MUSCLE FLEXIBILITY AND EXPLOSIVE POWER IN YOUNG ARTISTIC GYMNAST BOYS AT DIFFERENT PERFORMANCE LEVEL

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Abstract
A gymnast can not succeed without enough muscle strength and endurance. The aim of this study was to determine the differences between explosive power and flexibility in young boy gymnasts at different performance levels. Ninety-five young boys who participated in this study were divided into three groups: two artistic gymnast groups (N=53) and a sedentary (N=42) group. Artistic gymnasts were classified by their performance level and sports history to an elite (E, N=15) and/or a non-elite (Ne, N=38) group. The explosive power of subjects was determined via vertical and standing long jumps. The sit and reach flexibility test was used to determine lower body muscle flexibility. Our results showed that explosive power and flexibility test records were significantly different among the three groups ($P \leq 0.001$). They led to a conclusion that sport specific exercise training resulted in a concurrent improvement in explosive power and flexibility of young gymnasts.

Keywords: *explosive power, flexibility, young gymnast.*

INTRODUCTION

There are plenty of studies focused on anthropometrical & physiological characteristics of high level performance (Alp & Gorur et al., 2020; Marinšek & Pavletič, 2020; Mahoodet al., 2001) and talent identification in sports (Elferink-Gemser et al., 2004). Blanksby et al (Blanksby et al., 1986) stated that success of any talent detection and development program completely relies on clear comprehension of specific performance requirements in different kinds of sports. Data on these requirements, based on the diversity of anthropometrical, physiological and physical fitness measurements, is helpful in all sports including gymnastics, a highly specialized discipline, which involves excellent use of flexibility and explosive power (Kinser et al., 2008).

Muscle flexibility refers to the absolute range of movement in a joint or a series of joints, and length in muscles that cross the joints to induce bending movement. Flexibility varies among individuals, particularly in regards to differences in length of multi-joint muscles (Blakey & Educational, 1994). Similarly, the term explosive power refers to the ability to exert maximum muscular contraction instantly in an explosive burst of movements (Bompa & Buzzichelli, 2015). Researchers have shown that flexibility as a pain-free range of motion

(ROM) and explosive power are the two crucial factors in gymnast's performance. For example, Douda et al. found some morphological and physiological characteristics in elite gymnastics, including flexibility and explosive power. In other words, they were significantly higher in elite gymnasts compared to non-elite gymnasts (Douda et al., 2008).

Most studies so far have focused on the information about the relationship between the body composition and physical fitness in children from developed countries (Douda et al., 2008; Linthorne et al., 2005) with conflicting results, as well as on the biomechanical and kinematical characteristics of elite athletes, narrowed down to biomechanical long jump characteristics such as velocity, angle, and the distance of jumping (Muraki et al., 2005). As we mentioned, there are similar research studies in some other sports. For instance, Hansen et al (Hansen et al., 1999) investigated performance differences between 11-year-old elite and non-elite soccer players over a two-year period. Their results showed an initial preponderance in broad jump and isometric strength in elites as opposed to non-elites that remained in place throughout the two-year period. Kubo et al (Kubo et al, 2006) compared fat-free mass and thicknesses of various muscles among judo players in three different levels including Olympians, universal competitors and a group who did not participate in intercollegiate competitions. They reported the best scores for the first group, followed by universal competitors and the third group.

Overall, our review of literature indicates that limited and inconclusive data are available regarding young artistic gymnasts at different performance levels. In spite of a fairly universal recognition of the need for flexibility and explosive power in gymnastics, surprisingly little research has been conducted to compare flexibility and explosive power in young gymnast at different performance levels. Thus, the present study attempted to elucidate the potential effects of training specificity on muscle flexibility and anaerobic power in young artistic gymnasts at different performance levels. In other words, since our subjects were in the same age group and were teenagers, we wanted to know to what extent their differences were due to sport-specific training for young gymnasts as this may have different effects on flexibility and anaerobic power. Therefore, the aim of the present investigation was to study the possible effects of training specificity on muscle flexibility and anaerobic power in young artistic gymnasts at different performance levels.

METHODS

Ninety five healthy children volunteers performed the fitness and performance tests. Before the beginning of the study, invitation letters were sent to the parents for passive consent to their children's participation. The young athletes' participation was totally voluntary even with their parents' consent and all procedures were approved by University Hospital authorities. The inclusion criteria were: sedentary lifestyle (for a minimum of at least 9 months prior to participating in the testing), normal resting heart rate, absence of cardiovascular and pulmonary signs and symptoms. Exclusion criteria included obesity (BMI greater than or equal to 30 kg/m^2), presence of musculoskeletal disorders, history of cardiovascular disease, orthopedic problems, or other medical conditions that would contraindicate exercise. The anthropometric parameters and health related physical fitness were assessed in 95 boys who participated in this analysis. The children were divided into two groups: gymnasts (N=53) and sedentary (N=42). Within the gymnast group, athletes were classified on the basis of their sports history and performance level in an E (N=15) or a NE (N=38) group with those who won first to third place in official competitions as elite gymnasts and those who trained for 6 to 9 months and did not earn any position in official competitions as beginners.

The subjects completed a 15 minute warm-up (consisting of walking around the mat, streching the muscles, jogging, joints rolls & calestenics, running, floor stretching) at 60–75% of their personal capacity before the physical test protocols were performed. Each testing session was conducted and monitored by the investigators. The subjects were encouraged to exert maximal effort in all tests. Following the initial evaluations, the subjects were instructed to maintain the same level of physical activity throughout the study (three training sessions per week, each session lasted between 75 to 90 min). The subjects performed two different types of jumps: standing long jumps (LJ) and vertical jumps (VJ) as well as the sit and reach test to measure flexibility.

For LJ, the child stands behind a line marked on the ground with feet slightly apart. The subject takes off and lands using both feet, swinging the arms and bending the knees to provide forward drive. The subject attempts to jump as far as possible.

The vertical jump height was determined using a force platform with specifically designed software (Bioware, Kistler, Switzerland). Ground reaction as well as moments of force were collected by a Bertec force plate (Model 4060A). A video-based (60 Hz), three-dimensional motion analysis system (Motion Analysis Corp.) was used to collect and process the cinematic data. Cinematic data were refreshed by a low-pass, fourth-order Butterworth filter with an effective cutoff frequency of 8Hz. Jumping height was determined as the centre of mass displacement calculated from force development and measured body mass. Each subject had three trials interspersed with a one minute rest interval between the jumps. During the test, subjects used hands in the jumping motion. The best jump from each subject was used in data analysis (Lucertini et al., 2013).

The subjects were seated on the ground with their legs fully extended in front of them, feet 20 centimeters apart, toes pointed upwards, and soles of the feet flush with the base of the flexibility box. If it was difficult for the subject to fully straighten their legs, an assistant could help press the legs down by applying pressure above or below the knees. The push could be smooth and static, no bouncing or lunging was allowed. The subject then reached slowly forward, the fingertips of both hands remaining in contact with the slide at all times. Once the subjects had reached their farthest extension point, the position had to be held for a “two count”.

The participant was allowed two more attempts, if desired, and the best of the three was recorded. The scores were measured in half-centimeter increments, rounding up to the nearest half-centimeter. Subjects were asked to do each repetition at maximum power. Also, in order to increase the subjects' motivation, the record of each repetition was announced loudly and there were special rewards for five people per group who achieved the best results. The test was performed without shoes. These tests are easy to administer, can be done both indoors or outdoors, and a young population can be assessed in a short time (Opstoel et al., 2015).

Anthropometric measurements were taken by one operator (CM) using conventional criteria and measuring procedures. Weight was assessed to the nearest 0.1 kg using a certified electronic scale (Tanita electronic scale BWB-800 MA (Wunder SA.BI. Srl)) (2). Height to the nearest 0.01 m was measured using a Harpenden portable stadiometer (Holtain Ltd., Crymych, Pembs. UK). The body mass index (BMI) was calculated as kg/m^2 (Siahkouhian & Esmaeilzadeh, 2011).

One-way ANOVA was used to detect differences among the groups. If differences were found, the Tukey's post hoc test was used to analyze differences among the specific groups. The Pearson product-moment correlation was also used to determine the relation between the selected variables. The significant level for statistical analysis was set at 0.05.

RESULTS

Standing long jump records showed that there were significant differences among the three groups (mean±SD of E, NE, and sedentary groups: 156.20±16.38 vs. 140.68±25.16 vs. 120.62±34.68 cm respectively; P≤0.01, Figure 2).

Comparison of vertical jump records also showed that there were significant differences among the three groups (mean±SD of E, NE, and sedentary groups: 29.47±4.89 vs. 26.58±5.45 vs. 21.74±9.65 cm respectively; P≤0.05, Figure 3).

Findings showed that there was a strong significant correlation between VJ

Physical characteristics of the subjects are presented in Table 1. Muscle flexibility comparison of the three groups using One-way ANOVA is shown in Figure 1. Our results revealed that sit and reach records were significantly different among the three groups (mean±SD of in E, NE, and sedentary groups: 21.53±2.9 vs. 14.13±5.61 vs. 5.62±4.16 cm, respectively; P≤0.001, Figure 1).

(r=0.72, P≤0.001) and LJ (r=0.63, P≤0.01) in flexibility in the E group. A significant positive correlation was found between VJ and LJ (r=0.84, P≤0.001) in the E group. Results also showed a significant positive correlation between VJ (r=0.54, P≤0.01) and LJ (r=0.49, P≤0.01) in flexibility in the NE group. A significant positive correlation was found between VJ and LJ in the NE group (r=0.64, P≤0.001). No significant correlation was found between variables in the sedentary group (Table 2).

Table 1
Demographic data of the subjects in the three groups.

Variables	Sedentary	Intermediate	Elite	p value
Number	42	38	15	-
Age (yrs)	8.79±1.74	9.53±1.33	9.93±1.48	0.855
Height (cm)	130.12±11.52	126.61±10.78	128.87±10.55	0.636
Weight (kg)	31.43±11.01	27.89±4.27	24.67±4.62	0.421
BMI (kg/m^2)	21.45±3.58	19.72±5.07	18.65±4.12	0.764

Table 2
Correlation coefficient between flexibility and lower body explosive power among three groups.

Groups	E Group	NE Group	Sedentary Group
		Flexibility	
Vertical Jump	R= 0.72 P≤ 0.001	R= 0.54 P≤ 0.01	R= -0.03 P≤0.8
Long Jump	R= 0.63 P≤ 0.01	R= 0.49 P≤0.05	R= 0.20 P≤0.19

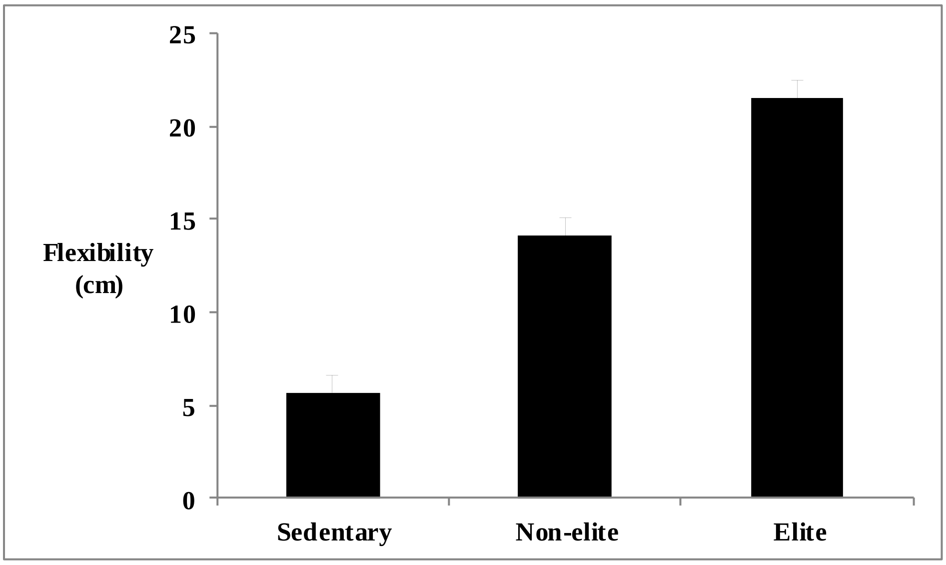

Figure 1. Comparison muscle flexibility in the three groups.

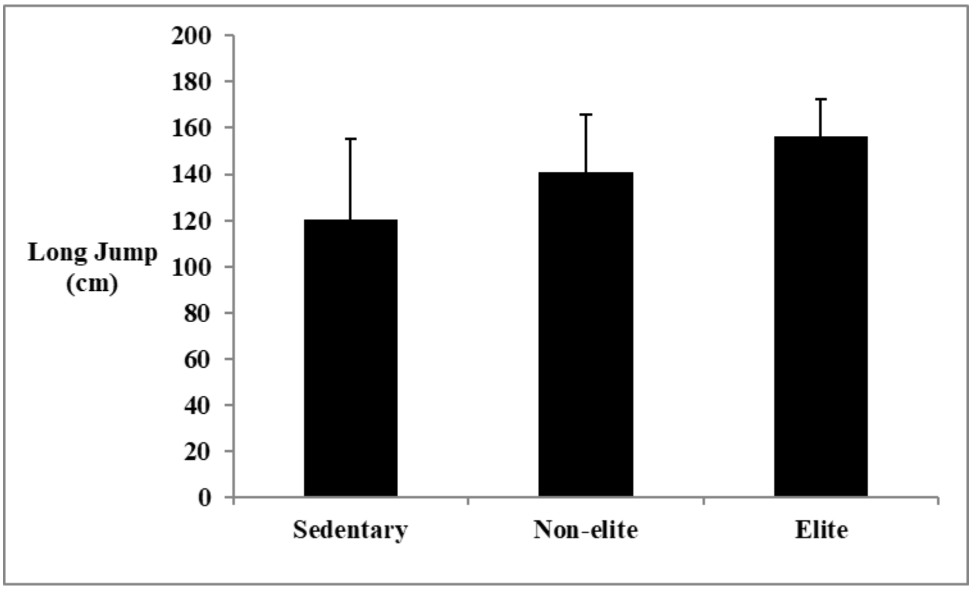

Figure 2. Comparison standing long jump records in the three groups.

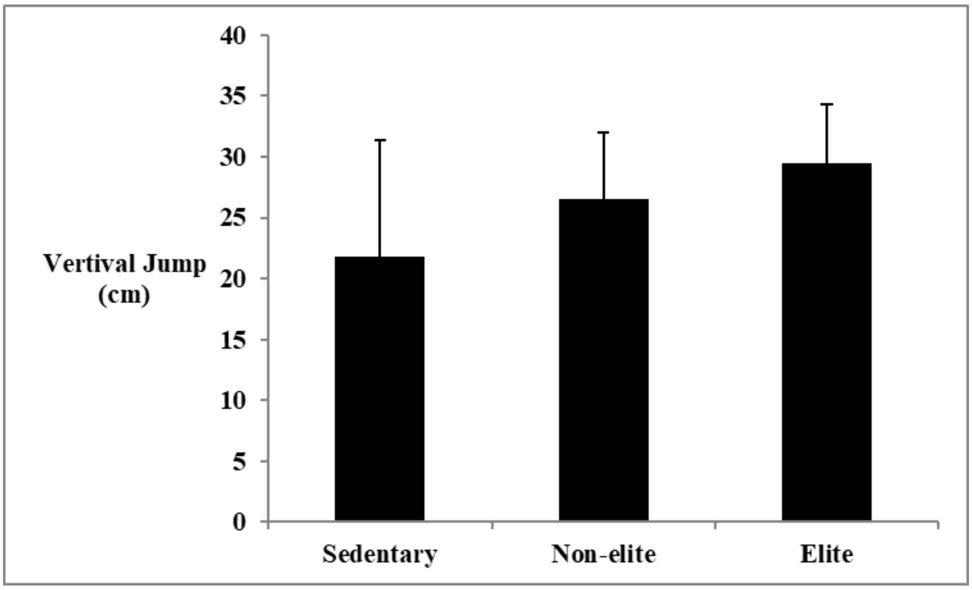

Figure 3. Comparison vertical jump records in the three groups.

DISCUSSION

In contrast with other studies, we focused mainly on young boy artistic gymnasts at different performance levels rather than on high class athletes. We matched the artistic gymnasts ages at different performance levels in the three groups to minimize the effects of maturation on the performance (Chimera et al., 2004). This leads to more accurate conclusions, refers to the differences between the performance characteristics of the subjects, and helps to distinguish the role of training on superiority. Another reason we studied young boys was because younger children have immature joints. In addition, we included young boys only to avoid delaing with the differences in physical abilities between boys and girls due to the muscular growth of young boys (Kamtsios, 2008).

Our results revealed that muscle flexibility and explosive power were significantly different among the three groups. In fact, the E artistic gymnasts had higher muscle flexibility and explosive power than the NE artistic gymnasts and the sedentary subjects indicating that these abilities are crucial for gymnastic performance (Karve, 2015). Both the E and the NE artistic gymnasts recorded well above the reported values for the sedentary subjects. Among sports disciplines, gymnastics has always been known for its intensive training (Malina et al., 2013). Monem et al (Jemni et al., 2006) surveyed and compared the performance level of the upper body and the lower body in national (N) and international (I) level gymnasts in relation to their training schedule. They argued that differences in quality and quantity of their strengh training, implemented by coaches, led to their preponderance in performance compared to another group. Similarly, it has been shown that whole body vibration (WBV) improves flexibility and explosive strength of lower limbs in young trained artistic gymnasts and at least maintains the initial level of performance (Dallas & Kirialnais, 2013; Dallas et al., 2014; Dallas et al., 2014). In fact, it has been shown that the status and improvement of physical conditioning in pre-adolescence is significantly related to the kind and extent of physical activity performed (Mellos et al, 2014). It can therefore be argued that specific kinds of gymnastic trainings have significant effects even on younger children. Also, this might indicate that the E artistic gymnasts are better trained for sprints and able to utilize more ATP-CrP in short sprints (Kuznetsova et al., 2015).

While there are studies that demonstrate superiority of muscle strength (Hansen et al., 1999), maximal anaerobic power (Kubo et al., 2006), fat-free mass (Lopes et al., 2005) and peak power (Lucertini, Spazzafumo,), in E athletes compared to NE ones, there are also others, such as Malina et al (Malina et al., 2013) and Kuno et al (Kuno et al., 1995), who disagree. Our results are consistent with the results of those researches who reported preponderance of elite athletes.

A higher degree of explosive power in the E artistic gymnasts compared to the NE and the sedentary subjects may be due to their training status. This may provide an explanation for the discrepancy in values (Massidda et al., 2014). It seems that anaerobic metabolism, specifically the ATP-CrP system, is more developed in E artistic gymnasts than in others, indicating that sport-specific training may influence the ATP-CrP energy production (Kuznetsova et al., 2015; Fernandez-Villarino et al., 2015). This indicates that the explosive power is mainly related to the specificity of training.

Hence, jumping performance may be more dependent on the specificity of training, since it is reasonable to assume that the higher explosive power in the E artistic gymnasts is due to their better neuromuscular coordination (Mehrtash et al., 2015). In addition, it seems that practicing gymnastics at the professional level causes neuromuscular adaptations, including an increase in tension and muscle elasticity, and a reduction in the sensitivity of the Golgi tendon organs. Stretch reflection occurs during the eccentric contraction phase, and leads to a further facilitation of the motor unit recruitment during concentric contraction. Additionally, tissue transplantation stores elastic energy, and if muscles contract quicker, components of connective tissue can produce more power. Finally, the sensitivity of the Golgi tendon organs that play a protective role against too much pressure on muscles decreases in the course of professional practice of gymnastics (Chimera et al., 2004, Impellizzeri et al., 2008).

We showed a strong relation between muscle flexibility and explosive power in the E gymnasts, while the NE artistic gymnasts showed moderate relationships between muscle flexibility and explosive power. Previously Živković et al (Živković & Lazarević, 2011) reported a strong linear connection between the set of tests of dimensions of flexibility and explosive power as a predicting system and a criterion variable for sprint speed at 100 and 200 metres.. The strong relationship between muscle flexibility and explosive power in the E artistic gymnasts indicates that elasticity of the muscles may play an important role (Wilson & Flanagan, 2008). As muscle flexibility and explosive power are mainly recruited in the gymnastic routines, it seems that the specificity of the training with regards to the motor patterns used in gymnastic emphasizes the more complex neuromuscular tasks and facilitates a concurrent improvement in these abilities.

CONCLUSIONS

Overall, our results revealed that sport-specific exercise training has a substantial effect on improvement of explosive power and flexibility even in young gymnasts. It seems that increased experience of gymnastic exercise training did not limit the lower body muscle flexibility; rather, it improved muscle flexibility concurrent with the lower body explosive power.

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