Resistance training and pediatric health

Entrenamiento de fuerza y salud pediátrica

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ABSTRACT
Although some clinicians and youth coaches once considered resistance training unsafe and potentially injurious to the developing musculoskeletal system, a compelling body of scientific evidence indicates that resistance exercise can be a safe, effective and worthwhile method of conditioning for children and adolescents provided age-appropriate training guidelines are followed. The qualified acceptance of supervised and well-designed youth resistance training programs by medical, fitness and sport organizations has become widespread and current public health objectives now aim to increase the number of boys and girls who participate in muscle strengthening activities. In addition to increasing muscular strength, regular participation in a pediatric resistance training program can facilitate weight control, strengthen bone, enhance motor skill performance and increase a young athlete’s resistance to sports-related injuries. In this article, the importance of enhancing muscular strength early in life will be discussed, the potential health-related benefits associated with youth resistance training will be reviewed, and program design considerations for developing youth resistance training programs will be outlined.

Key Words: Strength training, weightlifting, motor skills, young athlete, physical education.

RESUMEN
Aunque muchos médicos y jóvenes entrenadores consideran que el entrenamiento de fuerza es potencialmente peligroso e inseguro para el sistema músculo esquelético en desarrollo, una gran cantidad de evidencias científicas
INTRODUCTION
A growing number of children and adolescents are participating in resistance training programs in sport centers and contemporary physical education programs now include strength-building activities as part of a health-enhancing approach to fitness education (A. Faigenbaum et al., 2009; National Association for Sport and Physical Education, 2011). Nowadays, evidence-based reports regarding both the safety and efficacy of resistance training in children and adolescents are common and acceptance of pediatric resistance training by medical, fitness and sport organizations has become widespread (A. Faigenbaum, et al., 2009; A. Faigenbaum & Myer, 2010b; American College of Sports Medicine, 2010; Behm, Faigenbaum, Falk, & Klentrou, 2008; British Association of Exercise and Sport Sciences, 2004; Malina, 2006). As more children and adolescents resistance train in schools, recreation centers, and sport training facilities, it is important to understand both the potential benefits of resistance exercise and establish safe and effective practices by which this type of conditioning can improve the health of younger populations. In addition, as many parents and youth coaches want to know the age at which children can start resistance training, guidelines for initiating participation in structured strength and conditioning activities are discussed.

In the current article, the term resistance training refers to a method of conditioning that involves the progressive use of a wide range of resistive loads, different movement velocities and a variety of training modalities including weight machines, free weights (dumbbells and barbells), elastic bands, medicine balls and body weight. For simplicity, the terms pediatric and youth refer to both children (Tanner stages 1 and 2 of sexual maturation; approximately up to age 12 years) and adolescents (Tanner stages 3 and 4 of sexual maturation; approximately 13 to 18 years).

Physical Activity for Youth
Several organizations have developed physical activity guidelines for children and adolescents and it is generally agreed that youth should participate daily in 60 minutes or more of moderate to vigorous physical activity (MVPA) that is developmentally appropriate, enjoyable and involves a variety of activities (Martinez-Gomez et al., 2010; Strong et al., 2005; United States Department of Health and Human Services, 2008). Regular participation in MVPA helps to reduce body fat, improve blood lipids, build skeletal tissue, strengthen muscles, and improve aerobic fitness (Gutin & Owens, 2011; Strong, et al., 2005). Moreover, well-designed physical activity programs can enhance motor performance skills, reduce the risk of injuries in youth sports and simply makes boys and girls feel better about themselves (National Association for Sport and Physical Education, 2011; Valovich McLeod et al., 2011). Recent studies have also shown positive relationships between school-based physical activity and academic achievement (Centers for Disease Control and Prevention, 2010).

Perhaps of greater importance is the observation that health-related behaviors that are acquired during childhood and adolescence are likely to be carried into adulthood (Telama, 2009). In fact, it appears that youth who master fundamental movement skills and gain confidence in their physical abilities are more likely to be active later in life (Barnett, Van Beurden, Morgan, Brooks, & Beard, 2008; Barnett, Van Beurden, Morgan, Brooks, & Beard, 2009; Stodden, Langendorfer,
Fundamental movement skills are commonly developed during childhood and include locomotor (e.g., hopping), object control (e.g., catching) and stability (e.g., balancing) skills. As illustrated in figure 1, a child’s motor skill competence and proficiency can drive participation in health-related fitness activities (e.g. adequate amounts of MVPA), which, in turn, may increase the likelihood that this positive lifestyle choice will be carried over into adulthood.

Conversely, children who do not develop fundamental movement skills early in life may not be able to break through a hypothetical “proficiency barrier” later in life that would allow them to participate in a variety of sports and activities with confidence and vigor (Seefeldt, 1980). Current findings suggest that the eventual decline and disinterest in physical activity during this critical period of life may be a contemporary corollary of reduced motor skill proficiency and low muscle strength (Malina, Bouchard, & Bar-Or, 2004). Yet despite these age-related gains in muscular fitness, a compelling body of scientific evidence indicates that children and adolescents can significantly increase their muscle strength above and beyond growth and development providing that the resistance training program is of sufficient duration, intensity and volume (Behringer, Vom Heede, Yue, & Mester, 2010; Faigenbaum & Myer, 2010a; Myer, Faigenbaum, Ford et al., 2011). Children as young as age six have benefited from resistance training (Faigenbaum, Westcott, Loud & Long, 1999; Weltman et al., 1986) and studies lasting two to three school years have been reported with positive adaptations in the study participants (Falk et al., 2002; Sadres, Eliakim, Constantini, Lidor & Falk, 2001).

Resistance training can offer unique health and fitness benefits to children and adolescents provided that appropriate training guidelines are followed. In addition to enhancing muscle strength, the safe and proper prescription of resistance exercise has been shown to favorably influence cardiovascular risk, body composition, bone mineral density, psychosocial well-being, and resistance to sports-related injuries (Behm et al., 2008; Faigenbaum, 2007; Myer, Faigenbaum, Chu et al., 2011; Valovich McLeod et al., 2011). More recently, a meta-analysis demonstrated that regular participation in a structured resistance training program can significantly improve running, jumping and throwing performance in children and adolescents (Behringer, Vom Heed, Matthews & Mester, 2011). Since these motor performance skills provide the foundation for participation in exercise and sport, these important findings highlight the potential salutary effects of youth resistance training on lifetime physical activity. In the aforementioned report (Behringer et al., 2011), the highest effect sizes
were observed in studies that combined traditional resistance training with plyometric training, although differences between combined training and solo training (i.e., resistance training or plyometric training alone) on motor performance skills did not reach statistical significance.

Although various training modalities and a variety of training regimens have been used, all the training programs used in research studies were closely supervised and appropriately prescribed to ensure that the training program was matched to the initial capacity of the child. In the vast majority of resistance training intervention studies, the injury occurrence in children and adolescents was either very low or nil and the resistance training stimulus was well-tolerated by the young subjects (Faigenbaum & Myer, 2010b; Malina, 2006). Of interest, significant gains in strength without any report of injury have been reported in prospective studies in which weightlifting movements (including modified cleans, pulls and presses) were incorporated into youth resistance training programs (Faigenbaum & McFarland, 2008). These findings are supported by observations from others who found that the sport of weightlifting can be safe for youth provided that well-informed coaches supervise all training sessions and competitions in order to carefully prescribe the weight lifted (Byrd, Pierce, Rielly & Brady, 2003).

While the both the safety and efficacy of pediatric resistance training applied has been strongly supported in the scientific literature, youth coaches and physical education teachers need to be keenly aware of proper resistance training procedures to prevent the aggressive progression of training loads and the development of poor exercise technique that can be injurious in lifters of any age (Lavallee & Balam, 2010; Greg Myer, Quatman, Khoury, Wall & Hewett, 2009). A recurring theme in most youth resistance training-related injuries is the lack of qualified adult supervision and instruction. However, with guidance from qualified professionals in a safe training environment, neuromuscular deficits can be identified and successfully treated. For example, in figure 2 pre-training neuromuscular deficits are observable in an 8 year old girl performing the back squat exercise. Following resistance training which included instruction and practice to address these neuromuscular deficits, her exercise performance and perceived confidence to perform multi-joint lifts improved (Figure 3).

Professionals who prescribe and supervise youth resistance training programs should be cognizant of the potential for injury and should attempt to reduce injuries through the identification of risk factors and injury patterns in young lifters. Modifiable risk factors associated with youth resistance training injuries which can be reduced or eliminated with qualified supervision and instruction are outlined in table 1 (Faigenbaum, Myer, Naclerio & Casas, 2011). While these risk factors are applicable to most youth training programs, it is important to realize that each sport or activity poses its own risk for injury and each participant may have individual risk factors related to their physical and psychological well-being.
Table 1. Modifiable risk factors associated with resistance training injuries in children and adolescents which can be reduced (or eliminated) with qualified supervision and instruction*.

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Modification by Qualified Professional</th>
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<tbody>
<tr>
<td>Unsafe exercise environment</td>
<td>Adequate training space and proper equipment layout</td>
</tr>
<tr>
<td>Improper equipment storage</td>
<td>Secure storage of exercise equipment</td>
</tr>
<tr>
<td>Unsafe use of equipment</td>
<td>Instruction on safety rules in the training area</td>
</tr>
<tr>
<td>Excessive load &amp; volume</td>
<td>Prescription and progression of training program driven by technical performance of prescribed exercise movement</td>
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<tr>
<td>Poor exercise technique</td>
<td>Clear instruction and feedback on exercise movements</td>
</tr>
<tr>
<td>Poor trunk control</td>
<td>Targeted neuromuscular training</td>
</tr>
<tr>
<td>Muscle imbalances</td>
<td>Training program includes agonist and antagonist exercises</td>
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<tr>
<td>Previous injury</td>
<td>Communicate with treating clinician and modify program</td>
</tr>
<tr>
<td>Sex-specific growth</td>
<td>Targeted training to address deficits</td>
</tr>
<tr>
<td>Inadequate recuperation</td>
<td>Incorporate active rest and consider lifestyle factors such as proper nutrition and adequate sleep</td>
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* From Faigenbaum, Myer, Naclerio, & Casas, 2011

**Pediatric Resistance Training Guidelines**

Although there is no minimum age for participation in a youth resistance training program, all participants must be able to follow coaching instructions and undergo the stress of a resistance training program. In our youth programs, we introduce 6 and 7 year old children to resistance training activities using body weight activities and external loads (Faigenbaum et al., in press; Faigenbaum et al., 1999). However, regardless of the starting age, all youth should receive safety instructions from qualified professionals on proper exercise technique, appropriate exercise behavior, sensible starting loads and the correct handling of exercise equipment. This is particularly important in schools and recreation centers because untrained youth tend to overestimate their physical abilities and this may increase their risk of injury. This type of instruction not only enhances participant safety and enjoyable of the training experience, but direct supervision of youth resistance training programs can improve program adherence and optimize strength gains (Coutts, Murphy & Dascombe, 2004).

There does not appear to be one “optimal” combination of sets, repetitions, and exercises that will promote favorable adaptations in young athletes. Rather, the sensible integration of different training methods and the periodic manipulation of program variables over time will keep the training stimulus effective, challenging and enjoyable for the participants. We refer to this concept as integrative neuromuscular training because it incorporates a combination of performance-enhancing and injury-reducing components (e.g., strength, power, and balance) into one fitness program (Myer, Faigenbaum, Chu et al., 2011). This type of training does not necessitate expensive equipment, but it does require qualified instruction, a systematic progression of training variables, and an understanding of pediatric exercise guidelines.

Program design variables that should be considered when designing pediatric resistance training programs include: 1) choice of exercise, 2) training intensity and 3) training volume. From our experience, resistance training with free weights, medicine balls and one’s own body weight may be particularly beneficial for youth who need to enhance motor skill performance, balance, core strength, and muscle power as part of an integrated training program. Increased dynamic balance may help to provide children and adolescents with a stable core (i.e., pelvis, abdomen, trunk and hip) that will be better prepared to respond to the high forces generated at the distal body parts during fitness activities and athletic events (Myer, Chu, Brent, & Hewett, 2008).

Training intensity typically refers to the amount of resistance used for a specific exercise whereas training volume generally refers to the total amount of work performed in a training session. Although different combinations of sets and repetitions have been used in research studies, in a recent analysis that examined the
effects of resistance training on children and adolescents, the average training program consisted of 2 to 3 sets with 8 to 15 repetitions and loads between 60% and 80% of the 1 repetition maximum on 6 to 8 exercises (Behringer et al., 2010). While these observations are in accordance with youth resistance training guidelines from the National Strength and Conditioning Association (Faigenbaum, et al., 2009), youth must first learn how to perform each exercise correctly with a light load and then gradually progress the training intensity and/or volume without compromising exercise technique. Detailed descriptions of youth resistance training programs using different types of equipment are beyond the scope of this article but are available elsewhere (Faigenbaum & Westcott, 2009).

CONCLUSION

Scientific evidence and clinical impressions indicate that resistance training has the potential to offer observable health value to children and adolescents provided that appropriate training guidelines are followed and qualified instruction is available. Although training-induced benefits are observable at any age, it may be particularly beneficial to initiate resistance training during preadolescence. Comprehensive pediatric training programs that integrate different elements of resistance exercise are most likely to enhance fundamental movement skills, reduce the risk of injury, and promote lifelong physical activity. Important future research goals should aim to elucidate the mechanisms responsible for the performance enhancement and injury reduction benefits associated with pediatric resistance exercise, establish the combination of program variables that may optimize training adaptations and exercise adherence in children and adolescents, and explore the long-term effects of resistance exercise on the health and fitness of school-age youth.

ACKNOWLEDGEMENTS

Gregory Myer would like to acknowledge funding support from the National Institutes of Health Grants R01-AR049735 and R01-AR055563.

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