Effects of Medicine Ball Training on Fitness Performance of High-School Physical Education Students

Avery D. Faigenbaum and Patrick Mediate

Abstract

The purpose of this study was to examine the effects of medicine ball training on the fitness performance of high-school physical education students. Sixty-nine high-school students participated in a 6-week medicine training program during the first 10 to 15 minutes of each physical education class. A group of 49 students who participated in physical education lessons but not medicine ball training served as controls. Performance on the shuttle run, long jump, sit and reach flexibility, abdominal curl, medicine ball push-up, and medicine ball seated toss was assessed at baseline and post-training. Students who participated in the medicine ball training program made significantly greater gains on all fitness tests as compared to the control group. These data suggest that medicine ball training can enhance selected measures of speed, agility, power and muscular endurance when incorporated into a high school physical education class.

Introduction

High-school students need to participate regularly in physical activities that enhance and maintain their cardiovascular and musculoskeletal health. Regular physical activity during adolescence is associated with numerous physiological and psychosocial benefits and has the potential to improve the quality of life for boys and girls (Corbin & Pangrazi, 1993; United States Department of Health and Human Services, 1996). Furthermore, it appears that physical activity habits established early in life may persist into adulthood (Taylor, Blair, Cummings, Wun, & Malina, 1999). Yet despite these potential health benefits, numerous studies show that children and adolescents are often physically inactive (Rowland, 1999; United States Department of Health and Human Services, 1996).

The need to improve the physical fitness of youth has prompted the development of new and creative approaches that provide an opportunity for all boys and girls to participate in regular, healthful physical activity. Indeed, the National Task Force on Community Prevention Services recommends modifying school physical education in order to enhance physical activity behaviors and improve physical fitness (Centers for Disease Control and Prevention, 2001). While children and adolescents have traditionally been encouraged to participate in aerobic activities such as jogging and swimming, compelling scientific evidence suggests that resistance training (also called strength training) can be a safe and effective method of conditioning for boys and girls, provided that appropriate training guidelines are followed (Faigenbaum, 2003; Guy & Micheli, 2001).

Resistance training is a specialized method of physical conditioning that involves the progressive use of a wide range of resistive loads —from medicine balls to high intensity plyometrics—that enhance or maintain muscular fitness (i.e. muscular strength, muscular power, and local muscular endurance). Research into the effects of resistance exercise on youth has increased over the past decade, and the qualified acceptance of youth resistance training by medical and fitness organizations is becoming universal (American Academy of Pediatrics, 2001; American College of Sports Medicine, 2000; Faigenbaum et al.,

1996). The interest in resistance training among youth is supported by findings from the Youth Risk Behavior Survey which indicate that 52% of high school students reported that they performed exercises to "strengthen or tone" their muscles on three or more days in the week before the survey (Centers for Disease Control and Prevention, 2003).

In addition to enhancing motor skills and sports performance, regular participation in a youth resistance training program has the potential to positively influence several measurable indices of health. It helps strengthen bone, facilitate weight control, enhance psychosocial well-being and improve one's cardiovascular risk profile (Faigenbaum, 2001). Moreover, a stronger musculoskeletal system will enable boys and girls to perform daily activities with more energy and vigor, and may help to enhance functional abilities and reduce the likelihood of developing some chronic diseases such as osteoporosis later in life (Turner & Robling, 2003). Therefore, the importance of resistance training needs be emphasized early in life as part of a multifaceted approach to lifetime health and fitness.

Physical education lessons that include resistance training typically include body weight exercises (e.g., chin-ups and push-ups), free weight exercises (e.g., barbell squat and dumbbell curl) and weight machine exercises (e.g., chest press and lat pulldown). Some physical education teachers, however, have started to incorporate medicine ball training into their lessons. Medicine balls are relatively inexpensive weighted balls that are available in a variety of colors, shapes and sizes (ranging from the size of a baseball to larger than a basketball). Physical education teachers are now rediscovering the many benefits that can be achieved by incorporating medicine balls in their classes. Unlike other approaches to resistance training, medicine ball training provides students the opportunity to strength their bodies through dynamic movements that require balance and coordination. Furthermore, body weight resistance exercises such as chin-ups may be too challenging for some youth who are sedentary and overweight. In that regard, medicine ball training programs that involve throwing, catching, and rotational movements can be structured in a way that is appropriate for all students.

At present, there is a paucity of data available about the effects of medicine ball training on health, fitness, and sports performance. From a research perspective, the effects of medicine ball training on the physical fitness of high school physical education students has not been published. While researchers have investigated the effects of different modes of resistance training including weight machines, free weights, and body weight exercises on youth (Faigenbaum, Westcott, LaRosa Loud, & Long, 1999; Pfeiffer & Francis, 1986; Sailors & Berg, 1987; Siegal, Camaione, & Manfredi, 1989), published research investigating the effects of medicine ball training on muscular fitness in high-school physical education students seems to be lacking.

Since quality physical education programs should help students develop health-related fitness and physical competence (National Association for Sports and Physical Education, 2004), physical education teachers who use medicine balls need assurance that medicine ball training is safe, beneficial, and worthwhile. Moreover, proven methods for incorporating medicine ball training into the high school physical education curriculum are needed, as adolescence is a critical period for promoting physical activity as a lifetime behavior (Rowland, 1999). Accordingly, the purpose of this study was to examine the effects of medicine ball training on the fitness performance of high-school physical education students. Although a myriad of training programs could have been used for this study, the Medicine Ball for All training program was used because it is progressive, easy to implement and designed for students who have limited experience performing medicine ball training (Mediate & Faigenbaum, 2004).

Methodology

Subjects and Setting. One hundred and eighteen subjects in grade 10 (age 15-16 years) from a public New England city high school volunteered to participate in this study. Sixty-nine subjects (42 male, 27 female) participated in the medicine ball training program and 49 subjects (35 male and 14 female) served as controls. Exclusionary criteria included subjects with a chronic pediatric disease or orthopedic limitation. This high school was chosen for this study because of the relationship between local university faculty and the physical educators at this school who had experience developing and implementing youth resistance training programs. The subjects gave their informed consent as part of their class requirements consistent with the policies of our institution's internal review board for use of human subjects in research.

Testing Procedures. Subjects in both groups participated in one orientation session prior to testing procedures. During this time they were taught the proper technique on each testing exercise and any questions they had were answered. A warm-up session consisting of at least 5 minutes of low- to moderate-intensity aerobic exercise and stretching preceded all tests. Measurements were made with identical equipment positioning and a 6 lb leather medicine ball was used when necessary. A physical education teacher supervised all testing procedures. Each test was performed 3 times and the best score was recorded to the nearest 1.0 cm or 0.1 s.

Standardized protocols for fitness testing were followed according to methods previously described (American Alliance of Health, Physical Education, Recreation and Dance, 1980; Safrit, 1995; Mediate & Faigenbaum, 2004). Briefly, lower back and hamstring flexibility was evaluated by the sit and reach test. Lower body power was evaluated by the standing long jump test. Abdominal strength was measured by a medicine ball abdominal curl. To perform this test, subjects were positioned on their backs with knees bent at 90˚, and a medicine ball was placed on their shins. Subjects curled forward lifting their shoulder blades off the floor as they touched the ball with both hands and then returned to the starting position. Upper body strength was assessed by medicine ball push-up. While in the push-up position, subjects placed both hands on a leather medicine ball instead of the floor. They lowered their chests to the ball and then returned to the starting position, with back flat, arms extended and feet positioned wider than shoulders. Upper body power was evaluated with the medicine ball toss. Subjects sat on the floor with their feet in front of their bodies, knees bent and a six lb medicine ball in front of their chests. Subjects were instructed to toss the medicine ball (at a 45˚ angle) as far forward as possible. Speed and agility were evaluated with the medicine ball shuttle run. Subjects sat on the floor with their legs fully extended and the heels of both feet on medicine balls. On command, the subject stood up and ran to a second medicine ball placed 15 feet away. The subject touched the second medicine ball and then ran back through a line where the first medicine ball was positioned.

Medicine Ball Training Program. The exercise group trained twice per week on nonconsecutive days for six weeks under monitored conditions in a co-educational class. All training took place during the first 10 to 15 minutes of regularly scheduled 45 minute physical education classes. During the remaining 30 to 35 minutes of each class period subjects participated in traditional physical education activities (e.g., racquet sports and basketball). A physical education specialist discussed and demonstrated proper medicine ball training procedures during every class, and students had an opportunity to ask questions. Throughout the study period children exercised in groups of 25 and all training sessions took place in the high school gymnasium.

Each medicine ball training session consisted of a warm-up period (3-5 minutes) and a conditioning phase (7 to 10 minutes). During the warm-up period subjects performed a series of six to ten low to moderate intensity exercises with a

six lb leather medicine ball. For example, while jogging the subjects pressed the ball overhead, moved the ball around the waists and tossed the ball to themselves.

During the medicine ball conditioning phase, subjects performed a variety of medicine ball exercises that progressed from simple to complex as their competence and confidence improved. The various medicine ball conditioning exercises were grouped into the following seven categories: lower body (e.g., underhand squat), upper body (e.g., shoulder press), stability (e.g., single leg toss), reaction (e.g., wall chest pass), core (e.g., V-sit on ball), specialty movements (e.g., lateral taps), and flexibility (e.g., straddle ball roll). Each group of exercises focused on a specific fitness parameter, with specialty movements designed to enhance spatial awareness, reaction time and speed. Most medicine ball exercises involved lifting and throwing. Within each category, the exercises progressed from the least challenging to the most challenging. All subjects performed the same number of exercises for the same number of sets and repetitions throughout the study period. A summary of the medicine ball training program is in Table 1. A more detailed description of all medicine ball exercises used in this study is available elsewhere (Mediate & Faigenbaum, 2004).

The progressive medicine ball training program used in this study was designed to enhance physical fitness. Subjects gained confidence in their abilities to perform Level 1 exercises before progressing to more advanced exercises which required more balance, stability and agility. The medicine ball program used in this study was specifically designed to allow all students— including sedentary individuals and varsity athletes —with an opportunity to experience small successes every day so that they gained confidence in their abilities to exercise with medicine balls.

Subjects in the control group did not perform medicine ball training during the study period but did participate in the same traditional physical education activities with the same physical education teacher as the exercise group. The influence of the medicine ball training program on field measures of physical fitness was assessed by comparing changes between exercise and control groups.

Statistical Analysis. Descriptive statistics (mean ± SD) for age and fitness scores were calculated. Comparisons of absolute changes (Post results—Pre results [Δ]) between groups for each dependent variable were analyzed with independent student t-tests. The alpha level was set at 0.05 and all analyses were carried out using the Statistical Package for the Social Sciences version 11.0 (SPSS, Inc. Chicago, IL).

Results

Comparison of group changes for the dependent variables can be found in Table 2. The group that participated in the medicine ball training program made significantly greater gains in the shuttle run, long jump, sit and reach flexibility, medicine ball abdominal curl, medicine ball push-up and medicine ball toss as compared to the control group ($p < .05$).

Discussion

The primary finding of this investigation was that regular participation in a progressive medicine ball training program produced greater magnitudes of improvement in muscular fitness and specific motor performances than traditional physical education lessons in high school students after short-term training. Since both groups participated in physical education lessons for the same period of time, such differences are likely due to the specific training adaptations that resulted from medicine ball training. No injuries occurred as a result of medicine ball training throughout the study period. The present observations suggest that incorporating medicine ball training into the physical education curriculum may be a safe and valid means to promote physical fitness in high school students. These findings have important practical relevance for designing physical education lessons for high school students since muscular fitness is an important health-related

Table 1. Summary of medicine ball (MB) training program

	Weeks 1 & 2	Week 3 & 4	Weeks 5 & 6
Total Time (min)	10	12	15
Sets/Reps	1/5-7	2/7-10	2-3/10-15
MB Exercise level*	1 & 2	2, 3 & 4	4, 5, & 6
Number of exercises	15-20	20-30	30-40

*MB exercises were subjectively placed into one of six levels. Level 1 exercises were simple movements that were relatively easy to perform whereas level 6 exercises were multitask movements that involved explosive actions throughout all planes of motion.

Table 2. Pre- and Post-Training Results for the Physical Fitness Tests

Variable	Group	Pre-training	Post-training	Δ
Shuttle Run (sec)	Control	4.1 ± 0.38	4.1 ± 0.39	0.0
	Exercise	4.5 ± 0.54	4.2. ± 0.52	-0.3*
Long jump (cm)	Control	170.3 ± 40.9	172.4 ± 41.4	2.1
	Exercise	163.4 ± 36.2	178.1 ± 38.4	14.7*
Flexibility (cm)	Control	27.1 ± 9.5	27.4 ± 9.5	0.3
	Exercise	29.7 ± 7.1	34.1 ± 6.9	4.4*
MB Abdominal Curl	Control	16.7 ± 10.4	16.8 ± 10.6	0.1
	Exercise	20.2 ± 14.2	27.0 ± 16.6	6.8*
MB Push-up	Control	19.9 ± 13.0	20.1 ± 13.2	0.2
	Exercise	8.6 ± 7.1	12.2 ± 7.9	3.6*
MB Toss (cm)	Control	398.4 ± 133.1	394.5 ± 136.0	-3.9
	Exercise	357.1 ± 96.2	423.5 ± 113.1	66.4*

Data are presented as mean ± SD.
* Significantly different from control, $p<.05$.

fitness component that contributes to tasks of daily life, participation in recreational activities, and reduction of disease (National Association for Sport and Physical Education, 2004).

Today, it is generally accepted that resistance exercise can be safe and worthwhile for children and teenagers provided that the training intensity and training duration are sufficient (Faigenbaum et al. 1996; Guy & Micheli, 2001). In general, it seems that boys and girls can increase their strength by about 30-50% during the first eight weeks of resistance training (Falk & Tenebaum, 1996). The present results are comparable with these findings as the progressive training program that included explosive types of medicine ball exercises resulted in gains in upper body strength and abdominal strength of 42% and 34%, respectively. The mechanisms responsible for these gains are not entirely understood nor were they examined in this study, but changes in motor unit activation and motor unit coordination, recruitment and firing are probable mechanisms that can explain, at least in part, these short-term training-induced gains (Ramsay et al., 1990).

There is a limited amount of information about the effects of resistance training on motor performance skills in youth. Although it is attractive to assume that a stronger and more powerful adolescent will perform better on motor performance tests, the data is equivocal. Several studies involving youth have noted significant improvements in the long jump, vertical jump, sprint speed and agility run time following resistance training (Falk & Mor, 1996; Weltman et al., 1986; Lillegard, Brown, Wilson, Henderson, & Lewis, 1997). However, others have noted significant gains in strength without significant improvements in motor performance skills (Faigenbaum, Zaichkowsky, Westcott, Micheli, & Fehlandt, 1993). It is likely that these inconsistent findings could be explained by the design of the resistance training program. That is, programs that include exercises on weight machines that are less specific to the test may be less likely to enhance motor skills performance than programs characterized by more specific exercises that involve body weight exercises, free weights and medicine balls. This is consistent with the well-known principle of training specificity which states that training adaptations are specific to the muscles trained, the intensity of the exercise performed and the metabolic demands of the exercise (Hoffman, 2002).

In the present study, students who participated in the medicine ball training program made significantly greater gains on the long jump (9%), shuttle run (6%) and medicine ball toss (19%) than changes in the control group (1%, 0%, -1%, respectively). These results show that high school students respond to medicine ball training by increasing their ability to perform selected strength and motor skills. Unlike training on weight machines, some medicine ball exercises require the body to function as a unit instead of separate parts. Moreover, medicine balls provide a unique type of resistance that can be used for a variety of exercises that can be performed at different movement speeds (from slow to explosive). Thus it is likely that the ability of medicine ball training to enhance motor performance skills is due to the ability to create exercises with medicine balls that mimic natural body positions and movement speeds that occur in daily life and game situations.

Medicine ball training also resulted in significant gains in lower back and hamstring flexibility (15%) as compared to control group gains (1%). These observed flexibility gains were consistent with others who examined the effects of resistance training on youth (Faigenbaum, Zaichkowsky, Westcott, Micheli & Fehlandt, 1993; Faigenbaum et al, 2002). It must be emphasized, however, that the medicine ball training program in the present study included upper and lower body flexibility exercises. These findings suggest that resistance training with medicine balls will not result in a loss of flexibility, but may actually improve flexibility as long as dynamic stretching exercises with medicine balls are incorporated into the training program.

A limitation of this study is that it addressed only the initial phase of medicine ball training in high school physical education students. Thus, the results from this investigation may not be applicable to other populations nor do the results provide insight into long-term training adaptations. Notwithstanding these limitations, the practical importance of incorporating medicine ball training into a high school physical education curriculum should not be overlooked. Students in this study had an opportunity to learn proper medicine ball training procedures and develop the skills necessary to design a personal medicine ball fitness program that can help them achieve and maintain a health-enhancing level of physical fitness. In addition, a medicine ball training program may be more acceptable and certainly more cost-effective for enhancing muscular fitness in high school physical education students than a resistance training program that involves weight machines.

In summary, regular participation in physical education lessons can make an important contribution to the health and well-being of adolescents provided that students have opportunities to participate in a variety of meaningful physical activities that enable them to achieve health-related levels of physical fitness (National Association for Sport and Physical Education, 2004). While aerobic games and activities are often part of the obligatory physical education curriculum, a growing body of evidence suggests that resistance exercise can offer observable health and fitness value to boys and girls (Faigenbaum, 2001). While present findings are consistent with the results of earlier studies that noted significant gains in muscular fitness in youth following resistance training using other modes of training (Faigenbaum et al., 1996; Guy & Micheli, 2001), the magnitude of muscular fitness adaptations in the present study resulting from medicine ball training are novel. Owing to the growing popularity of resistance training among high school students, future long-term studies are needed to evaluate the effects of different resistance training programs on health and fitness measures in youth.

REFERENCES

American Academy of Pediatrics. (2001). Strength training by children and adolescents. *Pediatrics, 107*, 1470-1472.

American Alliance of Health, Physical Education, Recreation and Dance. (1980). *Health related Physical Fitness Test Manual.* Reston, VA:AAHPERD.

American College of Sports Medicine. (2000). *ACSM's Guidelines for Exercise Testing and Prescription*, (6th ed.). Baltimore: Lippincott, Williams & Wilkins.

Centers for Disease Control and Prevention. (2001). Increasing physical activity: a report on recommendations of the Task Force on Community Preventive Services. Morbidity and Mortality Weekly Report, 50 (RR-18), 1-14.

Centers for Disease Control and Prevention (2003). Youth risk behavior survey—United States 2003, Morbidity and Mortality Weekly Report.

Corbin, C.B. & Pangrazi, R.P.. (Eds.). (1993). The health benefits of physical activity. In Physical activity and fitness research digest, Series 1(1) (pp. 1-7). Washington, DC: President's Council on Physical Fitness and Sports.

Faigenbaum, A.D. (2001). Strength training and children's health. *Journal of Physical Education Recreation and Dance, 72*, 24-30.

Faigenbaum, A.D. (2003). Youth strength training. *Presidents Council on Physical Fitness and Sports Research Digest, 4*, 1-8.

Faigenbaum, A.D, Kraemer, W.J. Cahill, B., Chandler, J., Dziados, J., Elfrmnk, L.D., Forman, E., Gaudiose, M., Micheli, L., Nitka, M., & Roberts, 5. (1996). Youth resistance training: Position statement paper and literature review. *Strength and Conditioning Journal, 18*, 62-75.

Faigenbaum, A.D., Milliken, L.A., LaRosa Loud, R., Burak, B.T., Doherty, C.L., & Westcott, W.L. (2002). Comparison of 1 and 2 days per week of strength training in children. *Research Quarterly for Exercise and Sport, 73*, 416-424.

Faigenbaum, A.D.,Westcott, W.L., LaRosa Loud, R., and Long, C. (1999). The effects of different resistance training protocols on muscular strength and muscular endurance development in children. *Pediatrics, 104*, e5.

Faigenbaum, A.D., Zaichkowsky, L.D.,Westcott, W.L, Micheli, L.J, & Fehlandt, A.F. (1993).The effects of a twice per week strength training program on children. *Pediatric Exercise Science, 5*, 339-346.

Falk, B., & Mor, G. (1996). The effects of resistance and martial arts training in 6 to 8 year old boys. *Pediatric Exercise Science, 8*, 48-56.

Falk, B., & Tenenbaum, G. (1996). The effectiveness of resistance training in children. A meta-analysis. *Sports Medicine, 22*, 176-186.

Guy, J.A., &. Micheli, L.J. (2001). Strength training for children and adolescents. *Journal of the American Academy of Orthopedic Surgery, 9,* 29-36.

Hoffman, J. (2002). *Physiological Aspects of Sports Training and Performance*. Champaign, IL: Human Kinetics.

Lillegard, W., Brown, E., Wilson, D., Henderson, R., and E. Lewis. (1997). Efficacy of strength training in prepubescent to early postpubescent males and females: effects of gender and maturity. Pediatric Rehabilitation, 1, 147-157.

Mediate, P. & Faigenbaum, A. (2004). *Medicine for All Training Handbook.* Monterey, CA: Healthy Learning.

National Association for Sport and Physical Education (2004). *Moving Into the Future: National Standards for Physical Education.* (2nd ed.). Reston, VA: Author.

Pfeiffer, R., & Francis, R. (1986). Effects of strength training on muscle development in prepubescent, pubescent and postpubescent males. *Physician and Sports Medicine. 14*, 134-143.

Ramsay, J.A, Blimkie, C.J, Smith, K., Garner, S., MacDougall, J.D. & Sale, D. (1990). Strength training effects in prepubescent boys. *Medicine and Science in Sports and Exercise, 22*, 605-614.

Rowland, T.W. (1999). Adolescence: A 'risk factor' for physical inactivity. *Presidents Council on Physical Fitness and Sports Research Digest, 3*, 1-8.

Safrit, M. (1995). *Complete Guide to Youth Fitness Testing*. Champaign, IL: Human Kinetics.

Sailors. M., & Berg, K. (1987). Comparison of responses to weight training in pubescent boys and men. *Journal of Sports Medicine, 27*, 30-37.

Siegal, J.A, Camaione, D.N, & Manfredi, T.G. (1989). The effects of upper body resistance training in prepubescent children. *Pediatric Exercise Science, 1*, 145-154.

Taylor, W.C., Blair, S.N, Cummings, S.S., Wun, C.C., & Malina, R.M. (1999). Childhood and adolescent physical activity patterns and adult physical activity. *Medicine and Science in Sports and Exercise, 31*, 118-123.

Turner, C., & Robling, A.. (2003). Designing exercise regimens to increase bone strength. *Exercise and Sport Science Reviews, 31*, 45-50.

U.S. Department of Health and Human Services. (1996). *Physical Activity and Health: A Report from the Surgeon General*. Atlanta: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion.

Weltman, A, Janney, C., Rians, C., Strand, K., Berg, B., Tippit, S., Wise, J., Cahill, B., & Katch, F.I. (1986).. The effects of hydraulic resistance strength training in pre-pubertal males. *Med Sci Sports Exercise, 18*: 629-638.

Dr. Faigenbaum teaches in the Health and Exercise Science Department at The College of New Jersey and Patrick Mediate teaches physical education at Greenwich High School in Connecticut.