CRONOS Pediatric Physical Activity

Resistance training for overweight youth

Entrenamiento de fuerza en niños y jóvenes obesos o con sobrepeso

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ABSTRACT
A compelling body of evidence suggests that resistance training can be a safe and effective method of conditioning for children and adolescents provided that appropriate training guidelines are followed. In addition to enhancing muscular strength and motor skills, regular participation in a youth resistance training program has the potential to positively influence several measurable indices of health including body composition and various metabolic parameters. Due to the growing prevalence of overweight and obesity among children and adolescents in the European Union, the potential health benefits associated with regular participation in a youth resistance training program should not be overlooked. Program design considerations for optimizing resistance training adaptations and maximizing exercise adherence in this target population are discussed.

Key Word: Strength training, obese, children, adolescents, physical activity.

RESUMEN
Las investigaciones científicas actuales indican que la realización de programas de entrenamiento de fuerza adecuadamente planificados y supervisados, por niños y adolescentes, constituye una metodología segura y efectiva que, además de mejorar la fuerza y las habilidades motrices, influye positivamente en diferentes índices de salud como la composición corporal y otras variables metabólicas. Debido a la creciente prevalencia del sobrepeso y obesidad entre niños y adolescentes de la Unión Europea, los beneficios potenciales sobre la salud asociados con la realización sistemática de programas de entrenamiento de fuerza desde las edades tempranas no deben ser pasados por alto. El objetivo de esta revisión es analizar los aspectos más importantes a tener en cuenta para diseñar programas de entrenamiento en niños y jóvenes con sobrepeso u obesidad por medio de los cuales se optimicen las adaptaciones y mejore la adherencia a los programas de ejercicio físico en este grupo poblacional.

Palabras Clave: Entrenamiento de fuerza, obesidad, niños adolescentes, actividad física.

INTRODUCTION

The epidemic of pediatric obesity and associated comorbidities has become a critical public health threat for the 21st century (Suggs and McIntyre 2011). Current finding indicate that the European Union can expect the number of overweight and obese youth to rise by approximately 1.3 million children per year (Jackson-Leach and Lobstein 2006). In Spain, the prevalence of overweight among youth increased by 3.2% in boys and 4.6% in girls from 1987 to 2006 (Salcedo et al. 2010), with population estimates for the prevalence of obesity in Spanish children and young people reaching 13.9% (Aranceta et al. 2007). Furthermore, data from a cross-sectional study found that only 48% of Spanish children and adolescents regularly engage in 60 min or more of health-enhancing physical activity (Roman et al. 2008). If current trends continue, physical inactivity and childhood obesity will likely pose an unprecedented burden on youth, their families, and the health care system.

Understanding how sensible lifestyle choices such as regular physical activity can improve the body composition and enhance the health and well being of youth is a growing area of interest among physical education teachers, pediatric researchers and health care providers. While there is not one "cook book" program of proven efficacy that professionals can use to manage this condition, multifaceted interventions that include behavioral counseling, nutrition education and physical activity promotion offer the best chance for success (Davis et al. 2009) . Of these components, regular physical activity is critical for weight maintenance and the prevention of abnormal weight gain (Krebs and Jacobson 2003). In addition to aerobic forms of exercise (e.g., walking and sustained games), new insights indicate that resistance training can be a safe, effective and worthwhile method of conditioning for all youth regardless of body size (Behringer et al. 2010; Faigenbaum and Westcott 2007).

This review discusses the potential benefits of resistance exercise for youth who are overweight or obese and provides suggestions for prescribing resistance exercise which can be part of a comprehensive treatment plan. In this review, the term resistance training (or strength training) is defined as a specialized method of physical conditioning that involves the progressive use of a wide range of resistive loads and a variety of training modalities including free weights (barbells and dumbbells), medicine balls, elastic bands and body weight exercises. The term "obese" refers to a body mass index (BMI) equal to or greater than the 95th percentile of the age- and gender-specific BMI whereas the term "overweight" refers to a BMI between the 85th and 94th percentile (Barlow, 2007). The terms youth and pediatric are broadly defined in this review to include children and adolescents.

POTENTIAL BENEFITS OF RESISTANCE TRAINING FOR OVERWEIGHT AND OBESE YOUTH

Along with dietary changes and behavior modification, regular physical activity is a cornerstone of treatment for overweight and obese youth. Although both normal weight and overweight children and adolescents have traditionally been encouraged to participate in aerobic activities such as walking and swimming, they have not always been encouraged to participate in resistance training. Unfounded concerns regarding the potential effects of strength-building exercise on the growth and development of young lifters sometimes limits their participation in this type of training.

Over the past two decades, a compelling body of evidence has accumulated to indicate that resistance training can be a safe, effective, and beneficial method of conditioning for all youth regardless of body size (Behringer et al. 2010; Faigenbaum and Myer 2010). Research into the effects of resistance training on normal weight and overweight children and adolescents has increased over the years, and the qualified acceptance of youth resistance training by medical and fitness organizations has become universal. The American College of Sports Medicine (American College of Sports Medicine, 2010), the British Association of Sports and Exercise Science (British Association of Exercise and Sport Sciences, 2004), the Canadian Society for Exercise Physiology (Behm et al. 2008), and the National Strength and Conditioning Association (Faigenbaum et al. 2009) support participation in youth resistance training activities provided the program is appropriately designed and competently supervised.

In addition to enhancing muscular strength and local muscular endurance, appropriately prescribed and competently supervised resistance training programs may also offer observable health value for boys and girls. Regular participation in resistance training activities has been shown to positively influence bone mineral density, cardiorespiratory fitness, blood lipids and psychosocial wellbeing (Faigenbaum et al. 2009). More recently, the effect of resistance training on body composition and various metabolic parameters has received increased attention (Faigenbaum, 2010) .

Although aerobic exercise is typically prescribed for decreasing body fat, several youth resistance training studies have reported a decrease in fatness among overweight or obese children and adolescents (Benson et al. 2008; Davis et al. 2010; McGuigan et al. 2009; Schwingshandl et al. 1999; Shaibi et al. 2006; Sothern

et al. 1999; Velez et al. 2010; Watts et al. 2004; Yu et al. 2005). Of interest, Watts et al. found that circuit resistance training (both cycle ergometry and resistance training) not only improved the body composition of obese adolescents, but also normalized vascular dysfunction in this population (Watts et al. 2004). Other researchers found that participation in a progressive resistance training program significantly decreased body fat and increased insulin sensitivity in overweight adolescent males (Shaibi et al. 2006). Because the increase in insulin sensitivity remained significant after adjustment for changes in total fat mass and total lean mass in the aforementioned report (Shaibi et al. 2006), these researchers speculated that resistance training may have resulted in qualitative changes in skeletal muscle that contributed to enhanced insulin action. Interestingly, researchers have identified muscular strength as an independent and powerful predictor of better insulin sensitivity in youth age 10 to 15 years (Benson et al. 2006).

These important findings highlight the potential clinical relevance of resistance training in overweight and obese youth who are less willing and often unable to participate in prolonged periods of moderate to vigorous aerobic exercise without rest. Excess body weight not only hinders the performance of some weight bearing physical activities such as tag games, basketball, or soccer, but excess body weight can also increase the risk of musculoskeletal overuse injuries (Stovitz et al. 2008). While all children and adolescents need to be physically active on most if not all days of the week, overweight and obese youth often lack the motor skills and confidence to be physically active and they may actually perceive prolonged periods of aerobic exercise to be boring or discomforting. In support of these observations, researchers have reported that total body fat was inversely related to minutes of vigorous physical activity per day in both boys and girls (Dencker et al. 2006).

However, most overweight children and adolescents find resistance training activities enjoyable because this type of exercise is not aerobically taxing and provides an opportunity for all youth -- regardless of body size --to experience success and feel good about their performance. Overweight and obese youth tend to enjoy resistance training because it is typically characterized by short periods of physical activity interspersed with brief rest periods between sets as needed. This type of exercise provides all participants with an opportunity to enhance motor skill performance and while gaining confidence in their abilities to be physically active. The potential benefits of resistance training for obese youth are summarized in table 1.

Table 1. Potential Benefits of Youth Resistance Training.

• Increase muscle strength and power
• Increase local muscular endurance
• Increase bone mineral density
• Increase cardiorespiratory fitness
• Improve blood lipid profile
• Improve body composition
• Improve insulin sensitivity
• Improve motor performance skills
• Enhance sports performance
• Increase resistance to injury
• Enhance mental health and well-being
• Stimulate a more positive attitude toward lifetime physical activity

DESIGNING RESISTANCE TRAINING PROGRAMS FOR OVERWEIGHT YOUTH

A variety of training modalities and different combinations of sets and repetitions have provided an adequate stimulus for strength enhancement and favorable changes in body composition in both normal weight and overweight youth (Faigenbaum and Westcott 2009). However, youth resistance training programs need to be carefully prescribed because unsupervised and poorly performed strength testing and resistance training may be injurious (Myer et al. 2009). While there is no minimal age requirement for participation in a resistance training program (Faigenbaum et al. 2009), overweight children and adolescents should be seen by their physician or health care provider before they begin this or any other exercise program. In addition, youth with pre-existing medical conditions including hypertension or seizure disorders should be withheld from resistance training until medical clearance is obtained (American Academy of Pediatrics, 2008).

All training sessions should be conducted by qualified professionals who understand the fundamental principles of resistance exercise, appreciate the uniqueness of childhood and adolescence, and take the time to teach proper exercise technique (Figure 1). This is particularly important for overweight youth who typically have limited experience participating in a structured exercise program. Close supervision, age-appropriate instruction, and a safe exercise environment are paramount. While different factors can influence program commencement and program continuation in parents and youth, the quality of the program, the child's improved weight status, coordination and confidence, and pleasant social interactions with peers and instructors have been found to be noteworthy considerations to

successfully recruit and retain intervention participants (Pescud et al. 2010).

Figure 1. Children should learn proper exercise tec hnique from a qualified instructor.

RESISTANCE TRAINING PROGRAM DESIGN

When working with overweight and obese youth, it is important to remember that the goal of the program should not be limited to increasing muscle strength and improving body composition. Obese youth have fewer friends and miss more school days than their normal weight peers (Potts-Datema and Taras 2005). Thus, the first step in encouraging obese children and adolescents to exercise may be to increase their confidence in their ability to be physically active in a socially supportive environment, which in turn may lead to an increase in regular physical activity, an improvement in body composition and, hopefully, exposure to a form of exercise that can be carried over into adulthood.

From our experience, overweight youth tend to be the strongest students in class and they often receive unsolicited positive feedback from their normal weight peers who are often impressed with the amount of weight they can lift. In support of these observations, Davis et al reported mean 1 repetition maximum (RM) loads of 271 kg on the leg press exercise in a group of overweight male adolescents who completed a 16 week resistance training program (Davis et al. 2009). Unlike other types of exercise and sport, participation in resistance exercise gives youth with a high percentage of body fat a chance to "shine" and gain confidence in their abilities to be physically active. This is where the art and science of developing a youth resistance training program come into play because the principles of training specificity and progressive overload need to be balanced with individual needs, goals and positive social interactions in order to optimize gains, prevent boredom and promote exercise adherence. Resistance exercises such as the medicine ball partner can be enjoyable and effective for school-age youth (Figure 2).

Figure 2. Medicine ball partner twist exercise

Teaching youth about their bodies, promoting safe training procedures, and providing a stimulating program that gives participants a more positive attitude toward resistance training and physical activity are equally important. Since there is not one "optimal" combination of sets, repetitions, and exercises that will promote favorable adaptations in muscular strength and body composition in all youth, many program variables need be altered over time to achieve desirable outcomes. Clearly, resistance training programs for overweight and obese youth need to be individualized and based on each participant's health history, training experience, personal goals and time available for exercise.

Of interest, (Castro-Piñero et al. 2009) recently reported that overweight and obese youth (6 to 17.9 years old) had worse performance than their underweight and normal weight counterparts on 8 different muscular strength tests that required participants to move their body weight (Castro-Piñero et al. 2009). However, overweight and obese youth recorded the highest values on the medicine ball toss in the aforementioned report which suggests that body weight exercises such as pull ups, isometric bent arm hang or even push-ups may not be ideal for this population in

which excess body mass hinders performance (Castro-Piñero et al. 2009). When working with overweight and obese youth, the use of light loads (e.g, unloaded barbell) and medicine balls during the introductory period may be a safer and more enjoyable mode of training which can provide an opportunity for all participants to learn and practice basic resistance training movements with proper technique. Table 2 summarizes general resistance training guidelines for children and adolescents.

Table 2. General Youth Resistance Training Guidelines

• Provide qualified instruction and supervision
• Ensure the exercise environment is safe and free of hazards
• Teach youth the benefits and concerns associated with resistance training
• Begin each session with a 5 to 10 minute dynamic warm-up
• Start with one or two light/moderate sets of 10 to 15 repetitions on a variety of exercises
• Progress to 2 or 3 sets of 6 to 15 repetitions depending on needs and goals
• Increase the resistance gradually as strength improves
• Focus on the correct exercise technique instead of the amount of weight lifted
• Strength train two to three times per week on nonconsecutive days
• Use individualized workout logs to monitor progress

Choice and Order of Exercise

Although a limitless number of exercises can be used to enhance muscular fitness, it is important to select exercises that are appropriate for an overweight child's body size, fitness level, and exercise technique experience. Weight machines as well as free weights, elastic bands, and medicine balls have been used by normal weight and overweight youth in clinical- and school-based exercise programs (Faigenbaum and Westcott 2009). With most machine weight exercises, the path of movement is fixed and therefore the movement is stabilized and easier to perform. Moreover, since most weight machine exercises are performed in the sitting position, excess body weight does not hinder the performance of overweight individuals. This consideration is important when choosing exercises for overweight youth who have limited experience resistance training. Regardless of the mode of exercise, each lift should be performed in a controlled manner with proper exercise technique.

There are many ways to arrange the sequence of exercises in a resistance training session. Most overweight youth will perform total body workouts several times per week involving multiple exercises stressing all major muscle groups each session. Large muscle group exercises should be performed before smaller muscle group exercises, and multiple-joint exercises should be performed before single-joint exercises. Following this exercise order will allow heavier weights to be used on the multiple-joint exercises because fatigue will be less of a factor. It is also helpful to perform more challenging exercises earlier in the workout when the neuromuscular system is less fatigued. Thus, if an overweight child is learning how to perform a multi-joint exercise such as a squat, this exercise should be performed early in the training session so that the child can practice the movement without undue fatigue.

Training Intensity

The use of repetition maximum (RM) loads is a relatively simple method to prescribe strength training intensity. In adult populations, RM loads of 6 or less have the greatest effect on developing muscle strength, whereas RM loads of 20 or more have the greatest impact on developing local muscular endurance. However, most studies involving youth suggest that lighter loads and higher repetitions (e.g., 10-15 RM) are most beneficial for enhancing muscular strength during the initial adaptation period (Faigenbaum et al. 1999). Since different combinations of sets and/or repetitions may be needed to promote long-term gains in muscular fitness, the best approach for an overweight child may be to start resistance training with one or two sets of 10-15 repetitions on a variety of exercises during the first six to eight weeks of training, and then systematically perform additional sets and vary the training intensity (e.g., 6-10 RM) in order to avoid training plateaus and optimize training adaptations (Faigenbaum and Naclerio 2011).

The importance of gradually increasing the exercise intensity is an important program design consideration. For example, Shaibi et al. reported favorable training-induced changes in body composition and insulin sensitivity along with an impressive 96% exercise adherence rate following participation in a 16 week resistance training program with prescribed intensities progressing from 62% to 97% 1 RM (Shaibi et al. 2006). More recently, McGuigan et al. found that an eight week periodized resistance training program that included power exercises (e.g, squat jumps and high pulls) enhanced muscular fitness and reduced body fat in overweight and obese boys and girls between 7 and 12 years of age (McGuigan et al. 2009). Since type IIx muscle fibers are the most insulin resistant and seem to be more prevalent in obese cohorts (Venojärvi et al. 2005), periodized training programs that include high force/high velocity muscle actions that specifically tar-

get type IIx muscle fibers may be particularly beneficial and worthwhile for overweight and obese youth.

Training Volume

It is generally recommended that children and adolescents perform one to three sets on each exercise to achieve muscular fitness goals (Behm et al. 2008; Faigenbaum et al. 2009). In general, one, two, or three-set protocols will be effective for normal weight and overweight youth during the first few months of resistance training provided that reasonable training loads are used. Although long-term training studies (> 6 months) are needed to explore the effects of different training programs on muscular strength and body composition in normal weight and obese youth, a multiple set training protocol is likely to be more effective than a single set protocol for maximizing training adaptations and maintaining exercise adherence in youth over the long-term (Faigenbaum and Naclerio 2011).

By periodically varying the training intensity, number of sets and choice of exercises, the training stimulus will remain effective and the adaptations to the training program will likely be maximized. Of potential relevance, Foschini et al. (Foschini et al. 2010) reported similar changes in muscular endurance in obese adolescents who completed a 14 week aerobic and resistance training program that followed a linear (i.e. gradual changes in intensity and volume) or undulating (i.e., weekly changes in intensity and volume) periodized training model . However, these researchers also found that there may be more notable changes in various metabolic parameters following undulating training than linear training (Foschini et al. 2010). Although additional research is needed to examine the effects of different periodized resistance training programs on health and fitness outcomes in youth, the importance of program variation and weekly progression must not be overlooked if long-term gains in health and performance are desired.

Rest Interval Between Sets and Exercises

In general, the length of the rest interval between sets and exercises will influence energy recovery and the training adaptations that take place. Obviously, training intensity, training goals and fitness level will influence the rest interval. Although few data examining the effects of rest interval length on strength performance in younger populations are available, it appears that children and adolescents can recover faster than adults between several repeated sets of resistance exercise at the same relative intensity (Faigenbaum et al. 2008). Thus, a shorter rest interval may suffice in children and adolescents when performing a moderate-intensity resistance exercise protocol, although the likelihood that adolescents may fatigue more rapidly than children should be considered. In general, a rest period of 1 minute between sets is appropriate for most beginners. Short rest periods (<30 s between sets and exercises) need to be carefully prescribed because of the muscular discomfort associated with this type of training.

Repetition Velocity or Cadence

The velocity or cadence at which an exercise is performed can affect adaptations to training. Since beginners need to learn how to perform each exercise correctly, it is recommended that untrained youth perform exercises in a controlled manner at a moderate velocity in order to maintain proper exercise technique throughout the entire range of motion. As youth gain experience, different training velocities may be used depending on the choice of exercise and program goals. For example, selected medicine ball exercises such as the chest push (Figure 3) can be performed explosively with a low cadence whereas the medicine ball lunge (Figure 4) can be performed at a more controlled velocity with a higher cadence as performance improves. Although additional research is needed, it is likely that the integration of strength and power exercises performed at different velocities with varying cadences/tempos within a training program may provide the most effective training stimulus (McGuigan et al. 2009).

Figure 3. Medicine ball chest push exercise

Figure 4. Medicine ball lunge exercise

Training Frequency

Training frequency typically refers to the number of training sessions per week. A training frequency of 2-3 times per week on nonconsecutive days is recommended for children and adolescents. Limited evidence indicates that one day per week of resistance training may be suboptimal for enhancing muscular strength in normal weight children (Faigenbaum et al. 2002). A training frequency of 2-3 times per week on nonconsecutive days will allow for adequate recovery between sessions and will be effective for enhancing muscle strength and performance. Factors such as the training volume, training intensity, exercise selection and nutritional intake should also be considered when prescribing a training frequency for an overweight participant as these factors may influence one's ability to recover from and adapt to the training program. In addition, professionals need to consider school vacation schedules and travel plans when designed youth resistance training programs.

In summary, with qualified supervision and instruction, overweight youth can begin resistance training with 1 or 2 set of 10 to 15 reps (~% 60-75% 1 RM) on 6 to 10 different exercises with ~ 1 min of rest between sets. As confidence and competence to perform resistance exercise improves, they can systematically perform additional sets and vary the training intensity in order to limit training plateaus, maximize performance gains, and reduce the likelihood of overtraining. When working with overweight youth, it is important to promote safe training procedures and providing a rewarding program in a supportive environment that gives all participants a more positive attitude towards physical activity. Close supervision, enthusiastic leadership, social support, sensible progression and a safe exercise environment are paramount.

CONCLUSION

As pediatric researchers, physical education teachers, and health care providers continue to embrace the challenge of dealing with overweight and obese youth, creative interventional techniques and motivational strategies are needed to increase the likelihood for successful outcomes in schools, recreation centers and primary care settings. Progressive resistance training gives overweight and obese youth an opportunity to improve their health, fitness and quality of life. While additional clinical trials are needed to examine the long-term effects of resistance exercise on children and adolescents who are overweight or obese, current findings indicate that resistance training may offer observable health and fitness value to children and adolescents regardless of body size provided the exercise programs are supervised by competent professionals and systematically varied over time. We now have a growing body of evidence to recommend participation in resistance training in schools, recreational centers and health care facilities as part of a multi-faceted approach to long-term health and well-being.

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