Original article

# INFLUENCE OF STRENGTH TRAINING PROGRAM ON ISOMETRIC MUSCLE STRENGTH IN YOUNG ATHLETES

*Aleksandar Ignjatovic, Dragan Radovanovic and Ratko Stankovic**

Strength training, or resistance training, is a form of physical conditioning used to increase the ability to resist force. Since muscular strength is required for success in many sports, it is logical to assume that stronger and more powerful young athletes will achieve better results. The aim of the study was to examine the effects of strength training on young athletes. An eight-week strength training program for developing muscle strength was performed in this study. Training protocol was designed specifically for young adolescent's athletes. The program consisted of exercises for lower and upper body, abdominal and lower back muscles. The programs did not involve the maximal (1-3 repetitions maximum) and other very hard intensity exercises that may had negative effect on young athletes. The results showed that strength training program had positive effects on maximal isometric muscle force ($F_{max}$) and motor skill. The increase presents the combined influence of strength training and growth. *Acta Medica Medianae 2007;46(3):16-20.*

**Key words**: *strength training, young athletes, isometric muscle force*

Faculty of Sport and Physical Education, University of Nis

*Correspondence:* Ignjatovic Aleksandar
Faculty of Sport and Physical Education
9/35 Koste Stamenkovica Street
18000 Nis, Serbia
Phone: +381643357820
E-mail: aleksig79@yahoo.com

## Introduction

As youth sports become increasingly popular, athletes and their parents are looking for the best ways to gain a competitive edge. One topic that has been highly debated for the past few decades has been whether or not children and adolescents should participate in strength training programs. Since muscular strength and power are required for success in many sports, it is attractive to assume that stronger and more powerful young athletes will perform better. Despite the belief that strength training was dangerous or ineffective for children, the safety and effectiveness of such programs are now well documented (1,2,3).

Strength training, or resistance training, is a form of physical conditioning used to increase the ability to resist force. By increasing muscle strength, strength training can improve sports performance in young athletes. Different types of exercises are used in strength training in young athletes, including weight machines, free weights, and exercises which use a body's own resistance. By using different combinations of exercise repetitions, young athletes can achieve increases in strength. Strength training with young athletes is a common practice in sports like handball, basketball, and other team sports in which size and strength are desirable.

The programs that involve lifting heavy resistance (1-3 repetitions maximum) may result in injury or overstress in young athlete resulting negatively on future development. Performing programs designed for elite athletes or other high intensity programs may have negative effect on young athletes. These are the reasons why we decide to avoid very high intensity exercises in our program.

Increasing size and strength of skeletal muscle is an important feature of childhood and adolescence. The key areas of interests in strength training during childhood are related to the risk of injury, the effectiveness of training to increase strength especially during pubertal years, and the mechanisms underlying training-induced strength gains and changes in strength during detraining.

Researches conducted over past ten to fifteen years clearly demonstrate that children and adolescents may benefit from strength training activities. The qualified acceptance of youth strength training by medical and fitness organizations is becoming universal (4-7). In addition to increasing muscular strength and muscular power, regular participation in a youth strength training program has the potential to positively influence cardio-respiratory fitness (8-11), body composition (8), blood lipids (12), bone mineral density (8,13) and motor performance skills (14).

The mechanisms allowing strength changes in children and adolescents are usually accomplished with little increases in muscle size, and more with improved motor skill coordination, increased motor unit activation and other neurological adaptations. Also, regular strength training usually results in lower total body fat and higher fat-free mass (15,16).

Since the rate of anatomical growth, maturation and changes induced with training may vary independently, it is hard to isolate their combined influence on strength. There is a lack of information about the factors that initiate and control the process of increasing muscle size and strength in adolescents. It is also hard to identify exact increase of strength changes with growth and with resistance training.

Strength increases rapidly during the initial stage of training program due to initial training effects, and more slowly during the later stage of training is due dampened training effect. The increases in muscle strength will be different regarding individual characteristics and the training program. The greatest increase in muscle strength will be with the optimal amount and type of exercises recommended in strength training program. Training program which is individually based depending on medical status, maturity and skill level, as well as prior exercise experience will also have the greatest effects. When training program is not at an appropriate level, and it is with too high intensity and not adequate rest between exercises to minimize injury and maximize recovery it could produce negative effect on muscle strength development (Figure 1. Training 4 (T4)).

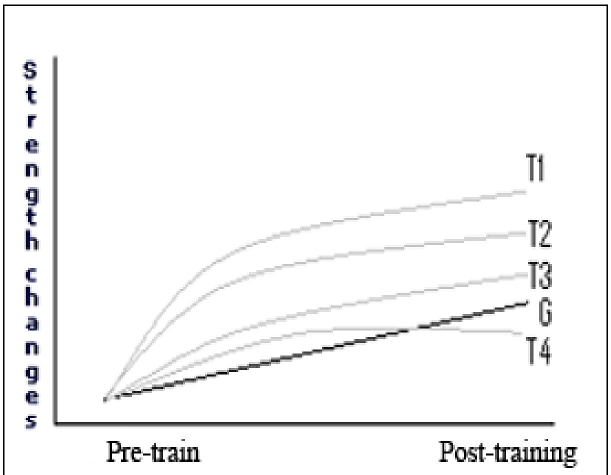


*Figure 1. Hypothetical model of expected strength changes*

Hypothetical model of expected strength changes with growth (G), and resistance training (T) during adolescences period. This hypothetical model shows different potential strength changes depending on different training program.

Motor performance is most often measured in a variety of gross motor tasks witch requires abilities such as speed, balance, flexibility, explosive strength and local muscular endurance, while muscular strength is traditionally measured by static dynamometric tests such as gripping, pulling and pushing (17,18).

The maximal isometric force (Fmax) of a muscle is directly related to its cross-sectional area (19). Strength training produces an increase in muscular force while muscular hypertrophy becomes appreciable at a later time (19). Many other adaptations in the muscle nerve, and connective tissue may still be occurring. Such adaptations include changes in muscle protein (i.e., myosin isoforms), recruiting patterns, and connective tissue, all of which could contribute to improved strength, sport performance, and injury preventions.

**Methods**

The subjects of this study (n=21) were young basketball players at the chronological age of 15.4years±0.6. The age was computed from the date of birth and date of examination. All subjects were members of basketball club Junior, Cadet Champion of the Regional League of Nis Region, Serbia in 2005/06. All the players volunteered to participate in the study. Before the beginning of the study, the informed consent of both the players and the coach were obtained. A total of 21 subjects in this group underwent a protocol of investigation.

The investigation consisted of two testing protocols: initial and final. During the examination, subjects were using sport equipment. The investigation protocol included anthropometric measurements, and measurements of maximal isometric muscle strength. Anthropometric apparatus was calibrated according to the manufacturer's instruction. Stature was measured by a stadiometer (GPM, Swiss) to the nearest 0.1 cm. Body weight was determined using electronic balance scale (Tefal, M6010, France) to nearest 0.1 kg. Fat mass and the fat free mass (FFM) were determined by bioelectrical impedance analysis-BIA (20) using an Omron (Japan) device according to standardized procedure for the type of device used (21,22). Measurement of maximal isometric force of lower body muscle was carried out by the isometric dynamometer interfaced with the specially designed software for automatic data registration. Maximal isometric force (F max) is maximal force registered during maximal voluntary muscle contraction. Muscle tests were carried out under standardized isometric conditions on the following muscle groups: the leg extensors, by means of the "Standing Leg Muscle Extension" test – SLME, and the calf muscles extension from a sitting position by means of "Sitting Calf Muscles Extension" the - SCME. Maximal vertical height of jump were measured with digital camera interfaced with motion analysis software system (KAVideo, San Francisco, USA).

An eight-week training protocol was designed specifically for all players. Training program was conducted during eight weeks. Each training consisted of 10-minute-worm up and 30- minute-strength training. In the first 3 weeks of strength training program, two sessions per week were performed. In weeks 3-6 of training program, three sessions per week were performed. In weeks 7-8 of training program, two training session were performed. This made a total of 19 training sessions in 8 weeks of strength training program. The program consisted of exercises for lower and upper body, abdominal and lower back muscles (23,24). In each training session, 3 series of 6 different exercises were performed. Every series consisted of six repetitions in the first week, and the number of repetitions was raised for two repetitions in a series after 3rd and 6th week. The training sessions were predominantly directed to the lower body muscles with 3 different exercises in one session, and only one to other muscle groups. The strength training protocol was conducted under the author supervision.

Statistical analyses were carried out with Statistica 5 statistical package (Corvallis, Oregon, USA). All values were expressed as mean ± standard deviation (SD). Total variability as well as the differences between particular results during the tests was analyzed using MANOVA.

**Results**

Anthropometric characteristics of the subjects included in the investigation and measured values of isometric strength are shown in Table 1 and Table 2 (means±SD). All results of the maximal isometric force (F max) for the leg extensors (SLME test) and the calf muscles extension (SCME tests) are shown in Figure 2.

**Discusion**

The applied training for strength development had lead to increase in maximal isometric force (Fmax) registered during maximal muscle voluntary contraction. The results of statistical analysis shows that difference was not statistically significant (Manova: Wilkins lambda=0.68, F approximation=0.80, df 1=10 and df 2=17, p=0.63). The test of leg extensor muscles (SLME test) has produced increase in Fmax for 12% (177.95 N ±60.55 pre vs. 201.9 N ±62.27 post), while the test of calf muscles (SCME test) produced the increase by 7% (112.48 N ±26.24 pre vs. 120.81 N ±22.48 post). Motor performance was measured with vertical jump test. Mean values for high jump was 281.5 cm ± 15.3 on initial testing and 283.4 cm ± 16.4 on the final. The gains achieved with the strength training program are significant but not at statistically significant level. Nevertheless, the gain produced showed that strength training program was well designed and had the positive effects on maximal isometric muscle force.

A variety of training modalities including weight machines, free weights and exercises with body weight as well as different combinations of sets and repetitions have proven to provide an adequate stimulus for strength development in young athletes during the initial adaptation phase (25). On average strength gains of 30% to 40% have been observed in untrained children following short term (eight to twelve weeks) training programs (25). But it is unrealistic to expect a young athlete already engaged in organized sport activity to make the similar strength gains.

Most of the resistance-training study on adolescents found positive effects on muscle strength and motor performance (26,27,28,29,30). Despite theoretical benefits and the results from previously mentioned studies, some scientific studies have failed to consistently show that improved strength enhances running speed, jumping ability, or overall sports performance in young athletes (31,32). And that young people who want to improve sports performance will generally benefit more from practicing and perfecting skills of the sport than from resistance training (9). On the other hand, emphasizing only sport skills as opposed to fundamental fitness abilities in children and adolescent whose motor skills and strength capabilities are not as well developed may lead to acute and overuse injuries (34). The optimal solution is to make adequate and rational training program that include strength training sessions and practicing motor performance skills. The program that exceeds participant capabilities is not only ineffective, but it can increase risk of injury and, even may have determinate effects on normal growth and development.

Limited direct and indirect evidence suggests that well designed youth strength training programs will in all likelihood result in some degree of improvement in sports performance. Gains in muscular fitness during the childhood and adolescence may not only provide the foundation for dramatic strength gains during adulthood, but as children and adolescents gain self-confidence in their physical abilities they may be more likely to experience success and less likely to drop out of sport.

**Conclusions**

Training program for strength development in young athletes resulted in increase in maximal isometric muscle contraction and in increased performance of tested motor task. The increase presents the combined influence of strength training and growth. And the question remains if the increase with strength training can be greater without negative effects on growth and development.

Research is still needed on the specific developmental stage at which an individual acquries the adult characteristics for strength training. Studies at cellular level are needed to tell wheter there are any age or maturation related differences in muscle fiber types that are recruited during strength training. With regards to training exercise planning and dosing in our conditions, from the practical point of view, there is a need to conduct several longitudinal studies on a bigger sample of children of both genders in order to get a broader picture of muscle strength capacity depending on the chronological and biological age. These data would present significant practical directions for the beginning and intensification of strenght training program during the preadolescent and adolescent period.

The ability of older athletes to improve strength and motor performance using programs designed for collegiate or professional athletes is in part a result of theirs years of resistance training experience. Children and adolescent should not perform this kind of programs. Lifting heavy resistance is also contrary to the guidelines established for the children. Forcing preadolescents or adolescents to perform programs designed for mature, gifted athletes can overstress them and may result in injury.

On the base of our results we can support adolescent's participation in appropriately designed and competently supervised strength training programs. Benefits include increasing the muscular strength of young athletes and improvements in theirs body composition and sports performance.

Limited direct and indirect evidence suggests that well-designed youth strength training programs will in all likelihood result in some degree of improvement in sports performance. Gains in muscular fitness during the childhood and adolescence may not only provide the foundation for dramatic strength gains during adulthood, but as children and adolescents gain self-confidence in their physical abilities they may be more likely to experience success and less likely to drop out of sport.

*Table 1.* Anthropometrical characteristics of subject under investigation

| Variables | Initial measurement | Final measurement |
|---|---|---|
| Age | 15.4±0.6 | |
| Body Height (cm) | 180.7±7.9 | |
| Body Weight (kg) | 68.6±11.6 | 70.1±10.9 |
| Fat mass (%) | 15.56±4.88 | 15.03±5.22 |
| Fat free mass (kg) | 11.03±5.33 | 10.89±5.56 |

*Table 2.* Maximal isometric force and jump height of subject under investigation

| Variables | Initial measurement | Final measurement |
|---|---|---|
| SLME (N) | 177.95 N ±60.55 | 201.9 N ±62.27 |
| SCME (N) | 112.48 N ±26.24 | 120.81 N ±22.48 |
| Jump height (cm) | 281.5 ± 15.3 | 283.4 ± 16.4 |

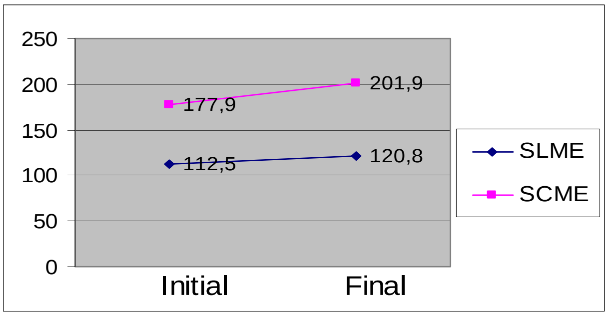


*Figure 2. Maximal isometric force (F max) in initial and final test.*

Abbreviations: Standing Leg Muscles Extension test – SLME, Sitting Calf Muscles Extension – SCME

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# UTICAJ PROGRAMA ZA RAZVOJ SNAGE NA IZOMETRIJSKU MIŠIĆNU SILU KOD MLADIH SPORTISTA

*Aleksandar Ignjatović, Dragan Radovanović i Ratko Stanković*

Trening za razvoj snage je oblik fizičke aktivnosti koji teži povećanju sposobnosti savlađivanja otpora. Imajući u vidu da je savladavanje otpora, odnosno mišićna snaga neophodna za uspeh u mnogim sportovima, nameće se logičan zaključak da će snažniji sportisti postizati i bolje rezultate. Cilj ovog istraživanja bio je proučavanje efekata treninga za razvoj mišićne snage na mladim sportistima. Trenažni program u trajanju od osam nedelja za razvoj mišićne snage je specijalno dizajniran za sportiste u periodu adolescencije. Program se sastojao od vežbi za donje i gornje ekstremitete, abdominalnu i dorzalnu muskulaturu. Program nije uključivao vežbe maksimalnog i veoma visokog intenziteta koje bi mogle imati negativno dejstvo na mlade sportiste. Rezultati ukazuju da ovakav program za razvoj snage ima pozitivan uticaj na maksimalnu voljnu izometrijsku silu (F max) i motoričke sposobnosti. *Acta Medica Medianae 2007;46(3):16-20.*

***Ključne reči**: trening snage, mladi sportisti, izometrijska mišićna sila*