

Perceived benefits and concerns of resistance training for children and adolescents

Beneficios y variables percibidas del entrenamiento de fuerza para los niños y adolescentes

Fleck, S.J.¹

¹ Sport Science Department. Colorado College, U.S.A.

Contact details

Steven J. Fleck:

Reception day: 30th of April, 2011

Acceptance date: 14th of May, 2011

ABSTRACT

The evidence is convincing that resistance training is a safe and effective physical conditioning modality in preadolescents and adolescents. In this population resistance training results in a strength and muscle hypertrophy, although muscle hypertrophy may be less evident than in adults. Although less information is available it appears resistance training also reduces disease risk in preadolescents and adolescents. This decrease is a result of decreased resting blood pressure, positive effects on the blood lipid profile, increased insulin sensitivity and increased bone mineral density. Accidental injury is the most common form of injury in preadolescents and adolescents while resistance training. Although epiphyseal injuries are of concern when preadolescents and adolescents perform resistance training this form of injury is very rare. In summary, a properly supervised resistance training program in which proper safety precautions are used is a very safe and effective activity for Preadolescents and adolescents.

Key Words: resistance training and pediatric physical activity.

RESUMEN

Las evidencias científicas actuales demuestran que el entrenamiento de fuerza es una forma de actividad física segura y efectiva para niños y adolescentes. En estas edades el entrenamiento de fuerza produce incrementos de fuerza muscular e hipertrofia, siendo el grado de esta última adaptación algo inferior al alcanzado por los adultos. Además, y aunque hay menos evidencias, también parece que el entrenamiento de fuerza es efectivo para reducir le incidencias de enfermedades en los niños y jóvenes. Estos efectos positivos se relacionan con una disminución de la presión arterial en reposo, mejor perfil de lípidos sanguíneos, sensibilidad insulínica y un incremento de la densidad mineral ósea.

Los accidentes, son la causa más común de lesiones en niños y, adolescentes que realizan entrenamientos de fuerza. Aunque las lesiones sobre la placa epifisaria constituyen un motivo de preocupación en los niños pre-púberes y adolescentes que realizan entrenamientos de fuerza, este tipo de lesión es muy rara. En resumen un programa de entrenamiento de fuerza adecuadamente supervisado, en donde se consideren normas de seguridad adecuadas, constituye una forma de actividad física muy segura para niños y adolescentes.

Palabras clave: entrenamiento de fuerza y actividad física pediátrica.

INTRODUCTION

Even though the evidence is convincing that strength training is safe and effective in children and adolescents (Canadian Society for Exercise Physiology. 2008; National Strength and Conditioning Association. 2009) the efficacy of strength training in this population is doubted by many in the general population as well as by many physicians and strength training professionals. Perhaps the most prevalent misunderstanding concerning children and adolescents performing weight training is that they will experience no or at best minimal skeletal muscle hypertrophy. As more research is performed on the effects of resistance training in children and adolescents it is becoming apparent that this population experiences benefits that are similar to adults performing weight training. These benefits include muscle hypertrophy as well as positive effects on bone mineral density, the blood lipid profile, insulin sensitivity, cardiac function and prevention of injury when performing other sports or activities. Additionally, when weight training is performed by children and adolescents many individuals believe there is increased risk for various types of injuries, compared to adults. In particular epiphyseal plate damage is of concern when children and adolescents perform resistance training. Although there are unique considerations when weight training is performed by children and adolescents weight training is a very safe and effective training modality in this population.

Similar to adults any benefit children or adolescents receive from weight training is in part dependent upon the type of weight training program performed including training intensity and volume (number of sets per exercise, number of repetitions per set, resistance lifted, types of exercises performed). Thus similar to adults, weight training programs of insufficient training intensity and volume will not cause positive adaptations. The purpose of this review is to summarize what is currently known concerning the efficacy and safety of weight training when performed by children and adolescents.

Strength Increases

As in adults increased strength is the most obvious benefit in children and adolescents performing resistance training. Strength increases can be as dramatic as 74% in eight weeks of training, however typically approximately 30% increases are apparent in 8-20 weeks of training (National Strength and Conditioning Association 2009). For example, 13.9-year-old children performing a periodized multi-set nine week training program showed significant increases of 19% in squat 10 repetition maximum (RM) resistance and a 15% in 10 RM bench press ability (Faigenbaum et al. 2007). Children as young as six years of age have performed resistance training and shown strength increases. In children and adolescents normal growth results in significant strength increases. Thus when considering strength increases it is important to note they are greater than normal growth in children and adolescents.

Muscle Hypertrophy

Early studies indicated that preadolescents did not demonstrate significant muscle hypertrophy when performing resistance training. These studies, however, typically used skinfolds, a very insensitive measure of total body fat free mass, to determine muscle hypertrophy. Skinfold measurements even when performed by experienced researchers using population specific formulas are probably not sensitive enough to measure changes in fat free mass brought about by resistance training in children.

More recent studies using predominantly dual energy x-ray absorptiometry (DEXA) have shown small significant increases in lean body mass in preadolescents and adolescents performing weight training. Training of boys and girls 8-10 years old for 8-24 weeks resulted in significant increases of lean body mass at 8, 16 and 24 weeks of training ranging from 5-11% (Sgro et al. 2009). Training boys and girls for 8 weeks aged 9.7 years (Mc Guigan et al. 2009) and 12 years (Naylor et al. 2008) resulted in significant increases in

lean body mass of 5% and 2%, respectively. In adolescents (15 years old) increases in lean body mass of 4% and 7.4% over 12 and 16 weeks of training have been shown (Shabi et al. 2006; Van Der Heijden et al. 2010). All of the studies trained overweight or obese (body mass indexes ranging from 26-35) preadolescents and adolescents. There is however no good reason to believe that if lean body mass increased in these individuals it would not also occur in young individuals not overweight or obese. It is also important to note that the increase in lean body mass can be greater than that due to normal growth in a group of none exercising children (Naylor et al. 2008).

Although hypertrophy does occur in younger individuals neural adaptations are also very important for increases in strength with training, especially when minimal or no significant hypertrophy occurs. Many other adaptations in the muscle, nerve, and connective tissue of children may still be occurring, even if muscle hypertrophy is not apparent, such as changes in muscle protein (i.e., myosin isoforms), recruitment patterns, and connective tissue, all of which could contribute to improved strength, sport performance, and injury prevention.

Starting at puberty in males, the influence of testosterone on muscle size and strength is dramatic without any training. Although muscle mass gains beyond normal growth are possible in younger children, muscle hypertrophy should not be a major goal of their training programs. Only after a child has entered adolescence is it realistic to expect large gains in muscle mass. However, because of differences in maturation rates among children, care must be taken to evaluate muscle hypertrophy as a training goal individually, especially for girls and boys 13 to 15 years of age.

Disease Risk Factors

Due to the increase in childhood obesity treatment and prevention of disease risk factors is of concern in preadolescents and adolescents. This may be particularly true for factors related to cardiovascular disease. In adult males resistance training positively effects a variety of disease risk factors which results in epidemiological data indicating weight training for 30 minutes or more per week reduces overall cardiovascular risk approximately 23% (Tanasescu et al. 2002).

Resting blood pressure is a cardiovascular risk factor. Resistance training in adults reduces resting systolic and diastolic blood pressure approximately 3-4 mm Hg (Cornelissen and Fagard 2005) and is recommended as an adjunct to aerobic training for the treatment and prevention of hypertension (American College of Sports Medicine 2004). Although information concerning the effect of resistance training on the blood pres-

sure of children is limited it appears resistance training does have a positive effect on the blood pressure of preadolescents and adolescents (National Strength and Conditioning Association 2009).

Another cardiovascular risk factor is the blood lipid profile. In adults resistance training can positively affect the blood lipid profile by reducing low-density lipoprotein, increasing high-density lipoprotein, introducing total cholesterol (Prabhakaran et al. 1999). In children information is limited, but it appears resistance training can have a positive effect on the blood lipid profile of children. Similarly in adults resistance training can positively affect insulin sensitivity and this appears to be true in children as well (Shaibi et al. 2006; Van Der Heijden et al. 2010).

In adults resistance training typically has no effect or small positive effects on cardiac systolic and diastolic function (Fleck 2003). Although information is limited this also appears to be true in children. For example, in 12-year-olds resistance training resulted in a small positive effect on cardiac diastolic function (Naylor et al. 2007). Collectively all of the above effects probably reduce overall disease risk in preadolescents and adolescents.

Bone Mineral Density

Osteoporosis is of concern in older adults and it is clear that weight bearing activity, including weight training, can positively affect bone mineral density in adults. In children bone mass shows a significant correlation to fat free mass and weight bearing activity increases both bone mass and fat free mass in prepubertal children (Vincente-Rodriguez 2006). Additionally, training programs including resistance training can positively affect bone mineral density in youth (National Strength and Conditioning Association 2009). In adults changes in bone mineral density are typically small. This appears to be true in children as well. For example, in adolescents aged in 15.5 years a 12 week resistance training program significantly increased bone mineral density 1.4% (Van Der Heijden et al. 2010).

Sports Injuries

With the increasing prevalence of youth sports it is not surprising that the number of reported injuries due to sports participation has also increased. Such injuries may in part be due to young athletes not being properly physically conditioned prior to participation (National Strength and Conditioning Association 2009). Total conditioning programs including resistance training, plyometric training or both types of training reduce sports related injuries in adolescent athletes (National Strength and Conditioning Association 2009). Knee injuries are particularly prevalent in fema-

le athletes, including young female athletes. Although not consistently shown conditioning programs including resistance training and plyometric exercise have reduced knee injuries in adolescent female athletes (Hewett et al. 1999; Mandelbaum et al. 2005). Thus it appears various forms of resistance training can help to reduce injuries in young athletes.

Accidental Injuries and Sprains or Strains

Weight training like any physical activity has an inherent risk of potential injury. Acute injury refers to a single trauma that causes an injury. Acute injury to muscles, such as strains and sprains or to the skeletal system, such as growth cartilage damage or bone fractures, are rarely caused by weight training. Perhaps surprisingly accidental injuries while weight training account for 77% of all injuries sustained by 8-13-year-old children (Meyer et al. 2009). Two thirds of these injuries are to the hand and foot with the cause of injury description including "dropping" or "pinching" (Meyer et al. 2009). This high percentage of accidental injury in 8-13-year-old children decreases with age (8-13 > 14-18 > 19-22 = 23-30 year olds). Thus the majority of injuries to children and adolescents while weight training are accidental and thus preventable. This makes it apparent that having proper supervision and stressing weight room safety when training this population is an important aspect of the training program.

Muscle strains and sprains are a common injury in all age groups (Meyer et al. 2009). Strains and sprains account for 18%, 44%, 60% and was 66% of all injuries in 8-13, 14-18, 19-22 and 23-30-year-olds (Meyer et al. 2009). So strains and sprains as an injury form are lowest in children and increase in frequency with age. Strains and sprains can be the result of not warming up properly before a training session. Trainees should perform several sets of exercise before beginning the actual training sets of a workout. Other common causes of muscle strain or sprain is attempting to lift too much weight for a given number of repetitions and improper exercise technique. As in any population children and adolescents should understand that the suggested number of repetitions is merely a guideline, and that they can perform less or more repetitions than prescribed in the training program. The incidence of this type of injury, as with all injury types, can be reduced by emphasizing all proper safety precautions, such as spotters and stressing proper exercise technique.

Growth Cartilage Injury

Growth cartilage injury is a traditional concern for children performing weight training. This type of injury can either be acute or chronic (due to repetiti-

ve microtrauma over long periods of time) in nature. However, this type of injury is a very rare in children and adolescents performing weight training. Growth cartilage is located at three sites in the skeletal system. The epiphyseal plates or growth plates at the end of long bones; the epiphysis or cartilage on the joint surface; and the apophyseal insertion, or tendon insertion where a muscle's tendon attaches to bone. The long bones of the body grow in length from the epiphyseal plates. So damage to the epiphyseal plates can decrease linear bone growth. Normally, because of hormonal changes, the epiphyseal plates ossify after puberty. Once ossified, growth of long bones, and therefore increased linear growth of bones, is no longer possible.

The epiphyseal plate is weakest during phases of rapid growth and so during pubescence (Caine et al. 2005). Additionally, bone mineralization may lag behind linear growth making the bone more susceptible to injury (Caine et al. 2005). The cartilage of the epiphysis acts as a shock absorber between the bones that form a joint. Damage to this cartilage may lead to a rough articular surface and subsequent pain during joint movement. The growth cartilage at apophyseal insertions of major tendons ensures a solid connection between the tendon and bone. Damage to apophyseal insertions may cause pain and also increase the chance of separation between the tendon and bone, resulting in an avulsion fracture. It has also been proposed that during the growth spurt of children muscle tendon tightness around joints increases resulting in a decrease in flexibility. If excessive muscular stress occurs because the growth cartilage is weak during the growth spurt injury to the growth cartilage may occur (Caine et al. 2005). This injury mechanism however is controversial.

The epiphyseal plate is prone to fractures in children because it is not yet be ossified. Thus it is not surprising epiphyseal plate fractures in preadolescent and adolescent weight trainees have occurred (Caine et al. 2005; National Strength and Conditioning Association 2009). However this type of injury is a rare occurrence. The majority of epiphyseal plate fracture cases involve lifting near-maximal resistances, improper exercise technique, or lack of qualified supervision (National Strength and Conditioning Association 2009). Thus appropriate precautions for prepubescent and adolescent trainees should be followed. For example, maximal or near-maximal lifts (1RM) should be discouraged, especially in unsupervised settings. Additionally, because improper lifting technique is a contributing factor to many injuries, appropriate increases in resistance and proper technique in all exercises should be emphasized to young resistance trainees.

Fractures

Because the metaphysis or shaft of the long bones is more elastic in children and adolescents than in adults, fractures of the shaft occur more readily in children and adolescents (Naughton et al. 2000). Peak fracture incidence in boys occurs between the ages of 12 and 14 and precedes the age of peak height increase, or growth spurt (Blimkie 1993). The increased fracture rate appears to be caused by a lag in cortical bone thickness and mineralization in relation to linear growth (Blimkie 1993). Therefore, controlling the resistance used during weight training by boys between the ages of 12 and 14 may be important. The same line of reasoning may apply to girls between the ages of 10 and 13.

In summary, weight training is a very safe and effective training modality in preadolescent and adolescents

when the program is properly supervised and appropriate safety precautions utilized. Although muscle hypertrophy may be less evident in preadolescent than adults it does occur. As adolescents approach adulthood increases in muscle hypertrophy become more apparent. Similar to adults other benefits of weight training in pre-pubescence and adolescents include increased strength and positive effects, such as decreased resting blood pressure, changes in the blood lipid profile, and insulin sensitivity which are factors related to reduced disease risk. The majority of injuries during weight training in children are accidental and thus preventable. Although growth plate damage is of concern when children perform weight training it is a very rare occurrence. Thus children should be encouraged to perform weight training as part of a total fitness program.

REFERENCES

- American College of Sports Medicine. (2004). American College of Sports Medicine position stand: exercise and hypertension. *Medicine and Science in Sports and Exercise*, 36, 533-553.
- Blimkie, C.J.R. (1993). Resistance training during preadolescence issues and controversies. *Sports Medicine*, 15, 389-407.
- Caine, D., DiFiori, J., Maffulli, N. (2006). Physal injuries in children and youth sports: reasons for concern? *British Journal of Sports Medicine*, 40, 749-760.
- Faigenbaum, A.D., McFarland, J.E., Johnson, L., Kang, J., Bloom, J., Ratamess, N.A., Hoffman, J.R. (2007). Preliminary evaluation of an after school resistance training program for improving physical fitness in middle school age boys. *Perceptual Motor Skills*, 104, 407-415.
- Caine, D., DiFiori, J., and Maffulli, N. (2006). Physal injuries and children's and youth sports: reasons for concern? *British Journal of Sports Medicine*, 40, 749-760.
- Canadian Society for Exercise Physiology. (2008). Position paper: Resistance training in children and adolescents. *Journal of Applied Physiology, Nutrition and Metabolism*, 33, 547-561.
- Cornelissen, V.A., Fagard, R. H. (2005). Effect of resistance training on resting blood pressure: a meta-analysis of randomized controlled trials. *Journal of Hypertension*, 23, 251-259.
- Fleck, S.J. (2003). Cardiovascular Response to Strength Training. In P.V. Komi (ed.) *Strength and Power in Sport: Volume III of the Encyclopedia of Sports Medicine* 2nd Edition. (pp. 387-408). Berlin: Blackwell Scientific Publications.
- Hewett, T., Riccobene, J., Lindenfeld, T., Noyes, F. (1999). The effects of neuromuscular training on the incidence of knee injury in female athletes: a prospective study. *American Journal of Sports Medicine*, 7, 699-706.
- Mandelbaum, B., Silvers, H., Watanabe, D., Knarr, J., Thomas, S., Griffin, L., Kirkendall, D., Garrett, W. (2005). Effectiveness of a neuromuscular and proprioceptive training program in preventing anterior cruciate ligament injuries in female athletes. *American Journal of Sports Medicine*, 33, 1003-1010.
- McGuigan, M.R., Tatasciore, M., Newton, R.U., Pettigrew, S. (2009). Eight weeks of resistance training can significantly alter body composition in children who are overweight or obese. *Journal of Strength and Conditioning Research*, 23, 80-85.
- Meyer, G.D., Quatman, C.E., Khoury, J., Wall, E.J., and Hewitt, T.E. (2009). Youth versus adult "weightlifting" injuries presenting to United States emergency rooms: accidental versus non-accidental injury mechanisms. *Journal of Strength and Conditioning Research*, 23, 2064-2080.

- National Strength and Conditioning Association. (2009). Youth resistance training: Updated position statement paper from the National Strength and Conditioning Association. *Journal of Strength and Conditioning Research*, 23, S60-S79.
- Naughton, G., Farpour-Lambert, N.J., Carlson, J., Bradney, M., and Van Praagh, E. (2000). Physiological issues surrounding the performance of adolescent athletes. *Sports Medicine*, 30, 309-325.
- Naylor, N.H., Watts, K., Sharpe, J.A., Jones, T.W., Davis, E.A., Thompson, A., George, K., Ramsay, J.M., O'Driscoll, G., Green, D.J. (2008). Resistance training and diastolic myocardial tissue velocities in obese children. *Medicine and Science in Sports and Exercise*, 40, 2027-2032.
- Prabhakaran, B., Dowling, E.A., Branch, J.D., Swain, D.P., Leutholtz, B.C. (1999). Effect of 14 weeks of resistance training on lipid profile and body fat percentage in premenopausal women. *British Journal of Sports Medicine*, 33, 190-195.
- Sgro, M., McGuigan, M.R., Pettigrew, S., Newton, R.U. (2009). The effect of duration of resistance training interventions in children who are overweight or obese. *Medicine and Science in Sports and Exercise*, 23, 1263-1270.
- Shaibi, G.Q., Cruz, M.L., Ball, G.D., Weigensberg, M.L., Salem, G.J., Crespo, N.C., Goran, M.I. (2006). Effects of resistance training on insulin sensitivity in overweight Latino adolescent males. *Medicine and Science in Sports and Exercise*, 38, 1208-1215.
- Tanasescu, M., Leitzmann, M.F., Rimm, E. B., Willett, W. C., Stampfer, M. J., Hu, F. B. (2002). Exercise type and intensity in relation to coronary heart disease in men. *Journal of the American Medical Association*, 288, 1994-2000.
- Van Der Heijden, G., Wang, Z.J., Chu, Z., Toffolo, G., Manesso, E., Sauer, P.J.J., Sunehag, A.L. (2010). Strength exercise improves strength exercise improves muscle mass insulin sensitivity in obese youth. *Medicine and Science in Sports and Exercise*, 42, 1973-1980.