Strength Training: A Guide For Teachers and Coaches

Avery D. Faigenbaum, Ed.D., C.S.C.S.
Lasell College
Newton, Massachusetts

For many years, strength training was primarily used by adult male athletes to improve sports performance or enhance their physique. During that era, scientific and empirical evidence supported the role of strength training as an important component of a conditioning program. Increases in voluntary strength, explosive power and lean body mass, along with a reduction in sports related injuries were often observed in various strength training programs (22). Over the past 20 years, however, it has become commonplace for males and females, from novices to professionals, to strength train to improve sports performance, overall fitness and physical appearance.

But adults are not the only ones who benefit from a well designed strength training program. Despite the previously held contention that prepubescent boys and girls could not increase strength due to insufficient levels of circulating androgens (2), current research suggests that prepubescents can safely make significant gains in strength if appropriate training guidelines are followed (Table 1). Furthermore, motor performance gains (56, 86, 90) and health-related benefits (14, 15, 20, 42, 72, 83, 86, 87) have also been reported in children in response to progressive strength training programs.

The focus of the following information is on the potential benefits and concerns of strength training among prepubescent children. Guidelines are offered to help coaches and teachers ensure that prepubescent children participating in strength training activities do so safely and effectively.

By definition, strength training (also termed resistance training) is a method of conditioning using progressive

<table>
<thead>
<tr>
<th>Reference</th>
<th>Age/Grade</th>
<th>Sex</th>
<th>Training Mode</th>
<th>Testing Mode</th>
<th>Duration (Weeks)</th>
<th>Frequency (Per week)</th>
<th>Control Group</th>
<th>Strength Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hetherington</td>
<td>Grade 5</td>
<td>M</td>
<td>Isometric</td>
<td>Isometric</td>
<td>6-8</td>
<td>2-5</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Vrijens</td>
<td>10.4</td>
<td>M</td>
<td>Weights</td>
<td>Isometric</td>
<td>8</td>
<td>3</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Nelson et al.</td>
<td>7-19</td>
<td>F</td>
<td>Isometric</td>
<td>Isometric</td>
<td>5</td>
<td>3</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Baumgartner &amp; Wood</td>
<td>Grades 3-6</td>
<td>M, F</td>
<td>Calisthenics</td>
<td>Calisthenics</td>
<td>12</td>
<td>3</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Clarke et al.</td>
<td>7-9</td>
<td>M</td>
<td>Wrestling</td>
<td>Isometric; Calisthenics</td>
<td>12</td>
<td>3</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>McGovern</td>
<td>Grades 4-6</td>
<td>M, F</td>
<td>Weights</td>
<td>Weights</td>
<td>12</td>
<td>3</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Sevedio et al.</td>
<td>11.9</td>
<td>M</td>
<td>Weights</td>
<td>Isokinetic</td>
<td>8</td>
<td>3</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Pfeiffer &amp; Francis</td>
<td>8-11</td>
<td>M</td>
<td>Weights</td>
<td>Isokinetic</td>
<td>8</td>
<td>3</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Sewall &amp; Micheli</td>
<td>10-11</td>
<td>M, F</td>
<td>Weights;</td>
<td>Isokinetic</td>
<td>9</td>
<td>3</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Weltman et al.</td>
<td>6-11</td>
<td>M</td>
<td>Isometric</td>
<td>Isokinetic</td>
<td>14</td>
<td>3</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Funato et al.</td>
<td>6-11</td>
<td>M, F</td>
<td>Hydraulic</td>
<td>Isokinetic</td>
<td>12</td>
<td>3</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Sailors &amp; Berg</td>
<td>12.6</td>
<td>M</td>
<td>Weights</td>
<td>Isokinetic</td>
<td>12</td>
<td>3</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Siegel et al.</td>
<td>8.4</td>
<td>M, F</td>
<td>Weights;</td>
<td>Isokinetic</td>
<td>12</td>
<td>3</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Ramsay et al.</td>
<td>9-11</td>
<td>M</td>
<td>Weights</td>
<td>Isokinetic; Calisthenics</td>
<td>20</td>
<td>3</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Williams</td>
<td>10.5</td>
<td>M</td>
<td>Weights</td>
<td>Isokinetic</td>
<td>8</td>
<td>3</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Brown et al.</td>
<td>Tanner 1-2+</td>
<td>M, F</td>
<td>Weights</td>
<td>Weights</td>
<td>12</td>
<td>3</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Westcott</td>
<td>10.5</td>
<td>M, F</td>
<td>Weights</td>
<td>Weights</td>
<td>7</td>
<td>3</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Faigenbaum et al.</td>
<td>10.8</td>
<td>M, F</td>
<td>Weights</td>
<td>Weights</td>
<td>8</td>
<td>2</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Abstract;
+Refers to Tanner Stages 1 and 2 of sexual maturation (79).
Resistance to increase the ability to exert or resist force (3). This term must be distinguished from the sport of weightlifting in which individuals often train at high intensities (90 to 100 percent of a one repetition maximum (1 RM)) and attempt to lift maximal amounts of weight. Prepubescent (or prepubertal) refers to a period of time before puberty when boys and girls who have not yet developed secondary sex characteristics such as noticeable pubic hair, axillary hair or pronounced breast development (79). Girls up to the age of 11 to 13 years old and boys younger than 13 to 15 years old are generally considered prepubescent, although individual variations do occur (35).

**Strength Training Benefits**

**Voluntary Strength.** A variety of training programs and methodologies have been used to evaluate the potential for strength gains in prepubescent children. Researchers have manipulated the acute program variables (choice of exercise, order of exercise, sets, loads and rest periods) and have used different training modalities, including weight machines (both adult- (49, 58, 59, 70, 84, 90) and child-size (20, 88)), free weights (9, 59, 65, 69), hydraulic machines (86), pneumatic machines (70), isometric contractions (27, 33, 56), wrestling drills (12), modified pull-ups (5) and calisthenics (72) to provide an adequate stimulus for strength enhancement. Studies have lasted up to 20 weeks (59) and various methods of evaluating changes in voluntary strength have been used. Despite a few inconsistencies (33, 84) which may be explained by limitations in the study design (i.e., low volume of exercise and short study duration), most of these reports, as well as clinical observations (4, 51), clearly indicate that prepubescent children can significantly increase voluntary strength in response to progressive strength training programs (Table 1).

The degree of strength enhancement and improvement on various fitness tests may be influenced by several factors including program design, quality of instruction, study duration, specificity of testing and training and whether or not researchers accounted for the learning effect. Following 14 weeks (three times per week) of circuit weight training (three circuits of approximately 30 repetitions at 10 exercise stations), Weltman, et. al. (86), reported significant increases in strength (25.5 percent vs. 4.0 percent in the control group) and maximal oxygen consumption (ml/kg/min) (13.8 percent vs. -5.4 percent in the control group) in prepubescent boys. In later reports, the subjects trained on hydraulic resistance equipment (concentric contraction only) and were tested isokinetically. In another example, Faigenbaum, et. al. (20), noted strength gains of 74.3 percent in prepubescent boys and girls (as compared to the control group gain of 13.0 percent) following an eight-week (twice per week) progressive strength training program (three sets of 10 to 15 repetitions) using child-size equipment for training and testing. There was no loss of flexibility in either of the aforementioned reports. However, exercises were performed throughout the full range of motion and static stretching was performed prior to the strength training session and at the completion of every workout. Similarly, other studies involving prepubescent children have indicated no change in flexibility (69, 70) or an improvement in flexibility (9, 72, 88) following several weeks of strength training.

Since it is generally accepted that prepubescent children will become stronger in response to progressive strength training programs, recent efforts have attempted to determine the precise underlying mechanisms of training induced strength gains in this population. Without adequate levels of circulating androgens to stimulate increases in muscle hypertrophy, it has been shown that prepubescent children experience more difficulty increasing their muscle mass consequent to strength training (up to 20 weeks), as compared to adult populations (57, 59, 84). Although some findings are at variance with this suggestion (26, 50), researchers have focused on neural adaptations as plausible explanations for training induced strength gains in prepubescent children. In a well-designed study by Ramsay, et al. (59), it was concluded that a trend toward increased motor unit activation, as well as several neurological adaptations such as changes in motor unit coordination, recruitment and firing, were responsible for training induced strength gains in prepubescent boys following 20 weeks of weight training. Furthermore, it was suggested that improvements in motor skill performance and the coordination of the involved muscle groups could be partly responsible for the noted strength gains. Similarly, one abstract (57) reported significant strength gains in prepubescent children without corresponding changes in circumference or skinfold measures, but consistent with increases in the integrated electromyographic (EMG) amplitude of the trained muscle group. In support of these findings, others have observed significant improvements in strength without corresponding increases in limb circumferences, as compared to similar control groups (20, 49, 86).

Limited evidence (57, 59) suggests that neuromuscular mechanisms, in contrast to hypertrophic factors, are essentially responsible for prepubescent strength gains during the first five months of training. This contention provides an impetus for coaches to provide close and competent instruction, with a focus on correct form and safe body mechanics, to optimize strength gains. Although an instructor to child ratio of 1:8 to 1:10 has been suggested (3), it may be helpful to decrease this ratio during the first few weeks of training when children are learning (often for the first time) the correct technique of various exercises. In fact, one study (20) reported an instructor to subject ratio of 1:5 and noted relatively large increases in strength (74.3 percent) in a short period of time (eight weeks).

**Motor Skills and Sports Performance.** In addition to increases in voluntary strength in response to progressive resistance training programs,
the potential for enhanced sports performance is of great interest to youth coaches. A few studies (20, 49, 86, 90) have explored the effects of strength training on various motor performance skills of prepubescent children, although a majority of data involves older populations (22). In one abstract (90), it was reported that prepubescent boys showed significant increases in vertical jump, number of pushups to failure, 30-meter dash time and agility run time following eight weeks of weight training, as compared to an age-matched control group. Other reports (56, 86) involving prepubescent children have also noted increases in vertical jump in response to strength training.

In contrast to these findings, one study (20) reported significant increases in voluntary strength in prepubescent boys and girls without significant improvements in vertical jump and seated medicine ball put measurements when compared to an age-matched control group. Consequently, it is suggested that large gains in strength resulting from a short-term, twice per week, weight training program will not significantly improve upper and lower body motor performance in prepubescent children. This suggestion is consistent with Brown, et al. (9), who concluded that strength gains made by prepubescent boys and girls following a 12-week weight training program were not good predictors of improvement on selected motor performance skills.

The foregoing inconsistencies suggest that the question of training specificity must be addressed when evaluating the training-induced effects of youth strength training programs. As previously noted in adults (67), it appears that training adaptations in children may not only be specific to the movement pattern, but also to the velocity of movement, contraction type and contraction force. Thus, if children are strength training specifically for increases in voluntary strength, should gains in various motor performance tests be expected? At present, the answer is equivocal at best. Some studies (56, 86, 90) have noted significant increases in motor performance tests (primarily the vertical jump) following various strength training programs, whereas others (9, 20) reported inconsistent improvements, as compared to age-matched control groups. However, confounding variables such as the choice of exercise (leg extension vs. leg press), speed of training (fast speed vs. slow speed) and the subjects (both experimental and control) involvement in various sport activities (such as basketball) throughout the study period may have influenced the results.

Although speculative, a youth strength training program characterized by relatively fast speed movements (e.g., isokinetic training above 180 degrees per second) which are specific to the test may be more likely to induce improvements in various motor performance skills, as noted in adults (75), when compared to a weight training program using slow, methodical contractions and less specific movements.

The specific nature of the training effect in children — and the possible transfer to related activities — was observed by Nielsen, et. al. (56). In this study, young girls trained for a particular test (isometric strength, vertical jump or sprint acceleration) by running, jumping or performing isometrics. Following a five-week exercise period, it was shown that the greatest improvements were made in the activity for which the subjects specifically trained. Interestingly, it was also reported that there was some degree of transfer to nonspecific movements, i.e., subjects who performed jumping drills improved on the strength test as well as on the vertical jump, although gains made in the latter test were relatively larger in comparison. This evidence suggests that some transfer of training to similar movements does occur in children, a phenomenon previously noted in adults (22). Nevertheless, if a child has satisfactorily performed basic exercises in an introductory strength training program for an appropriate period of time and wishes to progress to the next step (see strength training guidelines), it may be prudent to incorporate several exercises specific to the child’s sport to increase the likelihood of enhancing sports performance.

Although empirical evidence supports the claim that strength training by prepubescents will improve sports performance, scientific data is limited. One study reported that exercises performed in a swimming pool with a rubber cord may improve strength and swimming technique among 11 and 12-year-old swimmers (10). Conversely, others (23) have observed no significant differences in 14 and 15-year-old boys who attempted to improve various basketball skills via weight training or basketball practice, although it was suggested by the authors that a combined program (including weight training and basketball drills) may produce the most desired results. Even though more applied research involving prepubescents is needed before definitive conclusions can be made, empirical evidence from children and their parents (20, 86), as well as data from older populations (22, 51), suggest that appropriately designed and competently supervised strength training programs will not have a negative effect on sports performance and, in all likelihood, will result in some degree of improvement.

Injury Prevention

Accompanying the suggestion of improved sports performance is the question of whether or not strength training will reduce the risk and severity of injuries in prepubescents. Since information on prepubescent populations is limited, conclusions on the injury-prevention capabilities of strength training are typically based on adolescents and adults. In a study involving 13 to 19-year-old males and females, Henja, et. al. (32), observed that athletes who strength trained had a lower injury rate (26 percent) and required less time for rehabilitation, compared to their teammates who did not strength train (72 percent). In support of these findings, Cahill and Griffith (11) observed that a preseason conditioning program, (which included strength training) for high school foot-
ball players, decreased the number and severity of knee injuries throughout the season, and Dominguez (16) reported that weight training may actually decrease the incidence of shoulder pain in 13 to 18-year-old swimmers. At present, limited data supports the contention that strength training may decrease the risk of injury in adolescents and it has been suggested that the same benefit could occur in prepubescent populations, providing that appropriate training guidelines are followed (3, 42, 51, 54).

Health-Related Benefits

Youth strength training programs may significantly affect various physiological, anatomical and psychological parameters. Improvements in blood lipid profiles (87) and body composition measures (20, 72) of prepubescents and decreases in blood pressure of mildly hypertensive adolescents (31) have been reported as a result of strength training. Anatomically, the bone mineral density of junior competitive weight lifters is reportedly greater than reference norms (15, 83). In addition, an important but often overlooked corollary of youth strength training programs is the potential positive influence upon the psychological and social well-being of children (3, 54).

Reports indicate that strength training may have a favorable effect on the blood lipid profile of adults (36, 81) and limited data suggest similar findings in prepubescents (87) and adolescents (26). In one report involving prepubescent boys (87), total serum cholesterol significantly decreased 15.7 percent (vs. a control group decrease of 3.2 percent) following 14 weeks of strength training. Based upon a review of adult strength training studies (36), and limited data involving prepubescents (87), it appears that moderate loads with a relatively high number of repetitions (e.g., circuit training) are more likely to result in favorable alterations in the blood lipid profiles.

Another potential benefit which may influence the health of children regards the effects of strength training on body composition. As the prevalence of childhood obesity in this country continues to grow (45), coaches more often work with “overfat” children on their teams or in their classes. Several strength training studies involving prepubescents have resulted in a decrease in body fat (20, 72) – a benefit previously reported in adults (91). However, most of the literature on children and strength training suggest that this type of exercise will not significantly affect the body composition of prepubescent populations (49, 59, 86). Factors such as the volume of training, type of training, and the subject’s involvement in various aerobic activities throughout the duration of the study period may be responsible for the reported inconsistencies. For example, high volume circuit weight training programs characterized by moderate intensities and short rest periods seem more likely to elicit positive changes in body composition compared to low volume strength training routines using high intensities and long rest periods. Nevertheless, if fat loss is a top priority, it appears that aerobic exercises (and, perhaps, circuit weight training programs) have the potential to offer the most benefit to prepubescents. It must be emphasized, however, that the issue of childhood obesity is complex and obese children were not studied in the foregoing reports. (See Rowland, 1990, for a review of the role of exercise in the management of childhood obesity.)

An earlier report indicated that children who performed heavy labor in remote areas of Japan experienced damage to their epiphyseal plates which resulted in significant decreases in stature (41); however, etiologic factors, such as nutrition, were not controlled for this study. To date, most of the literature (3) indicates no evidence of a decrease in stature due to heavy repetitive lifting in controlled environments. In fact, Ekblom (18) actually noted an accelerated rate of growth in stature in adolescent boys who participated in a training program, and similar findings have been reported in prepubescents (20, 59, 65, 72, 84, 86). Furthermore, strength training has been shown to enhance the bone mineral density of adults (1, 30, 74, 76), and Fleck and Kraemer (22) have suggested that the development of bone and connective tissue in children would be improved by long-term strength training.

Although the latter contention conflicts with preconceived concerns regarding children and strength training (2, 17, 46), recent findings support their claim (14, 15, 83, 89). If properly performed, strength training appears to be an effective stimulus for bone mineralization in young populations. This suggestion may be especially important for young women who are at increased risk of developing osteoporosis (47).

Despite the common misbelief that strength training will cause chronic hypertension in adults, limited data suggest that strength training will not adversely effect resting blood pressure of prepubescent in the short-term (8-12 weeks) (20, 60, 69). In fact, Serviedo et al. (69) actually reported a decrease in the diastolic blood pressure of prepubescent boys following eight weeks of weight training. Hagberg et al. (31) noted a decrease in blood pressure of hypertensive adolescents following a weight training program using submaximal resistances and Zahka (92) has recommended a low intensity, high repetition weight training program for hypertensive adolescents who want to train with weights. Note that proper form and technique, with a focus on correct breathing mechanics, must be emphasized throughout youth strength training programs. To date, evidence suggests that the resting blood pressure of prepubescent appears to decrease (69) or remain unchanged (20, 60) in response to short-term strength training programs (8 to 12 weeks).

In addition to the aforementioned anatomical and physiological benefits, the potential physiological and social effects of the strength training experience should also be considered. In one study (60), it was reported that the socialization, motor learning and mental discipline exhibited by prepubescents in the strength training program
were similar to the experiences of children participating in team sports. Typically, children are introduced to proper training guidelines and taught the correct technique on various exercises throughout the duration of training programs. Furthermore, coaches often have the opportunity to educate children about the benefits of a healthy lifestyle and, in turn, children are exposed to new learning environments and teaching methodologies outside of the classroom. One report suggested that conditioning programs, which include strength training, may positively influence children’s attitudes toward physical education, physical fitness and lifelong exercise (88). The National Strength and Conditioning Association (NSCA) (54) and the American Orthopaedic Society for Sports Medicine (AOSSM) (3) have stated that this type of coaching will have lasting benefits on young populations.

Several reports have indicated that strength training may positively affect the self-concept of college-age students (38, 77, 82) and similar findings have been suggested in children (3, 54). In one report (86), parents of prepubescents reported that their children were more attentive to homework and other responsibilities on the days that they weight trained. Faigenbaum (21) observed that parents of children in the exercise group noted improvements in their children’s willingness to perform various sport skills and household chores throughout an eight-week strength training program. In the later study (21), verbal and written comments from most of the parents suggested that the effects of the training program extended beyond physiological measures, and likely included improvements in self confidence and fitness awareness. Although speculative, it appears that prepubescent strength training may have the potential to offer various psychological benefits if strength training programs are well-designed and closely supervised by qualified teachers and coaches who appreciate the uniqueness of children and the importance of having fun.

**Strength Training Concerns**

Due to the potential for serious injury among prepubescents while strength training, safety must be of utmost concern to coaches. Injuries have occurred and the potential for injury while strength training has been noted in the literature (6, 28, 29, 39, 40, 48, 62, 64). Thus, despite position statements (3, 54), literature reviews (42, 66, 85) and scientific reports (Table 1) expounding the safety and effectiveness of prepubescent strength training, coaches must be aware of the risk of injury inherent in this type of activity. Furthermore, strength training may be inadvisable among children with various medical ailments such as Marfan syndrome or aortic valve disease (63).

It appears that the potential for injury due to strength training is no greater (and may even be less) than the risk associated with participation in other recreational activities and organized sports. Following a one-year evaluation of sports-related injuries in school-aged children, Zaricznyj, et al. (93), observed that football and basketball had the highest incidence of injuries (19 and 15 percent, respectively), whereas weight lifting (the correct terminology presumably is strength training) resulted in 0.7 percent of all injuries. When the data was evaluated in terms of injuries per 100 participants, football (28.3), wrestling (16.4) and gymnastics (13.3) were at the top of the list; weight lifting was not included in this analysis. Nevertheless, the potential for injury to the epiphyseal plate or growth cartilage while strength training is a unique concern among prepubescents and deserves attention (42, 66, 68, 71). In fact, growth cartilage is often referred to as the weak link in the young skeleton because the strength of cartilage is less than that of bone (7, 73). Most concerns regarding prepubescent strength training focus on the potential for growth cartilage injuries, which may result in limb deformity and the cessation of limb growth (42, 73).

A few reports (29, 40, 62, 64) have indeed noted epiphyseal plate injuries (or accidents) in young weight trainers. However, these reports were case studies and typically involved the performance of heavy, overhand lifts in unsupervised settings. Thus, it is premature to conclude from the foregoing reports that strength training is dangerous for prepubescents when none of the studies previously cited (Table 1) noted injurious effects. In one report (60), the safety of prepubescent strength training was evaluated via biphasic musculoskeletal scintigraphy, as well as the measurement of creatine phosphokinese (CPK), which is a muscle enzyme that is released during muscle necrosis. Following 14 weeks of strength training, no evidence of damage to bones, epiphyses or muscles was found and CPK levels were not elevated (one weight training related shoulder strain resolved within one week of rest). Although the effects of strength training on the articular cartilage and axial skeleton were not evaluated in this study, it was concluded that closely supervised, primarily concentric strength training is safe for prepubescent boys in the short term.

Interestingly, Micheli (51) noted that the potential for a growth plate injury in prepubescents may be even less than in pubescents because the growth plate may be stronger and more resistant to shearing-type forces in younger children compared to adolescents. And this shearing-type load has been reported to be the causal factor of many overuse injuries involving the growth cartilage of children and adolescents (52). Nevertheless, youth coaches must always be aware of the potential for growth cartilage injuries and the abilities (or inabilities) of prepubescent children to withstand the physical demands of strength training.

The potential for injury to the growth cartilage is a constant concern. But injuries to the low back region seem to pose the greatest problem to clinicians (37, 66, 85). Brown and Kimball (8) surveyed 71 adolescent powerlifters who reported training approximately four times per week (it is
assumed that maximal or near maximal lifts were attempted throughout the training period). It was noted that the athletes incurred 98 injuries during their training periods, of which 49 (50 percent) were in the low back area. Similarly, Brady et al. (6) observed that 29 of 43 (67 percent) injured high school athletes developed lumbosacral pain as a direct result of their weight training program. In this study, 17 of the 29 injured athletes used a device designed to improve vertical jump, which may place undue stress on the extended lumbar spine if used incorrectly. It seems possible that similar injuries to the low back region could occur in pubescent if poorly-designed equipment is used and if adult training guidelines are followed.

In addition to the potential for musculoskeletal injuries, there is concern that strength training may cause blackouts (loss of consciousness) and hypertension (3, 54). In adult, competitive weight lifters performing maximal lifts, blackouts have occurred in response to hyperventilation followed by the valsalva maneuver (13). Blackouts have not been reported in adults or prepubescents who follow proper training guidelines and use low to moderate training intensities. Although the acute blood pressure responses to lifting weights are reportedly similar between children and adults (55), chronic hypertension, which has been observed in adult athletes who overtrain (34), has not been reported in young weight trainers who follow appropriate training guidelines.

**Strength Training Guidelines**

A variety of strength training programs have been developed and recommended for children (3, 19, 43, 53, 54, 61). Different types of equipment and various combinations of the acute program variables have proven to be safe and effective when appropriate resistances are used and competent supervision is provided. It is important, however, to look beyond the mere prescription of sets and repetitions when working with prepubescent. With this age group, the goal of the program should not be limited to increasing voluntary strength. Teaching children about their bodies, promoting lifetime fitness and, above all, providing a stimulating program that gives children a more positive attitude toward strength training and exercise in general is equally important.

Coaches must understand and appreciate the uniqueness of children when developing a teaching plan. Children must not be treated as adults; nor should adult training guidelines and teaching methodologies be imposed on prepubescents. Although most 8-year-olds should be able to perform various exercises and understand the risks and benefits associated with strength training, they should not be expected to execute maximal, multi-joint lifts or comprehend the intricacies of periodization. Furthermore, competition should be played down and the focus should remain on proper lifting technique and having fun (80). Instead of being encouraged to compete, children should be taught to embrace self-improvement and feel good about their performances. The use of individualized workout logs will help children focus on improvement.

Based upon position statements from the NSCA (54) and the A0SSM (3), as well as several review articles (24, 43, 66, 85), the following guidelines for the design and implementation of youth strength training programs are recommended:

- Require a medical examination before participation.
- Ensure a safe exercise environment.
- Require emotional maturity to accept and follow directions.
- Consider the physical and psychological uniqueness of the child.
- Include warm-up and cool-down exercises.
- Demonstrate proper exercise technique, including full range of motion on each exercise.
- Increase resistance gradually as strength improves.
- Prohibit 1 RM maximal lifts.
- Encourage strength training as part of an overall conditioning program.

These guidelines should provide the foundation upon which coaches develop the specifics of their program, based, in part, upon the needs and goals of the children. Administrative concerns (i.e., availability of equipment and space), the amount of time available to children for participation in such programs, and risk of injury associated with overtraining should also be considered. Strength training programs should not merely be added on to children’s exercise routines, which may already include several hours of sport-specific training and cardiovascular conditioning.

Ideally, youth coaches should incorporate strength training into periodized conditioning programs which vary in volume and intensity throughout the year (78). The NSCA recommends that 50 to 80 percent of a prepubescent athlete’s time be devoted to a variety of different activities in order to improve various aspects of physical fitness including strength, cardiovascular endurance, flexibility, speed, power and agility (54).

Two important areas of concern which must be addressed prior to the initiation of any youth strength training program are quality of instruction and mode of training. Coaches must have a thorough understanding of strength training guidelines and safety procedures, be enthusiastic about their profession and speak to children on a level they understand. Instructions must be clearly explained and exercises properly demonstrated. Questioning should be encouraged and children should be able to state their concerns about the program. During the first few weeks of training, an instructor to child ratio of less than 1:10 is suggested.

Certification in strength conditioning is highly desirable and is available through the NSCA. Although the efforts of untrained volunteers are appreciated, it is unlikely that they will be able to provide the level of instruction and supervision required for safe and effective program development. However, trained volunteers can assist qualified coaches in the testing and
training of children. Second, coaches should evaluate the various modes of strength training now available for children. In addition to body weight exercises and inexpensive rubber tubing, coaches may use extra pads and wooden boards to adapt their adult-size machines for smaller, prepubescent. Although the safety of such adaptations is debatable, these devices appear to provide relatively safe and effective modes of conditioning. Note that the machines should be placed far enough apart to allow for easy access and maneuverability, and the exercise room should be well-lighted and adequately ventilated. Prepubescent may also use free weights (barbells and dumbbells) which allow for a larger variety of exercises to be performed and require greater balance and coordination. While training with free weights, appropriate training guidelines and spotting procedures should be followed at all times. Weights should not be stored next to mirrors, the floor should be a non-skid surface and kept clean and free of plates and dumbbells. Coaches should be cognitive of the exploratory nature of young children and remove or disassemble any potential hazards or broken equipment from the exercise room before classes start.

Several companies manufacture weight training machines specifically designed for children. Although people may assume that child-size equipment is safer than adult-size machines, research supporting this claim is lacking. Yet researchers who used child-size equipment in their youth strength training studies reported relatively large gains in strength (66 to 74 percent) in short periods of time (seven to eight weeks) (20, 88). It is conceivable that the difficulty small children may experience when performing weight training exercises on large equipment may adversely affect their potential for large gains in strength. Furthermore, it has been suggested that adult-size weight training equipment may place undue stress on the joints of young weight trainers (66). Although speculative, weight training equipment designed for children may be biomechanically superior for prepubescent and, therefore, may afford the opportunity for greater strength gains and a decreased potential for injury. At this time, however, sound teaching methodologies and competent supervision appear to be more crucial to the safety and effectiveness of prepubescent strength training than the actual mode of training.

Four-Step Program

The following four step strength training program provides practical information for teachers and coaches who plan to incorporate strength training into children's conditioning programs. Although there is no minimum age requirement, each child must have the emotional maturity and attention span to understand basic training guidelines and comply with coaching instructions. The program begins with an introduction to strength training and proceeds through the successful skill performance and sound comprehension of training techniques and safety procedures. Note that a novice may need an extended period of time at step one and an experienced child may be able to start at step two. In addition to the acute program variables, information on various domains of learning — as they apply to strength training — is provided. The cognitive domain refers to an individual’s knowledge base, the effective domain focuses on values and a sense of right or wrong, and the psychomotor domain addresses the ability to complete a given task. (See Kraemer and Fleck, 1993 (42) for more information on sport-specific strength training guidelines for children.)

Step One (2 to 4 weeks): Children are introduced to various strength training exercises and safety procedures. Child-size equipment should be used if available, or adult equipment may be modified. If machines are not available, dumbbells and body weight exercises (push-ups, modified pull-ups and abdominal curls) may provide an alternative mode of training. One set of 10 to 15 repetitions should be performed. The initial load should be estimated to allow for a prescribed training intensity (e.g., 12 repetition maximum).

Coaches should be cautious and start with relatively light resistances, allowing for appropriate adjustments to be made. Exercises such as the leg extension, leg curl, bench press, lat pull-down, tricep extension and bicep curl, performed two to three times per week, are appropriate. Throughout steps one and three, a low training volume and a one to two minute rest period between exercises or sets is appropriate. Training sessions should last approximately 20 to 30 minutes and include warm-up and cool-down periods with static stretching.

Furthermore, it is important to progressively increase the “overload” placed upon the various muscle groups as each child gets stronger and is capable of performing more work. Typically, if a child is able to correctly perform a prescribed number of repetitions on a given exercise (and wants to progress to a higher level), the weight or resistance should be increased and the prescribed number of repetitions should be decreased. When changes are made, however, it is extremely important to increase the resistance gradually. In most instances, a two to five pound increase in weight will be consistent with a five to 10 percent increase in overall load. Progression may also be achieved by increasing the number of sets, exercises and training sessions per week; however, the amount of time available for strength training must also be considered.

Coaches should assess the willingness and motivation of each child to participate in the program and children should begin to understand the potential benefits and risks of strength training. Throughout the program, children should be encouraged to express concerns about the program and be assured that their comments will be addressed.

Step Two (4 to 8 weeks): The emphasis should be on safe and effective exercise techniques. Specific guidelines on proper breathing and correct body mechanics should be reviewed throughout this phase.
Explain to each child that the technique of each exercise, not the amount of weight lifted, is the primary focus. Children should genuinely appreciate the potential injuries effects of strength training and begin to understand basic training guidelines. As the child masters each exercise, resistance may be increased while keeping the repetitions within the 10 to 15 range; two sets may be performed on the major muscle group exercises. Each session should last approximately 25 to 30 minutes and the training frequency may be increased from two to three times per week. In addition, preparatory exercises for the abdominal and lower back region should be incorporated into the program. The frequency, magnitude and duration of the strength training program, and each child’s involvement in various sport activities, must be closely monitored to avoid overtraining.

Step Three: Before progressing to step three, each child must be able to safely and effectively perform the basic exercises. Furthermore, each child must be physically and emotionally ready to handle the demand of more advanced training programs. Children should feel comfortable with the equipment and show a genuine appreciation for the skills required to successfully complete each exercise. If this standard is met, heavier intensities and high training volumes may be introduced throughout this step, which may last several months. Two to three sets of eight to 12 repetitions, three times per week, may be performed on the primary exercises. In addition, new free weights (barbells and dumbbells) and weight machine exercises may be introduced into the program. However, when performing any new exercise the child should start with a relatively light weight (or possibly a broomstick) to focus on learning the correct technique of each exercise while minimizing muscle soreness. Coaches should clearly explain and demonstrate proper spotting procedures. Variables, such as rest periods and order of exercises, may be manipulated depending upon the needs and goals of the children. Throughout the program, each child’s adaptation to the strength training program should be carefully evaluated and the amount of time spent strength training, in comparison to other interests and activities, should be considered. To avoid overtraining and possible injury, it must be emphasized that strength training must be incorporated into — not simply added onto — a youngsters conditioning regimen.

Step Four: Only children who have mastered the biomechanics of the primary exercises and comprehend sound training guidelines and safety procedures may advance to step four. During this step, the child’s training program may increase in volume and intensity. After a relatively light warm-up set (approximately 50 percent of the 10 repetition maximum), three sets of six to 10 repetitions may be performed on the primary exercises. Coaches may want to alter the training program based on the periodization model. In addition, advanced exercises, including multi-joint lifts (e.g., Olympic lifts and modified cleans, pulls and presses) and sport-specific exercises, may be incorporated into the training regimen. Although this level of training may not be necessary for general conditioning purposes, a child who wants to learn advanced lifts under the watchful eye of a knowledgeable coach may benefit from this type of program if the focus remains on proper form and the appropriate loads are used. At this stage of development, the purpose of teaching advanced lifts to children should be to develop neuromuscular coordination and skill technique. Undoubtedly, coaches must be aware of injury risks associated with these lifts and the considerable amount of time that is required to effectively teach the correct technique. In some countries, children as young as 8-years-old are taught the proper technique in competitive lifts, although weight is not added to the bar until age 12 or 13 (44). Maximal lifting is inappropriate for children under age 16 (22).

Throughout the entire training program, each child should be reminded that strength training is only one part of a total conditioning program, which also includes cardiovascular, flexibility and agility exercises. Last, providing enthusiastic leadership while receiving support from family and friends will add to the success of the program.

Summary

Research continues to indicate that prepubescents can increase their voluntary strength, above and beyond the effects of normal growth and maturation, by participating in progressive strength training programs. Furthermore, limited data suggest that health-related benefits and sports performance gains may be contemporary corollaries of youth strength training programs. Coaches must understand the physical and psychological uniqueness of young children and, in turn, children must genuinely appreciate the potential benefits and risks associated with strength training. If appropriate guidelines are followed and if children are treated with respect, strength training may provide an opportunity for children to be continually challenged and to feel good about their successes.

References

Surg. 56(4A):688-703.
21. Faigenbaum, A. Boston University, unpublished observations.


