
| | physical preparation | physical preparation | break | physical preparation | physical preparation | 2-week holiday |

Table 2.
*Changes in selected somatic and motor parameters ($\bar{x}$ - average value; sd - standard deviation; EC - eyes closed; PU – push-ups; ET - endurance test; SR - shuttle run; * $p \leq 0.05$; ** $p \leq 0.01$).*

| | PARAMETERS | Input | | Output | |
|---|---|---|---|---|---|
| | | $\bar{x}$ | sd | $\bar{x}$ | sd |
| anthropometric parameters | body height [cm] | 130.21 | 9.21 | 135.86** | 9.41 |
| | body weight [cm] | 26.88 | 6.10 | 30.30** | 5.96 |
| | BMI | 15.59 | 1.57 | 16.29** | 1.51 |
| motor parameters | 1 leg stand with EC [s] | 32.00 | 18.81 | 27.2 | 20.97 |
| | 4x10 m shuttle run [s] | 12.78 | 0.67 | 12.02** | 0.77 |
| | standing long jump [cm] | 142.78 | 16.38 | 153.96** | 19.51 |
| | bent arm hang [s] | 36.10 | 19.77 | 38.87 | 23.32 |
| | straddle support hold [s] | 13.58 | 8.81 | 19.54* | 10.23 |
| | back extension [number] | 36.87 | 10.55 | 45.83* | 25.58 |
| | hanging knee tucks [number] | 14.22 | 5.70 | 15.48 | 7.43 |
| | modified PU [number] | 17.70 | 3.67 | 21.35** | 4.50 |
| | sit-ups in 60 s [number] | 39.43 | 4.94 | 43.87** | 7.32 |
| | 2-min endurance SR [number] | 18.48 | 2.19 | 18.22 | 1.93 |

*Motor changes.* The mean values of the following motor tests increased significantly at the level of $p \leq 0.05$: straddle support hold and back extension endurance test. The following tests increased significantly at the level of $p \leq 0.01$: 4x10m shuttle run, standing long jump, modified push-ups, and sit-ups in 60s. No significant changes were observed in the following tests: bent arm hang test and hanging knee tucks. On the other hand, the values of 1 leg stand with eyes closed and 2-min endurance shuttle run decreased insignificantly. Detailed data of all tests are presented in Table 2.

## DISCUSSION

The results of the study revealed that the examined group of girls improved significantly in most of the examined parameters, which leads to the conclusion that aerobic gymnastics training has beneficial effects on the development of

motor abilities in 6-11-year old children. It is commonly known that physical and motor development of children is further enhanced when they grow in a supportive environment that offers multiple developmentally appropriate activities (Božanić et al., 2011; Šalaj et al., 2019). On the other hand, positive effects of gymnastics training itself is undoubtable and can be seen in many other research findings (Fallah et al., 2015; Mertashl et al., 2015; Karachle et al., 2017).

Aerobic gymnastics, as one of the types of gymnastic that offer a wide range of complex movements, plays an important role in the development of motor abilities. According to Jemni et al. (2006), aerobic gymnasts are characterized by incredible neuromuscular connections and high level of strength, power, flexibility, and muscular endurance, as well as speed and coordination. Typical for aerobic gymnastics performance are frequent changes of the body position in space, transitions from static to dynamic elements and vice versa (Culjak et al., 2003; Bressel et al., 2007). However, some authors (Beunen et al., 1999; Caine et al., 2001) have stated that it is impossible to establish the effects of training on performance in gymnastics due to such factors as limitations in the available data, incomplete information about the training process and inability to consider other factors affecting growth and maturation.

Surprisingly, our study revealed that the examined group's performance in the test examining postural stability decreased, which is contrary to other researchers' findings. Poliszczuk et al. (2012) examined the dynamic balance abilities over the period of 2-year training in young rhythmic gymnasts. They noted that their ability to maintain dynamic balance increased as they progressed in their training. In the study by Boraczyński et al. (2013), the authors noted significant changes in the static balance test in 7-year-old girls after completing a 12-month specific artistic gymnastics training. Akın (2013) analyzed the effects of 12-week gymnastics training on preschool children and noted a positive effect on the development of balance abilities as well. We don't have an explanation for the decrease of balance abilities in our research group; however, it might have been the result of dramatic changes in postural control that may occur around the eigth year of life (Forssberg, 1985; Shumway-Cook & Woollacott, 1985). Another performance decrease was seen in the 2-min endurance shuttle run. This particular test is used to assess the level of aerobic fitness; however, the score can be highly influenced by the practice and motivation levels. For this reason, the scoring can be subjective, and it does not have to reflect a decrease in the group's performance level.

There have also been significant changes in the anthropometric parameters like body weight, body height and BMI. These findings were expected and can be attributed to the process of biological maturation during the one-year period of the research. According to Laczo (2014), the dynamics of the growth of school-age children (6-11 years) is characterized by a 5cm annual increment. However, it should be noted that an increase in body mass can have a negative influence on performance in aesthetic sports as there is a high power to body mass ratio (Boraczyński et al., 2013). Similar results could be seen in many other research findings (Tibenská et al., 2010; Poliszczuk et al., 2012; Genc, 2020).

## CONCLUSION

The positive effects of one-year aerobic gymnastics training on the group of 6-11-year-old girls could be seen in most of the examined parameters. Considering anthropometric parameters, the mean values of body height, body weight, and BMI increased significantly at the level of $p \leq 0.01$. Considering motor parameters, significant changes at the level

of $p \leq 0.05$ were observed in the following tests: straddle support hold and back extension endurance test. Significant changes at the level of $p \leq 0.01$ were observed in the following tests: 4x10m shuttle run, standing long jump, modified push-ups, and sit-ups in 60s. Positive but insignificant changes were observed in the following tests: bent arm hang test and hanging knee tucks. The values of 1 leg stand with eyes closed and 2-min endurance shuttle run decreased insignificantly. It is important to note that coaches did not specifically paid attention to a performance improvement in the selected tests during the period of one-year training. The gymnasts completed their regular trainings and competitions that included general physical preparation, performance of the routines and difficulty elements of aerobic gymnastics. An analysis of the results of our study makes it possible to conclude that:

1. The body height, body weight and BMI of examined group increased considerably.

2. One-year aerobic gymnastics training had positive effects on the development of explosive power of lower limbs, explosive power of back muscles, explosive power of upper limbs, speed and dynamic and static power of abdominal muscles.

3. Coaches should pay more attention to the development of static power of upper limbs, balance abilities and aerobic fitness.

4. More research concerning the effects of aerobic gymnastics training on motor abilities is needed to expand the knowledge in this particular field.

## REFERENCES

Akın, M. (2013). Effect of gymnastics training on dynamic balance abilities in 4-6 years of age children. *International Journal of Academic Research, 5*(2), 142-146.

Bencke, J., Damsgaard, R., Saekmose, A., Jorgensen, O., Jorgensen, K., & Klausen, K. (2002). Anaerobic power and muscle strength characteristics of 11-year-old elite and non-elite boys and girls from gymnastics, team handball, tennis player and swimming. *Scandinavian Journal of Medicine & Science in Sports, 12*(3), 171-178.

Beunen, G.P., Malina, R.M., & Thomis, M. (1999). Physical growth and maturation of female gymnasts. In F.E. Johnston, B. Zemel, & P.B. Eveleth (eds.), *Human growth in context (*p. 281–289). London: Smith-Gordon.

Boraczyński, T., Boraczyński, M., Boraczyńska S., & Michels, A. (2013). Changes in body composition and physical fitness of 7-year-old girls after completing a 12-month artistic gymnastics training program. *Human Movement, 14*(4), 291-298.

Božanić, A., Kalinski, S. D., & Žuvela, F. (2011). Changes in fundamental movement skills caused by a gymnastics treatment in preschoolers. *Proceedings of Science of Gymnastics Journal 23 Science of Gymnastics Journal the 6th Congress FIEP-a Europe "Physical Education in the 21st century – pupils' competencies",* 89-94.

Bressel, E., Yonker, C. Y., Kras, J., & Heath, E. (2007). Comparison of static and dynamic balance in female collegiate soccer, basketball, and gymnastics athletes. *Journal of Athletic Training, 42*(1), 42-46.

Caine, D., Lewis, R., O'Connor, P., Howe, W., & Bass, S. (2001). Does gymnastics training inhibit growth of females? *Clinical Journal of Sport Medicine, 11*(4), 260–270.

Culjak, Z., Cavar, M., Crnjac, D., Maric, K., & Corluka, M. (2003). Effectiveness of the school of gymnastics in 7 years old children. *Sport SPA, 8*(8), 41-45.

Douda, H. T., Toubekis, A. G., Avloniti, A. A., & Tokmakidis, S. P. (2008). Physiological and anthropometric determinants of rhythmic gymnastics

performance. *International Journal of Sports Physiology and Performance, 3*(1), 41–54.

Fallah, E., Nourbakhsh, P., & Bagherly, J. (2015). The effect of eight weeks of gymnastics exercises on the development of gross motor skills of five to six years old girls. *European Online Journal of Natural and Social Sciences, 4*(1), 845-852.

Federation Internationale de Gymnastique (2017). *2017 – 2020 Aerobic Gymnastics Code of Points*. Retrieved from http://www.fig-gymnastics.com/publicdir/rules/files/aer/AER_CoP_2017-2020-e_January_2017.pdf

Fisher, A., Reilly, J. J., Kelly, L. A., Montgomery, C., Williamson, A., Paton, J. Y., & Grant, S. (2005). Fundamental movement skills and habitual physical activity in young children. *Medicine & Science in Sports & Exercise, 37*(4), 684–688.

Forssberg, H. (1985). Ontogeny of human locomotor control. I. Infant stepping supported locomotion and transition to independent locomotion. *Experimental Brain Research, 57*(3), 480-493.

Gallahue, D., Ozmun, J. C., & Goodway, J. D. (2012). *Understanding motor development: Infants, children, adolescents, adults (7th ed.)*. New York: McGraw-Hill.

Genc, H. (2020). The effect of gymnastics training on anthropometric, somatotype and some performance characteristics in preschool girls. *Progress in Nutrition*, *22*(2), 547-554.

Hájková, J. et al. (2006). Soutěžní formy aerobiku. [Aerobics Competition Forms]. In *J. Hájková, et al. Aerobik soutěžní formy. Kompletní průvodce tréninkem. [Competition forms of Aerobics. Full Training Guide]*. Praha: Grada Publishing, a.s.

Jemni, M., Sands, W.A., Friemel, F., Stone, M.H. & Cook, C.B. (2006). Any effect of gymnastics training on upper-body and lower-body aerobic and power components in national and international male gymnasts? *Journal of strength and Conditioning Research*. *20*(4), 899-907.

Karachle, N., Dania, A. & Venetsanou, F. (2017). Effects of recreational gymnastics program on the motor proficiency of young children. *Science of Gymnastics Journal, 9*(1), 17-25.

Kochanowicz, K. (2006). *Podstawy kierowania procesem szkolenia sportowego w gimnastyce* [*The basics of controlling the process of sports training in artistic gymnastics*]. Gdańsk: AWFiS.

Kochanowicz, K., & Kucharska, E. (2010). Body balance in children aged 11-13 years and the process of physical education. *Polish Journal of Sport Tourism, 17*, 87-96.

Kyselovičová, O., Labudová, J., Zemková, E., Čierna, D. & Jeleň, M. (2016). Anthropometric and cardiovascular variables of elite athletes. *Acta Facultatis Pharmaceuticae Universitatis Comenianae, 56*(2), 143-158.

Kyselovičová, O. & Danielová, K. (2012). The functional response to training and competition load in aerobic gymnastics athletes. *Acta Facultatis Educationis Physicae Universitatis Comenianae, 52*(2), 31-36.

Laczo, E. (2014). Motorický vývoj detí a mládeže (ISCED 1 a ISCED 2). [Motor Development in Children and Youth (ISCED 1 and ISCED 2)]. In E. Laczo, G. Buzgó, I. Cihová, J. Cvečka, M. Kalinková & Ľ. Rupčík. *Rozvoj a diagnostika pohybových schopností detí a mládeže*. [*Development and diagnostics of motor abilities in Children and Youth*], (p. 51-54). Bratislava: Národné športové centrum v spolupráci s Fakultou telesnej výchovy a športu Univerzity Komenského v Bratislave.

Mertashl, M., Rohani, H., Farzaneh, E. & Nasiri, R. (2015). The effect of 6 months specific aerobic gymnastic training on motor abilities in 10-12 years old boys. *Science of Gymnastics Journal, 7*(1), 51-60.

Mlsnová, G. (2016). Effects of a 6-month conditioning program on motor and sport performance in the group of children's fitness competitors. *Acta Facultatis Educationis Physicae Universitatis Comenianae, 56*(2), 115-128.

Opstoel, K., Pion, J., Elferink-Gemser, M., Hartman, E., Willemse, B., Philippaerts, R., Visscher, C., & Lenoir, M. (2015). Anthropometric characteristics, physical fitness and motor coordination of 9 to 11-year-old children participating in a wide range of sports. *PLoS ONE, 10*(5), 1-16.

Ortega, F. B., Ruiz, J. R., Castillo, M. J., & Sjöström, M. (2008). Physical fitness in childhood and adolescence: a powerful marker of health. *International Journal of Obesity, 32*(1), 1-11.

Pajek, M. B., Čuk, I., Kovač, M., & Jakše, B. (2010). Implementation of the gymnastics curriculum in the third cycle of basic school in Slovenia. *Science of Gymnastics Journal, 2*(3), 15-27.

Piek, J., Hands, B., & Licari, M. (2012). Assessment of motor functioning in the preschool period. *Neuropsychology Review, 22*(4), 402-413.

Poliszczuk, T., Broda, D., & Poliszczuk, D. (2012). Changes in somatic parameters and dynamic balance in female rhythmic gymnasts over a space of two years. *Polish Journal of Sport and Tourism*, 19, 240-245.

Prassas, S., Kwon, Y., & Sands, W. A. (2006). Biomechanical research in artistic gymnastics: A review. *Sports Biomechanics, 5*(2), 261-91.

Raiola, G., Giugno, Y., Scassillo, I., & Di Tore, P. A. (2012). An experimental study on aerobic gymnastics: performance analysis as an effective evaluation for technique and teaching of motor gestures. *Journal of Human Sport & Exercise, 8*(2), 297-306.

Šalaj, S., Milčić L., & Šimunović, I. (2019). Differences in motor skills of selected and nonselected group of children in artistic gymnastics in the context of their motor development. *Kinesiology, 51*(1), 133-140.

Sawczyn, S. (2000). *Training loads for many years training of young gymnastics*. Gdańsk: AWFiS.

Shumway-Cook, A., & Woollacott, M. (1985). The growth of stability: postural control from a developmental perspective. *Journal of Motor Behavior, 17*(2), 131-147.

Slovak Gymnastics Federation (2019). Sekcia športového aerobiku. Metodický popis batérie motorických testov pre zaradenie do reprezentačných úsekov (verzia 2019). [*Section of aerobic gymnastics. Methodic description of the battery of motor tests for selection of the national team (version 2019)*]. Retrieved from http://www.sgf.sk/article/5919af637faa780100fc1ce2

Tibenská, M., Kyselovičová, O., & Medeková, H. (2010). Anthropometric and functional changes and their relationship after two-year aerobic gymnastics training. *Acta Facultatis Pharmaceuticae Universitatis Comenianae, 57*(1), 114-120.

Werner, P. H., Williams, L. H., & Hall, T. J. (2012). *Teaching Children Gymnastics (3rd ed.).* USA: Human Kinetics.

Zaporozhanov, V. A., & Boraczyński, T. (2012). Empirical reliability of diagnostic and prognostic estimation of physical standards in children going in for sports. *Pedagogics, Psychology, Medical-Biological Problems of Physical Training and Sports, 11*, 38-42.

Živčič, M. K., Čavar, I., & Sporiš, G. (2012). Changes in gymnasts motor abilities during the nine-month training process of female gymnasts 5-6 years of age. *Science of Gymnastics Journal, 4*(1), 45-54.

**Corresponding author:**

Anita Lamošová
Comenius University in Bratislava, Faculty of Physical Education and Sports
Nábr. arm. gen. L. Svobodu 9, 814 69 Bratislava, Slovakia
Email: anita.lamosova@uniba.sk
Tel.: +421918372995

Article received: 13.11.2020
Article accepted: 9.2.2021