IMPACT OF GYMNASTICS PROGRAM ON HEALTH-RELATED FITNESS IN ADOLESCENT PUPILS

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Abstract

The aim of this study was to determine the effects of gymnastics program in school on health related fitness in adolescent pupils. The study involved 58 adolescent pupils (14.82±0.44 years) attending the first grade at high school involved in a 12 week of gymnastics classes. The variables were selected within the battery of tests Eurofit, measuring abdominal strength, flexibility, aerobic fitness and upper and lower body strength, speed and agility. The results showed average initial level and later dynamic increase in the physical fitness of the participants. Pre-test to post-test values showed significant improvements in all tested variables ($p<0.05$), except for the 4x10m test. Therefore, participation in gymnastics must be recommended as a positive foundational activity for school-aged children, from early childhood to adulthood. Additionally, the results can provide useful information in optimizing the training loads of pupils involved in gymnastic training throughout Physical Education classes.

Keywords: *effects, PE classes, training, physical fitness.*

INTRODUCTION

Health-related physical fitness includes the characteristics of functional capacity and is affected by the physical activity level and other lifestyle factors. Regular participation in moderate and vigorous levels of exercise increases physical fitness, which can lead to many health benefits (Ruiz et al., 2006). Fitness, physical activity behavior and motor skill development are important components of the Physical Education (PE) curricula and are potentially indicators of child health (Lloyd, Colley, & Tremblay, 2010). Physical fitness in children and adolescents has also been linked to positive health outcomes in adults (Kvaavik, Klepp, Tell, Meyer, & Batty, 2009). Moreover, motor skills can be used for talent identification to predict sport success in children (Grice, 2003).

Gymnastics is an excellent mechanism for the teaching basic motor skills and promoting health-related fitness in children of all ages (Coelho, 2010; Donham-Foutch, 2007). Many agree that involvement in gymnastic training can contribute significantly to the all-around development of a child (Sloan, 2007) and that a physical education program including gymnastics benefits children in many areas (Werner, Williams, & Hall, 2012). Gymnastics is commonly included in PE programs across the world. It represents an activity with many benefits, to the point that it has been described as a fundamental and critical part of the PE curriculum that should be offered in preschool through faculty (Donham-Foutch, 2007). One such benefit is that it promotes abilities related to health and fitness (Werner et al., 2012; Baumgartner & Pagnano-Richardson, 2010). There are several well-known, health-related fitness batteries to assess fitness in all its dimensions in young people. A good example in Europe is the Eurofit battery (Committee of Experts on Sports Research EUROFIT, 1993).

Many authors have reported that modern artistic gymnastics requires greater strength and power because of the ever-increasing technical difficulty required through revision of the Code of Points (Jemni, Sands, Friemel, Stone & Cooke, 2006). Previous research has demonstrated the positive effects of a four-week after school programme addressing motor skills and fitness can have in young children (Matvienko & Iradge, 2009). Madić et al. (2009) conducted research on a sample of 250 girls involved in the program of gymnastics development as well as on the 580 girls who were not involved in sports. The authors applied a battery of eight motor tests, emphasizing that the research results clearly confirm that the gymnastic facilities have a positive impact on motor abilities. Delas Kalinski, Miletic & Bozanic (2011) found out that gymnastics skills learned at the age of 6.5 are retained over time after a period without any practice which makes them suitable for PE classes. Learning gymnastics skills in childhood can increase children's capacity for skill performance and improve their motor abilities. One of the major benefits of children's participation in gymnastics compared to that of untrained participants in other sports is enhanced strength (Andersson, Sward, & Thorstensson, 1988; Benke, Damsgaard, Saekmose, Jorgensen, & Klausen, 2002; Maffulli, King & Helms, 1994).

Understanding the benefits of participation in gymnastics training implemented in schools would provide relevant information for this area. It is widely known that PE classes have positive impact on the children's physical fitness. However, a great amount of researches were conducted on preadolescent children or younger because of early specialization in Gymnastics. However, establishing normative ranges for these physical tests in adolescent children will be valuable for practitioners conducting similar physical fitness testing in the future. Therefore, the aim of this research is to determine the effects of gymnastics program in school on health related fitness in adolescent pupils.

METHODS

Fifty eight adolescent pupils (14.82±0.44 age) from a High School in Leskovac, Serbia, participated in the present study. They were enrolled in Artistic gymnastics classes. All participants were male. They were informed of the nature and possible inconveniences associated with the experiment. Ethical approval was granted by the University Ethics Committee. Prior to data collection parental consent and child assent was obtained. No child had any reported history of learning difficulties or any behavioral, neurological or orthopedic problems that would qualify as exclusionary criteria for this study. Children participated in 45 minutes per session of sport gymnastics training that included activities based on fundamental movement skills. Data was collected during two sessions, before and after the eight-week gymnastics training programme in school.

Table 1
Baseline physical characteristics.

	Initial	Final	
Height (m)	175.00±6.65	177.45±6.56	p=0.220
Body Mass (kg)	68.69±11.82	66.54±10.45	p=0.938
BMI (kg·m-2)	22.05±2.57	21.46±2.34	p=0.970

The variables were selected within the battery of tests Eurofit so that the research results could later be compared with the results of other research studies carried out in Europe. The measuring instruments were either the same as or similar to, but of the same metric characteristics, those prescribed and described in the instructions for the realization of Eurofit testing.

Anthropometric variables were measured according to the guidelines of the International Biological Program. Body height was measured to the nearest 0.1 cm by a metric measuring tape. Body weight was measured to the nearest 0.01 kg using a digital scale. BMI stands for Body Mass Index. It is a measure of body composition. BMI is calculated by taking a person's weight and dividing by their height squared.

Health related physical tests

Traditional practice of testing which assessed the so-called latent dimensions of motor space (e.g., speed, strength, coordination, etc.), has been replaced by tests that assess the health-related physical fitness of children (Hastad & Lacy, 1998). First grade pupils were chosen because of certain past experience with artistic gymnastics skills and because their motor development is still in progress. Also, it is expected that their activity and inactivity outside of school would be similar.

All tests were performed at similar times in the morning on different days. At least 2 hours separated each test from the preceding meal. Diet was not controlled during the study. All subjects were instructed to have a light breakfast, and to avoid coffee and cigarettes during the testing day. They were also instructed not to engage in strenuous activity during the day before an exercise test.

The day before the test, the motor test battery was introduced to all the pupils, who did three test trials. Pupils were measured indoor, after standard warm up (5 minutes of running, and 10 minutes of dynamic stretching). They were encouraged to show maximum effort in all tests. If a subject made a procedure error during the tests, instructions and demonstrations of the task were repeated, before the child made a new attempt.

Sit and reach test (flexibility): sit and reach test apparatus was used to determine the trunk flexibility. Children were seated with the extended knees and the feet totally leaning in the seat. The subject tried to reach the largest distance slowly with the hands, without bending the legs. The measures were taken three times, with the best attempt recorded in centimeters.

Standing long jump (explosive strength): the child started with her feet in parallel behind a starting line, one shoulder width apart. After a signal the subject was allowed to swing her arms backwards and forwards and tried to jump as far as possible. The jump distance was measured in centimeters. The measures were taken two times and the highest value was recorded at the two attempts.

Vertical jump (explosive strength): the person stands side on to a wall and reaches up with the hand closest to the wall. Keeping the feet flat on the ground, the point of the fingertips is marked or recorded. This is called the standing reach. The person puts chalk on their finger-tips to mark the wall at the height of their jump. The person then stands away from the wall, and jumps vertically as high as possible using both arms and legs to assist in projecting the body upwards. Attempt to touch the wall at the highest point of the jump. The difference in distance between the standing reach height and the jump height is the score. The best of three attempts is recorded.

Sit-ups (abdominal strength and muscular endurance): A standard procedure for the 30 sec bent-knee sit-up test was applied (Semenick, 1994). The subject lay supine on a gymnastic mat with his knees bent and feet fixed on the floor 25–30 cm apart. The subject’s fingers were interlocked behind the neck, and the backs of the hands touched the mat. The sit-up was correctly completed when the elbows touched the thighs and the subject returned to the starting position until the upper portion of the back made contact with the mat. The number of sit-ups correctly completed in 30 sec became the score.

Bent arm hanging (strength and endurance): The child was hung on the uneven bar with an overhand grasp with the assistant's support. She raised her body off the floor to a position in which the chin is above the bar; elbows were flexed and chest was close to the bar. Upon a signal, stopwatch was started and the hanging time was recorded.

4x10m (test of speed and agility). Marker cones and/or lines are placed five meters apart. Start with a foot at one marker. When instructed by the timer, the subject runs to the opposite marker, turns and returns to the starting line. This is repeated four times without stopping (covering 40 meters total). At each marker both feet must fully cross the line. Result is a record of the total time taken to complete 40 m.

Push - up (strength and endurance): The subject did a push - up position on the mat with hands placed wider than the shoulders; fingers stretched out and whole body went straight on the mat. Then the subject lowered the body using the arms until the elbows bent at a 90 degree angle, and upper arms were parallel to the floor. The subject pushed up and continued in the movement until the arms were straight on each repetition. The score was the number of 90 degree push – ups performed (The Cooper Institute, 2007).

Aerobic fitness was assessed using the *20 m Shuttle Run Test* or the Beep Test; it was first described by Leger and Lambert (Leger & Lambert, 1982) and identified in a recent review as a reliable and valid field test for use among children and adolescents. (Freedson, Curetan & Heath 2000). Pupils are required to run between two lines 20 m apart (one "lap"), starting at 8.5 km/h and increasing by 0.5 km/h every two minutes, in synchrony with a cadence tape. Students were tested in groups of about 15, and the test was supervised by at least two of the field team. The number of laps completed was determined by the student failing to keep pace with the cadence tape on two consecutive laps or voluntarily withdrawing. The last completed stage or half-stage at which the participant drops out was scored.

These tests were chosen because they have been clearly defined and validated in other studies (Beurden, Barnett, Zask, Dietrich, Brooks, & Beard, 2003; Espana Romero, Artero, Jimenez-Pavon, Cuenca-Garcia, Ortega, & Castro-Piaero, 2010; Fjortoft, 2000), they are easy to administer, and time efficient, and they cover a variety of skill components.

Experimental program

The experimental program was implemented during the school year 2013-2014 in a period of twelve weeks in the high school in Leskovac. The fundamental aim of the training process was to influence the improvement of motor abilities, to help pupils to learn to implement some gymnastics elements and to prepare them for the exam of the subject. One week before the training program players performed the general conditioning in order to prevent possible injuries. None of the players was performing any additional resistance or aerobic training outside of the 2 PE gymnastics classes.

The sport gymnastics program was conducted two times a week. Each session lasted for a 45 minutes. Pupils were divided in two groups with equal number of participants. All workouts were supervised by trained artistic gymnastics instructors and a PE teacher. Both groups had the same conditions and the same instructors and teachers. Each class unit contained three training phases (Table 2): First phase started with a warm-up which included slow running and stretching and ended with a polygon with different kind of movements. This was followed by a set of gymnastic exercises. The third phase of class was focus on restoring the normal level of emotional, mental and physiological bodily functions and re-establishing the same state that the pupils were in before the beginning of the practice period. The experimental treatment included basic gymnastics skills, according to apparatus available at the moment:

Acrobatic, vault, mini trampoline, parallel bars (Table 2).

The basic learning and teaching method was the synthetic method, with the analytic method used if there was an acquisition of new motor skills. Information was presented to the pupils participating in the practice or PE lessons by means of oral presentation, motor demonstration or performance of simple motor tasks. The most commonly used methodological organizational forms of work was work in groups of 6 to 8, and frontal work. Class was divided into four groups. Pupils change their place/apparatus according to number of repetitions or when the planned time for that apparatus ends. Training impact (loads) were primarily administered on four gymnastics apparatuses (7-8 min on each): (1) acrobatics: 10-15 repetitions for roles and cartwheel ; 7-10 repetitions other skills ; (2) parallel bars : 15-20 repetitions in 3 sets for swings; 5-10 repetitions in 3 sets for dips; 8-10 repetitions for dismounts (3) Mini trampoline: 15-20 jumps; and (4) Vault: 15-20 jumps. Training load was determined according to the level of skills. In the first six weeks pupils performed easier gymnastic skills, which referred to a greater amount of repetitions. Other six weeks included more complex skills, as well as connected elements into exercise, which influenced the lower number of repetitions.

Statistical analysis

All data analyses were performed in IBM SPSS Statistics 19.0 statistical program. The Kolmogorov-Smirnov test was used to assess normal distribution of the variables. Basic descriptive statistics were calculated (mean value and standard deviation). Comparisons between baseline and the 12 week post-study testing for all performance variables were performed using a paired-samples t-test. Effect sizes (ES) were also calculated to determine the magnitude of the group differences. ES (Cohen's d) were classified as follows: <0.2 was defined as trivial, 0.2–0.6 was defined as small, 0.6–1.2 was defined as moderate, 1.2–2.0 was defined as large, and >2.0 was defined as very large (Hopkins, Marshall, Batterham, & Hanin, 2009). In additional, percent changes were determined for all variables after 12-weeks training program. In all cases, the level of significance was accepted at $p<0.05$.

RESULTS

Table 1 shows the results of the basic anthropometric characteristics of tested pupils in both trials (pre and post-) and the significance of differences between the variables.

Table 2

Training program used between weeks 1 and 12.

Goal: improvement of motor abilities and health related fitness Sessions 1–24 (Tuesday -Friday)	
Exercises	
Warm up (8-10 min)	General warm up followed by polygon with different kind of movements. Five circles were performed with 20 sec break between.
Acrobatic	Rolls, dive roll, rolls combined with other elements , cartwheel, handstand, handstand and roll forward; roll backward to handstand, forward handspring
Vault	Split and squat jump on soft mats with assistant support, straddle through
Mini trampoline	Straight jump, split jump, tucked jump, piked jump, piked split jump
Parallel bars (30-32 min)	Swing in hang and support, -dip, dip swing, - back swing dismount, back swing dismount tucked half turn with support, front swing dismount
Stretching (3-5)	5 minutes of stretching for the muscle groups mainly involved in sessions

Table 3
Results of the health related physical tests in adolescent pupils (N=58).

Test	Initial	Final	ES	Δ changes	P value
Standing long jump	173.62±28.08	186.45±26.56	0.46	7.4%	0.009
Vertical jump	41.937±8.132	47.564±7.65	0.71	13.4%	0.001
Sit-ups	20.84±3.98	26.35±4.24	1.34	26.4%	0.001
Bent arm hanging	39.23±19.31	43.56±17.23	0.24	11.0%	0.019
Push - up	20.12±10.57	24.5±9.36	0.44	21.8%	0.001
Sit and reach	7.85±8.7	10.15±7.4	0.28	29.3%	0.005
Shuttle-run	6.4±2.3	6.9±2.1	0.23	7.8%	0.025
4x10m	11.79±1.56	11.24±1.36	-0.38	-4.7%	0.998

Table 3 shows the participants' results in eight Eurofit tests. Results for the pre-test post-test values of the experimental programme showed significant improvements in all tested variables ($p<0.05$), except for the 4x10m test. There was no statistically significant difference between the two measurements with regard to speed and agility testing.

DISCUSSION

We have tested the hypothesis that 12 weeks of gymnastic PE class program would lead to significant improvements in fitness performance in healthy boys. It was observed that pupils who added gymnastic training to their PE program were able to achieve great improvements in Eurofit testing battery. The average height and mass of boys was 175.00±6.65 cm and 68.69±11.82 kg. The results were similar or better compared to the norms for body height and mass in comparison with the general population of boys in this age group founded in several researches (Lovecchio, Casolo, Invernizzi, & Eid, 2012; Vaid, Kaur, & Lehri, 2009; Lissau et al., 2004). Body mass index (BMI) in both trials was little higher than the general population norms of boys in other researches (Lissau et al., 2004). Lovecchio et al. (2012) found BMI values for 15-year-old students of 20.20±2.70 which is lower than values obtained by our research.

Table 3 shows the participants' results in the eight Eurofit tests. The results of the test measuring flexibility (sit-and-reach test) were at a very low level at baseline. Katic (1995) showed that 6-month athletic training did not significantly improve flexibility in contrast to Violan et al. (1997), 6-month karate training. In our study adolescents were exclusively submitted to lower body stretching at each session. However, as with other components of physical fitness, flexibility is a parameter that has to be emphasized specifically. Limited flexibility of hamstring in adolescents might cause low-back pain in any age groups (Rodriguez, Santonja, López-Minorro, Sáinz de Baranda, & Yuste, 2008). Our results show significant improvement in the sit and reach test after the 12 week of gymnastics PE program. Therefore, similar programs for increasing flexibility should be implemented in the classes. The test results of lower limb explosive power (standing long jump and vertical jump) showed great improvement with statistical significance $p<0.05$. The increase in explosive power noted in the present study is in accordance with previous research that also found increased lower body power in young girls with a similar protocol involving gymnastic training (Boraczyński, Boraczyński, Boraczyńska, & Michels, 2013). Gymnasts generally use their own body weight to carry out specific conditioning exercises using gymnastics apparatus. Moreover, it is considered that skill-learning itself represent specific strength conditioning, because gymnasts have to repeat the exercise while carrying their body weight in different positions, switching from one to another position, sometimes with added weights (Jemni, Sands, Friemel, Stone, & Cooke, 2006).

This gymnastic training implemented in PE classes certainly results in lower body power enhancement in adolescent pupils.

Similar level of performance at baseline (20.84±3.98) was found in the sit-ups test compared to Hungarian and Finnish adolescents as well as among Americans in the study Kaj, Németh, Tékus, & Wilhelm (2013). However, above mentioned study included younger adolescents compared to those in our study. Significant improvement was noted at post-test ($p<0.01$) following 12 weeks of PE gymnastic program. Very high performance was observed in the test of arm and shoulder muscular endurance (bent-arm hang test), showing very high progress at post-test ($p=0.01$). One of the major benefits of children's participation in gymnastics compared to that of untrained participants in other sports is enhanced strength (Halin, Germain, Buttelli, & Kapitaniak, 2002). However, general strength results for children tend to plateau and in some cases decline in late adolescence and adulthood (Hunsicker & Reiff, 1976). Therefore, it is important to provide an indispensable approach for this strength training in early childhood, late childhood and adolescence. Gymnastics participation, as well other active sport activities, plays an important role here.

The results of 20m shuttle run test were significantly higher in final measurement compared to initial ($p<0.05$). This finding is an indicator that participating in this kind of sports activities could regularly improve VO2 consumption. Similar results were found in other studies conducted on European adolescents (Ortega et al., 2008; Ortega et al., 2011). Conceptually, gymnastics is very different from running. Current understanding would suggest that energetic requirements during gymnastics are mainly anaerobic in nature because of the high intensity and short duration of competitive routines (Jemni, Sands, Friemel, Stone, & Cooke, 2006). Nonetheless, a considerable improvement in shuttle run test was recorded in our pupils following eight weeks of gymnastic program. Possible reason could be found in the fact that training sessions were shorter and intense compared to training of professional gymnasts. Moreover, the results have been supported by Hoff et al. (1999) and Millet et al. (2002), who demonstrated that even though typical strength training has minimal effects on maximal oxygen uptake, it may be possible that stronger athletes are more efficient and economical, leading to enhanced endurance capabilities as a result of performing less work for a given task.

There were no statistically significant improvements after 12 weeks of gymnastic training only in the speed agility test (4 × 10 m). Agility is very important in gymnastics because with floor routines you need to be able to change direction under control. Possible reason could be found in the fact that PE and the most gymnastics floor apparatus consists of several mats in line which is different from official floor apparatus. This fact points to the need for more in-depth analysis of the training process used by trainers with focus on the applied methods.

In studies on young elite gymnasts in three age groups, increasing age and competitive level was correlated with improved motor abilities both in regards to fitness level and coordination ability (Sawczyn, 2000; Kioumourtzoglou, Derri, Mertzanidou, & Tzetzis, 1997). Overall, the level of physical fitness of the participants improved significantly in seven of the Eurofit motor fitness tests. Our results are similar with ten weeks study conducted in children following gymnastics training which improved flexibility, explosive/static strength, muscular endurance, speed and balance parameters (Alpkaya, 2013). Although it is considered that the best period for learning gymnastic skills is at the early age because of early specialization model (Jayanthi et al, 2012), this study has shown that motor abilities can also be improved in later years using an appropriate training programme. In addition to our results is statement from Ismail, (1976) who claimed that the development of physical abilities of pupils aged 8 and over improves steadily and gradually over the years the ages 18 to 19. Sawczyn (1985) 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, it is very hard to try to isolate the effects of gymnastics training on physical fitness. This is in line with some researchers (Beunen, Malina, & Thomis, 1999; Caine et al., 2001) who 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, thus taking into account covariates such as age, body size, and physical maturity.

A limitation of this short-term study is that a control group which was involved in a regular physical exercise program in school was not included. However, having in mind that regularly classes include basketball, volleyball, handball, educational-athletic games, running and jumping, it was very difficult to explain the structure and intensity of that program. Thus, the focus of the present study was on discovering the effects of twelve weeks of gymnastic training in adolescent pupils. Also, we did not assess biological maturation before the start of the study considering the possible baseline differences in physical performance.

Twelve weeks of gymnastics training implemented in PE classes had a beneficial effect on abdominal strength, flexibility, aerobic fitness and upper and lower body strength in adolescent pupils. Therefore, participation in gymnastics must be recommended as a positive foundational activity for school-aged children, from early childhood to adulthood. Data provided from this study represent useful information because of the physical tests norms in adolescent pupils, which should be helpful for practitioners conducting similar physical function testing in the future.

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