PRELIMINARY EVALUATION OF AN AFTER-SCHOOL RESISTANCE TRAINING PROGRAM FOR IMPROVING PHYSICAL FITNESS IN MIDDLE SCHOOL-AGE BOYS

AVERY D. FAIGENBAUM JIM E. McFARLAND, LARRY JOHNSON
Department of Health and Exercise Science Hillsborough School District
The College of New Jersey Hillsborough, New Jersey

JIE KANG, JASON BLOOM, NICHOLAS A. RATAMESS, AND JAY R. HOFFMAN
Department of Health and Exercise Science
The College of New Jersey

Summary.—Most after-school physical activity programs for youth focus on aerobic games and activities. The purpose of this study was to evaluate the efficacy of an after-school resistance training program on improving the physical fitness of middle school-age boys. 22 boys (M = 13.9 yr., SD = .4 yr.) participated in a periodized, multiple-set, 9-wk. (2x/week) resistance training program. All subjects were pre- and post-tested on their 10-repetition maximum squat, 10-repetition maximum bench press, vertical jump, medicine ball toss, flexibility, and also percentage of body fat and the progressive aerobic cardiovascular endurance run (PACER). Statistical analysis indicated that subjects significantly improved performance on the squat (19%), bench press (15%), flexibility (10%), vertical jump (5%), medicine ball toss (12%), and the PACER (36%). Although this design minus a control group limits interpretation, this after-school resistance-training program can improve muscular fitness and cardiovascular fitness in boys and should be replicated with appropriate experimental controls.

Current guidelines suggest that children and adolescents need to participate daily in 60 min. or more of moderate to vigorous physical activity (Strong, Malina, Blimkie, Daniels, Dishman, Gutin, Hergenroeder, Must, Nixon, Pivarnik, Rowland, Trost, & Trudeau, 2005). Regular physical activity can improve body composition, enhance cardiovascular health, and increase the strength of muscles, bones, and connective tissue (United States Department of Health and Human Services, 1996; Strong, et al., 2005). Moreover, habits of physical activity established early in life may persist into adulthood (Telama, Yang, Viikari, Valimaki, Wanne, & Raitakari, 2005). Yet, despite these potential benefits, a growing number of youth are physically inactive and the prevalence of childhood obesity has increased markedly over the last two decades (United States Department of Health and Human Services, 1996; Carnethon, Gulati, & Greenland, 2005; Ogden, Carroll, Curtin, McDowell, Tabak, & Flegal, 2006).

1Address correspondence to Avery D. Faigenbaum, Ed.D., Department of Health and Exercise Science, The College of New Jersey, P.O. Box 7718, Ewing, NJ 08628-0718 or e-mail (faigenba@tcnj.edu).

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Quality school-based physical activity programs are needed to help students develop health-related fitness and physical competence (National Association for Sports and Physical Education, 2004). This need has prompted the development of new and creative approaches as opportunity for children and adolescents to participate in regular, healthful physical activity. Indeed, the National Task Force on Community Prevention Services recommended modifying school programs to enhance physical activity and improve physical fitness (Centers for Disease Control and Prevention, 2001). While boys and girls have traditionally been encouraged to participate in aerobic activities such as jogging and swimming, compelling scientific evidence, as well as position papers from medical and fitness organizations, indicate that resistance training can be a safe and effective method of conditioning for boys and girls provided appropriate training guidelines are followed (Faigenbaum, Kraemer, Cahill, Chandler, Dziados, Elfrink, Forman, Gaudiose, Micheli, Nitka, & Roberts, 1996; American Academy of Pediatrics, 2001; British Association of Exercise and Sport Sciences, 2004).

Although researchers have examined the effects of different resistance training protocols with children and adolescents (Ramsay, Blimkie, Smith, Garner, MacDougall, & Sale, 1990; Faigenbaum, Westcott, LaRosa Loud, & Long, 1999; Faigenbaum, Milliken, Moulton, & Westcott, 2005), research concerning the effects of school-based resistance-training programs on muscular fitness, cardiovascular fitness, and body composition in youth is limited. Since childhood and adolescence are critical periods for promoting physical activity as a lifetime behavior, methods for incorporating resistance training into school-based programs are needed. Given that children and adolescents enjoy intermittent and sporadic activities (Bailey, Olsen, Pepper, Poraszasz, Barstow, & Cooper, 1994), it is likely they will perform relatively large volumes of resistance training which is typically characterized by frequent periods of moderate to vigorous physical activity with rest between sets and exercises. Accordingly, the purpose of this preliminary study was to examine the efficacy of an after-school progressive resistance-training program on improving physical measures in middle school-age boys. It was expected that muscular fitness, cardiovascular fitness, and body composition would improve following regular participation in such a program.

Method

Since most after-school physical activity programs focus on aerobic games and activities, this study examined the efficacy of an after-school resistance-training program on selected measures of health and fitness in middle school-age boys. Before and after a progressive, 9-wk. resistance-training program, all subjects were tested on body composition, cardiovascular fitness, and muscle strength and power. Researchers and physical education
teachers monitored testing and training sessions. This simple design allowed
performance to be examined after a resistance-training program in which the
response of each subject to study procedures was carefully monitored. Since
all potential subjects participated in this school-based program, a control
group was not used in this preliminary exploration.

Subjects

 Twenty-two boys (age $M=13.9$ yr., $SD=.4$ yr.; height $M=168.9$ cm,
$SD=7.9$ cm; mass $M=67.9$ kg, $SD=16.7$ kg) from a public middle school
volunteered to participate. No subject was currently participating in an inter-
scholastic or community-based sports program. All subjects continued to par-
ticipate in regular physical education classes during the study period. Exclu-
sionary criteria included subjects with a chronic pediatric disease or orthope-
dic limitation. The methods and procedures used were approved by the Insti-
tutional Review Board for use of human subjects at The College of New Jer-
sy, and informed consent was obtained from all subjects and their parents.

Measures

 Subjects participated in one orientation session prior to being tested. During this time boys’ body mass and height were measured using a cali-
bbrated balance scale and stadiometer. They were taught the proper tech-
nique on each fitness test and performed several sets with a light load on the
bench press and squat exercises. Any questions or uncertainties they had
were addressed during this session. The research staff and physical educa-
tion teachers supervised the testing procedures. Standardized protocols for
testing were followed using methods previously described (Safrit, 1995; Coo-
per Institute for Aerobics Research, 1999; Faigenbaum, et al., 1999). Briefly,
upper body strength and lower body strength were assessed by the 10-repe-
tition maximum bench press and back squat, respectively. The 10-repetition
maximum was recorded as the maximum resistance which could be lifted 10
times throughout the full range of motion (based on the unweighted posi-
tion), using proper form. Following two submaximal warm-up sets, subjects
performed a series of 10-repetition maximum trials with increasing loads. If
the weight was lifted with proper form, weight was increased by approximately 2.3 to 4.5 kg depending upon the effort required to perform the lift.
On average, the 10-repetition maximum was judged within three to five tri-
als.

 Upper body power and lower body power were evaluated by the seated
medicine ball (2.7 kg) toss and the vertical jump test, respectively. Lower
back and hamstring flexibility were evaluated by the sit-and-reach test. Car-
diovascular fitness was assessed with the progressive aerobic cardiovascular
endurance run (PACER). The PACER test is a multistage, shuttle run at spec-
fied speeds which begin at 8.5 km/hr. and increase 0.5 km/hr. each succes-
sive minute (Leger, Mercier, Gadoury, & Lambert, 1988). The objective is to run as long as possible back and forth across a 20-m space at a preset pace which becomes faster each minute. The PACER test is a valid, enjoyable alternative to distance runs for measuring aerobic capacity of youth (Safrit, 1995; Cooper Institute for Aerobics Research, 1999). Based on prior findings, test-retest reliability for the cardiovascular and muscular fitness tests used in this study was high ($r > .90$). Skinfold measurements of the triceps and medial calf were used to assess percent body fat using the equation by Slaughter, Lohman, Boileau, Horswill, Stillman, Van Loan, and Bemben (1988).

Training

Subjects trained after school twice per week on nonconsecutive days (Monday and Thursday) for 9 wk. under carefully monitored and controlled conditions in a school fitness center. Each 90-min. training session began with a 10-min. warm-up period which included a jog at a self-selected comfortable pace followed by calisthenics. After the warm-up session, subjects participated in an Olympic-style lifting progression with light loads and performed two or three different exercises, e.g., the clean pull and the push jerk. Subjects then performed seven different strength exercises using free weights and plate-loaded machines. Although exercises varied over the 9-wk. training period, the following exercises are an example of a typical training session: barbell squat, leg curl, bench press, front lat pull-down, seated row, biceps curl, and triceps extension. Details regarding the training regimen are in Table 1.

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>RESISTANCE TRAINING PROGRAM</th>
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<tbody>
<tr>
<td><strong>Olympic-style Lift</strong></td>
<td><strong>Resistance Exercise</strong></td>
</tr>
<tr>
<td>Weeks 1–3</td>
<td>Sets: 3</td>
</tr>
<tr>
<td></td>
<td>Repetitions: 1–4</td>
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<td></td>
<td>Exercises: 2</td>
</tr>
<tr>
<td>Weeks 4–6</td>
<td>Sets: 3</td>
</tr>
<tr>
<td></td>
<td>Repetitions: 1–4</td>
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<tr>
<td></td>
<td>Exercises: 2–3</td>
</tr>
<tr>
<td>Weeks 7–9</td>
<td>Sets: 3</td>
</tr>
<tr>
<td></td>
<td>Repetitions: 1–4</td>
</tr>
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<td></td>
<td>Exercises: 5</td>
</tr>
</tbody>
</table>

$^a$Repetition maximum.

All training sets for each exercise were preceded by a warm-up set of 10 repetitions with a relatively light load at about 50% of the training weight. Subjects rested about 1 to 2 min. between sets and exercises on large muscle-group exercises for the legs, chest, and back, and rested 30 sec. to 1 min. between smaller muscle-group exercises for the biceps and triceps. At
the end of each workout, subjects performed two sets of 12 to 25 repetitions of abdominal, lower back, and rotator cuff strengthening exercises in addition to static stretching. A staff or teacher to subject ratio not greater than 1 to 5 was maintained throughout the 9 wk. Teachers and the research staff regularly reviewed each subject’s workout log and made adjustments in training weight and repetitions when subjects were able to complete each set on a given exercise with proper form.

Statistical Analysis

Paired t tests were used to analyze mean changes on all six variables from pre- to posttraining values. The alpha level was set at .05, and all analyses were carried out using the Statistical Package for the Social Sciences Version 11.0 (SPSS, Inc., Chicago, IL).

RESULTS AND DISCUSSION

All participants completed the study. The means and standard deviations for the two training assessments are presented in Table 2. The primary finding was that the regular participation over 9-wk. in this progressive resistance-training program yielded significant improvement in both muscular fitness and cardiovascular fitness in this sample of middle school-age boys. Following nine weeks of training, subjects made significant improvements in upper and lower 10-repetition maximum strength as well as performance on the PACER test. Since the training adaptations were greater than what can

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pretraining</th>
<th>Posttraining</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>PACER* (sprints)</td>
<td>37.0</td>
<td>49.8</td>
<td>36%</td>
</tr>
<tr>
<td>10 RM squat, kg</td>
<td>56.9</td>
<td>67.6</td>
<td>19%</td>
</tr>
<tr>
<td>10 RM bench press, kg</td>
<td>41.1</td>
<td>47.4</td>
<td>15%</td>
</tr>
<tr>
<td>Medicine ball (2.7 kg) toss, cm</td>
<td>356.5</td>
<td>368.3</td>
<td>12%</td>
</tr>
<tr>
<td>Flexibility, cm</td>
<td>24.8</td>
<td>27.3</td>
<td>10%</td>
</tr>
<tr>
<td>Vertical jump, cm</td>
<td>48.9</td>
<td>51.1</td>
<td>5%</td>
</tr>
</tbody>
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*PACER refers to progressive aerobic cardiovascular endurance run; RM = repetition maximum. "Mean difference Pre- vs Posttraining (p < .05).

be expected from growth and development (Weltman, Janney, Rians, Strand, Berg, Tippit, Wise, Cahill, & Katch, 1986; Rowland & Boyajian, 1995; Fagenbaum, et al., 2005), the observed differences are likely associated with the specific training program. All subjects completed the program, and no injuries occurred during this resistance training. Subjects’ compliance with the exercise program averaged 95% (range 89% to 100%). These data suggest that this kind of resistance training may be a safe, effective means of enhanc-
ing physical fitness in middle school-age boys. These findings when replicated with a suitable design may have important practical relevance for design of after-school programs since cardiovascular fitness and muscular fitness are important health-related fitness components which contribute to tasks of daily life, participation in recreational activities, and reduction of disease (National Association for Sport and Physical Education, 2004).

A novel finding of this study was that resistance training enhanced performance on the PACER test known as a valid and reliable measure of cardiovascular fitness in youth (Safrit, 1995; Cooper Institute for Aerobics Research, 1999). Although prolonged periods of aerobic exercise are often prescribed to enhance cardiovascular fitness in youth (Rowland, 2003), in the present study 9 wk. of progressive resistance training increased performance on the PACER test by 36% for these boys. Although data on this topic are limited, Weltman, et al. (1986) reported gains in maximal oxygen consumption of 19% of boys after participation in a 14-wk. circuit strength-training program which required 30 sec. at each of 10 exercise stations followed by 30 sec. of rest between stations. Differences in the design of resistance-training programs as well as the tests used to measure aerobic fitness could explain, at least in part, the reported differences in training-induced gains in aerobic fitness. For example, Weltman, et al. (1986) used open circuit spirometry to measure maximal O₂ uptake, whereas the PACER test was used in this study to assess aerobic fitness.

While it is possible that observed gains in aerobic fitness in the present study may reflect improvements in running economy, familiarity with the PACER test, or growth and development, it is reasonable to suggest that the design of our progressive resistance training program, which included a 10-min. aerobic warm-up, contributed to the observed gains in aerobic fitness. Unpublished findings from our youth fitness center indicate that children's heart rates, as measured by heart-rate monitors usually fluctuate between 130 and 170 bpm during resistance training. Furthermore, present subjects' pre-training scores on the PACER test indicate that they scored in the so-called "Healthy Fitness Zone" before their enrollment in this study (Cooper Center for Aerobics Research, 1999). Although speculative, as children become stronger and more powerful, they may be better able to perform both aerobic and anaerobic fitness tests. When compared to adults who can be highly specialized in either aerobic or anaerobic fitness, children are sometimes regarded as metabolic 'nonspecialists' with respect to fitness testing and training (Rowland, 2004). The present results suggest that performance on aerobic fitness tests such as the PACER could be enhanced with regular participation in a progressive resistance-training program which includes multiple sets of large muscle-group exercises.

The gains in muscle strength in the present study (15 to 18%) were
consistent with data from prior studies (Weltman, et al., 1986; Ramsay, et al., 1990; Faigenbaum, et al., 2005). Weltman, et al. (1986) reported strength gains of 18 to 37% following 14 wk. of circuit strength-training, and Faigenbaum, et al. (2005) observed that children enhanced their muscular strength by 21 to 23% following 8 wk. of strength training. Differences in the training levels of these subjects as well as the intensity, volume, and duration of the training programs could explain the variance between these findings and the present results.

In the present study, subjects made significant improvements in performance of the vertical jump (5%) and medicine ball toss (12%) after the resistance-training program. From these findings one may infer that these middle school-age boys generally respond to resistance training by increasing their muscular power. Most researchers, but not all (Flanagan, Laubach, DeMarco, Alvarez, Borchers, Dressman, Gorka, Lauer, McKelvy, Metzler, Poeppelman, Redmond, Riggenbach, Tichar, Wallis, & Weseli, 2002) have reported significant improvement on measures of muscular power by youth after resistance training (Weltman, et al., 1986; Lillegard, Brown, Wilson, Henderson, & Lewis, 1997). It seems that such resistance training which includes higher velocity movements, e.g., Olympic-style lifts, and multijoint free-weight exercises, e.g., squat and bench press, are most likely to enhance muscular power of youth.

A traditional concern about resistance training of youth is possible loss of flexibility of the children; however, in the present study, subjects improved their lower back and hamstring flexibility by 10%. These findings suggest that properly performed resistance training combined with postexercise static stretching is not likely to result in a loss of flexibility and may even enhance flexibility in middle school-age boys.

Whilst body mass significantly increased over the 9-wk. training period ($M=67.9$ kg, $SD=16.7$ kg to $M=68.7$ kg, $SD=16.2$ kg), no significant change ($p=.15$) was observed in percent body fat (22.7% to 22.1%). However, when combined with aerobic training and nutritional counseling, resistance training has shown a favorable effect on the body composition of obese children (Southern, Loftin, Udall, Suskind, Ewing, Tang, & Blecker, 2000). This needs further exploration.

A limitation of this study is that an age- and sex-matched control group was not tested. In addition, since biologic maturation was not assessed initially, one can not state that all subjects were preadolescents. Given the short-term nature of this study, the results do not provide insight into longer-term training adaptations. Notwithstanding these limitations, present results suggest that a progressive, school-based resistance-training program can have unique effects on both aerobic and anaerobic fitness in middle school-age boys. Further, these limitations are amenable to control in carefully designed
studies. Moreover, the practical importance of incorporating resistance exercise into an after-school program should not be overlooked. These boys had an opportunity to learn proper resistance-training procedures and develop skills that could help keep them safe as well as achieve and maintain health-enhancing physical fitness. Given the growing popularity of youth resistance training, carefully controlled studies are required to evaluate the effects of longer-term training programs on health and fitness measures of both boys and girls.

REFERENCES


AFTER-SCHOOL RESISTANCE TRAINING


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