Integrative Training for Children and Adolescents: Techniques and Practices for Reducing Sports-Related Injuries and Enhancing Athletic Performance

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Abstract: As more children and adolescents participate in sports and conditioning activities (sometimes without consideration for cumulative workload), it is important to establish age-appropriate training guidelines that may reduce the risk of sports-related injury and enhance athletic performance. The purpose of this article is to review the scientific evidence on youth strength and conditioning and to provide age-appropriate recommendations for integrating different strength and conditioning activities into a well-designed program that is safe, effective, and enjoyable. Integrative training is defined as a program or plan that incorporates general and specific strength and conditioning activities that enhance both health- and skill-related components of physical fitness. The cornerstone of integrative training is age-appropriate education and instruction by qualified professionals who understand the physical and psychosocial uniqueness of children and adolescents.

Keywords: youth; sports; injury; prevention; training

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Introduction

With increased participation in recreational and interscholastic sports by children and adolescents, it is important for youth coaches and health care providers to help reduce the risks of sports-related injuries and optimize performance in this young population.[1–4] To achieve these desired outcomes, strength and conditioning activities are being introduced into middle- and high-school curricula.[5] In addition, training programs specifically designed to enhance sports performance have become a "Top 10" fitness trend for 2010.[6] Moreover, public health initiatives aim to increase the number of youth who engage in muscle-strengthening activities ≥ 3 days per week.[7] As more children and adolescents participate in sports and conditioning activities in schools and private (select or club sports) programs, sometimes without consideration for cumulative workload, it is important to establish age-appropriate training guidelines that may reduce the risk of sports-related injury and enhance athletic performance.

Despite concerns regarding the safety and efficacy of strength training for youth,[8] a compelling and growing body of evidence indicates that regular participation in well-designed, sensibly progressed, and properly instructed strength and conditioning programs can offer measurable health and fitness benefits for children and adolescents.[3,9–12] Thus, there is a growing need for health care providers, fitness professionals, physical education teachers, and youth coaches to design, implement, and integrate different types of conditioning into safe, age-appropriate, efficacious, and enjoyable programs.[13,14] This is particularly important for aspiring young athletes who may not be prepared for the physical and psychological demands of sports practice and competition due to the apparent decline in free-time physical activity among children and adolescents.[13,14] Currently, sports and overexertion are the most common causes of all injury-related visits to primary care physicians by children and adolescents.[15]

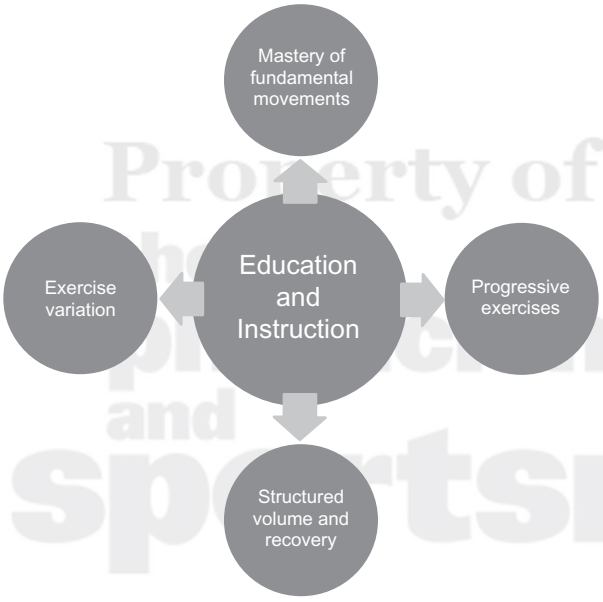
In this article, we aim to review the scientific evidence on youth strength and conditioning and provide age-appropriate recommendations for integrating different strength and conditioning activities into a well-designed program. Integrative training is defined as a program or plan that incorporates general and specific strength and conditioning activities, which enhance both health- and skill-related

components of physical fitness. The cornerstone of integrative training is age-appropriate education and instruction by qualified professionals. This type of training allows youth to master fundamentals, improve movement mechanics, and gain confidence in their physical abilities, while participating in a program that includes variety, progression, and proper recovery intervals (Figure 1).

Trainability of Young Athletes

For the purpose of this article, the terms youth and young athletes refer to both children (Tanner stages 1 and 2 of sexual maturation; ≤ 10–12 years) and adolescents (Tanner stages 3 and 4 of sexual maturation; 13–18 years). The beneficial effects of progressive resistance, as well as power (speed applied rapidly) and speed training on increases in strength and power in adult athletes are well documented.[16–20] Strength improvements achieved from progressive resistance, and power and speed training in adult populations occur via muscle hypertrophy (increases in muscular cross-sectional area), muscle fiber structural changes (pennation angle changes), and neuromuscular (increased motor unit synchrony and recruitment) and metabolic (improved energy delivery) adaptations.[20–26] In contrast, early reports on resistance, power, and speed training in youth have suggested that similar adaptations would not occur, although methodological limitations could partly explain these findings.[27,28]

Figure 1. Diagram of the relationship between 5 presented components to successful integrative training programs.



More recent studies that investigated the trainability of youth with more intense and high-volume training protocols demonstrated significant improvements in selected performance measures in children and adolescents following progressive training programs.[29–37] The benefits of resistance, power, and speed training in children and adolescents are now known to be greater than those attributable to normal growth and development. These gains are derived largely from neuromuscular adaptations in preadolescent children, along with increases in fat-free mass in adolescents, since testosterone and other hormonal influences on muscle hypertrophy would be operant during and after puberty.[38]

Regular participation in a progressive resistance, power, and speed training program also has the potential to positively influence several measurable aspects of health and fitness.[3,9,11,39] Moreover, regular participation in an integrative strength and conditioning program with qualified instruction can allow young, aspiring athletes to learn proper exercise technique, gain confidence in their abilities to be physically active, and receive basic education on program design, safety concerns, and healthy lifestyle choices, including proper nutrition and adequate sleep. Potential benefits for youth strength and conditioning include increased muscle strength, power, and endurance; increased bone mineral density; increased cardiorespiratory fitness; improved blood lipid profile; improved insulin sensitivity in overweight youth; improved body composition; improved motor performance skills; enhanced sports performance; increased resistance to injury; enhanced mental health and well-being; and simulation of a more positive attitude toward lifetime physical activity.[40,41]

Risks and Concerns Associated with Training in Young Athletes

Age Comparisons in Training-Related Injuries

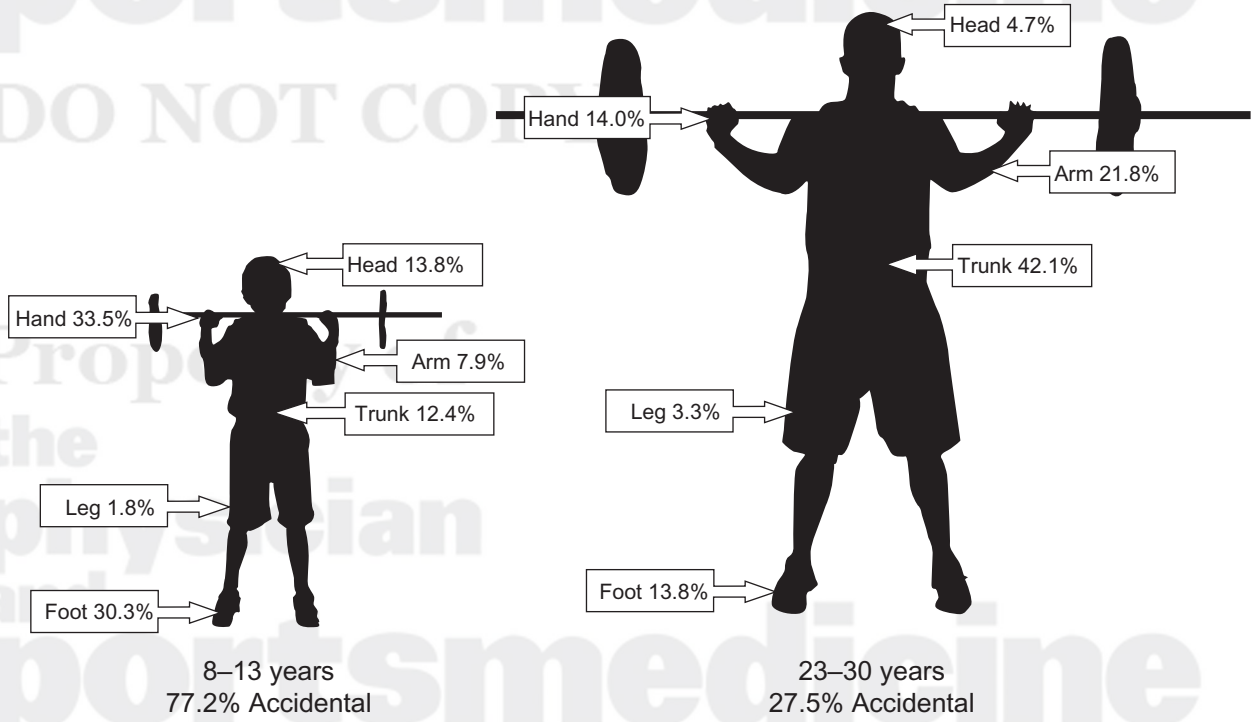
There are limited epidemiologic studies related to injury risk associated with performance enhancement training in children. Myer et al[42] reviewed the US Consumer Product Safety Commission (CPSC) National Electronic Injury Surveillance System from 2002 to 2005 using the CPSC code for "weightlifting." The broad coding of weightlifting injury in this study was applied to patients who reported any related exercise involvement, regardless of the setting at the time of injury (eg, school, fitness center, home). Subjects aged 8 to 30 years were grouped by age categories: elementary to middle school

(aged 8–13 years), high school (aged 14–18 years), college (aged 19–22 years), and adult (aged 23–30 years).[42] Injuries were classified as accidental if the injury occurred as a result of a weight dropped or improper equipment use. In the 4111 patients sampled, accidental injuries decreased with each successive age group. Conversely, sprain/strain injuries increased in each successive age group. Evaluation of only the nonaccidental injuries (n = 2565) showed that the categories with the oldest age groups (college-aged and adult) demonstrated a greater percentage of sprains and strains when compared with younger age categories.

Two-thirds of the injuries sustained in the elementary/middle school age group occured in the hands and feet, and were most often related to dropping (ie, dropping plates on toes) and pinching (ie, pinching hands when racking weight bar). Interestingly, there was an increased percentage of fractures observed in the elementary/middle-school age group relative to all other groups.[42] Figure 2 presents the relative amount of resistance training-related injury per location between children and adults. These observations are supported by epidemiological findings by Kerr et al,[43] who recently reported that children aged ≤ 12 years sustained a larger proportion of hand and foot injuries during resistance training when compared with older participants. Of the reported injuries, 65% were caused by weights falling on the person, and 10% of reported injuries were caused by a body part being smashed by weights.[43] Although many factors should be considered when examining these data, the importance of proper exercise technique, strict adherence to safety rules, and qualified instruction should be emphasized.

Strength and conditioning programs can be implemented safely when they are properly supervised and progressed.[3,9,44,45] Unsupervised and/or poorly designed training programs can result in injury. For example, youth are more likely to attempt to lift weights that exceed their abilities, or perform an excessive number of repetitions with improper exercise technique.[40,42,46] Thus, qualified professionals should be available to oversee training sessions and design exercise programs that are consistent with the participants' needs, interests, and abilities. In general, if a parent completes a health form for a child and the child is healthy with no preexisting health issues (eg, diabetes, recent surgery), then he/she can begin

Figure 2. Percentage of injuries of the oldest and youngest age categories.



Note that the small prevalence of leg injuries in the elementary/middle-school category provides invalidated results and should be interpreted with caution. Reproduced with permission from Myer et al.[42]

integrative training with a qualified instructor. However, preexisting health concerns should be referred to their primary care physician to obtain consent prior to integrative training.

We are not aware of any prospective trials that have focused specifically on measures to prevent training-related injuries in young athletes who participate in strength and conditioning activities. It is reasonable to assume, however, that qualified professionals who are familiar with strength and conditioning guidelines, specifically as they apply to the needs and abilities of youth (see recommended Guidelines for Initiation of Integrative Exercise Program), should provide supervision and instruction.[40] Furthermore, if young athletes participate in strength and conditioning programs that include plyometrics (eg, tuck jumps and lateral hops) and weightlifting exercises[3] (eg, modified cleans, pulls, and presses), professionals should have additional knowledge and experience to properly instruct and prescribe this type of training. Regardless of the age and experience of the participants, the focus of youth strength and conditioning programs should be on the development of correct exercise technique, proper movement mechanics, the safe use of exercise equipment, and instruction on proper weight room etiquette.

Considerations for Integrative Training: Education and Instruction

Proper education and instruction are paramount in integrative training. Age-appropriate education and qualified instruction are required to successfully integrate different components related to fundamental movements, program variation, exercise progression, and structured recovery. When considering that a growing number of school-aged youth are exposed to strength and conditioning activities in physical education classes, recreational activities, and sports training programs, it is important that children and adolescents be given qualified and enthusiastic instruction tailored to their needs, goals, and abilities. Children and adolescents who participate in integrative training programs should be knowledgeable of the potential risks and concerns associated with exercise equipment (eg, treadmills, weight machines, barbells) as well as the potential risk of injury if they do not follow established training guidelines and safety procedures. Ultimately, education and instruction will determine the levels of success that can be achieved within each component of an integrative training program (Figure 1).

Considerations for Integrative Training: Mastery of Fundamental Movements

Although there is no minimum age for participation in youth strength and conditioning programs, all participants must be able to follow coaching instructions and undergo the stress of a training program. In general, a child who is deemed ready for structured sports participation (about age 7–8 years) would typically be ready for some type of resistance training.[3] Regardless of the starting age, however, all youth should receive safety instructions on starting weights, proper spotting, the correct use of collars, and the proper handling of barbells, dumbbells, and plates. This is particularly important in schools and recreation centers because untrained youth tend to overestimate their physical abilities, thereby increasing risk of injury.[48] Qualified instruction not only enhances participant safety and enjoyment of the training experience, but direct supervision of youth resistance training programs can improve program adherence and optimize strength gains.[49]

To reduce the occurrence of nonaccidental injuries, proper fundamental movement skills and gradual progression of training programs should be emphasized. If a young athlete does not master fundamental movement skills at less intense levels, deficits displayed during the exercise will likely be amplified as training intensity is increased. Instructors should give continuous feedback to every participant during and after each exercise session. This will improve the athlete's awareness of proper movement mechanics and decrease the likelihood of undesirable or potentially injurious body positions. Using mirrors and video equipment can help young lifters identify poor biomechanics.[50,51] Visual and verbal feedback can help young athletes to match their perceived technique with their actual technique. Table 1 summarizes modifiable risk factors that have been associated with youth resistance training injuries.[52]

Various strength and conditioning programs have been shown to be safe and effective for children and adolescents.[12,39,53–57] Although weight machines, free weights, and medicine balls can be beneficial, strength and conditioning techniques can be initiated without the addition of external resistance.[58] For example, progressive resistance, power, and speed training can begin using only body weight as resistance. Although some body weight exercises, such as the squat, may be challenging for some young lifters who lack flexibility and core strength, this fundamental movement should be mastered before this exercise is performed with external resistance. Instructors who focus on proper exercise technique and cor-

Table 1. Modifiable Risk Factors Associated with Youth Strength Training and Conditioning

Risk Factor	Modification by Qualified Professional[52]
Lack of supervision	Substantive and timely instruction
Unsafe exercise environment	Adequate training space and proper equipment layout
Improper equipment storage	Secure storage of exercise equipment
Unsafe use of equipment	Instruction on safety rules in the training area
Excessive load and volume	Prescription and progression of training program driven by technical performance of prescribed exercise movement
Poor exercise technique	Clear instruction and feedback on exercise movements
Poor trunk control	Targeted neuromuscular training
Muscle imbalances	Training program includes agonist and antagonist exercises
Inadequate recuperation	Incorporate active rest and consider lifestyle factors such as proper nutrition and adequate sleep

rect movement mechanics, and prescribe a sensible number of repetitions, can increase the likelihood of success. For example, during squat exercise, some inexperienced young lifters have difficulty maintaining normal lordotic posture, and often demonstrate excessive forward tibial and trunk progression.[58] Instructors should correct these technical flaws with feedback and coaching cues, demonstrate proper exercise technique, and provide continuous feedback on movement mechanics during each phase of progression (Figure 3, see article online).

Considerations for Exercise Integration: Exercise Variation

Though numerous program components and exercises can enhance muscular strength and power, it is important to select exercises that are appropriate for the participant's body size, fitness level, and exercise technique. Weight machines (both child-sized and adult-sized), free weights, elastic bands, medicine balls, and body weight exercises have been used by children and adolescents in clinic settings and school-based exercise programs.[55,59] Though no single mode of resistance training provides the most effective or safest means for young athletes, body weight training may be particularly beneficial for the development of fundamental motor skills before they progress into more intense training programs. Training exercises that progress to free weights and medicine balls may provide a unique opportunity for young athletes to achieve desirable muscle adaptations that can increase muscle power, improve core stabilization, and enhance balance. Integration of different resistance training modalities may optimize training adaptations and reduce the likelihood for plateaus in performance, although additional research is warranted.[56,58]

The isolated effects of core training (eg, pelvis, abdominal, trunk, and hip training) on measures of performance have not been clearly demonstrated. However, the specific effects of this type of neuromuscular training are likely substantial and can be combined with other training modes.[60] For example, core strengthening combined with balance training can improve dynamic balance and stability.[61,62] Increased balance may help the athlete with a dynamically stable core, and he or she can then be better prepared to respond to the high forces generated at the distal body parts during athletic competition.[12,39] Young athletes can safely and effectively strengthen their core musculature without the aid of external resistance (Figure 4, see article online).[58] Many factors should be considered when designing and progressing core training programs, such as age, fitness level, choice of exercise, and progression of training loads. The importance of strength and conditioning for enhancing core strength should also be emphasized.

Insufficient strength, muscular endurance, and/or stability in the lower back may be associated with current and future low back pain in adolescents.[63,64] Thus, progressive core strengthening exercises should be included in all youth strength and conditioning programs as a preventive measure to reduce the prevalence and/or severity of sports-related injuries to the lower back. The effects of core training may be best attained with the integration of functional balance and core strengthening in an athlete's training program.

Combining resistance training (Figure 5, see article online) with plyometric training (Figure 6, see article online) may provide additional benefits. Individuals who performed a combined plyometric and squat training program demonstrated greater gains in vertical jump compared with individuals who only trained with squats or plyometrics alone.[65] Others have reported that plyometrics and resistance training had greater effects compared with each type of training performed alone.[66]

Guidelines for the integration of plyometric exercises into youth training programs are beginning to emerge.[56,67,68] A growing body of evidence indicates that plyometric exercises may be safely initiated when athletes begin with less intense exercises and learn proper functional movement patterns. Of note, youth can benefit from technique training and feedback during plyometric exercises even without prior participation in a resistance training program, provided that the exercises are consistent with an individual's abilities and training experience. The anterior step progression (Figure 7, see article online) can be used as a movement pattern check prior to the initiation of lower extremity plyometric exercises. Once young athletes have mastered stability progressions, integration of agility and movement progression are indicated (Figure 8, see article online).

Plyometric activities should begin with movements that an athlete can perform with proper technique and should progress only if the desired movement can be performed with adequate dynamic postural control. Plyometric training should be progressed by carefully manipulating the exercise, intensity, volume, and rest interval between sets. The choice of which acute program variables to manipulate at which time is based on an athlete's performance, training goals, and consideration of other activities, such as sports participation and competition, which are part of his or her weekly program. In general, the volume of a particular plyometric activity is increased first to ensure appropriate neuromuscular control before increasing the intensity or frequency of training. Although young athletes should be given adequate time to recover between sets to maintain a high level of performance, studies have shown that rest interval recommendations for adults may not be consistent with the needs and abilities of children and adolescents because of growth- and maturation-related differences in response to physical exertion.[69,70] Thus, a shorter rest interval between sets (about 1–2 minutes) may suffice when performing this type of training.

Considerations for Exercise Integration: Progressive Exercises

There is considerable evidence that regular participation in progressive and multifaceted resistance training may reduce the risk of injury in young athletes.[58,69,71,72] This evidence is based on the beneficial adaptations in bones, ligaments, and tendons following training, and is supported by epidemiologically based reports on potentially beneficial muscular adaptations from pre-season and in-season training programs designed to reduce injury risk factors.[73–75] Different program variables have been shown to be safe and effective for young athletes, provided that the program is supervised, sensibly progressed, and consistent with the participants' abilities and interests. Lehnhard et al[76] were able to significantly reduce injury rates using progressive resistance, power, and speed training in male soccer players. Cahill and Griffith[77] incorporated progressive resistance, power, and speed training into their pre-season conditioning for adolescent football players, and reported a reduction in knee injuries, including knee injuries that required surgery, over 4 competitive seasons. Hejna et al[78] reported that young athletes (aged 13–19 years) who included progressive resistance, power, and speed training as part of their exercise regimen sustained fewer injuries and recovered quicker from injuries. Recent evidence indicates that youth (average age, 10 years) who participated in an integrative injury prevention program were able to reduce injury risk factors with simultaneous improvement in power and performance.[79] Collectively, these findings indicate that comprehensive training regimens that integrate resistance, power, and speed training into pre-season and in-season conditioning can reduce the risk of sports-related injury in adolescent athletes.[11,12,80–83]

Progressive exercises (Figures 3–8, see article online) are a critical component of integrative training protocols.[54] Five or more exercise phases can facilitate progressions designed to improve an athlete's ability to master fundamental movements while enhancing core stability. End-stage progressions can incorporate perturbations that require the athlete to decelerate and control the trunk to successfully execute the prescribed technique. Exercises selected for the initial phases (Figures 3–8, see article online) can be adapted from previous epidemiological or interventional investigations, which have reported reductions in injury risk or risk factors.[67,80,82,84] Although it is unrealistic to create a training or prevention program that eliminates sports-related injuries completely, evidence indicates that multifaceted integrative programs, which include progressive resistance, power, and speed training are not only safe activities for young athletes, but may also reduce injuries during sports practice and competition.[68,79,80,85] Including progressive, resistance, power, and speed training into pre-season and in-season practice may provide optimal injury prevention.[68,85]

At the beginning of training, all participants should receive instruction on proper training procedures and the importance

of proper exercise technique. Most young athletes who begin this type of program will have little if any prior exposure to resistance training techniques. Therefore, youth should be encouraged to progress gradually, embrace self-improvement, and feel good about their ability to perform advanced movements with proper technique. The use of workout logs can help athletes monitor progress, recollect coaching cues, and focus their efforts on their goals.

During the first 2 to 3 weeks of the program, athletes should begin training with a relatively light load (or body weight), and progress gradually. Once an athlete has performed a movement correctly, he or she has "earned the right" to advance. Understanding and implementing these fundamental movements is essential to the overall progression of the training program. Over time, the program can be progressed to include additional sets with heavier loads that are consistent with the prescribed repetition maximum (RM) or repetition range. For example, a child may begin resistance training with 1 to 2 sets of 10 to 12 repetitions with a relatively light load to help him or her develop proper exercise technique. After this stage, he or she can progress by performing additional sets on selected exercises with heavier loads (eg, 6–10 RM). Regardless of the method used for prescribing exercise intensity, it is important to note that not all exercises should be performed for the same number of sets and repetitions. In general, power exercises are typically performed for ≤ 6 repetitions so that the athlete can maintain explosive velocity for each repetition, whereas strength exercises generally range from 6 to 15 repetitions.[3]

Considerations for Exercise Integration: Structured Volume and Recovery

We recommend integrating resistance, power, and speed training into a progressive conditioning program, in which the volume and intensity of training periodically change throughout the year. It is important to note that the systematic structuring of program variables along with individual effort, qualified instruction, and adequate recovery will determine the outcomes associated with progressive resistance, power, and speed training. The importance of adequate recovery between challenging training sessions is sometimes overlooked in youth conditioning programs, which appear to focus primarily on rest between sets or the allotted time for protocol completion. Instructors of integrative training programs should remember that training athletes of any age involves balancing the demands of training with the need for recovery, which are both required for adaptation. This is particularly important for youth who represent different sports teams or participate in extracurricular conditioning activities at private training centers.

The total work performed in an exercise session is the volume of exercise. Nonintegrative programs often base volume solely on one particular variable or component of training and do not consider the cumulative workload from competition, practice, and multiple conditioning modalities. For example, guidelines for volume prescription related to a single plyometric training bout based on experience level suggest that adult athletes with novice experience using plyometric movement training should employ a training session volume with 80- to 100-foot contacts per session, whereas adult athletes with more experience can use 120- to 140-foot contacts per session.[86] Other guidelines suggest that ≤ 400 contacts is considered appropriate for low-intensity exercise and ≤ 200 contacts for very-high-intensity exercise in trained adult athletes.[87] These volume recommendations are difficult to determine when considering only one variable, not to mention the influence of other confounding variables, such as sports training, sports competition, and recreational free play. Thus, it is important that other training factors (most notably technical performance and fatigue response) are considered along with experience level and exercise intensity when determining a young athlete's training volume. Activities performed outside of the integrative training programs should also be considered when evaluating a young athlete's overall training exposure. Thus, strength and conditioning exercises need to be carefully prescribed to avoid overtraining and injury.[2,55,56,58]

The prescribed exercises, sets, and repetitions for an integrative exercise program should serve as an attainable goal for the athlete, but should also be modified as needed. Initial volume selection should be low to allow the athlete to learn how to perform the exercise with proper technique. Volume (or resistance, when applicable) should be increased after the athlete can properly perform the exercise at the prescribed volume and intensity. The professional who supervises the athletes should be able to recognize proper technique for a given exercise and should provide constructive feedback when appropriate. Once the athlete becomes proficient in all exercises in a progression phase, he or she can advance to the next phase. Also, young athletes should participate periodically in less intense training exercise sessions to reinforce learning of specific movement patterns.[88] Since recovery is an integral part

of all training programs, high-intensity and/or high-volume training sessions should be balanced with less intense training exercise sessions and other recovery strategies to maximize training adaptations while minimizing the risk of overtraining.[89]

Children and adolescents should be encouraged to engage in ≥ 60 minutes of physical activity per day,[7] but high-intensity training should only be performed 2 to 3 times per week on nonconsecutive days to allow time for recovery between training sessions.[3] Although some young athletes may participate in strength and conditioning activities > 3 days per week, factors such as the training volume, training intensity, exercise selection, and nutritional intake should be considered, as these factors may influence one's ability to recover from and adapt to the training program. As training programs become more advanced, and possibly more complex, the importance of reinforcing proper exercise technique should not be overlooked. Moreover, youth coaches should be aware of the symptoms of overtraining (eg, muscle soreness that lingers for several days, decrease in performance, and lack of desire to train), and should be made aware that some children with relatively immature musculoskeletal systems may not be able to tolerate the same amount of exercise as their teammates. Of potential relevance, recent data indicate that participation in organized sports activities does not inevitably ensure ≥ 60 minutes of moderate-to-vigorous physical activity during practice sessions.[90,91] Integrative training may also provide coaches with a supplemental mechanism to ensure that youth gain the health benefits associated with an active lifestyle, while considering additional practice activities.

Recommended Guidelines for Initiation of Integrative Exercise Program

We recommend the following:

- Provide qualified, feedback-driven instruction to athletes performing strength and conditioning exercises.
- Consider each athlete's physical and psychosocial maturity to determine if he or she is prepared to begin a strength and conditioning program.
- Take reasonable precautions to remove or limit exposure to any environmental hazards. The training area should be well lit, free of potential hazards, and large enough to accommodate all participants.
- Begin each session with a brief (5–10 minutes) dynamic warm-up that includes multidirectional movement patterns.
- Start with relatively light loads to develop proper exercise technique.
- Perform 8 to 12 exercises for the upper body, lower body, and torso.
- Include 4 to 6 exercise movements that train all major muscle groups and emphasize the core musculature, including pelvis, abdominal, trunk, and hip.
- Include exercises that require balance and coordination during movement.
- Perform 1 to 3 sets of each exercise per session.
- For general strength building exercises, use a resistance that can be performed for about 6 to 15 repetitions with proper technique.
- For power exercises, such as plyometric and weightlifting exercises, perform ≤ 6 repetitions and focus on the quality of each repetition during a set.
- Gradually progress the intensity and/or volume of training depending on goals and abilities.
- Perform high-intensity training only 2 to 3 nonconsecutive days per week.
- Systematically vary the program variables to keep the training stimulus effective.
- Periodically integrate less intense training exercise sessions that focus on movement skill acquisition into the training program.
- Use training logs to help young athletes monitor and progress training intensity and volume.

Conclusion

Regular participation in organized sports activities does not ensure that youth are adequately exposed to fitness components that can improve their health and reduce risk of injury.[91,92] Comprehensive training programs that integrate all fitness components with sports participation can enhance athletic performance, improve movement biomechanics, and reduce risks of sports-related injury.[3,9,11,67,68,79,92] Ideally, integrative training programs should have qualified professionals who first focus on basic training guidelines, proper use of equipment and safe training procedures, and encourage young athletes to embrace self-improvement and positive awareness about their abilities to perform resistance, power, and speed training activities. Once these fundamental skills and abilities are developed, young athletes can begin to participate in strength and conditioning programs with the appropriate intensity and volume of training to optimize training adap-

tations. With an understanding of the physical and psychosocial uniqueness of childhood and adolescence, integrative training that is sensibly progressed and consistent with athletes' individual needs, goals, and abilities can be part of a safe and health-oriented approach to lifelong physical activity.

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Conflict of Interest Statement

Donald A. Chu, PhD, PT, ATC, CSCS discloses confilcts of interest with Athercare and D. C. Enterprises, Inc. Gregory D. Myer, PhD, CSCS; Avery D. Faigenbaum, PhD, FACSM, Jeff Falkel, PhD, PT, CSCS*D, Kevin R. Ford, PhD, FACSM, Thomas M. Best, MD, PhD, FACSM, and Timothy E. Hewett, PhD, FACSM disclose no conflicts of interest.

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