



Resistance Training for Obese Children and Adolescents

Abstract

The prevalence of obesity among children and adolescents is increasing at an alarming rate. If current trends continue, this epidemic will likely pose an unprecedented burden on youth, their families and our health care system. It is important to understand how sensible lifestyle choices such as regular exercise can enhance the health and well-being of obese children and adolescents. While aerobic exercise has traditionally been recommended for obese youth, a growing body of scientific evidence indicates that resistance training can be a safe, effective, and enjoyable method of exercise provided that appropriate training guidelines are followed and qualified instruction is available. In addition to favorable changes in body composition, regular participation in strength-building activities gives obese youth a chance to experience success, feel good about their performances, and gain confidence in their abilities to be physically active. Moreover, participation in resistance exercise gives youth with a high percentage of body fat a chance to be exposed to a form of exercise that can be carried over into adulthood. In this paper, we will discuss the potential benefits of resistance training for obese youth and describe program design considerations for designing resistance training programs for obese children and adolescents.

The prevalence of obesity during childhood and adolescence has reached epidemic proportions worldwide.^{41, 52} This unabated epidemic is occurring in boys and girls across all socioeconomic strata and it appears that obese children and adolescents are at high risk for becoming obese adults.^{14, 27, 29, 31} These trends have led some observers to predict that the overall adult life expectancy will decrease due to the increased prevalence of obesity-related co-morbidities such as type 2 diabetes, cardiovascular disease and cancer.⁴⁰ Today, childhood obesity, with its associated co-morbid conditions and its likelihood of persistence into adulthood, is considered a critical public health threat for the 21st century.^{29, 31} Learning how sensible lifestyle choices, such as regular exercise, can improve the body composition and enhance the health and well-being of obese children and adolescents is a growing area of interest among health and physical education teachers, researchers, health care providers, and government officials.

While both normal weight and obese youth have traditionally been encouraged to participate in aerobic activities such as walking and cycling, 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 exercise for all youth regardless of body size.^{24, 38, 54} Research into the effects of resistance exercise on normal weight and obese children and adolescents has increased over the years, and the qualified acceptance of youth resistance training by medical and fitness organizations has become almost universal.^{1, 3, 6, 16} This paper discusses the potential benefits of youth resistance training and provides program design considerations for developing resistance training programs for obese children and adolescents.

For the purpose of this paper, the term “obese” refers to youth (both children and adolescents) with a body mass index (BMI [weight in kg/height in m²]) equal to or greater than the 95th percentile of the age- and gender-specific BMI

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distribution.³⁵ The term “at risk for obesity” is defined as a BMI at or above the age- and gender-specific 85th percentile but less than the 95th percentile. The term “resistance 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 to increase one’s ability to exert or resist force. The term “children” refers to boys and girls who have not yet developed secondary sex characteristics (approximately age 11 in girls and 13 in boys) and the term “adolescence” refers to the period between childhood and adulthood and includes girls 12 to 18 years and boys 14 to 18 years.

Potential Benefits of Resistance Training for Obese Youth

Although psychosocial, economic and environmental factors likely play a role in the development of obesity during childhood and adolescence,² it is becoming more apparent that the increasing prevalence of obesity in school-age youth is due, at least in part, to a reduction in total daily energy expenditure. Societal changes during the last several decades have reduced the need to be physically active and increasing urbanization has resulted in the lack of safe play areas in some communities.^{10, 11, 43} Even though the absolute energy cost of any given movement increases as a child becomes obese, fewer boys and girls participate regularly in physical activity. For example, only 28% of high school students attend physical education class daily¹¹ and children’s motorized transportation to and from school has increased.¹⁰ Furthermore, youth spend more time with electronic media (e.g., video games and computers) and on a typical day 33% of children watch television for more than 3 hours.⁴³

Clearly, all children and adolescents need to be physically active on most, if not all, days of the week.⁴⁹ However, 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.¹² Sadly, the decline in regular physical activity may start early in life in obese youth.²⁸

Conversely, obese youth seem to enjoy resistance training because it is typically characterized by short periods of physical activity interspersed with brief rest periods between sets, as needed.¹⁵ The intermittent rather than continuous nature of resistance training is more

consistent with how youth move and how youth play.⁵ Scientific evidence and clinical observations support the contention that participation in strength-building activities gives obese children and adolescents a chance to experience success and gain confidence in their abilities to be physically active.^{45, 47, 48, 54, 56}

In addition to enhancing muscular strength and local muscular endurance, appropriately prescribed and competently supervised resistance training programs may also positively influence bone mineral density, cardiorespiratory fitness, blood lipids, and psychosocial well-being.¹⁵ Moreover, regular participation in a resistance training program may result in favorable changes in fat and lean tissue in obese youth.⁵⁴ Several studies have reported favorable changes in body composition in children and adolescents who were obese or at risk for obesity following participation in a resistance training program.^{44, 45, 48, 50, 51, 53, 57} In short, a stronger musculoskeletal system will enable obese youth to perform life’s daily activities with more energy and vigor. The potential health-related benefits of resistance training for obese youth are summarized in Table 1.

Table 1 Potential Health-Related Benefits of Resistance Training for Obese Youth
• Increase muscle strength
• Increase local muscular endurance
• Improve neuromuscular control
• Increase bone mineral density
• Increase cardiorespiratory fitness
• Improve blood lipid profile
• Improve body composition
• Reduce risk of sports-related injuries
• Enhance psychosocial well-being
• Stimulate a more positive attitude towards lifetime physical activity

Although resistance training is not typically characterized by high caloric expenditure, this type of training has proven to be an important component of weight management programs for obese youth. Sothorn et al.⁴⁸ studied the safety and feasibility of a progressive, moderate intensity resistance training program (1 set of 8-12 repetitions, with weights (e.g., intensity) of 60% 1 repetition maximum [RM]) in a group of obese children during a multidisciplinary outpatient treatment program.

During the intervention period, there were no reported injuries or accidents, and 79% of the subjects completed the 10 week program. Body weight, BMI and percent body fat were reduced significantly at 10 weeks and had not significantly increased at one year follow-up assessment.

Treuth et al.⁵¹ reported gains in fat-free mass in obese children who participated in a five month resistance training program (2 sets of 12-15 repetitions, with weights $\geq 50\%$ 1 RM). Compliance with the resistance training program was high, with 83% of the participants completing the five month training program. Participants in this study increased their bench press and leg press strength by about 25%. While total body weight and percent body fat (measured by dual-energy x-ray absorptiometry) also increased during the intervention period, intra-abdominal adipose tissue (measured by computed tomography) did not significantly change from before training to after training. Since central obesity is associated with cardiovascular risk in children, this finding may have important health implications. Schwingshadl et al.⁴⁴ also demonstrated gains in fat-free mass (estimated from bioelectrical impedance analysis) in obese youth who participated in a 12 week resistance training program (2 to 4 sets with weights $\geq 50\%$ 10 RM) as compared to those who did not resistance train. In addition, the changes in body weight at one year follow-up were inversely correlated with the change in fat-free mass after 12 weeks. This finding suggests that loss of fat-free mass during weight reduction in obese youth may be associated with subsequent weight regain.

Watts et al.⁵³ found that circuit training (the combination of cycle ergometry [65% to 85% maximum heart rate] and resistance training [55% to 70% 1 RM]) not only improved the body composition of obese adolescents, but it also normalized brachial artery endothelial cell responsiveness (e.g., improved arm blood flow capacity) in these subjects. Since endothelial cell dysfunction is an early manifestation of atherosclerotic disease,⁹ this important finding highlights the potential clinical relevance of circuit training in obese adolescents.

More recently, Shabi et al.⁴⁵ examined the effects of 16 weeks of resistance training (1 to 3 sets, 3 to 15 repetitions, with weights of 62 to 97% 1 RM) on insulin sensitivity and body composition in adolescent males who were at risk for obesity. Compliance to this intervention was impressive with 96% of participants completing the exercise training program. These researchers reported that subjects in the training group increased their bench press and leg press strength about

26%. Moreover, it was reported that participation in a progressive resistance training program significantly decreased body fat and significantly increased insulin sensitivity. Since the increase in insulin sensitivity remained significant after adjustment for changes in total fat mass and total lean mass, it appeared that resistance training produced qualitative changes in skeletal muscle that contributed to enhanced insulin action. Longitudinal investigations are needed to determine if these observed benefits of resistance training during adolescence will correspond to the prevention of atherosclerotic disease and type 2 diabetes during adulthood.

Program Design Considerations

The first step in encouraging obese children and adolescents to exercise is to increase their confidence in their ability to be physically active, 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. Nevertheless, youth resistance training programs need to be carefully prescribed because unsupervised and poorly performed resistance training may be injurious.⁴² This is particularly important for obese youth who typically have limited experience participating in a structured exercise program. Accordingly, when working with inactive youth it is always better to underestimate their physical abilities and gradually increase the volume and intensity of training than overestimate their abilities and risk an injury.

When working with obese children and adolescents, it is important to remember that the goal of the program should not be limited to increasing muscle strength and improving body composition. Other program objectives include teaching youth about their bodies, promoting safe training procedures, and providing a stimulating program that gives participants a positive attitude towards resistance training and physical activity. As such, the “pass-fail” mentality that may discourage some obese boys and girls from participating is to be avoided. Instead, the workout should be considered as a “challenge” in which all participants can feel good about their performance and get excited about monitoring their progress.

The emphasis on guaranteed outcomes should be reduced, and instead the focus should be placed on intrinsic factors, such as skill improvement, personal success and having fun. Because obese youth tend to be the strongest students in class, they often receive unsolicited positive feedback from their normal weight

peers who are often impressed with the amount of weight they can lift. Unlike prolonged periods of continuous aerobic exercise, 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: The principles of training specificity and progressive overload need to be balanced with individual needs and abilities in order to optimize gains, prevent boredom and promote exercise adherence.

Although there is no minimal age requirement for participation in a youth resistance training program, it is important that all participants understand the potential risks and benefits associated with resistance training. All training sessions should be conducted by qualified professionals who understand the fundamental principles of resistance exercise and appreciate the uniqueness of childhood and adolescence. Close supervision, age-appropriate instruction and a safe exercise environment are paramount. Also, obese children and adolescents should be seen by their physician or health care provider before they begin this or any other exercise program.^{1, 16}

Despite various claims about the best resistance training program for children and adolescents, there does not appear to be one “optimal” combination of sets,

repetitions, and exercises that will promote favorable adaptations in muscular strength, muscular power, local muscular endurance and body composition in youth. Rather, by periodically varying the training variables over time, the training stimulus will remain effective and adaptations to the training program will be maximized. The program variables that should be considered when designing a resistance training program include: (1) choice of exercise, (2) order of exercise, (3) training intensity, (4) training volume (total number of number of sets and repetitions), (5) rest intervals between sets and exercises, (6) repetition velocity and (7) training frequency.²⁶ By varying one or more of these program variables, a limitless number of resistance training programs can be designed. Table 2 summarizes youth resistance training guidelines. Detailed information on designing youth resistance training programs is available elsewhere.^{21, 33, 39, 55}

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 obese child’s body size, fitness level, and exercise technique experience. Also, the choice of exercises should promote muscle balance across joints and between opposing muscle groups (e.g., quadriceps and hamstrings). Weight machines (both child-sized and adult-sized) as well as free weights (barbells and dumbbells), elastic bands, and medicine balls (weighted balls filled with sand or cloth) have been used by children and adolescents in school- and clinical-based exercise programs.^{4, 17, 18, 23, 47, 53, 56}

Of note, excess body fat can hinder the performance of obese youth on weight-bearing exercises such as push-ups and pull-ups. However, excess body weight does not hinder the performance of obese individuals on most weight machine exercises. This is an important consideration when choosing exercises for obese youth who have limited experience with resistance training. It may be reasonable to start resistance training on weight machines and gradually progress to weight-bearing free weight and medicine ball exercises that generally require more coordination and skill to perform correctly. Regardless of the mode of exercise, the concentric (muscle shortening) and eccentric (muscle lengthening) phases of 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 obese youth will perform total body workouts two or three times per week, which involve multiple exercises stressing all major muscle groups each session. In this

Table 2 General Youth Resistance Training Guidelines
• Provide qualified instruction and supervision
• Ensure the exercise environment is safe and free of hazards
• Begin each session with a 5 to 10 minute dynamic warm-up period
• Start with one light to moderate set 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
• Cool down with low intensity activities and static stretching
• Resistance train two to three times per week on nonconsecutive days
• Keep the program fresh and challenging by systematically varying the training program.

type of workout, 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 obese child is learning how to perform a squat exercise, this exercise should be performed early in the training session so that the child can practice the exercise without undue fatigue.

Training Intensity. One of the most important variables in the design of a resistance training program is the training intensity.³⁴ Gains in muscular strength and performance are influenced by the amount of weight lifted, which is highly dependent upon other program variables such as exercise order, training volume (total work performed), repetition speed and rest interval length. To maximize gains in muscle strength, youth should first learn how to perform each exercise correctly and then learn how to perform each set to temporary muscular fatigue using the appropriate resistance. In short, the act of resistance training in and of itself does not ensure that favorable changes in muscular strength and body composition will be realized. Rather, individual effort combined with a well-designed training program will ultimately determine the adaptations that take place.

The use of RM loads is a relatively simple method to prescribe resistance training intensity. RM loads refer to the amount of weight at which an exercise can be performed for a specified number of repetitions. For example, a 1 RM load is the amount of weight that can be lifted one time. Research studies involving adults suggest that 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.⁷ 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 first two months of training.^{19, 22, 23} Since different combinations of sets and/or repetitions may be needed to promote long-term gains in muscular fitness, the best approach for an obese child may be to start resistance training with one set of 10 to 15 repetitions on a variety of exercises, and then systematically perform additional sets and vary the training intensity in order to limit training plateaus, maximize performance gains, and reduce the likelihood of overtraining.

Interestingly, Falk et al.²⁵ observed that the level of adiposity was a strong negative predictor of the resistance training effect of the lower limbs following three school years of resistance training (2-3 days/week; 1-4 sets, 5-30 repetitions/set [mean weight load of 50-60% 1 RM]). Since the individually prescribed training program resulted in greater strength gains in normal weight children (14.5 to 16.7% body fat) compared with the non-responders (23.5 to 32.8% body fat) over the study period, it was suggested that a training intensity to increase strength in normal weight children may be insufficient in children who have excess body fat. These researchers suggested that obese youth may need a higher relative training intensity in order to produce the desired result. This may be particularly important for lower extremity exercises since the lower body of obese youth is relatively strong as it is stimulated on a daily basis through carrying greater body weight. Thus, when prescribing an appropriate training intensity for obese youth it seems reasonable to first establish a repetition range (e.g., 10 to 15), and then manipulate the training load to maintain the desired training intensity.

Training Volume. The training volume refers to the total amount of work performed in a training session. The number of exercises performed per session, the repetitions performed per set and the number of sets performed per exercise all influence the training volume. For example, if a child performs two sets of 10 repetitions with 100 lb on the leg press exercise, the training volume for this exercise would be 2000 lb ($2 \times 10 \times 100 = 2000$). Although there is some debate regarding training volume, it is important to remember that every training session does not need to be characterized by the same number of sets, repetitions and exercises.

In general, a one-set training protocol will be effective for obese youth during the first few resistance training sessions provided that reasonable training loads are used. However, multiple-set training protocols are likely to be more effective than a single-set protocol for maximizing training adaptations and maintaining exercise adherence in youth over the long term.³² A reasonable recommendation is for obese children and adolescents to start resistance training with a single-set program and then gradually increase the number of sets to two or three on selected exercises depending on personal goals and time available for training.

Rest Intervals Between Sets and Exercises. The rest interval between sets and exercises is an important but often overlooked resistance training variable. In general,

the length of the rest period will influence energy recovery and the training adaptations that take place. For example, if the goal is to promote energy expenditure, lighter weights and shorter rest periods (e.g., 1 min) are required. Training intensity, training goals, and fitness level will influence the length of the rest interval. In general, a rest period of 1 to 2 min between sets is appropriate for most beginners. Short rest periods (< 30 seconds between sets and exercises) need to be carefully prescribed because of the muscular discomfort associated with this type of training. However, over time, the rest periods can be reduced gradually to provide ample opportunity for the body to tolerate this type of resistance training (e.g., circuit weight training).

Repetition Velocity. The velocity or cadence at which a strength exercise is performed can affect the adaptations to a training program.²⁶ Since beginners need to learn how to perform each exercise correctly with a light resistance, it is recommended that untrained obese youth perform exercises in a controlled manner at a moderate velocity. As youth gain experience in resistance training, different training velocities may be used depending on the choice of exercise and program goals. For example, selected medicine ball exercises (e.g., chest pass) can be performed at a higher velocity than traditional strength-building exercises (e.g., bench press). Although additional research is needed, it is likely that the performance of different training velocities within a training program may provide the most effective resistance training stimulus.

Training Frequency. Training frequency typically refers to the number of training sessions per week. A resistance training frequency of two to three times per week on nonconsecutive days is recommended for children and adolescents.^{3, 16} Limited evidence indicates that one day

per week of resistance training may be suboptimal for enhancing muscular strength in youth.²⁰ A training frequency of two or three times weekly on nonconsecutive days will allow for adequate recovery between sessions (48 to 72 hours between sessions) and will be effective for enhancing muscle strength and performance. Factors such as the training volume, training intensity, and exercise selection should also be considered when prescribing a training frequency for an obese participant, as these factors may influence one's ability to recover from and adapt to the training program.

Summary

Regular participation in a resistance training program, along with other types of physical activity, gives obese children and adolescents yet another opportunity to improve their health, fitness and quality of life. While additional studies are needed to examine the long-term effects of resistance exercise on obese children and adolescents, scientific evidence and clinical observations suggest that progressive resistance training programs may offer observable health and fitness value to boys and girls who are obese or at risk for obesity. In addition to enhancing musculoskeletal strength, resistance training beneficially modifies body composition and seems to provide obese youth with an opportunity to experience success and feel good about their performance. When conducted by competent professionals who possess a sound understanding of resistance training principles and who genuinely appreciate the physical and psychosocial uniqueness of childhood and adolescence, regular resistance training can offer many benefits and lead to a lifelong interest in an enjoyable type of physical activity. There is a growing body of evidence to recommend participation in resistance training for children and adolescents who are obese or at risk for obesity.

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Regular participation in a resistance training program can improve health and fitness among obese children and adolescents. Obese youth tend to enjoy resistance training because it provides an opportunity for all participants to experience success and feel good about their performance. Thus, the first step in encouraging obese youth to exercise may be to increase their confidence in their abilities to be physically active, 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.

Please Post

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