

The Effects of a Twice-a-Week Strength Training Program on Children¹

**Avery D. Faigenbaum, Leonard D. Zaichkowsky,
Wayne L. Westcott, Lyle J. Micheli, and Allan F. Fehlandt**

The effectiveness of a twice-a-week strength training program on children was evaluated in 14 boys and girls (mean age 10.8 yrs) who participated in a biweekly training program for 8 weeks. Each subject performed three sets of 10 to 15 repetitions on five exercises with intensities ranging between 50 and 100% of a given 10-repetition maximum (RM). All subjects were pre- and posttested on the following measures: 10-RM strength, sit and reach flexibility, vertical jump, seated ball put, resting blood pressure, and body composition parameters. The subjects were compared to a similar group of boys and girls ($n = 9$; mean age 9.9 yrs) who were randomly selected to serve as controls. Following the training period, the experimental group made greater gains in strength (74.3%) as compared to the control group (13.0%) ($p < 0.001$), and differences in the sum of seven skinfolds were noted (-2.3% vs. $+1.7\%$, respectively, $p < 0.05$). Training did not significantly affect other variables. These results suggest that participation in a short-term, twice-a-week strength training program can increase the strength and improve the body composition of young boys and girls.

A variety of training programs and modalities have been employed to evaluate the potential benefits and risks of youth strength training as well as to investigate the underlying mechanisms of training-induced strength gains (4, 6–11, 13–15, 19, 20). Researchers have manipulated the acute program variables (choice of exercise, order of exercise, sets, loads, and rest periods) and have used different modes of training in order to provide an adequate stimulus for strength enhancement (and, presumably, to adhere to administrative concerns). However, previous reports involving children have employed a training frequency of three times a week—a frequency typically recommended for adults (5).

Due to the anatomical, physiological, and psychological uniqueness of young children, the risk of injury associated with overtraining, and the amount

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A.D. Faigenbaum and L.D. Zaichkowsky are with the Dept. of Human Movement, School of Education, Boston University, Boston, MA 02215. W.L. Westcott is with the South Shore YMCA, Quincy, MA 02169. L.J. Micheli and A.F. Fehlandt are with the Division of Sports Medicine, Children's Hospital, Boston, MA 02115.

of time available for children to participate in such programs, it is important to explore the potential benefits of less frequent training programs. The purpose of this study was to evaluate the effects of a short-term, twice-a-week strength training program on children.

Methods

Subjects

Twenty-five boys and girls between the ages of 8 and 12 volunteered to participate in this study. Both the children and their parents were informed about the nature of this project, and parental written consent was obtained. Children were randomized into an experimental group (mean age 10.8 yrs; 11 boys, 4 girls) or a control group (mean age 9.9 yrs; 6 boys, 4 girls). After the medical history questionnaire was completed, each child received a comprehensive physical examination in order to evaluate the musculoskeletal system and to rule out any medical contraindications for strength training. A physician also determined each child's stage of sexual maturation based on the Tanner scale (17).

The experimental group consisted of 10 subjects at Tanner Stage 1 and 5 subjects at Tanner Stage 2, while the control group had 9 subjects at Tanner Stage 1 and 1 subject at Tanner Stage 2. Three subjects in the control group classified as Tanner Stage 1 showed early signs of progressing to Tanner Stage 2. There were no significant differences between the two groups for age, height, weight, or Tanner ratings ($p > 0.05$). The following exclusionary criteria were used: (a) children with a chronic pediatric disease, (b) children with an orthopedic limitation, and (c) children classified as Tanner Stage 3. All volunteers were accepted. No subject had regularly participated in any form of resistance training prior to this study.

Testing Procedures

Following the medical examination, a variety of tests were administered in order to evaluate the health and fitness of each child. Each test was performed prior to and following the training period. A warm-up session consisting of low intensity aerobic exercise and stretching was used when appropriate. All children in both groups participated in two introductory classes during a 1-week period prior to the evaluation of strength and motor performance skills. During this time the children were taught the proper technique on each exercise and participated in several low volume training sessions. In addition, an instructor explained the upper and lower body tests of motor performance and the children practiced them.

Strength. Each child's 10-repetition maximum (RM) was determined on the following five dynamic constant resistance machines: leg extension, leg curl, bench press, overhead press, and biceps curl. Child-size weight training equipment (Heartline Fitness Equipment, Gaithersburg, MD) was used for all strength testing and training procedures. After an initial warm-up period, the 10-RM was found within three to four sets. The maximal weight that could be lifted 10 times using the correct form throughout the full range of motion was recorded. Following a 72-hr rest period, the strength testing procedures were repeated. The heaviest 10-RM load lifted on each exercise, on either testing day, was recorded as the

child's criterion 10-RM score. Test-retest reliabilities ranged from 0.930 to 0.971 for the five exercises.

Motor Performance. Lower body motor performance was evaluated by the vertical jump. The highest jump of three trials was reported. A seated two-hand medicine ball put was used to evaluate upper body motor performance. Although the latter test has been described previously (12), it was slightly modified for this study. Each child was asked to sit in a straight-back chair with both feet on the floor. The child held a 3-lb medicine ball against the chest and under the chin, then pushed the ball upward and outward for maximum distance. Three trials were allowed, and the furthest distance reached from the forward edge of the chair to the point of ball contact with the floor was recorded.

Flexibility. Lower back and hamstring flexibility were evaluated by the sit and reach test following guidelines suggested by the American Alliance of Health, Physical Education, Recreation and Dance (2).

Body Composition. Four circumferential and seven skinfold measurements were taken based on guidelines previously described (3, 16). The circumference of the chest, waist, thigh, and upper arm were measured using a Gulick tape. The following skinfold sites were measured using the Lange calipers: triceps, biceps, subscapular, chest, abdominal, suprailiac, and anterior thigh. Each site was measured to the nearest millimeter three consecutive times, and the mean of the three scores was recorded.

Resting Blood Pressure. Blood pressure was measured indirectly using a stethoscope and child-sized sphygmomanometer.

Strength Training Program

The experimental group trained twice a week on nonconsecutive days (Monday and Thursday or Tuesday and Friday) for 8 weeks. The strength training segment of each workout lasted 35 min. Approximately 5 to 7 min of calisthenics and stretches were performed before and after each strength training class. Weekly instructional sessions gave children in the experimental group an opportunity to comprehend the importance of proper form and technique as well as to appreciate the potential benefits and risks of strength training. Throughout the study, an instructor-to-subject ratio of at least 1 to 5 was maintained at all times.

Training consisted of three sets on the five primary exercises (leg extension, leg curl, chest press, overhead press, and biceps curl) with a 1-min rest period between sets. The training load for the first set was 50% of the 10-RM (10 repetitions), the second set was 75% of the 10-RM (10 repetitions), and the third set was 100% of the 10-RM (10 to 15 repetitions). When the child was able to perform 15 repetitions on the third set using the correct technique, the weight was increased by 1 to 2 lbs and the repetitions were decreased to 10. Subjects also progressed from one set of 10 repetitions to three sets of 15 repetitions on the secondary exercises (abdominal curls and bent-knee leg raises). The children exercised in groups of two and took turns at each station until both partners completed three sets. They were taught how to record their data on workout logs and did so throughout the training period. The instructors reviewed the workout logs daily and made appropriate adjustments in training loads and repetitions. The order of exercises was changed every session. No form of resistance training outside of the research setting was allowed. However, all the children were

permitted to participate in school-based physical education classes and organized sport activities.

Statistical Analysis

Two-way analysis of variance procedures with time as the repeated measure were employed to determine the significance of the effect of strength training on the dependent variables. The level of significance was set at $p < 0.05$.

Results

Twenty-three of the 25 subjects completed the study according to the aforementioned methodology. One boy (Tanner Stage 1) in the experimental group was unable to complete the study due to a scheduling conflict, and one boy (Tanner Stage 1) in the control group did not return for follow-up testing. The 14 children who completed the training program had an average attendance rate of 97.4%. Throughout the study, 11 children in the experimental group and 6 in the control group were actively involved in at least one sport (basketball, hockey, skiing, or soccer).

The strength training program resulted in significant ($p < 0.001$) increases in the 10-RM leg extension (64.5%), leg curl (77.6%), chest press (64.1%), overhead press (87.0%), and biceps curl (78.1%), whereas gains in the control group averaged 13.0% (range 12.2 to 14.1%) for the five motions tested (Table 1). A significant two-way interaction was present on all five exercises, indicating that the mean gains in strength for the experimental group were significantly greater than those for the control group.

Changes in the vertical jump and the seated ball put are presented in Table 2. The experimental group improved their vertical jump by 13.8% and their seated ball put by 4.0%. The control group improved their vertical jump by 7.7% and their seated ball put by 3.9%. There were no significant interaction effects on either variable; however, significant main effects (both groups combined) for

Table 1
Changes in Average 10-RM Strength Following the Training Period

Strength (in kg)	Experimental group (n = 14)					Control group (n = 9)				
	Pre		Post		% Change	Pre		Post		% Change
	M	SD	M	SD		M	SD	M	SD	
Leg extension	12.89	4.15	21.20	4.54	64.5	12.12	3.73	13.83	3.84	14.1**
Leg curl	10.39	4.05	18.45	4.35	77.6	12.00	3.61	13.58	3.76	13.2**
Chest press	15.23	3.38	24.99	4.92	64.1	13.37	2.59	15.04	2.14	12.5**
Overhead press	7.53	2.48	14.08	3.12	87.0	7.81	1.93	8.83	2.61	13.1**
Biceps curl	4.66	0.61	8.30	1.07	78.1	4.76	0.77	5.34	0.64	12.2**
Mean % change					74.3					13.0

*Main effect post > pre, $p < 0.05$; **Significant two-way interaction, $p < 0.001$.

Table 2
Changes in Flexibility, Performance Measures, and Body Composition
Parameters Following the Training Period

	Experimental group (<i>n</i> = 14)					Control group (<i>n</i> = 9)				
	Pre		Post		% Change	Pre		Post		% Change
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
Sit & reach (cm)	35.37	9.49	40.37	7.09	14.1	31.05	4.17	34.0	6.53	9.5*
Vertical jump (cm)	22.81	4.14	25.95	5.64	13.8	19.33	6.43	20.82	5.14	7.7*
Seated ball put (cm)	341.63	32.95	355.24	23.29	4.0	303.94	58.62	315.80	45.60	3.9*
Height (cm)	141.36	6.91	143.57	6.91	1.6	140.41	6.95	142.38	6.85	1.4*
Weight (kg)	41.60	12.77	42.21	12.67	1.5	38.92	7.65	39.71	7.14	2.0*
Σ 7 skinfolds (mm)	84.12	30.56	82.18	28.78	-2.3	89.22	28.22	90.78	28.72	1.7 [†]
Circumf. (cm)										
Upper arm	22.53	4.43	22.98	3.95	1.9	21.99	2.64	22.39	2.88	1.8
Chest	72.44	10.47	73.24	9.98	1.1	72.87	7.35	72.62	6.90	-0.3
Waist	68.80	12.41	68.83	12.25	0.004	65.94	5.87	67.02	5.90	1.6
Thigh	45.38	8.00	46.49	7.53	2.4	43.71	4.44	45.41	6.08	3.9*

*Main effect post > pre, $p < 0.05$; [†]Significant two-way interaction, $p < 0.001$.

time were found on both performance measures, $p < 0.05$. The increase in the sit and reach score of 14.1% by the experimental group was not significantly greater than the control group's gain of 9.5%, although a main effect for time was noted (Table 2).

Changes in body composition and anthropometric measures are presented in Table 2. Strength training resulted in a significant ($p < 0.05$) decrease in the sum of seven skinfolds (-2.3%) as compared to the control group change (+1.7%). For the circumference measures, the only site where a significant ($p < 0.05$) main effect occurred was at the thigh. Significant ($p < 0.05$) main effects for time, indicative of growth, were noted for height and weight following the training period.

No significant main effects or interactions were observed for resting systolic and diastolic blood pressures following the training period. No injuries occurred from the strength training program. One child in the experimental group sustained a toe fracture during school activities, but this did not limit his participation in the strength training program.

Discussion

Strength, Motor Performance, and Flexibility Measures

A major finding of the present study was that children between the ages of 8 and 12 (Tanner Stages 1 and 2 of sexual maturation) significantly increased their

voluntary strength in response to a twice-a-week, short-term strength training program. The observed increases in 10-RM strength on five dynamic constant resistance exercises ranged from 64.1 to 87.0% following 8 weeks of strength training (Table 1). These findings conflict with Vrijens' (18) earlier report, but are comparable to more recent studies (8, 9, 11, 14, 19, 20) that also noted significant gains in strength following progressive resistance training programs. Although direct comparisons between training frequencies of twice and thrice weekly cannot be made from this investigation, the magnitude of strength gain observed in this report (mean 74.3% for the five motions tested) was greater than the typical response, despite the reduced training frequency of twice per week. These short-term strength gains, however, may not be indicative of gains made over longer durations. Although speculative, a higher frequency of training may become more important after the initial adaptation period.

It must be emphasized that the low instructor-to-subject ratio (1 to 5) in this study gave the staff an opportunity to get to know each child and focus on the technical aspects of strength training such as correct form, proper breathing, and safe body mechanics. Consequently, it seems reasonable to expect relatively large increases in strength, if in fact neuromuscular adaptations—such as an improvement in motor skill coordination (9)—are partly responsible for prepubescent strength gains during the early stages of training. In the present investigation, it is not possible to evaluate the time course of strength gains over the 8-week period due to the pre- and posttest design. Thus strength gains due to physiological adaptations cannot be distinguished from gains resulting from an improvement in skill performance. The control group, who reportedly did not participate in any form of strength training throughout the study period, increased their 10-RM strength by 13.0% on the five primary exercises. The control group gain may be explained in part by normal growth and development as well as the children's involvement in organized sports. Nevertheless, the strength gains made by the experimental group were significantly greater than those that may be attributable to sport-specific conditioning.

Strength training has been shown to improve motor performance in adult populations (5), and one might speculate that children should receive a similar benefit. Indeed, several studies (7, 19, 21) have reported improvements in various motor skills, most notably vertical jump, following several weeks of strength training. The results of the present report do not support these findings. Despite a 13.8% improvement in vertical jump by the experimental group, the control group improved by 7.7%. Most of the children in both groups regularly participated in a variety of sport activities, including basketball, which may have contributed to the observed improvements in vertical jump. Strength training did not have a dramatic effect on the seated ball put test either. The experimental and control groups improved by almost the same amount, 4.0 and 3.9%, respectively.

Due to the specificity of testing and training, it appears that large gains in strength resulting from a twice-a-week program will not have significant effects on tests of upper and lower body motor performance. This suggestion is consistent with Brown et al. (4), who concluded that strength gains in prepubescent (Tanner Stages 1 and 2) boys and girls were not good predictors of improvement on selected motor performance skills. In the present report, however, the strength-trained subjects continually reported improvements in various sport activities throughout the study period.

Lower back and hamstring flexibility (sit and reach test) improved in both groups. It must be emphasized that stretching exercises were performed before and after each strength training session. This observation supports the contention that strength training will not result in a loss of flexibility as long as stretching exercises are incorporated into the training regimen (1).

Body Composition and Anthropometric Parameters

The experimental group reduced their levels of body fat, as measured by skinfolds, whereas the control group gained. This finding conflicts with most of the literature on children and strength training (6, 9, 13, 19), but is consistent with Siegal et al. (15), who also reported a decrease in the amount of body fat, as measured by skinfolds, following a resistance training program. The relatively high volume of each training session, coupled with the child's involvement in various aerobic sports, likely contributed to the estimated reduction in body fat in the present report. The training program did not affect anthropometrically determined limb circumferences, despite significant improvements in strength. These results are consistent with those of others who also noted significant gains in children's strength without concomitant increases in limb girths (6, 19) or muscle cross-sectional areas (9).

The results suggest that resting systolic and diastolic blood pressure will not be adversely affected by participation in a short-term strength training program. Others (10, 13) have also reported similar findings in children. In the present report, it is likely that close supervision and sound teaching methodologies contributed to the safety of the training program. One YMCA program director and two physical educators with experience in youth strength training maintained an instructor-to-subject ratio of at least 1 to 5 at all times.

Summary

A short-term, closely supervised, twice-a-week strength training program significantly increased the 10-RM strength of boys and girls between the ages of 8 and 12 (Tanner Stages 1 and 2). Strength increases were independent of changes in anthropometrically determined limb circumferences, but were consistent with decreases in body fat as measured by skinfolds. No injuries occurred as a direct result of the strength training program. These results demonstrate that a twice-a-week strength training program can be an effective method of conditioning for children, providing that appropriate training guidelines are followed.

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