Adolescents need to participate regularly in physical activities that enhance and maintain cardiovascular and musculoskeletal health. Not only does physical activity offer observable health value, but also a physically active lifestyle during childhood and adolescence appears to continue into adulthood. Available data suggest that adolescents should be physically active daily, or nearly every day, as part of their lifestyle and should engage in three or more sessions per week of moderate to vigorous physical exertion that last 20 min or more (Sallis & Patrick, 1994). Although fitness training for adolescents has traditionally emphasized aerobic activities, a compelling body of evidence indicates that resistance training can also be safe, beneficial, and enjoyable for adolescents provided that age-specific guidelines are followed (Faigenbaum et al., 1996; Guy & Micheli, 2001).

In this context, resistance training is defined as a program of regular exercise that uses any one or a combination of training methods in an attempt to enhance muscle strength, muscle power, or local muscle endurance (the ability to perform repeated contractions). Despite the previously held belief that resistance training might be unsafe or inappropriate for younger populations, research conducted over the past decade clearly demonstrates that children and adolescents can benefit from appropriately prescribed resistance-training activities. Although much of our current understanding about the stimulus of resistance exercise has been gained by exploring the responses of adults to various training protocols, research into the effects of resistance exercise on younger populations has increased in recent years. Strength gains of roughly 20–40% have been observed in adolescents after short-term (8–12 weeks) training programs, and evidence suggests that competently supervised, well-designed youth resistance-training programs are relatively safe when compared with many other sports and activities in which adolescents regularly participate (Hamill, 1994).

The popularity of youth resistance training is evidenced by the growing number of physical-education teachers and youth sports coaches who incorporate some form of strength or power training into their classes and conditioning programs. The American College of Sports Medicine (2000), the American Academy of Pediatrics (2001), the International Federation of Sports Medicine (1998), and the National Strength and Conditioning Association (Faigenbaum et al., 1996) support participation in youth resistance-training activities provided that the program is appropriately designed and competently supervised.

**Potential Benefits**

In addition to increasing muscle strength, muscle power, and local muscle endurance, regular participation in a resistance-training program has the potential to positively influence both health-related and sports-specific fitness.
Resistance training helps strengthen bone, facilitate weight control, enhance self-esteem, and improve one's cardiovascular-risk profile (Faigenbaum, 2001). In terms of its effect on muscle hypertrophy, training-induced strength gains in male adolescents are associated with an increase in fat-free mass owing to hormonal influences (e.g., testosterone), and lower levels of androgens limit muscle development in female adolescents. Regular participation in a resistance-training program might also improve sport-performance skills and reduce sport-related injuries (Smith, Andrish, & Micheli, 1993).

**Sports Performance**

Because many sports have a significant strength or power component, it is intuitively attractive to assume that a stronger athlete will perform better. Observed increases in the long jump, vertical jump, and sprint speed after resistance training have been reported in the literature. Flexibility has also improved, provided that stretching exercises were incorporated into the training program. At present, it seems that youth resistance-training programs characterized by relatively high-speed movements (i.e., jumping drills and medicine-ball exercises) that are specific to the motor-performance test or sport might be more likely to induce improvements in selected performance measures than are relatively low-speed movements that are not specific to the test or sport. Although additional clinical trials are needed, anecdotal reports from adolescents, parents, coaches, and athletic trainers suggest that properly designed resistance-training programs do not have an adverse effect on sports performance and likely result in some degree of improvement by enhancing muscle strength, muscle power, local muscle endurance, and general well-being.

**Injury Reduction**

Because of the growing incidence of sport-related injuries, a noteworthy benefit of youth resistance training might be its ability to better prepare adolescents for the demands of sports participation. Although factors such as improper equipment, hard playing surfaces, and time periods of rapid growth (i.e., peak height velocity) are recognized risk factors for overuse injuries in young athletes (Micheli, 1983), the background level of physical activity of aspiring young athletes must be considered. Most states lack a daily physical-education requirement, and sedentary pursuits such as television viewing and “surfing” the Internet occupy a significant portion of adolescents’ free time.

In a growing number of cases, it seems that the musculoskeletal system of many high school athletes is ill-prepared to handle the physical demands of practice and game situations. Because unfit athletes are more likely to suffer an injury than fit athletes are, it is not surprising that most injuries to young athletes occur early in the sport season, when players are less conditioned. Although there are many mechanisms to reduce sport injuries (e.g., coaching education, proper equipment), the establishment of fundamental fitness abilities as a preventive health measure should not be overlooked. In addition to enhancing cardiorespiratory fitness, all of the musculoskeletal structures—bones, musculotendinous units, and ligaments—must be gradually and progressively strengthened to handle the demands of sports training and competition. According to the American College of Sports Medicine, up to half of all injuries sustained by young athletes could be prevented if more attention were paid to physical deficits, training methods, safety equipment, and psychological health (Smith et al., 1993).

A few studies have demonstrated decreased injury rates in adolescent athletes who participated in resistance-training programs. In one study involving female soccer players (age 14–18 years), participation in a 7-week preseason conditioning program resulted in a significantly lower incidence of injury than in an age-matched group of untrained players (Heidt, Sweeterman, Carlonas, Traub, & Tekulve, 2000). In that study, the trained group also had a lower percentage (2.4%) of anterior cruciate ligament injuries than did the untrained group (3.1%), although this was not a statistically significant difference. Similar findings were noted by Hejna, Rosenberg, Buturusis, and Krieger (1982), who reported that male and female adolescent athletes who participated in a resistance-training program had a lower injury rate and required less time for rehabilitation than did their teammates who did not strength train.

Because of the risk of both macrotraumatic and repetitive microtraumatic injuries in youth sports, encouraging participation in preseason resistance-
training programs merits consideration. Although the total elimination of youth sports injuries is an unrealistic goal, it seems that participation in a conditioning program at least 6–8 weeks before the season starts might offer a protective effect. During this time, correctable risk factors such as poor physical conditioning can be identified and treated by athletic trainers and qualified coaches. This type of preseason conditioning might not only reduce sports-related injuries but also decrease the likelihood that adolescent athletes will drop out of sport because of frustration, embarrassment, failure, or injury. The potential benefits of strength training for adolescent athletes are outlined in the sidebar below.

**Risks and Concerns**

One of the traditional concerns associated with youth resistance training involves the potential for injury to the epiphyseal plate, or growth cartilage. Although epiphyseal fractures have been reported in adolescents, these reports were case studies and typically involved improper lifting techniques or heavy overhead lifts in unsupervised settings. An epiphyseal fracture has not been reported in any prospective study characterized by competent supervision and age-specific program design.

It appears that the risk of repetitive-use soft-tissue injuries might be the greatest concern for adolescents. In one survey involving adolescent power lifters, 50% of the 98 reported injuries were to the lower back region, 18% to the upper extremity, 17% to the lower extremity, and 14% to the trunk (Brown & Kimball, 1983). It should be noted that the use of maximal or near-maximal loads or poorly designed training programs might have been at least partly responsible for the relatively high incidence of lower back injuries in this report. Nevertheless, the potential for injury to the lower back should remain a concern for athletic trainers and coaches who work with adolescents.

**Program Design Considerations**

Although there is no minimal age requirement for participation in a youth resistance-training program, all participants should have the emotional maturity to accept and follow directions and should genuinely appreciate the potential benefits and risks associated with youth strength training. Although some observers have commented that participants should be at least 12 years old, no data support this contention, nor is there any evidence to suggest that participating in sport activities is safer than resistance training. A medical examination is not mandatory for apparently healthy adolescents who want to start resistance training, but adolescents with known or suspected health problems should check with their health-care providers before beginning a resistance-training program.

It has been suggested that adolescents perform one to three sets of 6–15 repetitions of a variety of exercises (Faigenbaum et al., 1996). Beginning with a training frequency of 2–3 days per week on non-consecutive days seems reasonable. Although some adolescents might want to see how much weight they can lift on the first day of the conditioning program, their enthusiasm and interest in resistance training should be redirected toward developing proper form and technique in a variety of exercises using submaximal loads. When introducing adolescents to resistance-training activities, it is always better to

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**Potential Benefits of Resistance Training for Adolescent Athletes**

- Increased muscle strength
- Increased muscle power
- Increased local muscle endurance
- Increased cardiorespiratory fitness
- Increased flexibility
- Improved agility and coordination
- Improved motor-performance skills
- Improved body composition
- Increased bone-mineral density
- Enhanced sports performance
- Increased resistance to injury
- Decreased time for rehabilitation
- Reduced dropout from sports
- Enhanced mental health and well-being
- A more positive attitude toward fitness and conditioning
underestimate their physical abilities rather than overestimate them and risk an injury. This can be particularly important for adolescents who are in a growth spurt, which increases their vulnerability to overuse injuries. Decreasing the volume and intensity of the training program during periods of rapid growth might be necessary. General youth resistance-training guidelines are outlined in the sidebar at right.

Training Modalities

Different training modalities including weight machines, free weights (barbells and dumbbells), bodyweight exercises, and medicine balls have proven to be effective. Although most children are too small for adult-size weight machines, many adolescents can fit into these machines if extra pads and boards are used. Observations from our youth training center suggest that beginners enjoy resistance training on weight machines because the exercise movement is relatively easy to learn and perform. When preparing adolescent athletes for sports participation, however, it is important to incorporate more advanced resistance-training exercises into the workout plan once introductory skills have been mastered. Because movement in sport does not occur in one plane, proprioceptively challenging exercises that require balance, stabilization, and coordinated multijoint movements should be included in an adolescent athlete’s training program. It seems reasonable to gradually progress from the stable environment of a weight machine to the relatively unstable environment of a free-weight or medicine-ball exercise in order to maximize performance gains and reduce boredom.

Advanced multijoint lifts such as the snatch and the clean and jerk (sometimes called Olympic-style lifting) can be incorporated into a training program provided that the adolescent has successfully mastered the performance of introductory exercises and that qualified instruction is available (e.g., a certified strength and conditioning specialist). Although the safety of Olympic-style lifting for adolescents was questioned in the past, current observations suggest that children and adolescents can perform successfully and benefit from these exercises if the focus remains on form and technique and if appropriate loads are used.

Medicine-ball training is becoming quite popular and can provide adolescents with the opportunity to develop strength and power through dynamic movements that require balance, stability, and coordination. Unlike weight-machine exercises, selected medicine-ball exercises can be performed explosively to enhance muscle power. Medicine balls are relatively inexpensive (about $20–35), but you can make your own from an old basketball, volleyball, or even a playground ball (for instructions, see Faigenbaum & Cloutier, 2002).

Plyometrics

There has been some concern regarding the appropriateness and effectiveness of plyometric exercises for young athletes. Plyometrics refers to exercises that link strength with speed of movement to produce power and typically include hops, skips, and jumps. Although adult athletes in nearly all sports use plyometrics, some observers believe that this type of training might be unsafe for adolescent athletes because of the stress placed on the developing musculoskeletal system. Plyometrics are a natural part of most movements, as evidenced by the hopping and jumping that can be seen on most school yards and playgrounds. Even jumping jacks and hop scotch can be considered plyometrics because they exploit the muscles’ cycle of lengthening and shortening to produce power.
Although additional clinical trials are needed to determine the most effective plyometric training program for adolescents, beginning with one to three sets of 6–10 repetitions on one low-intensity upper body exercise (e.g., medicine-ball chest pass) and one low-intensity lower body exercise (e.g., squat jump) twice a week on nonconsecutive days seems reasonable. Depending on individual needs and abilities, the plyometric training program can progress from low-intensity exercises to higher intensity exercises (e.g., medicine-ball push-up and tuck jump). Plyometric exercises can be introduced into the warm-up or incorporated into group activities. Plyometrics are not meant to be a stand-alone exercise program and should be incorporated into a program that includes other types of conditioning. Specific guidelines for developing plyometric training programs are available elsewhere (Chu, 1996).

Core Training

Another issue concerning the design of youth resistance-training programs regards the inclusion of core exercises for strengthening the hips, abdominals, and lower back. It seems that some high school athletes spend too much time training their “mirror muscles” (i.e., chest and biceps) and not enough time (or no time at all) strengthening their core musculature. Because of the potential for lower back injuries, prehabilitation exercises for the core musculature should be included in the training program. That is, exercises that would be prescribed for the rehabilitation of an injury should be prescribed beforehand as part of a preventive health measure.

Although traditional curl-ups and back extensions are useful, multidirectional exercises that involve rotational movements and diagonal patterns can be used to more effectively strengthen the core in a “functional” manner. If the core musculature is well-conditioned, adolescent athletes will benefit from an optimal transfer of energy from large to small muscles when they jump, run, lift, and throw. These days, it is common for many college and professional athletes to spend the first 15 min of a 1-hr conditioning workout strengthening their core musculature with medicine balls, stability balls, and body-weight exercises. The bottom line is that “a chain is only as strong as its weakest link,” and without a strong core, performance in the weight room and on the playing field will be compromised.

Safety Concerns

Two other areas of concern regarding the development of a youth resistance-training program are the quality of supervision and rate of progression. Those who supervise adolescents should have a thorough understanding of youth strength-training guidelines and safety procedures. They should supervise all exercise sessions, speak to adolescents at a level they understand, and keep the program fun and challenging. Athletic trainers who prescribe or recommend home strength-training and conditioning programs (especially if free weights are used) should ensure that the adolescent will be supervised by a competent adult (or training partner) and that proper training loads are used. If age-specific guidelines are not followed and if qualified instruction is not available, serious accidents are possible. During a 1-year period, 11 adult men died of asphyxia caused by barbell compression of the neck or chest as they performed heavy bench presses at home without a spotter (Lombardi, 1995), and a similar accident occurred in a 9-year-old boy (George, Stakiw, & Wright, 1989).

Another concern relates to the concept of progression. Increasing the weight (or resistance), the number of repetitions, or the number of sets is necessary to make continual gains. This does not mean, however, that every exercise session needs to be more intense or voluminous than the previous one. Although it is important to keep the program fresh and challenging, adolescents should be given the opportunity to develop proper form and coordination with minimal muscle soreness. Too often, the volume and intensity of resistance-training programs are too severe, and the recovery periods are inadequate for an adolescent’s current fitness level. In some cases, adolescent athletes might need to decrease the time they spend practicing sport-specific skills to allow time for preparatory conditioning.

When introducing adolescents to resistance training, it is always better to underestimate their physical abilities and gradually increase the volume and intensity of training than to overshoot their abilities and potentially risk an injury. Over time, the program...
variables (e.g., choice of exercise, number of sets and repetitions) can be systematically varied to limit training plateaus and maximize long-term performance gains (periodized training). By treating each adolescent as an individual and by being aware of interindividual differences in stress tolerance, resistance training can be made an enjoyable and worthwhile experience for adolescents of all abilities. Additional youth resistance-training guidelines are available elsewhere (Faigenbaum & Westcott, 2000).

**Conclusion**

Resistance training has the potential to be an enjoyable and beneficial experience for adolescent athletes provided that age-specific training guidelines are followed. In addition to positively influencing several measurable indices of health, regular participation in a resistance-training program can enhance sports performance and reduce the incidence of sports-related injuries. When athletic trainers communicate the value of resistance training to coaches, parents, and adolescents, they should highlight the potential benefits and concerns associated with this type of training and the type and amount of resistance training that are appropriate for young athletes.

**References**


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