

COMPARISON BETWEEN PHYSICAL CONDITIONING STATUS AND IMPROVEMENT IN ARTISTIC GYMNASTS AND NON-ATHLETES PEERS

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Abstract

The aim of the present study was to evaluate the status and improvement of physical conditioning in male gymnasts, aged 9-12 years, and to compare these results with non-athletes. Fifty seven gymnasts, with an experience of 4-5 years in training and competition and 74 non-athletes of the same age were enrolled in the study. All participants were tested twice, in a 12 month interval, on 9 depended variables selected from the Euro Fit Test Battery. Results showed that gymnasts had better results than non-athletes in overall the tests ($p < 0.01$). Except the improvement in the throwing tests, which seems to be mostly age related, the significant improvement in the jumping tests, was more evident in the gymnasts ($p < 0.01$), whereas the improvement in the flexed arm hang and balance tests were observed in the athlete group only. The 30m running speed improvement was observed only in the non- athlete group. Neither group displayed any improvement in the push-ups and the sit-and-reach tests. In conclusion, the status and improvement of physical conditioning in pre-adolescence is significantly related to the kind and extend of physical activity performed and the scholastic motor activity curriculum should be implemented with arm strength conditioning, balance and flexibility programs.

Keywords: *motor abilities, Euro Fit Test, boys, normal population, gymnasts.*

INTRODUCTION

Physical conditioning is important in artistic gymnastics to structure the technical requirements of exercises on various apparatus. The increase of exercise difficulty demands, required by the International Code of Points from the early age level, constrains the development of

high level static strength e.g. example in static strength elements (cross, blanche, etc.) as well in dynamic conditions, as an impact velocity of 8.5m/sec generate ground reaction forces which have been measured from 8 to 18 times the body weight (McNitt-Gray, 1991). The optimal combination of

muscle strength, speed, and flexibility consents to the neuromuscular system to produce maximal power output, maximizing the gymnastics performance (Bassa et al, 2002; Debu & Woolacott, 1998; Gleim & McHugh, 1997). Gymnasts, in order to reach these requirements might tolerate high level of loading on different parts of the body, as well must keep high level of flexibility to perform the technical elements of this sport (Bencke et al, 2002).

In order to improve their strength, gymnasts use resistance training, involving free weights or training machines. Several studies have shown that weight training is a safe and effective method of conditioning for children and young athletes, for its controlled and progressive increase of loads; provided that the appropriate exercise guidelines are followed (Faigenbaum et al, 2003). The current position of the National Strength and Conditioning Association (NSCA) of America indicated that weight training is safe for youth. Recent evidence dispels the myth that weightlifting in children is dangerous as a result of growth plate injury risk and ineffective because children are unable to increase strength or muscle mass (Meyer & Wall, 2006). Hamill (1994) showed a very low injury rate of weight training and weight lifting (0.0017%). Weight training increases muscular strength enhances the motor skill performance, increases athlete's resistance to sports-related injuries, can help to improve psychosocial well-being of youth, and to promote and develop exercise habits during childhood and adolescence (Faigenbaum et al, 2009). Some studies have also reported the positive personality effects in children (Faigenbaum, 2000) and athletes (Poiss et al, 2004). Moreover, it would seem that resistance training and weight training could have an influence on the neuromuscular system, with significant increase muscle strength without a concomitant augmentation in muscle size (Ramsay et al, 1990). Furthermore, other factors, such as balance (Debu & Woolacott, 1998) and flexibility (Gleim & McHugh, 1997) are necessary for technical

performance in gymnastics. Gymnasts must learn to keep their balance when performing leaping and tumbling maneuvers, as well as in static poses, barefoot on surfaces that vary in stiffness, or to balance to their hands, e.g. on still rings routines that require extraordinary balance ability by gymnasts. For this reason athletes improve balance significantly more than non athletes, as it has been verified by previous data (Balter et al, 2004; Bressel et al, 2007), and this improvement can be observed through practice (Tsigilis & Theodosiou, 2008). Flexibility demands are the most significant and unique aspect that characterized gymnastics from the other sports. Although there is a number of studies that refer to the effect of training programs (Bassa et al, 2002; Pfeiffer & Francis, 1986), neither about the fitness status of gymnasts during competitive session nor the rate of this improvement in relation to the previous annual season. Gymnastics training, in early age, develops strength indexes, comparing to non-athletes and even to athletes of other sports. It has been observed that gymnasts over 11 years old were stronger than untrained boys (Maffulli et al, 2004). Thus, the purpose of this study was to assess the physical conditioning level of young gymnasts aged 9-12 years between two annual competition seasons with a set of field tests. The knowledge of gymnast fitness status provides trainers with the ability to guide correctly the training procedures, and to reach the highest level of this status at the moment of the competition. Second aim of the study was to compare these findings with those of a group of non athletes for a need assessment of scholastic motor activity curriculum. We hypothesized that the physical conditioning of gymnasts could be a reference model of a health status for youth.

METHODS

Participants

A total of 131 health boys (54 gymnasts and 74 non-athletes) volunteered to participate in this study. Fifty-seven

were gymnasts (athletes) with a 4.5 ± 1.0 years training experience and they were from different clubs from Northern Greece. Seventy-four were children which participated only in school physical education classes. The study was designed according to the Declaration of Helsinki and was approved by the local Ethics Committee. Both the children and their parents were informed about this research project and parental written consent was obtained.

Procedure

Participants had followed training programs of their clubs during their five years training with a frequency of 3 hours per day, for six days per week. Two measurements were performed, each one after the end of the annual training competition period, in order to evaluate the effectiveness of the current training program. Subjects were instructed, orally and in writing prior to first testing. All subjects participated in familiarization practice, organized before the testing procedures. During this time, they were taught the proper technique on each testing exercise, and any questions they had were answered. The general physical fitness parameters that are stressed during an annual competition were in accordance with EUROFIT (1988) protocol and included muscle strength, muscle endurance, aerobic capacity, speed in upper and lower extremities, flexibility and balance test. The most commonly used field tests of upper body muscular strength-endurance are the pull-up and flexed arm hang test, meanwhile other tests such as push-ups and modified pull-ups have been included in some batteries (Ross & Pate, 1987). Prior to testing, the subjects performed a warm up of 10 minutes, consisting in low intensity running, stretching exercises for the lower limbs and the familiarization with testing apparatus. Minutes of rest was allowed between trials of different muscular group. One test leader, positioned at the side of the subject, controlled the correct technique of each test. The specific methods for

administration of each of these tests are presented below.

Push-ups: Prone position, elbows bent, hands flat on floor, thumbs pointing inward and next to chest; participant pushes body up until elbows are straightened, while heels, hips, shoulders, and head remain in the same straight line; repeat as many times as possible; record total number performed.

Flexed arm hang: Overhand grip; spotter raises participant to position with chin clearing bar, elbows flexed, chest close to bar; spotter releases support; extraneous body movements prohibited; record total time (s).

Strength of upper extremities: Throwing with two hands up of the head medicine ball 1 kg (m) and throwing with two hands under the head shot put 4 kg (m).

Sit and reach: Using a flexometer, trunk flexion was performed in the seated position. The better of two trials was recorded to the nearest 0.5cm (cm).

Vertical jump: Performed from a standing position facing parallel to a wall on which a measuring tape had been attached. Initial reach height was measured with the participant reaching as high as possible on the measuring tape with the arm and fingers of his dominant arm fully extended and the palm toward the wall (cm).

Strength of lower extremities: Standing long jump (cm).

Running speed: Running speed 30 m (s).

Balance test: Flamingo balance: Stand on the beam with shoes removed. Keep balance by holding the instructor's hand. While balancing on the preferred leg, the free leg is flexed at the knee and the foot of this leg held close to the buttocks. Start the watch as the instructor lets go. Stop the stopwatch each time the person loses balance (either by falling off the beam or letting go of the foot being held). Start over, again timing until they lose balance. Count the number of falls in 60 seconds of balancing. If there are more than 15 falls in the first 30 seconds, the test is terminated and a score of zero is given. Scoring: The

total number of falls or loss of balance in 60 seconds is recorded.

Statistical analysis

All data were presented as mean and standard deviation in pre and post tests, for the gymnasts and control group. Preliminary analysis revealed that the within subjects effect of the two measurements repeated at the one-year interval is commensurable with the between subjects effect of adjacent years on the dependent variables. Also there was no significant interaction of the measurement with the age factor. This was corroborated by the equality of the means, as proven with the independent samples t-test, of the second measurement of 9-year old athletes and novices (i.e. when they became 10-year olds) with the first measurement of 10-year olds, and likewise of the second measurement of 10-year old athletes and novices (i.e. when they became 11-year olds) with the first measurement of 11-year olds.

The above results provide evidence for the validity of the measurements and allow for the application of simpler multifactor MANOVA models, where the only factors that have to be examined are the boys' athletic level and age together with their interaction. Furthermore the age groups that can be examined are increased to four, spanning from 9 to 12 years, since the second measurement of boys who were initially 11 years old when they are 12 years of age can be considered autonomously.

Boys were included in the model only once (either in their first or second measurement), through randomization, ensuring that the age subgroups, both for athletes and novices, remain roughly equal in size. For each dependent variable, the F-values with their degrees of freedom, the corresponding p-values and the effect sizes of each factor and interaction are reported through the corresponding eta-square values in their percentage form. These values roughly represent the proportion of variance in each variable attributed to the effects of each factor. The MANOVA models were followed by post-hoc pairwise comparisons with Bonferroni corrections of age groups within each athletic level and of athletic levels within each age group. The level of significance was set at the 0.05 level.

RESULTS

Figure 1 shows the Mean values for the weight, height and BMI for athletes and non-athletes. The athletes had lower values than non-athletes in all three variables, at all ages.

The MANOVA procedure showed that in all the nine tests there was a significant level effect and a significant age effect (except in the push-ups test). In two tests there was also a significant Level X Age interaction (Flexed arm hang and running speed 30m) (table 1).

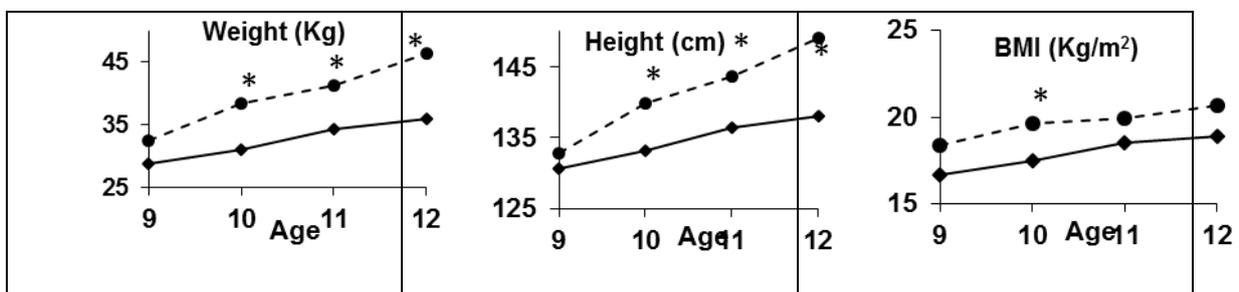


Figure 1. Mean values for the weight, height and BMI for athletes (continuous line) and non-athletes (dotted line). Asterisks denote statistically significant differences between athletes and non-athletes at the 0.05 level. * $p < 0.05$

Table 1. *F-values (degrees of freedom), p-values and effect size expressed through the eta-square values in their percentage form of the effect of level, age and their interaction on each of the nine parameters.*

	Level			Age			Level X Age		
	F(1,123)	p	η^2	F(1,123)	p	η^2	F(1,123)	p	η^2
Flexed arm hang	379	<0.01	75.5%	7.2	<0.01	14.9%	3.7	<0.05	8.3%
Balance test	25.7	<0.01	17.3%	5.0	<0.01	10.9%	1.2	NS	2.8%
Standing long jump	81.7	<0.01	39.9%	11.2	<0.01	21.4%	0.7	NS	1.7%
Vertical jump	39.5	<0.01	24.3%	7.9	<0.01	16.1%	0.9	NS	2.2%
Throwing shot put 4 Kg	9.5	<0.01	7.1%	30.1	<0.01	42.4%	0.6	NS	1.3%
Throwing medicine ball 1 Kg	31.3	<0.01	20.3%	16.6	<0.01	28.9%	2.2	NS	5.0%
Push ups	923	<0.01	88.2%	2.3	NS	5.4%	1.4	NS	3.2%
Sit and reach	385	<0.01	75.8%	3.1	<0.05	7.0%	1.8	NS	4.2%
Running speed 30m	40.3	<0.01	28.6%	3.5	<0.05	7.9%	3.1	NS	6.9%

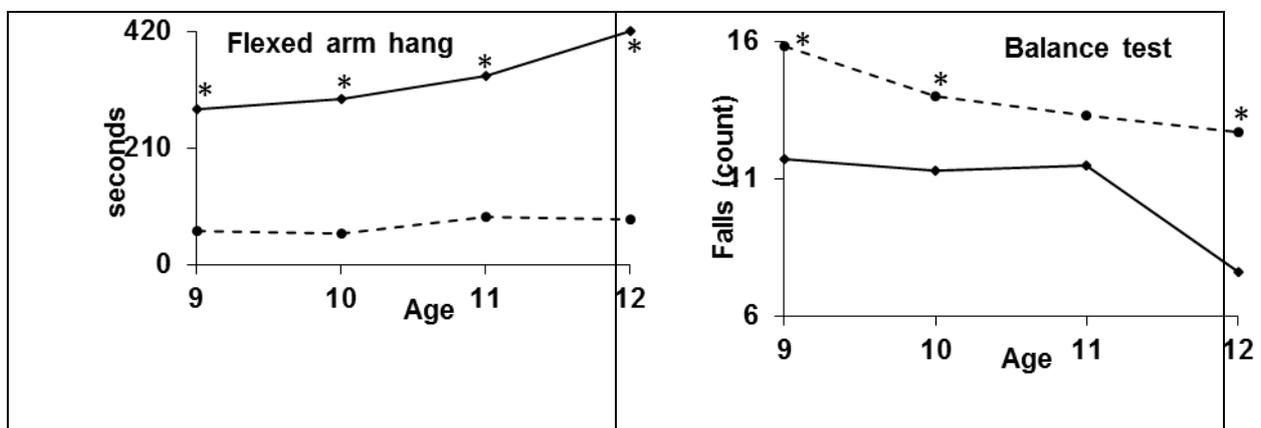


Figure 2. *Mean values for the flexed arm hang and balance tests for athletes (continuous line) and non-athletes (dotted line). Asterisks denote statistically significant differences between athletes and non-athletes at the 0.05 level. *p<0.05.*

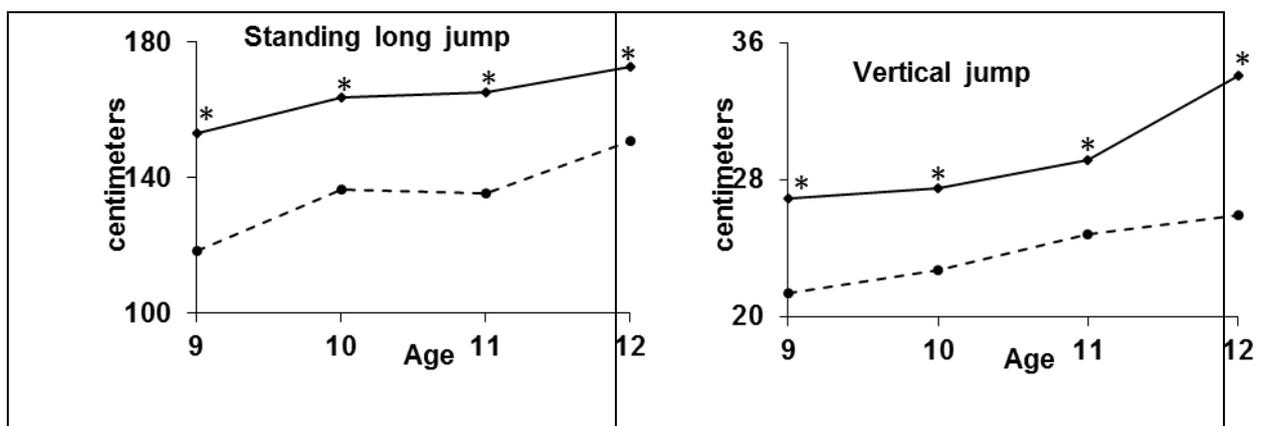


Figure 3. *Mean values for standing long jump and vertical jump for athletes (continuous line) and non-athletes (dotted line). Asterisks denote statistically significant differences between athletes and non-athletes at the 0.05 level. *p<0.05.*

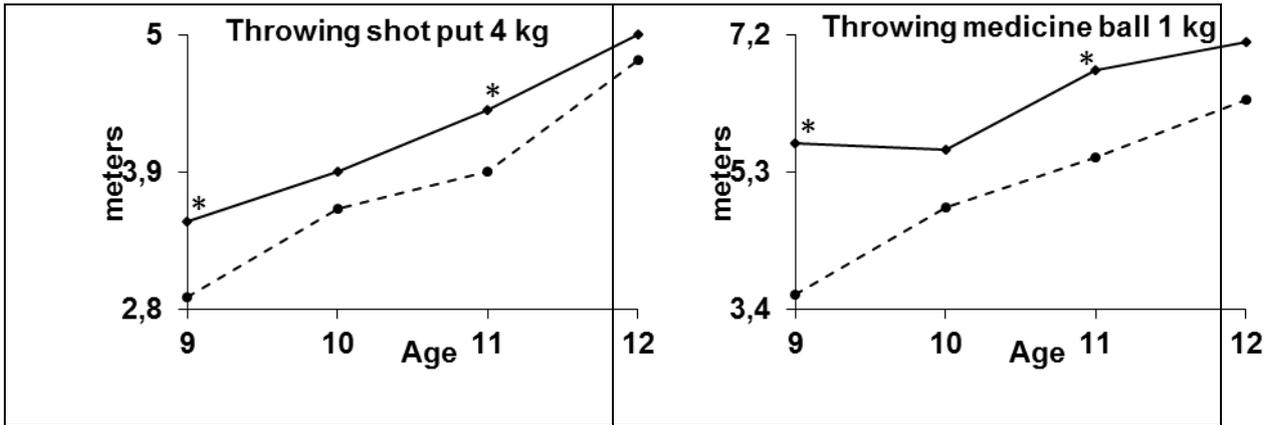


Figure 4. Mean values for the throwing shot put 4 Kg and throwing medicine ball 1 Kg tests for athletes (continuous line) and non-athletes (dotted line). Asterisks denote statistically significant differences between athletes and non-athletes at the 0.05 level. * $p < 0.05$.

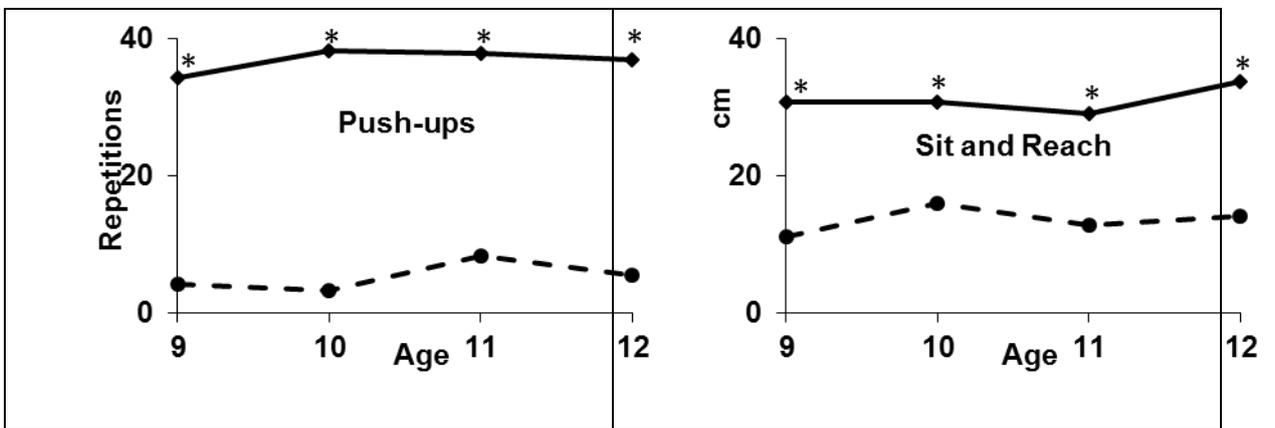


Figure 5. Mean values for the push-ups and sit and reach tests for athletes (continuous line) and non-athletes (dotted line). Asterisks denote statistically significant differences between athletes and non-athletes at the 0.05 level. * $p < 0.05$.

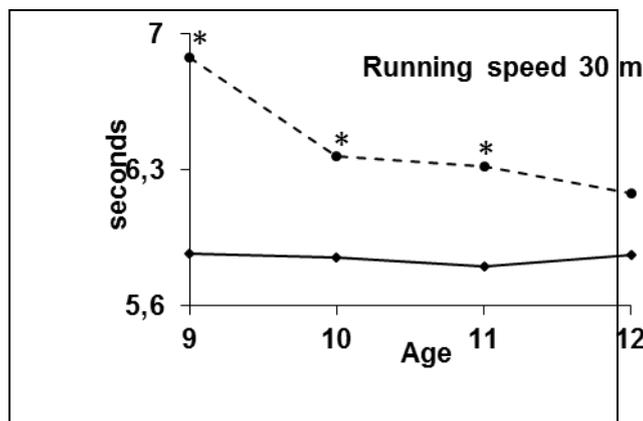


Figure 6. Mean values for the running speed tests for athletes (continuous line) and non-athletes (dotted line). Asterisks denote statistically significant differences between athletes and non-athletes at the 0.05 level. * $p < 0.05$.

As the corresponding effect size values showed, for three parameters (push-ups (88.2%), sit and reach (75.8%) and flexed arm hang (75.5%) the athletic level is responsible for more than three quarters of their variability. The effect size of age becomes more important than the effect size of level for the two throwing tests (throwing shot put 4 Kg (42.2% vs. 7.1%) and throwing medicine ball 1 Kg (28.9% vs. 20.3%)).

The results of the post-hoc pairwise comparisons revealed that the nine tests could be grouped into five different types, depending on the nature of the effect of group (athletes vs. non-athletes), age and their interaction on performance.

The first type of tests have been characterized by a significant improvement of athlete performance, especially after the age of ten years, while non-athletes did not show any significant improvement and performed, at all ages, significantly worse than athletes. In this type belong two tests – flexed arm hang and balance test (figure 2).

The second type of tests has been characterized by a significant improvement of both groups, with the athletes always performing significantly better than non-athletes. In this type belong two tests – standing long jump and vertical jump (figure 3).

The third type of tests has been characterized by a significant improvement of both groups, with the non-athletes performing almost as well as the athletes at all ages. In this type belong two tests – throwing shot put 4 Kg and throwing medicine ball 1 Kg tests (figure 4).

The fourth type of tests has been characterized by significant differences between athletes and non-athletes at all ages, with the athletes performing significantly better than non-athletes. However, neither the athletes, nor the non-athletes displayed any improvement with age. In this type belong two tests – the push-ups and sit and reach tests (figure 5).

In the fifth type belongs only one test – the running speed 30 m test. This test showed a significant improvement with age

of non-athletes, while athletes remained stationary. As a result at the age of twelve, there were no significant differences between the two groups (figure 6).

DISCUSSION

The main result of the study was that significant improvements of the athlete group in the arm strength test and balance test were found, while non-athletes did not show any improvement in these two tests, over the years from 9 to 12.

This result could be attributed to the daily training of gymnasts in general and to the special drills for muscle strengthening of the upper extremities. Moreover, artistic gymnastics promotes the improvement of the upper extremities, due to their predominant role in four of the six competition performances. Conversely non-athletes, especially in primary schools, take part in activities that are governed, as a rule, by the participation of the lower limbs (Alwis et al, 2008). Physiologically, the benefits of consistent strength training include an improvement in muscular strength, in tendon, bone, and ligament strength of the upper limbs also. For this reason it should be better to include the arm strength training for future health of non-athlete adolescents also (Harris & Eng, 2010).

Similarly the gymnasts had better balance performances than untrained adolescents, due to the technical training that could enhance postural control and balance (Vuillerme & Nougier, 2004). Balance constitutes a basic skill of performance in—gymnastics, since the athletes have to be “stabilized-immobilized” in the majority of the gymnastics exercises, during their landing from the apparatus, or indirectly executing specialized balance elements. Moreover balance requires achieving the most mechanically efficient position of the body, reducing the abnormal wearing of joint surfaces and reducing stress on the ligaments holding the joints of the spine together, becoming a useful skill for the daily life. In fact this training could

prevent the low back from becoming fixed in abnormal positions, low back pain, and lessens fatigue because muscles are being used more efficiently, allowing the body to use less energy (Harringe et al, 2007). The significant difference between gymnasts and non-athletes of the present study can be explained by the fact that superior balance among athletes is the result of repetitive training experiences that influence motor responses (Tsigilis & Theodosiou, 2008). To our knowledge although gymnasts did not dedicate a great part of their training to improve balance ability, especially in these particular ages, it is evident that this ability is enhanced during training (Hoffman et al, 1995). This aspect verifies the finding of Ashton-Miller, Wojtys, Huston & Fry-Welch (2001), which support that gymnasts often practice motionless balance skills on rings, so gymnasts may develop superior attention focus on cues that alter balance performance, such as small changes in joint position and acceleration (Bressel et al, 2007; Tsigilis & Theodosiou, 2008). This finding reinforces data of Balter and his colleagues (2004). The improvement in muscular strength, balance and flexibility can be achieved from gymnasts through gymnastics training during the annual training season. This ability to control the position and movement of the central portion of the body, referred as Core stability, assist in the maintenance of good posture and provide the foundation for all arm and leg movements. Also, good balance due to a good core stability can help maximize running performance and prevent injury, whereas, well-conditioned core muscles help to reduce the risk of injury resulting from bad posture. The ability to maintain good posture while running helps to protect the spine and skeletal structure from extreme ranges of movement and from the excessive or abnormal forces acting on the body.

A significant improvement of the standing long jump and vertical jump in both the athletes and non-athletes groups was found. In particular lower limb power is a decisive factor for a good performance in

the floor exercise and vault, and therefore it is exercised on a daily basis (Bosco & Komi, 1980). The significant difference in muscular strength of low extremities between gymnasts and non athletes, verified previous data who examined knee extensors strength (Bassa et al, 2002; Maffulli et al, 2004). In Vertical jump height, as Squat jump and Counter Movement Jump, which are expression of explosive muscle strength of lower limbs (Bosco et al, 2002), the gymnast mean value was the same value (28cm) to that published by Bencke, et al (2002). Non-athletes improved leg strength in their daily motor activity and leisure time, consisting and in running and jumping, even if the intensity of these exercises cannot match the corresponding of athletes (Sheerin et al, 2012).

The levels of the non-athlete group are very near the levels of the athletes in the two throwing tests. This result can be attributed to the fact that throwing is not a gymnast specific skill and not related to movements executed in their training programs. Further, the importance of upper arm strength is related to specialized gymnastics elements (Sands, 1994; Watanabe, 1997). Conversely in non-athletes these movements are executed in several school sport activities (e.g. volleyball, basketball) as well as in many activities during their leisure.

Push-ups constitute a basic exercise in strength training, even though the specific exercise has no great affinity with the specific tasks required in artistic gymnastics (Watanabe, 1997). No strengthening in the school curriculum of non-athletes was included, and they had a very low performance levels in this task.

Better results were found in gymnast sit and reach task, than non-athletes, who are not engage in any stretching exercises. The gymnasts stretched the knee flexors and low back extensors at the beginning and high flexibility levels have been maintained up to their twelfth year. Further, flexibility is an important component of fitness, which means that sport as artistic gymnastics rely heavily on the gymnast's ability to achieve

great range of limb position. Flexibility has an important role in sport performance and generally in health. It is well known that a safe and effective flexibility training program increases physical performance, which means that a flexible joint greatly decreases risk of injury and improves muscular balance and posture (Gleim & McHugh, 1997).

Similar results between the two groups were found in running exercises, either in their pure forms (sprints, relay races etc) or trained in team sports (basketball, football etc). Running constitutes the basic form of exercise for practically all non-athletes (Gorely et al, 2009). Therefore it is not surprising that non-athletes displayed a significant improvement in the specific years in the specific task. This improvement was similar to the athletes' level because they did not usually train for sprints up to 20 meters.

CONCLUSION

The status and improvement of physical conditioning in pre-adolescence is significantly related to the kind and duration of exercise, as in previous studies was highlighted (Debu & Woolacott, 1998; Gleim & McHugh, 1997; Bencke et al, 2002; Faigenbaum et al, 2009; Faigenbaum, 2000; Poiss et al, 2004). Moreover the present results are in accordance with previous findings (Pfeiffer & Francis, 1986; Haywood et al, 1986; Blimkie, 1993; Servedio et al, 1985), which stated that systematic sport specific training has a positive effect on muscular strength, balance and flexibility, in pre-pubertal children. Additionally, improvement of flexibility and balance plays an important role in the achievement of the technical aspects in artistic gymnastics and must improve through training procedure. The novelty of this study was significant differences were found in arm strength and balance and flexibility tests, between groups. Balance, as result of postural control, during standing and walking and of the ability to recover a stable posture rapidly is important not only

in sport but also in everyday life (Gautier & Thouvarecq, 2008). These findings highlighted that the scholastic motor activity curriculum should be implemented with arm strength conditioning, balance and flexibility programs. Certain limitations do not allow generalization of the present findings without caution. The research team was unaware of the physical activities after school involved for the members of both groups. No intermediate measures of physical conditioning were conducted and no reliability indexes were reported therefore.

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