FACTA UNIVERSITATIS
Series: **Physical Education and Sport** Vol. 7, Nº 2, 2009, pp. 189 - 196

Review article

RESISTANCE TRAINING FOR YOUTHS

UDC 796.015:371.212

Aleksandar Ignjatović[1], Ratko Stanković[2], Dragan Radovanović[2], Živorad Marković[1], Jan Cvećka[3]

[1]Faculty of Pedagogy, Jagodina, University of Kragujevac, Serbia
[2]Faculty of Sport and Physical Education, University of Niš, Serbia
[3]Faculty of Physical Education and Sport, Comenius University in Bratislava, Slovakia

Abstract. *Resistance training (also known as strength training) is the practice of using free weights, weight machines and elastic bands, or body weight to build muscles, to develop muscle strength, power and muscular endurance. The participation of youths in an organized resistance training program has not always been encouraged, but the positive results of the numerous studies in scientific literature over the past decade have clearly stated the benefits. In addition, the stands that leading world fitness and health organizations and review articles take all state that resistance training can be very beneficial for children and adolescents if done properly. Training must be done in a safe environment, it must be properly designed and under close supervision of a qualified practitioner.*

Key words: *Resistance training, children, adolescents, benefits, risks*

TRAINABILITY OF YOUTH

The development of muscle strength and power through resistance training in children and adolescents is still a subject of some debate and criticism. Early studies (Docherty, Wenger, Collis, & Quinney, 1987; Hetherington, 1976) that failed to demonstrate strength increases in children who participated in a resistance training program lead to the opinion that resistance training is ineffective in children. The American Academy of Pediatrics even concluded in their policy statement (American Academy of Pediatrics, 1976) that prepubescent boys (pubic hair stage 1 or 2) do not significantly improve their strength or increase their muscle mass in a weight training program because of an insufficient circulation of androgens in the blood.

Received July 11, 2009 / Accepted November 14, 2009
Corresponding author: Aleksandar Ignjatović
Koste Stamenkovića 9/35, 18000 Niš, Serbia • Tel: +381643357820 • E-mail: aleksig79@yahoo.com

The majority of the recent research (Szymanski et al, 2007; Tsolakis, C, Vagenas, G, & Dessypris, 2004; Faigenbaum & Mediate, 2006; Faigenbaum, Milliken, Moulton, & Westcott, 2005; Faigenbaum et al., 2001, 2007) provides convincing evidence that children and adolescents enrolled in properly designed resistance training programs can significantly increase their muscle strength and power, above and beyond growth and maturation. In addition, the stands that leading world fitness and health organizations (American Academy of Pediatrics, 2008; American College of Sports Medicine, 2006; British Association of Sport and Exercise Science, 2004; Canadian Society for Exercise Physiology, 2008; National Strength and Conditioning Association, 2009) and review articles (Faigenbaum 2000, 2007; Hass et al., 2001) take all state that strength training can be very beneficial for children and adolescents if done properly.

Meta analyses (Payne et al., 1997; Falk & Tenenbaum, 1996) also demonstrated significant strength gains following resistance training. The typical gains in muscle strength were approximately 13 - 30% greater than those which should be expected from growth and maturation (Falk & Tenenbaum, 1996). Greater strength gains (from 55 to 74%) have been found after 8 weeks of resistance training (Westcott, 1991, 1992; Faigenbaum, Zaichkowsky, Westcott, Micheli, & Fehlandt, 1993), although more typically strength gains of roughly 30% are expected after short term (8 to 20 weeks) resistance training program in children and adolescents (National Strength and Conditioning Association, 2009).

It is logical to assume that stronger and more powerful young athletes would be at an advantage, and that resistance training would help improve their performance. Improved motor fitness skills after resistance training were found in a number of studies (Szymanski, Szymanski, Bradford, Schade, & Pascoe, 2007; Flanagen et al., 2002; Faigenbaum & Mediate, 2006) involving youths. But increases in strength and power would not necessary lead to an improved motor task performance (Faigenbaum, Milliken, Moulton, & Westcott, 2005; Faigenbaum et al., 1993; Flanagen et al., 2002). For, greatest improvement strength training should be specific and include movement and muscle type activations similar to the ones in a performance task.

ADDITIONAL BENEFITS OF STRENGTH TRAINING

In addition to enhancing muscular strength, power and local muscular endurance, and the potential improvement in some motor skills and sport performances, regular participation in a youth resistance training program has the potential to influence several other aspects of health and fitness. Regular participation in resistance training may results in the improvement of body composition, increase bone mineral density, increase cardiorespiratory fitness, enhance mental health and well-being and stimulate a more positive attitude towards a lifetime of physical activity.

One of the outstanding benefits of resistance exercise is the improvement in body composition. Resistance training programs can increase fat-free mass and decrease the percentage of body fat by increasing energy expenditure during the exercise session and somewhat during recovery, and can influence the maintaining or increasing of the fat-free body mass while encouraging the loss of fat body weight. These improvements are most easily observed in obese youths following resistance training (Sothern et al., 2000; Watts et al., 2005), as well as in children with other chronic conditions (Salvedurai et al., 2002).

Improvements in body composition, total body weight, blood lipid levels (Su et al., 2002), insulin sensitivity and blood pressure (Benson, Torade, & Fiatarone Singh, 2006)

can indirectly influence the cardio-respiratory system. All of these improvements are still not well documented in healthy youths, but limited data suggest that they have a positive influence on the cardio-respiratory system.

Resistance training can have favorable effects on bone mineralization and growth (Turner and Robling, 2003, Vinsent-rodriges, 2006) as well as lead to a decreased risk of osteoporotic fractures later on in life (Hainonen et al., 2001). However, more studies are needed to determine optimal loading during resistance training more precisely, one required for positive effects on bone health.

Resistance training also provides psychological benefits for young participant. It has been observed that the socialization and mental discipline exhibited by children and adolescents participating in a resistance training program are similar to the experiences of youths participating in team sports and other activities (Faigenbaum, 1995).

POTENTIAL RISK OF RESISTANCE TRAINING

Resistance training, as do most physical activities, has some risk for injury. Yet this risk is no greater than the one in other sports/recreational activities in which children regularly participate. A variety of apparently sound reasons such as possible growth cartilage injury and stunted growth have been provided as grounds for not training youths. One of the strongest supporting documentations of this claim is a report from the US Consumer Product Safety Commission (United States Consumer Product Safety Commission, 1987) in which it is stated that weightlifting can cause injury to children. The report claims that 8543 weightlifting-related injuries occurred in children younger than 14 years of age. Strains, sprains and fractures are reported, but the conditions that may have predisposed the subjects to injury were not examined. Such injuries are uncommon and are believed to be largely preventable by avoiding impropriate training techniques, excessive load, poorly designed equipment and lack of qualified adult supervision. Current findings from prospective resistance training studies indicate a low risk of injury for children and adolescents who follow age-appropriate training guidelines.

PHYSIOLOGICAL MECHANISMS

It has been shown that in adults properly designed resistance training leads to morphological adaptations such as: muscle hypertrophy, potential hyperplasia, and changes in fiber-type composition. However, this has not always been the case in children and adolescents. Although a resistance training program has been shown effective in increasing muscle strength in youths, similar increases in the muscle sizes have been rather small. However, the studies (Mersch & Stoboy, 1989; Fukanaga, et al., 1992) that used more sensitive methods of measurements (magnetic resonance imagining and ultrasound) present the possibility of muscle hypertrophy in youths, although these small potential changes may be difficult to measure.

As there is no strong evidence showing signs of muscle hypertrophy in children, strength gains among children have been attributed mainly to neurological adaptations. Neural adaptation includes changes in motor unit activation, coordination, recruitment and the firing rate of muscles involved in the specific strength task. These changes have rarely been directly measured (in children or adolescent subjects), but have been inferred

based upon the ratio of strength increase to actual hypertrophy. There are only two research groups that have tried to directly measure neurological adaptations after resistance training in young subjects. Using an interpolated twitch technique Ramsay et al. (1990),reported increases in motor unit activation of 9% and 12% for elbow flexors and knee extensors respectively and an additional 3% and 2%, respectively, following another 10 weeks of resistance training. Similarly, using an integrated EMG (IEMG) Ozmun et al. (1994) reported an increased agonist activation of 16,8% after resistance training. Nevertheless, increases in neuromotor activation in bout studies were smaller than the increases in strength. This is logical, because the increases in muscular strength are always greater than the contribution by either morphological or neurological aspects.

DIFFERENT TYPES OF RESISTANCE TRAINING

Besides using free and fixed weights (child- and adult-sized weight machines), other alternative methods to provide resistance, such as the individual's own body weight (Falk & Mor, 1996; Siegal, Camaione, & Manfredi, 1989), medicine balls (Faigenbaum, & Mediate, 2006; Szymanski et al., 2007) and elastic bands (Annesi, Westcott, Faigenbaum, & Unruh, 2005) have also been shown safe and effective in children and adolescents.

Plyometric exercises typically include movements that exploit a stretch shortening cycle to increase muscle power. If different kinds of activity that include skips, hops, runs, jumps and medicine ball exercises are used with gradual progress, then there is no reason to believe that plyometrics are inappropriate or unsafe for youths. An increasing number of studies is now supporting the use of plyometric training, and showing that this method could be safe and effective for youths (Matavulj, Kukolj, Ugarković, Tihanyi, & Jarić, 2001; Faigenbaum et al., 2007; Diallo, Dore, Duche, & Van Praagh, 2001; Kotzamanidis, 2006; Lephart et al., 2005).

A resistance training program for youths may include exercises which could improve balance and coordination. This kind of training could be particularly beneficial for reducing risk of injury. Also, an advantage of training on an unstable surface is that high activation could be achieved without the imposition of a high resistive load (Behm et al., 2005).

TESTING OF YOUTHS

In order to monitor the progress of children and adolescents and the success of a strength training program we must first determine the baseline strength values. In order to do this we must have an adequate and valid muscle assessment, which will assist in the evaluation and progress of the resistance training program. Various indicators of strength are available, but in the context of practical use, the following strength testing procedures are generally considered: static (isometric) strength and dynamic strength.

Although the maximal isometric contraction provides information about the forces one is able to produce in a static position, in sport most movements are produced in a time-related condition with specific speed. But, due to the safety, validity and reliability of the test, the maximal isometric contraction is very popular in assessment of strength capabilities in children with neuromuscular diseases (Highland et al. 1992, Stuberg, Metcalf 1988).

The assessment of 1 RM (one repetition maximum) counts as a frequently applied strength testing procedure for adults. However, in the past several authors have considered inappropriate to test the 1RM on children (Metcalf et al., 1993; Webb, 1990), due to possible injuries of the epiphysial plate or grown cartilage. Later on, with the popularization of strength training, several studies have been published with the results that healthy children can safely perform the 1RM, provided that appropriate testing guidelines are followed (Faigebaum et al., 2003). When discussing the mentioned test procedure, attention should be paid to the testing of special groups, especially children with neuromuscular insufficiencies, as pushing them to 1RM represents an undesirable or even unacceptable procedure.

Due to several specifics in testing of the 1RM in children, the maximal power test presents a useful alternative in assessment of strength capabilities. No maximal weight lifting is necessary in this test. Using the maximal effort single repetitions with increasing weight is performed. The test may be interrupted once the maximum power has been achieved and the power starts to decline (Hamar, 2008).

GUIDELINES FOR YOUTH RESISTANCE TRAINING PROGRAM

The development of a youth resistance training program needs to follow the similar steps as that of an adult program, but it is important to remember that children and adolescents are not "miniature" adults. No matter how big and strong, they are still anatomically, physiologically, and psychologically immature. With proper and clear instruction and careful supervision, a youth resistance training program can be in aid of health and fitness improvement, and may develop a positive attitude towards strength training and a healthy lifestyle.

The following guidelines are the summary of general resistance training guidelines for youths:

- A young child should be physiologically and psychologically ready to participate in a resistance training program and should be evaluated by a sports medicine physician to identify any medical problems and musculoskeletal deficiencies.
- The program should start with a physical assessment where the trainer can evaluate the young athlete to help design a program based on the athlete's individual needs.
- The program should be implemented and closely supervised by a qualified strength and conditioning professional or personal trainer that understands the needs of young athletes.
- The instructions regarding the correct exercise technique, training guidelines, exercise room etiquette and spotting procedures must be clear and competent.
- The environment needs to be safe and free of hazards.
- When necessary, adult spotters should be nearby for safety.
- Youths should have realistic expectations and learn the benefits and risks associated with resistance training.
- The training session should start with a 5-10 minute warm-up.
- The training intensity and volume should be in line with what the child can cope with easily and safely.
- Resistance should be increased gradually as the strength improves.

- Target the major muscle groups in balance and include exercises to strengthen the lower back and abdominals.
- Cool down with less intense exercises and stretching.
- Optimize performance and recovery with good nutrition, proper hydration, and adequate rest and sleep.
- The exercise program must be made diverse, fresh and challenging by systematical variations in order to optimize gains and prevent boredom. It is important that every participant feels comfortable with the program and should look forward to next session.
- Support and encouragement from the parents and instructors will help maintain interest.

REFERENCES

American Academy of Pediatrics (1976). Fitness in the preschool child. Pediatrics, 1, 88-89.

American Academy of Pediatrics (2008). Strength training by children and adolescents. Pediatrics 121, 835–40.

American College of Sports Medicine (2006). ACSM's guidelines for exercise testing and prescription. 7th ed. Lippincott, Williams & Wilkins. Philadelphia, Pennsylvania.

Annesi, J., Westcott, W., Faigenbaum, A., & Unruh, J. (2005). Effects of a 12 week physical activity program delivered by YMCA after-school counselors (Youth Fit for Life) on fitness and self-efficacy changes in 5–12 year old boys and girls. Research Quarterly for Exercise & Sport, 76, 468-76.

Behm, D., Leonard, A., Young, W., Bonsey, A., & MacKinnon, S. (2005). Trunk muscle EMG activity with unstable and unilateral exercises. Journal of Strength Conditioning Research, 19, 193-201.

Benson, A., Torade, M., & Fiatarone Singh, M. (2006). Muscular strength and cardiorespiratory fitness is associated with higher insulin sensitivity in children and adolescents. International Journal of Pediatric Obesity, 1, 222-31.

British Association of Sport and Exercise Science (2004). BASES position statement on guidelines for resistance exercise in young people. Journal of Sports Sciences, 22, 383-90.

Canadian Society for Exercise Physiology position paper (2008). Resistance training in children and adolescents. Journal of Applied Physiology, Nutrition and Metabolism, 33, 547-61.

Diallo, O., Dore, E., Duche, P,, & Van Praagh, E. (2001). Effects of plyometric training followed by a reduced training program on physical performance in prepubescent soccer players. Journal of Sports Medicine & Physical Fitness, 41, 342-8.

Docherty, D. Wenger, H., Collis, M., & Quinney, H. (1987). The effects of variable speed resistance training on strength development in prepubertal boys. Journal of Human Movement Studies, 13, 377-82.

Faigenbaum, A, Milliken, L, Moulton, L, & Westcott, W. (2005). Early muscular fitness adaptations in children in response to two different resistance training regimens. Pediatric Exercise Science, 17, 237–48.

Faigenbaum, A. (1995). Psychosocial benefits of prepubescent strength training. Strength and Conditioning. 17(2), 28-32.

Faigenbaum, A. (2000). Strength training for children and adolescents. Clinics in Sports Medicine, 19, 593-619.

Faigenbaum, A. (2007). Resistance training for children and adolescents: Are there health outcomes? American Journal of Lifestyle Medicine, 1, 190-200.

Faigenbaum, A. D., Milliken, L. A., & Westcott, W. L. (2003). Maximal strength testing in healthy children. Journal of strength and conditioning research, 17(1), 162-6.

Faigenbaum, A., & Mediate, P., (2006). The effects of medicine ball training on physical fitness in high school physical education students. Physical Educator, 63, 160-7.

Faigenbaum, A., Loud, L., O'Connell, J., Glover, S., O'Connell, J., & Westcott, W. (2001). Effects of different resistance training protocols on upper body strength and endurance development in children. Journal of Strength Conditioning Research, 15, 459-65.

Faigenbaum, A., McFarland, J., Keiper, F., Tevlin, W., Kang, J., Ratamess, N., & Hoffman, J. (2007). Effects of a short term plyometric and resistance training program on fitness performance in boys age 12 to 15 years. Journal of Sports Science & Medicine, 6, 519-25.

Faigenbaum, A., Zaichkowsky, L., Westcott, W., Micheli, L., & Fehlandt, A. (1993). The effects of a twice per week strength training program on children. Pediatric Exercise Science, 5, 339-46.

Falk, B., & Mor, G. (1996). The effects of resistance and martial arts training in 6- to 8-year-old boys. Pediatric Exercise Science, 8, 48-56.
Falk, B., & Tenenbaum, G. (1996). The effectiveness of resistance training in children. A meta-analysis. Sports Medicine, 22, 176-86.
Flanagan, S., Laubach, L., DeMarco, G., Alvarez., C, Borchers, S., et al. (2002). Effects of two different strength training modes on motor performance in children. Research Quarterly for Exercise & Sport, 73, 340-44.
Fukunga, T, Funato, K, & Ikegawa, S. (1992). The effects of resistance training on muscle area and strength in prepubescent age. Annals of Physiological Anthropology Journal, 11, 357-64.
Hamar, D. (2008). Monitoring of power in the weight room. In Fleck, S. J. & Kraemer, J. W., 6th international conference on strength training (icst 2008) (pp. 355-59). Colorado Springs, CO, U.S.A.
Hass, C. J., Feigenbaum, M. S., & Franklin, B. A. (2001). Prescription of resistance training for healthy populations. Sports Medicine, 31, 953-64.
Heinonen, A., Sievanen, H., Kannus, P., Oja, P., Pasanen, M., & Vouri, I. (2000). High-impact exercise and bones of growing girls: a 9-month control trial. Osteoporosis International, 11, 1010-7.
Hetherington, M. (1976). Effects of isometric training on the elbow flexion force torque of grade five boys. Research Quarterly, 47, 41-7.
Highland T. R., Dreisinger, T. E., Vie, L. L., Russell, G. S. (1992). Changes in isometric strength and range of motion of the isolated cervical spine after eight weeks of clinical rehabilitation. Spine, 17 (6), 77-82.
Kotzamanidis, C. (2006). Effect of plyometric training on running performance and vertical jumping in prepubertal boys. Journal of Strength Conditioning Research, 20, 441-5.
Lephart, S., Abt, J., Ferris, C., Sell, T., Nagai, T., Myers, J., & Irrgang, J. (2005). Neuromuscular and biomechanical characteristic changes in high school athletes: A plyometric versus basic resistance program. British Journal of Sports Medicine, 39, 932-8.
Matavulj, D., Kukolj, M., Ugarkovic, J., Tihanyi, J., & Jaric, S. (2001). Effects of plyometric training on jumping performance in junior basketball players. Journal of Sports Medicine & Physical Fitness, 41, 159-64.
Mersch, F., & Stoboy, H. (1989). Strength training and muscle hypertrophy in children. In S. Oseid, & K. Carlsen, eds, Children and Exercise XIII (pp. 165–82). Champaign, IL: Human Kinetics Books.
Metcalf, J., & Roberts, S. (1993). Strength training and the immature athlete: an overview. Pediatric Nursing, (19), 325–32.
National Strength and Conditioning Association (2009). Youth resistance training: updated position statement paper. Journal of Strength Conditioning Research, 23(5 Suppl), S60-79.
Ozmun, J., Mikesky, A., & Surburg, P. (1994). Neuromuscular adaptations following prepubescent strength training. Medicine & Science in Sports & Exercise, 26, 510-4.
Payne, V., Morrow, J., Johnson, L., & Dalton, S. (1997). Resistance training in children and youth: A meta-analysis. Research Quarterly for Exercise & Sport, 68, 80-8.
Ramsay, J., Blimkie, C., Smith, K., Garner, S., Macdougall, J., & Sale, D. (1990). Strength training effects in prepubescent boys. Medicine & Science in Sports & Exercise, 22, 605-14.
Selvadurai, C., Blimkie, C., Meyers, N., Mellis, C., Cooper, J., & Asperen, V. (2002). Randomized controlled study of in-hospital exercise training programs in children with cystic fibrosis. Pediatric Pulmonology, 33, 194-200.
Siegal, J., Camaione, D., & Manfredi, T. (1989). The effects of upper body resistance training in prepubescent children. Pediatric Exercise Science, 1, 145–54.
Sothern, M, Loftin, J, Udall, J, Suskind, R, Ewing, T, Tang, S, & Blecker, U. (2000). Safety, feasibility and efficacy of a resistance training program in preadolescent obese youth. American Journal of the Medical Sciences, 319, 370-5.
Stuberg, W. A., & Metcalf, W. K. (1988). Reliability of quantitative muscle testing in healthy children and in children with duchenne muscular dystrophy using a hand-held dynamometer. Physical Therapy, 68, 977-82.
Sung, R., Yu, C., Chang, S., Mo, S., Woo, K., & Lam, C. (2002). Effects of dietary intervention and strength training on blood lipid level in obese children. Archives of Disease in Childhood, 86, 407-10.
Szymanski, D, Szymanski, J, Bradford, J, Schade, R, & Pascoe, D., (2007). Effect of twelve weeks of medicine ball training on high school baseball players. Journal of Strength & Conditioning Research, 21, 894-901.
Tsolakis, C., Vagenas, G., & Dessypris, A. (2004). Strength adaptations and hormonal responses to resistance training and detraining in preadolescent males. Journal of Strength & Conditioning Research, 18, 625-9.
Turner, C., & Robling, A. (2003). Designing exercise regimens to increase bone strength. Exercise & Sport Sciences Reviews, 31, 45-50.
United States Consumer Product Safety Commission (1987). National Electronic Injury Surveillance System. Washington, DC: Directorate for Epidemiology, National Injury Information Clearinghouse.
Vicente-Rodriguez, G. (2006). How does exercise affect bone development during growth? Sports Medicine, 36, 561-9.

Watts, K., Jones, T., Davis, E., & Green, D. (2005). Exercise training in obese children and adolescents. Sports Medicine, 35, 375-92.
Webb, D. (1990). Strength training in children and adolescents. Pediatric Clinic's North America, 37, 1187-210.
Westcott, W. L. (1991). Safe and sane strength training for teenagers. Scholastic Coach, 61 (3), 42-44.
Westcott, W. L. (1992). A look at youth fitness. American Fitness Quarterly, 11 (1), 16-19.

TRENING SA OPTEREĆENJEM KOD MLADIH

Aleksandar Ignjatović, Ratko Stanković, Dragan Radovanović, Živorad Marković, Jan Cvećka

Trening sa opterećenjem (popularno ali nepravilno nazivan: trening snage) obuhvata vežbanja na spravama, sa tegovima, ekspanderima ili vežbama koje koriste težinu sopstvenog tela, sa ciljem razvoja mišićne sile, snage i izdržljivosti. Uključivanje mladih u organizovani trening sa opterećenjem nije oduvek bilo ohrabrivano od strane stručnjaka, ali su rezultati brojnih istraživanja, jasno ukazala na pozitivne strane. Takođe, zvanični stavovi vodećih svetskih strukovnih udruženja i zdravstvenih organizacija, kao i pregledni članci jasno ukazuju na to da pravilno dizajniran trening sa opterećenjem može biti izuzetno koristan za decu i adolescente. Trening se mora izvoditi u bezbednom okruženju, pod stalnim nadzorom kvalifikovanih osoba.

Ključne reči: *trening sa opterećenjem, deca, adolescenti, pozitivne strane, rizici*