



## Youth Resistance Training

### Introduction

Although boys and girls have traditionally been encouraged to participate in aerobic activities such as bicycling and swimming, they have not always been encouraged to participate in resistance training. In recent years a growing body of evidence has accumulated to indicate that resistance training can be a safe, effective, and beneficial method of conditioning for youth. Research into the effects of resistance exercise on children and adolescents has increased over the past decade, and the qualified acceptance of youth strength training by medical and fitness organizations has become almost universal. The American Academy of Pediatrics (2001), the American College of Sports Medicine (2000), the American Orthopaedic Society of Sports Medicine (1988), and the National Strength and Conditioning Association (Faigenbaum et al., 1996) support participation in youth resistance training activities provided the program is appropriately designed and competently supervised.

Despite earlier concerns regarding the safety and efficacy of youth resistance training, it is now commonplace for boys and girls of all ages and abilities to resistance train in schools, recreation centers, and sport camps to enhance their health, fitness, and athletic performance. Regular participation in a resistance training program provides youth with an opportunity to be exposed to safe, effective, and fun training methods that can be carried over into adulthood. The purpose of this article is to discuss the trainability of muscular strength in youth, highlight the potential benefits and concerns associated with youth resistance training, and outline resistance training guidelines for children and adolescents.

It must be emphasized that the term resistance training refers to a specialized method of conditioning that involves the progressive use of a wide range of resistive loads and a variety of training modalities (e.g., free weights [barbells and dumbbells], weight machines, elastic cords, medicine balls, and body weight) designed to enhance muscle function, increase muscle size, improve body composition, boost sports performance, and reduce athletic injuries. While the terms resistance training, strength training, and weight training are sometimes used synonymously, the term resistance training encompasses a broader range of training modalities and a wider variety of training goals. The term resistance training should be distinguished from the competitive sports of bodybuilding, powerlifting, and weight lifting in which individuals routinely train at high intensities to maximize muscle size, strength, and power. In this paper the term children refers to boys and girls who have not yet developed secondary sex characteristics (approximately up to age 12) and the term adolescent includes boys and girls between 13 and 18 years of age. For ease of discussion, the term youth is defined broadly to include children and adolescents.

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### Trainability of Youth

Although the potential for adolescents to increase their muscular strength in response to resistance training is well established (Gallagher & DeLorme, 1949), the potential for children to enhance their muscular strength by resistance training has been questioned in the past (Vrijens, 1978). The prevailing attitude among some educators, scientists, and clinicians was that training-induced strength gains before puberty were not possible due to inadequate levels of circulating androgens. Even though findings from several research studies supported this contention, methodological limitations such as a short study duration or low training volume (sets x repetitions x load) may have influenced the results (Docherty, Wenger, Collis, & Quinney, 1987; Vrijens, 1978). Since muscular strength normally increases throughout childhood and

adolescence, perhaps a more appropriate conclusion from earlier reports which questioned the trainability of youth is that training-induced strength gains from a low volume, short-term training program are not distinguishable from gains attributable to normal growth and development.

Recent investigations using higher training volumes and longer training periods provide compelling evidence that training-induced strength gains are indeed possible during childhood and adolescence (see reviews by Faigenbaum et al., 1996; Falk & Tenenbaum, 1996; Guy & Micheli, 2000). A variety of training modalities and different combinations of sets and repetitions have provided an adequate stimulus for strength enhancement in young weight trainers. Strength gains of roughly 30% to 50% are typically observed in untrained youth following short-term (8-12 weeks) training programs. In general, it appears that percentage-based strength gains made by children and adolescents are similar to gains made by adults who resistance train. Observations from coaches, teachers, and health care providers provide additional evidence that well-designed resistance training programs can enhance the strength of children and adolescents beyond what is normally the result of growth and maturation.

***Mechanisms of Strength Gain***

Since children lack adequate levels of circulating androgens to stimulate increases in muscle hypertrophy, it is believed that neural adaptations are primarily responsible for training-induced strength gains during childhood. Several researchers reported significant gains in muscle strength in children without concomitant increases in limb circumference, as compared with age-matched controls (Ozmun, Mikesky, & Surburg, 1994; Ramsay et al., 1990). The observed training-induced gains in muscle strength in children have been attributed to neural adaptations including changes in motor unit activation and motor unit coordination, recruitment and firing. Researchers also postulate that intrinsic muscle adaptations as well as improvements in motor skill performance and the coordination of the involved muscle groups could be partly responsible for training-induced strength gains in children (Ramsay et al., 1990). In a review of this topic, Sale (1989) noted that untrained children may have more difficulty activating their muscles compared to adults and therefore may have more of a potential for an increase in strength due to neural factors rather than as increases due to hypertrophic factors.

It is possible, however, that longer training programs (> 5 months), higher training volumes and more precise measure techniques (e.g., computerized imaging) may uncover the potential for training-induced gains in muscle hypertrophy in children. In fact, two reports involving children have challenged the suggestion that training-induced gains before puberty are independent of changes in muscle size (Fukunga, Funato, & Ikegawa, 1992; Mersch & Stoboy, 1989). Thus it can not be stated with complete confidence that resistance

training will not result in at least some degree of muscle hypertrophy in children above and beyond growth and maturation. During adolescence, training-induced strength gains in boys are associated with an increase in fat free mass due to hormonal influences (e.g., testosterone) whereas muscular development in girls is limited by lower levels of androgens.

**Benefits of Youth Resistance Training**

In addition to enhancing muscular strength and local muscular endurance, regular participation in a youth resistance training program has the potential to influence several measurable indices of health and fitness. Youth resistance training programs may help strengthen bone, facilitate weight control, improve one’s cardiovascular risk profile, enhance motor skills and sports performance, and reduce injuries in sports and recreational activities. The potential benefits of youth strength training are summarized in table 1.

<b>Table 1. Potential Benefits of Youth Resistance Training</b>
<ul style="list-style-type: none"> <li>• Increase muscle strength</li> <li>• Increase muscular power</li> <li>• Increase local muscular endurance</li> <li>• Increase bone mineral density</li> <li>• Increase cardiorespiratory fitness</li> <li>• Improve blood lipid profile</li> <li>• Improve body composition</li> <li>• Improve motor performance skills</li> <li>• Enhance sports performance</li> <li>• Increase resistance to injury</li> <li>• Enhance mental health and well-being</li> <li>• Stimulate a more positive attitude towards lifetime physical activity</li> </ul>

***Health-related Benefits***

Although the health benefits of youth resistance training have not been unequivocally established, a growing body of evidence suggests that appropriately prescribed and competently supervised resistance training programs may have observable health value for boys and girls. Along with other types of physical activity, regular participation in resistance training activities has been shown to positively influence bone mineral density (Morris, Naughton, Gibbs, Carlson, & Wark, 1997), body composition (Sothorn et al., 2000), cardiorespiratory fitness (Weltman et al., 1986), blood

lipids (Weltman, Janney, Rians, Strand, & Katch, 1987) and psychosocial well-being (Holloway, Beuter, & Duda, 1988). In addition, preparatory conditioning that includes resistance training may decrease the incidence of some acute and overuse sports-related injuries in young athletes (Smith, Andrich, & Micheli, 1993).

A common misperception related to youth resistance training is that it will stunt the statural growth of youth or damage the epiphyseal or growth plates. This myth seems to have come from an earlier report that suggested that children who performed heavy labor experienced damage to their epiphyseal plates which results in significant decreases in stature (Kato & Ishiko, 1964). However, this study did not control for other etiological factors such as poor nutrition that could be responsible for the reported growth arrest. Current observations indicate no evidence of a decrease in stature in youth who participate in resistance training programs in controlled environments (Sadres, Eliakim, Constantini, Lidor, & Falk, 2001).

In all likelihood, if established training guidelines are followed and if nutritional recommendations (e.g., adequate calcium) are adhered to, participation in regular physical activity (including resistance training) will have a favorable influence on growth at any stage of development but will not affect the genotypic maximum (Bailey & Martin, 1994). In fact, the belief that resistance training is harmful to the immature skeleton of youth weight trainers is not consistent with current findings suggesting that childhood may be the period during which the bone-modeling process responds best to the mechanical loading of physical activities such as resistance training (Bass, 2000). This potential benefit may be especially important for young women who are at increased risk of developing osteoporosis.

Another potential health benefit of youth resistance training is its influence on body composition. As the number of overweight children and adolescents in the United States continues to increase (Styne, 2001), the effects of resistance training on body composition has received increased attention. Although aerobic exercise is typically prescribed for decreasing body fat, several youth resistance training studies have reported a decrease in fatness among participants (Faigenbaum, Zaichkowsky, Westcott, Micheli, & Fehlandt, 1993; Lillegard, Brown, Wilson, Henderson, & Lewis, 1997; Siegal, Camaione, & Manfredi, 1989). More recently, researchers observed that resistance training may be a valuable mode of exercise for treating childhood obesity (Sothorn et al., 2000). It appears that overweight and obese youth enjoy resistance training because it is not aerobically taxing and it gives all participants — regardless of body size — a chance to experience success and feel good about their performance. Whereas further study is warranted, the first step in encouraging overweight and obese youth to exercise may be to increase their confidence in their ability to be physically active, which in turn may lead to an increase in physical activity and a decrease in body fat.

The potential psychosocial benefits (i.e., psychological and social outcomes) should not be overlooked. It has been observed that the socialization and mental discipline exhibited by children and adolescents participating in a resistance training program are similar to experiences of youth participating in team sports and other activities (Faigenbaum, 1995). If age-specific training guidelines are followed and if the program is supervised by instructors who appreciate the uniqueness of childhood and adolescence, favorable changes in selected psychometric measures may be observed. Although speculative, it is likely that resistance training will have its greatest impact on youth who begin with relatively low levels of muscular strength and poor body attitudes. Keep in mind, however, that excessive pressure to perform beyond one's capability can negatively influence the resistance training experience and can lead to untoward consequences (Gould, 1993).

### ***Motor Skills and Sports Performance***

Since many sports have a significant strength or power component it is logical to assume that a stronger and more powerful athlete will perform better. Moreover, if young athletes gain confidence in their physical abilities they may be more likely to experience success and less likely to drop out of sports due to embarrassment, failure or possible injury. Several studies have demonstrated significant improvements in the vertical jump, long jump, sprint speed, agility run time, and medicine ball put in youth following resistance training (Falk & Mor, 1996; Flanagan et al., 2002; Lillegard et al., 1997, Weltman et al., 1986). However, others have reported gains in strength without any improvements in selected motor performance skills (Faigenbaum et al., 1993).

As previously observed in older populations, it appears that training adaptations in youth are not only specific to the movement pattern, but also to the velocity of movement, contraction type, and contraction force. Consequently, resistance training programs that include relatively fast speed movements (e.g., plyometrics) which are specific to the motor performance test may be more likely to induce improvements in selected performance measures compared with programs characterized by less specific exercises. Plyometric exercises such as hops, jumps, and throws can be incorporated into a youth resistance training program provided that the training intensity and volume does not exceed the abilities of the participants. A note of caution here; children should develop an adequate base of strength before participating in a plyometric training program or they should begin plyometric training with low intensity drills and gradually progress to higher intensities over time (Faigenbaum & Chu, 2001).

### ***Injury Reduction***

In the United States millions of boys and girls participate in school and community-based programs. But along with this remarkable interest in youth sport has been a concomitant

increase in the number of sports-related injuries due to ill-prepared and improperly trained young athletes (Outerbridge & Micheli, 1995). While factors such as growth, improper footwear, hard playing surfaces, anatomic malalignment of the legs, and underlying disease states have been implicated as risk factors for overuse injuries in youth (Micheli, 1983), the background physical activity level of young athletes must also be considered. Fewer youth are exposed to physical education than in the past and sedentary pursuits such as television viewing and “surfing the internet” continue to occupy a significant amount of a youngster’s free time (Dietz, 1990; Morrow & Jackson, 1999). According to the American College of Sports Medicine, an estimated 50% of all injuries sustained by youth while playing sports could be prevented if more emphasis was placed on developing fundamental fitness abilities prior to sports participation (Smith, Andrich, & Micheli, 1993).

By enhancing musculoskeletal strength and developing muscle balance around joints, resistance training may decrease the incidence of injury in young athletes. Several studies have reported decreased injury rates in adolescents who participated in a preseason conditioning program that included resistance training (Heidt, Swetterman, Carlonas, Traub, & Tekulve, 2000; Hejna, Rosenberg, Buturusis, & Krieger, 1982; Hewett, Lindenfeld, Riccobene, & Noyes, 1999) and it seems likely that resistance training could offer a similar protective effect to children (Faigenbaum & Micheli, 2000). While the total elimination of sports-related injuries is an unrealistic goal, encouraging aspiring young athletes to participate in several weeks of preparatory conditioning (which includes resistance training) before sports participation merits consideration. During this time correctable risk factors such as poor physical condition and muscle imbalances can be identified and treated by qualified coaches, teachers, and trainers. Participation in a preseason conditioning program may be particularly important for sedentary and overweight youth who may not be prepared to handle the duration and magnitude of forces that develop during sports practice and games situations. While participation in a preseason conditioning program may not be necessary for very young athletes or youth who plan to play recreational sports, the need for preseason conditioning becomes more important as the intensity and competitive level increase. The National Athletic Trainers Association (NATA) suggest that high school athletes engage in conditioning activities at least six weeks before the start of practice (NATA, 2002).

While resistance training itself has been shown to be safe and beneficial for youth, care should be taken to assure that resistance training does not contribute to overtraining. Other aspects of preparing youth for sports such as practicing sport-specific skills must also be considered. Practicing skills adds to the chronic repetitive stress placed on the musculoskeletal system, and therefore care should be taken not to simply add resistance training to a youngster’s workout, but rather to incorporate resistance training into a

well-balanced conditioning program. In some cases, youth may need to decrease the time they spend practicing sport-specific skills to allow time for preparatory muscle conditioning.

## Risks and Concerns

One traditional concern associated with youth resistance training involves the potential for injury to the epiphyseal plate or growth cartilage. Although epiphyseal plate fractures have been reported in adolescent weight trainers (Gumbs, Segal, Halligan, & Lower, 1982; Ryan & Salciccioli, 1976), these reports were case studies and typically involved improper lifting techniques or the performance of heavy loads with inadequate supervision. An epiphyseal plate fracture has not been reported in any prospective study that was competently supervised and appropriately designed. If resistance training programs are conducted by qualified instructors and are planned with age-specific needs in mind, the risk of joint injury is negligible. However, if established training guidelines are not followed, accidents and injuries are possible (Risser, 1991). Coaches, teachers, and trainers must be aware of the inherent risk associated with resistance training and should attempt to decrease this risk by following established training guidelines.

It is also important to keep in mind that youth should not resistance train on their own without guidance from qualified teachers and coaches. Training without supervision and instruction can result in injury and overtraining. Further, teachers and coaches should be careful to match the resistance training program to the needs, interests, and abilities of each participant. A structured resistance training program for a high school athlete would be inappropriate for a young child who should be given an opportunity to experience the mere enjoyment of different types of resistance exercise. In any case, it is always better to underestimate the physical abilities of participants rather than overestimate them and risk negative consequences (e.g., dropout or injury). With qualified instruction, gradual training progression, and knowledge of the developmental uniqueness of children and adolescents, youth can get stronger, feel good about their performance, and have fun.

## Youth Resistance Training Guidelines

Resistance training can be recommended to children and adolescents as one part of a well-rounded physical activity program that also includes games and activities designed to enhance cardiorespiratory fitness, flexibility, agility, and balance. The following guidelines should be considered by those who are interested in helping children and adolescents participate in resistance training programs.

**1. Adapt the program to the participant’s developmental level.** Although there is no minimal age requirement for participation in a youth resistance training program, first exposure to resistance training activities may be informal. For children beginning resistance training, it is important to



choose activities that match abilities. For example, body weight calisthenics and exercises with elastic cords or lightweight medicine balls are often appropriate for young resistance trainers. During this time children are unable to delay gratification in pursuit of some future benefit like strong bones. Adherence to more formal training programs requires emotional maturity and the ability to follow directions. These are characteristics possessed by most, but not all children, by the middle elementary school years. Abstract, rather than concrete thinking, begins to emerge in the upper elementary school years and at this time participants are more likely to see the benefits of a more comprehensive resistance training program. By adolescence, interest in resistance training may be greater and the ability to tolerate more structured training programs with more advanced exercises may be higher.

**2. Instruction by qualified professionals is essential.** Youth resistance training programs should be conducted by qualified instructors, teachers, and coaches who understand the fundamental principles of resistance exercise and the uniqueness of childhood and adolescence. Close supervision, age-appropriate instruction, and a safe exercise environment are paramount. A pre-training medical exam is not required for apparently healthy youth; however, professionals should refer participants with known or suspected health problems to their health-care provider before beginning a resistance training program.

**3. Start gradually and progressively increase overload.** It has been recommended that children and adolescents resistance train two or three days per week on nonconsecutive days and perform 1 to 3 sets of 6 to 15 repetitions on a variety of exercises that focus on the major muscle groups (Faigenbaum et al., 1996). However, when beginning a resistance training program, performing a single set of 10 to 15 repetitions per exercise twice per week will not only allow for positive changes in muscle function, but will also provide an opportunity for participants to gain confidence in their abilities before progressing to more advanced levels (Faigenbaum, Westcott, Loud, & Long, 1999). Table 2 highlights general youth resistance training guidelines.

Over time, continual gains can be made by gradually increasing the resistance, the number of repetitions, or the number of sets. On average, a 5% to 10% increase in training load (typically 2 to 5 pounds) is appropriate for most exercises. Once the desired number of repetitions can be performed, the weight can be gradually increased, and the repetitions can be decreased to allow for continual gains. This does not mean that every workout needs to be more intense than the previous session, but over time the demand placed upon one's body should be gradually increased.

**4. Adherence to sound training principles is critical.** Appropriate overload, gradual progression, and adequate recovery between exercise sessions are important considerations. Too often, the volume and intensity of

**Table 2.**  
**Youth Resistance Training Guidelines**

- Provide qualified instruction and supervision
- Ensure the exercise environment is safe and free of hazards
- Teach youth the benefits and risks associated with strength training
- Begin each session with a 5 to 10 minute warm-up period
- Start with one light set of 10 to 15 repetitions on a variety of exercises
- Include exercises to strengthen the lower back and abdominals
- Progress to 2 or 3 sets of 6 to 15 repetitions depending on needs and goals
- Increase the resistance gradually as strength improves
- Focus on the correct exercise technique instead of the amount of weight lifted
- Strength train two to three times per week on nonconsecutive days
- Listen carefully to each child's concerns and answer any questions
- When necessary, adults spotters should be nearby in the event of a failed repetition
- Focus on participation with lots of movement and positive reinforcement
- Keep the program fresh and challenging by systematically varying the training program

resistance training exceeds a participant's capabilities and the rest periods are too short for adequate recovery. This approach may be particularly hazardous for young children because it not only increases the risk of injury, but it may undermine enjoyment of the resistance training experience. Although it may be tempting to follow a college resistance training program or a workout described in a fitness magazine, each participant must be treated as an individual and therefore the training intensity, volume, and progression needs to be carefully prescribed.

**5. Proper technique should be taught and reinforced.** Although some participants might want to see how much weight they can lift on the first day of the program, their interest and enthusiasm in resistance training should be redirected toward developing proper form and exercise technique (i.e., controlled movements and proper breathing). In some cases it may be appropriate to use an unloaded barbell or a long wooded stick when teaching youth how to perform multi-joint free weight exercises.

**6. Emphasize intrinsic enjoyment.** When working with youth it is important to focus on intrinsic factors such as skill improvement, personal successes, and having fun. The use of personalized workout logs can help to focus each participant's attention on his or her own improvement.

**7. Incorporate variety into the training program.** Adding new exercises, changing the training mode, and varying the number of sets and repetitions can help to keep the program fresh and challenging. Incorporating calisthenics, elastic cords, and medicine balls into the resistance training program can be effective, beneficial, and fun.

**8. Consider multiple goals.** When working with boys and girls, it is important to remember that the goal of the program should not be limited to increasing muscle strength. Teaching youth about their bodies, promoting safe training procedures, and providing a stimulating program that gives participants a more positive attitude towards resistance training and physical activity are equally important.

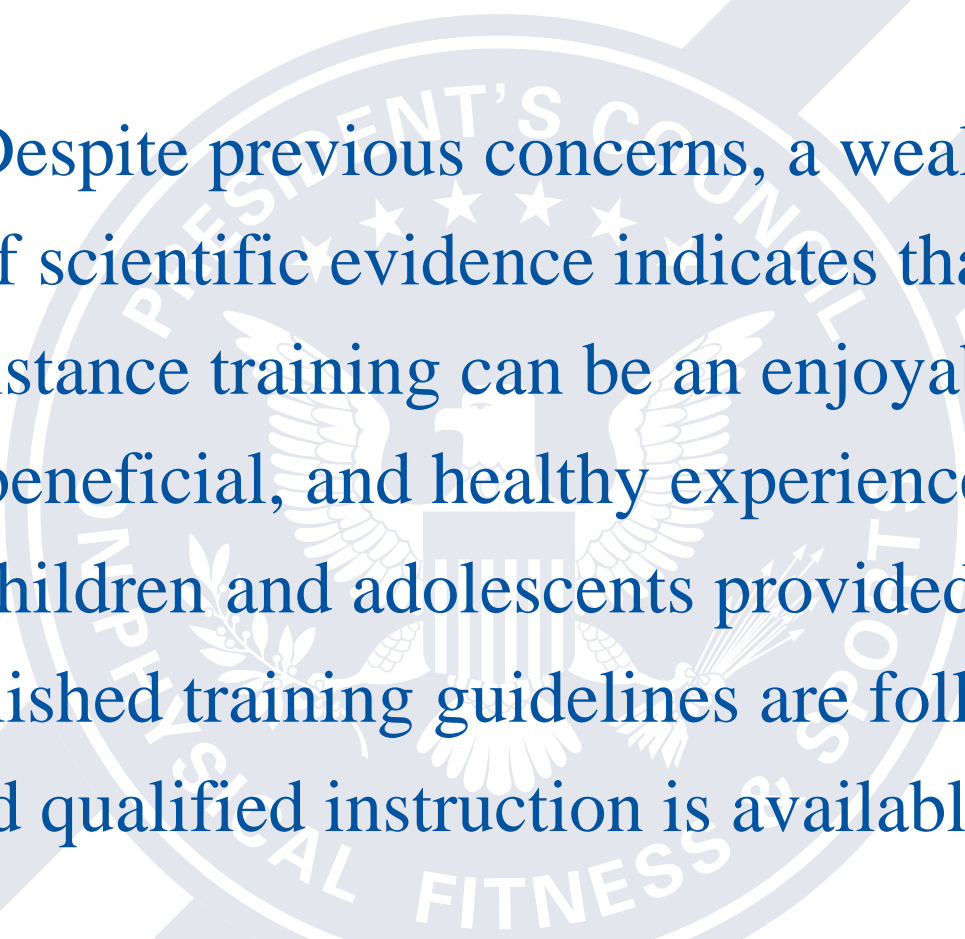
**9. Listen to children and teach them to listen to their bodies.** Regardless of the strength or size of a child, adult training guidelines and training philosophies (i.e., "no pain, no gain") should not be imposed on young resistance trainers. Adults need to listen to each participant's concerns, monitor progress, and understand the physical and psychological uniqueness of children and adolescents. Some youth with poor levels of fitness may not be able to tolerate the same amount of exercise some of their peers in the same training program can tolerate. This is where the art and science of developing a resistance training program comes into play because the principles of training specificity and progressive overload need to be balanced with individual

needs and abilities in order to optimize gains, prevent boredom, and reduce the stress from overtraining. Detailed information on designing youth resistance training programs is available elsewhere (Faigenbaum & Westcott, 2000).

## Summary

Participation in a resistance training program, along with other types of physical activity, gives children and adolescents yet another opportunity to improve their health and quality of life. Scientific evidence indicates that youth resistance training programs are no more risky than other sports and activities in which children and adolescents regularly participate. Medical and fitness organizations now support participation in well-designed and properly instructed youth resistance training programs. Regular participation in a youth resistance training program can favorably influence selected health- and fitness-related measures for all youth and can improve the preparedness of aspiring young athletes for the demands of sports practice and competition.

Parents, teachers, and coaches should realize that resistance training is a specialized method of conditioning that can offer many benefits, but at the same time can result in injury if age-appropriate training guidelines are not followed. When conducted by competent instructors who possess a sound understanding of resistance training principles and developmental needs of children and adolescents, resistance training can have many benefits and lead to a lifelong interest in physical activity. We now have the evidence to recommend participation in youth resistance training activities as part of a well-rounded physical activity program.



“Despite previous concerns, a wealth of scientific evidence indicates that resistance training can be an enjoyable, beneficial, and healthy experience for children and adolescents provided that established training guidelines are followed and qualified instruction is available.”

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## References

- American Academy of Pediatrics. (2001). Strength training by children and adolescents. *Pediatrics*. 107(6), 1470-1472.
- American College of Sports Medicine. (2000). *ACSM's Guidelines for Exercise Testing and Prescription* (6th ed.). Baltimore: Lippincott, Williams & Wilkins.
- American Orthopaedic Society for Sports Medicine. (1988). Proceedings of the conference on strength training and the prepubescent. Chicago: American Orthopaedic Society for Sports Medicine.
- Bailey, D., & Martin, A. (1994). Physical activity and skeletal health in adolescents. *Pediatric Exercise Science*. 6(4), 330-347.
- Bass, S. (2000). The prepubertal years. A uniquely opportune stage of growth when the skeleton is most responsive to exercise? *Sports Medicine*, 30(2), 73-78.
- Blimkie, C. (1993). Resistance training during preadolescence. Issues and Controversies. *Sports Medicine*. 15(6), 389-407.
- Dietz, W. (1990). Children and television. In M. Green & R. Hagerty (Ed.), *Ambulatory Pediatrics IV*. (pp. 39-41). Philadelphia, WB Saunders.
- 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(8), 377-382.
- Faigenbaum, A. (1995). Psychosocial benefits of prepubescent strength training. *Strength and Conditioning*. 17(2), 28-32.
- Faigenbaum, A., & Chu, D. (2001). Plyometric training for children and adolescents. American College of Sports Medicine Current Comment. December.
- Faigenbaum, A., & Micheli, L. (2000). Preseason conditioning for the preadolescent athlete. *Pediatric Annals*, 29, 156-161.
- Faigenbaum, A., Kraemer, W., Cahill, B., Chandler, J., Dziados, J., Elfrink, L., Forman, E., Gaudiose, M., Micheli, L., Nitka, M., & Roberts, S. (1996). Youth resistance training: Position statement paper and literature review. *Strength and Conditioning Journal*. 18(6), 62-75.
- Faigenbaum, A., & Westcott, W. (2000). *Strength and Power for Young Athletes*. Champaign, IL: Human Kinetics.
- Faigenbaum, A., Westcott, W., Loud, R., & Long, C. (1999). The effects of different resistance training protocols on muscular strength and endurance development in children. *Pediatrics*. 104 (1), e5.
- 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(4), 339-346.
- Falk, B., & Mor, G. (1996). The effects of resistance and martial arts training in 6 to 8 year old boys. *Pediatric Exercise Science*. 8(1), 48-56.
- Falk, B., & Tenenbaum, G. (1996). The effectiveness of resistance training in children. A meta-analysis. *Sports Medicine*. 22(3), 176-186.
- Flanagan, S., Laubach, L., DeMarco, G., Alvarez, C., Borchers, S., Dressman, E., Gorka, C., Lauer, M., McKelvy, A., Metzler, M., Poepelman, J., Redmond, C., Riggenbach, M., Tichar, S., Wallis, K., & Weseli, D. (2002). Effects of two different strength training modes on motor performance in children. *Research Quarterly for Exercise and Sport*. 73(3): 340-344.
- Fukunga, T., Funato, K., & Ikegawa, S. (1992). The effects of resistance training on muscle area and strength in prepubescent age. *Annals of Physiological Anthropology*. 11, 357-364.
- Gallagher, J., & DeLorme, T. (1949). The use of progressive resistance exercise in adolescence. *The Journal of Bone and Joint Surgery*. 31-A (4), 847-858.
- Gould, D. (1993). Intensive sports participation and the prepubescent athlete: Competitive stress and burnout. In Cahill, B., & Pearl, A. (eds). *Intensive Participation in Children's Sports*. Champaign, IL: Human Kinetics, pp 19-38.
- Gumbs, V., Segal, D., Halligan, J., & Lower, G. (1982). Bilateral distal radius and ulnar fractures in adolescent weight lifters. *American Journal of Sports Medicine*. 10(6), 375-379.
- Guy, J., & Micheli, L. (2001). Strength training for children and adolescents. *Journal of the American Academy of Orthopaedic Surgeons*. 9(1), 29-36.
- Heidt, R., Swetterman, L., Carlonas, R., Traub, J., & Tekulve, F. (2000). Avoidance of soccer injuries with preseason conditioning. *American Journal of Sports Medicine*. 28(5), 659-662.
- Hejna, W., Rosenberg, A., Buturusis, D., & Krieger, A. (1982). The prevention of sports injuries in high school students through strength training. *National Strength and Conditioning Association Journal*. 4, 28-31.
- Hewett, T., Lindenfeld, T., Riccobene, J., & Noyes, F. (1999). The effect of neuromuscular training on the incidence of knee injury in female athletes. *American Journal of Sports Medicine*. 27(6), 699-705.
- Holloway, J., Beuter, A., & Duda, J. (1988). Self-efficacy and training in adolescent girls. *Journal of Applied Social Psychology*. 18(8), 699-719.
- Kato, S., & Ishiko, T. (1964). Obstructed growth of children's bones due to excessive labor in remote corners. In S. Kato (Ed.), *Proceedings of the International Congress of Sports Sciences* (pp. 476). Tokyo: Japanese Union of Sports Sciences.
- Lillegard, W., Brown, E., Wilson, D., Henderson, R., & Lewis, E. (1997). Efficacy of strength training in prepubescent to early postpubescent males and females: Effects of gender and maturity. *Pediatric Rehabil*. 1(3), 147-157.
- Mersch, F., & Stoboy, H. (1989). Strength training and muscle hypertrophy in children. In S. Oseid & K. Carlsen (Ed.), *Children and Exercise XIII*. (pp. 165-182). Champaign, IL: Human Kinetics Books.
- Micheli, L. (1983). Overuse injuries in children's sports: The growth factor. *Orthopedic Clinics of North America*. 14, 337-360.
- Morris, F., Naughton, G., Gibbs, J., Carlson, J., & Wark, J. (1997). Prospective ten-month exercise intervention in premenarcheal girls: Positive effects on bone and lean mass. *Journal of Bone and Mineral Research*. 12, 1453-1462.
- Morrow, J., & Jackson, A. (1999). Physical activity promotion and school physical education. *The President's Council on Physical Fitness and Sports Research Digest*. 3(7):1-8.
- National Athletic Trainers Association. (2002). Minimizing the risk of injury in high school athletics. <http://nata.org/publications/brochures/minimizingtherisks.htm>
- Outerbridge, A., & Micheli, L. (1995). Overuse injuries in the young athlete. *Clinics in Sports Medicine*. 14, 503-516.
- Ozman, J., Mikesky, A., & Surburg, P. (1994). Neuromuscular adaptations following prepubescent strength training. *Medicine and Science in Sports and Exercise*. 26(4), 510-514.
- Ramsay, J., Blimkie, C., Smith, K., Garner, S., MacDougall, J., & Sale, D. (1990). Strength training effects in prepubescent boys. *Medicine and Science in Sports and Exercise*, 22(5), 605-614.
- Rians, C., Weltman, A., Cahill, B., Janney, C., Tippett, S., & Katch, F. (1987). Strength training for prepubescent males: Is it safe? *American Journal of Sports Medicine*, 15(5), 483-489.
- Risser, W. (1991). Weight training injuries in children and adolescents. *American Family Physician*. 44(6), 2104-2110.
- Ryan, J., & Saliciccioli, G. (1976). Fracture of the distal radial epiphysis in adolescent weight-lifters. *American Journal of Sports Medicine*, 4, 26-27.
- Sadres, E., Eliakim, A., Constantini, N., Lidor, R., & Falk, B. (2001). The effect of long-term resistance training on anthropometric measures, muscle strength, and self-concept in pre-pubertal boys. *Pediatric Exercise Science*. 13, 357-372.
- Sale, D. (1989). Strength training in children. In G. Gisolfi & D. Lamb (Ed.), *Perspectives in Exercise Science and Sports Medicine*. (pp. 165-216). Indianapolis, IN: Benchmark Press.
- Siegal, J., Camaione, D., & Manfredi, T. (1989). The effects of upper body resistance training in prepubescent children. *Pediatric Exercise Science*, 1(2), 145-154.
- Smith, A., Andrich, J., & Micheli, L. (1993). The prevention of sports injuries of children and adolescents. *Medicine and Science in Sports and Exercise*. 25 (Suppl. 8), 1-7.
- Sothorn, 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. *The American Journal of the Medical Sciences*. 319(6), 370-375.
- Styne, D. (2001). Childhood and adolescent obesity. *Pediatric Clinics of North America*, 48(4), 823-854.
- Vrijens, F. (1978). Muscle strength development in the pre-and post-pubescent age. *Medicine and Sport*, 11, 152-158.
- Weltman, A., Janney, C., Rians, C., Strand, K., Berg, B., Tippett, S., Wise, J., Cahill, B., & Katch, F. (1986). The effects of hydraulic resistance strength training in pre-pubertal males. *Medicine and Science in Sports and Exercise*, 18(6), 629-638.
- Weltman, A., Janney, C., Rians, C., Strand, K., & Katch, F. (1987). Effects of hydraulic-resistance strength training on serum lipid levels in prepubertal boys. *American Journal of Diseases in Children*, 141(7), 777-780.