Comparison of 1 and 2 Days Per Week of Strength Training in Children

Avery D. Faigenbaum, Laurie A. Milliken, Rita LaRosa Loud, Bernadette T. Burak, Christina L. Doherty, and Wayne L. Westcott

The purpose of this study was to compare the effects of 1 and 2 days per week of strength training on upper body strength, lower body strength, and motor performance ability in children. Twenty-one girls and 34 boys between the ages of 7.1 and 12.3 years volunteered to participate in this study. Participants trained either once per week (n = 22) or twice per week (n = 20) for 8 weeks at a community-based youth fitness center. Each training session consisted of a single set of 10–15 repetitions on 12 exercises using child-size weight machines. Thirteen children who did not strength train served as age-matched controls. One repetition maximum (1RM) strength on the chest press and leg press, handgrip strength, long jump, vertical jump, and flexibility were assessed at baseline and posttraining. Only participants who strength trained twice per week made significantly greater gains in 1RM chest press strength, compared to the control group (11.5 and 4.4% respectively, p < .05). Participants who trained once and twice per week made gains in 1RM leg press strength (14.2 and 24.7%, respectively) that were significantly greater than control group gains (2.4%). On average, participants who strength trained once per week achieved 67% of the 1RM strength gains. No significant differences between groups were observed on other outcome measures. These findings support the concept that muscular strength can be improved during the childhood years and favor a training frequency of twice per week for children participating in an introductory strength training program.

Key words: frequency, preadolescent, resistance training, weight training

A compelling body of evidence indicates that strength training can be a safe and effective method of conditioning for children, provided that appropriate exercise guidelines are followed (American Academy of Pediatrics, 2001; American College of Sports Medicine, 2000; American Orthopaedic Society for Sports Medicine, 1988). In addition to increasing muscular strength (Falk & Tenenbaum, 1996), reports indicate that regular participation in a youth strength training program may enhance bone mineral density (Morris, Naughton, Gibbs, Carlson, & Wark, 1997), improve body composition (Westcott, Tolken, & Wessner, 1995), and reduce injuries in sports and recreational activities (Smith, Andrisch, & Micheli, 1993). A growing number of boys and girls seem to be participating in strength training programs in physical education classes and after-school programs, and public health objectives discussed in the Surgeon General’s report aim to increase the number of children ages 6 years and older who regularly participate in physical activities that enhance and maintain muscular strength and muscular endurance (U.S. Department of Health and Human Services, 1996).

An important variable in the design of any strength training program is the training frequency, which typically refers to the number of training sessions in 1 week. Factors such as the participant’s strength training experience, program goals, sport involvement, projected exercise loads, and involvement in other physical activi-

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ties need to be considered. Without an appropriate training frequency, training may be unproductive or potentially injurious. In general, it is recommended that children strength train two or three times per week on nonconsecutive days (American College of Sports Medicine, 2000; Faigenbaum, Kraemer et al., 1996). While the literature supports the efficacy of strength training two (Faigenbaum, Westcott, LaRosa Loud, & Long, 1999; Faigenbaum, Zaichkowsky, Westcott, Micheli, & Fehlandt, 1998) or three (Ramsay, Blimkie, Smith, Garner, & MacDougall, 1990; Sewall & Micheli, 1986; Weltman et al., 1986) times per week, the effectiveness of strength training only once per week has not been explored in children. Less frequent training programs conserve training time and may encourage participation. Furthermore, due to current trends in physical education programming, the importance of evaluating the effectiveness of less frequent training programs is evident. For example, in Massachusetts recent findings suggest that 41% of elementary schools provide physical education programming only once per week (Doucette, 2001).

Previous studies have explored the effects of different training frequencies on developing and maintaining muscle strength in adults (Braith et al., 1989; Hoffman, Kraemer, Fry, Deschenes, & Kemp, 1990; Hunter, 1985; McLester, Bishop, & Guilhams, 2000) and teenagers (DeRenne, Hetzler, Buxton, & Ho, 1996; Gillam, 1981). However, no controlled, prospective trial comparing different strength training frequencies on muscular strength development in children has been reported, nor has the minimal strength training frequency for children been established. Because the physiological mechanism for strength development in children is different from older populations (Sale, 1989), more specific information regarding the prescribed frequency of strength training for children would be useful to physical educators, youth coaches, and health care providers. Therefore, the purpose of this study was to compare the responses of a 1- and 2-day per week strength training program on upper body strength, lower body strength, and motor performance ability in children.

at the university. Informed consent was obtained from the parents and their children, and parents completed a health history questionnaire for each child. Children with a medical concern that could be worsened by strength training and those older than 13 years of age at the beginning of the study were excluded from participation. Due to preexisting orthopedic concerns, 1 boy in the 1-day per week group did not perform one repetition maximum (1RM) testing on the chest press exercise but did participate in a lower body training program, and 1 boy in the 2-day per week group did not perform 1RM testing on the leg press exercise but did participate in an upper body training program. One obese 11-year-old boy (body weight: 123.6 kg) was excluded from participating, because he was too large for the child-size training equipment used in this study.

With the approval and support of their parents, participants volunteered to participate in either a 1-day per week (girls: n = 7; boys: n = 15) or a 2-day per week (girls: n = 9; boys: n = 11) strength training program. Following recruitment of the experimental groups, 13 children (girls: n = 5; boys: n = 8) were enrolled in this study as nontraining controls. Because boys and girls demonstrate fairly similar rates of strength gain during preadolescence, they were combined in this study (Blimkie, 1989). Table 1 presents descriptive characteristics of the participants by group.

### Testing Procedures

All participated in one introductory training session prior to the testing procedures. During this time, they were taught the proper technique (i.e., controlled movements and proper breathing) on each testing exercise, and any of their questions were answered. A warm-up session consisting of at least 10 min of low-intensity aerobic exercise and stretching preceded all tests. At the end of the testing session, participants performed 5 min of stretching exercises. All measurements for testing (baseline and posttesting) were made with the same test administrators and identical equipment positioning.

<table>
<thead>
<tr>
<th></th>
<th>Control (n = 13)</th>
<th>1 Day (n = 22)</th>
<th>2 Day (n = 20)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>SD</td>
<td>SD</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>9.3 ± 1.5</td>
<td>10.2 ± 1.4</td>
<td>9.7 ± 1.4</td>
<td>0.30</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>34.3 ± 9.7</td>
<td>43.9 ± 13.1</td>
<td>40.5 ± 11.5</td>
<td>0.08</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>136.5 ± 10.6</td>
<td>144.8 ± 7.3*</td>
<td>142.3 ± 9.8</td>
<td>0.04</td>
</tr>
</tbody>
</table>

*Note. M = mean; SD = standard deviation.
*p < .05 versus control group.
using child-size dynamic constant external resistance (DCER) equipment (Fit Systems, Inc., Sugar Land, TX)

**Performance Strength**

Each participant's 1RM strength was determined on the seated chest press and leg press exercises at baseline and following 8 weeks of training. The 1RM was taken as the maximum resistance that could be lifted throughout the full range of motion (determined in the unweighted position) using good form one time only. Before attempting a 1RM, participants performed three submaximal sets of one–six repetitions with a relatively light load. Participants then performed a series of single repetitions with increasing loads. If they lifted this weight with the proper form, the weight was increased by approximately 0.5–2.3 kg, and the participant attempted another repetition. The increments in weight depended on the effort required for the lift and became progressively smaller as the participant reached the 1RM. Failure was defined as a lift falling short of the full range of motion on at least two attempts spaced at least 2 min apart. The 1RM was typically determined within about 8–10 trials. Unpublished observations from our laboratory suggest that performing additional testing sets (with adequate rest between sets) may aid in the recruitment and coordination of the involved muscle groups and improve the accuracy of 1RM strength testing in children. Throughout all testing procedures, an instructor-to-participant ratio of 1:1 was maintained, and uniformed verbal encouragement was offered to all participants. Test-retest reliabilities in our laboratory for strength testing in children are > 0.93 (Faigenbaum et al., 1988).

**Handgrip Strength**

The grip strength of the right and left hands was evaluated using a Takei handgrip dynamometer (Takei, Tokyo, Japan). The test was performed in the standing position with the elbow at 90° flexion and shoulder at 0° flexion. The best of three trials was recorded to the nearest 0.5 kg for each hand. The sum total of the best score for the right and left hands was used in all analyses.

**Flexibility and Motor Performance Tests**

Lower back and hamstring flexibility were evaluated by the sit-and-reach test following guidelines suggested by the American Alliance for Health, Physical Education, Recreation and Dance (1980). Lower body motor performance was evaluated by the vertical jump and standing long jump tests following protocols previously described (Harman & Pandorf, 2000; Safrit, 1995). The best jump of three trials for each test was recorded to the nearest 1 cm.

**Strength Training Program**

The exercise groups trained either once per week (Tuesday or Thursday) or twice per week (Tuesday and Thursday) for 8 weeks. Prior to each strength training session, all participants performed 10 min of low- to moderate-intensity aerobic exercise and stretching (focusing on the muscle groups that were about to be trained), and instructors discussed and demonstrated proper strength training procedures. Instructional sessions gave children an opportunity to understand the importance of proper form as well as to appreciate the potential benefits and risks associated with strength training. Children 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 resistance and repetitions depending on exercise performance and the child's perception of the training load.

The strength training segment of each session lasted approximately 30–40 min. Each training session ended with 10 min of games, stretches, and cool-down activities. Throughout the training period, children typically exercised in groups of 6–10, and an instructor-to-participant ratio of at least 1:3 was maintained. All training sessions took place after school in a YMCA youth fitness center. During the study period, only research participants were permitted to exercise in the youth fitness center on Tuesday and Thursday afternoons.

The strength training program consisted of one set of 10–15 repetitions on 12 exercises using child-size strength training equipment. Two body weight exercises (abdominal curl and lower back extension) and 10 DCER exercises (leg press, leg extension, leg curl, seated chest press, chest crossovers, lat pull down, seated rows, shoulder press, biceps curl, and triceps extension) were performed. Right and left limbs were trained simultaneously on the DCER exercises. The last repetition of each set represented momentary muscular fatigue. Participants rested about 2 min between exercises. During the first week of training, the exercise loads were titrated on all DCER exercises to elicit volitional fatigue within 10–15 repetitions. When the participants were able to perform 15 repetitions with proper form on a DCER exercise, the weight was increased by 5–10%, and the repetitions were decreased to 10. If a participant missed a session, the training load was not increased at the returning session. On the abdominal curl and back extension exercises, participants performed up to one set of 15 repetitions with a 1-kg medicine ball to provide a general conditioning effect. The repetition range prescribed in this study was based on a previous report, suggesting that untrained children respond more favorably to moderate loads and a higher number of repetitions as opposed to a heavier load and fewer number
of repetitions during the initial adaptation period (Faigenbaum et al., 1999).

The order of exercises changed every session to maximize participant enjoyment, and no form of strength training outside the research setting was allowed. Participants were encouraged to perform all exercises properly, and, if necessary, the intensity of training was decreased during a training session if they could not maintain proper technique. All children were permitted to participate in school-based physical education classes and recreational activities throughout the study period. Attendance was taken at every training session. Participants in the control group were asked not to participate in any other strength training program.

Statistical Analysis

Descriptive statistics (means and standard deviations) for age, height, weight, motor performance, and strength tests were calculated. An analysis of variance (ANOVA) was used to detect differences between study groups in all baseline variables (descriptive, strength, flexibility, and motor performance). ANOVA was also used to determine whether differences existed between groups in the changes in each variable from baseline to posttest. Tukey post hoc tests were used to identify specific group differences. The probability of committing a Type I error was set at \( p < .05 \) and all analyses were carried out using the Statistical Package for the Social Sciences version 10.0 (SPSS, Inc. Chicago, IL).

Effect Size and Sample Size

A priori sample size calculations were performed using published strength training data in children (Faigenbaum et al., 1999). The effect sizes for the differences between the training group and the control group for the chest press and the leg extension 1RM were 0.99 and 1.15, respectively. The sample sizes needed to detect the observed differences at a power of 80% are 17 for the chest press and 12 for the leg extension. No data were available to perform effect size determinations for the differences between a 1-day per week training schedule and control group.

Results

All participants completed the training program according to the aforementioned methodology. There were no significant differences in baseline age, weight, 1RM chest press strength, 1RM leg press strength, handgrip strength, flexibility, vertical jump, or long jump among the three groups, but the height of the group who trained once per week was significantly greater than the control group (see Table 1). Average attendance at the training sessions over the 8 weeks for the 1- and 2-day per week training groups was 94.5 and 91.6%, respectively. Post hoc averaging of training loads indicated that the training stimulus on the chest press and leg press exercises for the 1-day group had been 62.3 and 68.8%, respectively, of their initial 1RM, whereas the 2-day group trained at an intensity of 61.1 and 67.4%, respectively, of their initial 1RM. Throughout the study period, 14 children (64%) in the 1-day group, 14 (70%) in the 2-day group, and 9 (69%) in the control group regularly participated (at least twice per week) in organized community sports programs (principaliy in swimming and soccer). No injuries occurred throughout the study period.

Only participants who strength trained twice per week made significantly greater gains in 1RM chest press strength as compared to the control group, \( F(2, 51) = 5.16, \ p < .05 \) (see Table 2 and Figure 1). Participants who trained twice per week increased 1RM chest press strength by 11.5%, whereas gains made by participants in the 1-day per week group and the control group were 9.0 and 4.4%, respectively. Participants who strength trained once or twice weekly made gains in 1RM leg press strength (14.2 and 24.9%, respectively) that were significantly greater than control group gains (2.4%), \( F(2, 51) = 9.17, \ p < .05 \). Strength gains made by the control group were likely due to growth, maturation, and the learning effect. There were no significant differences in handgrip strength, flexibility, vertical jump, and long jump among the groups following the training program, \( F(2, 51) = 2.95, 2.56, 0.69, \) and 0.46, respectively, \( p > .05 \) (see Table 3). In cases where no significant differences were found, the probability of creating a Type II error (accepting the null hypothesis when it is

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>Baseline M</th>
<th>Baseline SD</th>
<th>Posttraining M</th>
<th>Posttraining SD</th>
<th>( p ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest press (kg)</td>
<td>Control</td>
<td>18.2</td>
<td>4.0</td>
<td>19.0</td>
<td>3.8</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>1-day</td>
<td>22.3</td>
<td>5.9</td>
<td>24.3</td>
<td>6.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2-day</td>
<td>21.7</td>
<td>7.0</td>
<td>24.2</td>
<td>7.7*</td>
<td></td>
</tr>
<tr>
<td>Leg press (kg)</td>
<td>Control</td>
<td>62.2</td>
<td>13.6</td>
<td>63.7</td>
<td>12.6</td>
<td>.009</td>
</tr>
<tr>
<td></td>
<td>1-day</td>
<td>60.6</td>
<td>17.9</td>
<td>69.2</td>
<td>17.9*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2-day</td>
<td>56.9</td>
<td>24.0</td>
<td>71.1</td>
<td>27.5*</td>
<td></td>
</tr>
</tbody>
</table>

Note. \( M = \) mean; SD = standard deviation.

*Change in strength from baseline to posttest significantly (\( p < .05 \)) different from control group.

*Significance level from analysis of variance.
false) ranged from 40–94% (power = 6–60%). Power for the changes in chest press 1RM of the 1-day versus the control group was 51%.

Discussion

The present investigation differed from previous strength training studies on children by comparing and evaluating the effects of different strength training fre-

![Figure 1](image.png)

Figure 1. Mean baseline and posttest chest press and leg press 1 repetition maximum scores for the control, 1 day per week and 2 day per week groups. Error bars are standard deviations. Change in strength is significantly different (p < .05) than the change in strength for control.

...quencies on the development of muscular strength. In addition, by including flexibility and motor performance testing, it was also possible to explore the influence of training frequency on changes in these performance variables. To our knowledge, no other study has compared muscular strength and motor performance changes in children in response to 1 or 2 days per week of strength training. It should be noted that for the purpose of this study, children performed one set of 10–15 repetitions on 12 exercises during each training session. Although higher training volumes may provide a better training stimulus, a one-set protocol was used in this study, because no child had prior experience strength training.

Previous reports indicate that children can increase their muscular strength above and beyond normal growth and maturation by participating in a progressive strength training program (Falk & Tenenbaum, 1996). Gains in upper body and lower body strength by the group who trained only once per week averaged 78 and 57%, respectively, of the increases observed in participants who trained twice per week. These finding are consistent with most of the studies involving adults that suggest more frequent training sessions cause greater increases in strength (Graves et al., 1988; Hoffman et al., 1990; Hunter, 1985; McLeaster et al., 2000). Our data suggest that the prescribed frequency of training (either once or twice weekly) may influence strength training adaptations in children, particularly in terms of upper body strength development.

Table 3. Grip strength, long jump, vertical jump, and flexibility tests at baseline and posttraining

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>Baseline M</th>
<th>Baseline SD</th>
<th>Posttraining M</th>
<th>Posttraining SD</th>
<th>p value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grip strength (kg)</td>
<td>Control</td>
<td>33.5</td>
<td>6.2</td>
<td>32.8</td>
<td>7.4</td>
<td>.061</td>
</tr>
<tr>
<td></td>
<td>1 day</td>
<td>38.5</td>
<td>6.9</td>
<td>38.7</td>
<td>6.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 day</td>
<td>35.8</td>
<td>6.9</td>
<td>38.2</td>
<td>7.4</td>
<td></td>
</tr>
<tr>
<td>Long jump (cm)</td>
<td>Control</td>
<td>120.8</td>
<td>18.5</td>
<td>128.3</td>
<td>15.2</td>
<td>.635</td>
</tr>
<tr>
<td></td>
<td>1 day</td>
<td>123.9</td>
<td>22.3</td>
<td>130.8</td>
<td>24.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 day</td>
<td>129.5</td>
<td>15.6</td>
<td>138.5</td>
<td>15.6</td>
<td></td>
</tr>
<tr>
<td>Vertical jump (cm)</td>
<td>Control</td>
<td>21.6</td>
<td>2.5</td>
<td>22.3</td>
<td>2.2</td>
<td>.506</td>
</tr>
<tr>
<td></td>
<td>1 day</td>
<td>23.7</td>
<td>5.8</td>
<td>24.9</td>
<td>6.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 day</td>
<td>22.8</td>
<td>3.9</td>
<td>24.9</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>Flexibility (cm)</td>
<td>Control</td>
<td>24.1</td>
<td>6.8</td>
<td>24.5</td>
<td>8.1</td>
<td>.087</td>
</tr>
<tr>
<td></td>
<td>1 day</td>
<td>23.1</td>
<td>6.0</td>
<td>25.7</td>
<td>7.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 day</td>
<td>25.5</td>
<td>8.1</td>
<td>28.2</td>
<td>7.9</td>
<td></td>
</tr>
</tbody>
</table>

Note. M = mean; SD = standard deviation.
*Significance level from analysis of variance for the change from baseline to posttest in each performance variable.
Faigenbaum et al., 1999) and thrice (Ramsay et al., 1990; Weltman et al., 1986) weekly. However, the effects of strength training only once per week have not been reported previously in children. McLester et al. (2000) reported that experienced adults who strength trained once per week achieved about 62% of the 1RM increases in upper and lower body strength observed in adults who trained three times per week. Similar findings were reported by Braith et al. (1989) who observed that adults who strength trained twice per week derived 80% of the strength benefits achieved by those training three times per week. In a study designed to explore the effects of training frequency on strength maintenance in pubescent male baseball players (Mage = 13.2 years), strength training once per week was sufficient to maintain strength gains achieved during the preseason (DeRenne et al., 1996). In one report involving 9th through 12th grade high school students, strength training 3, 4, or 5 days per week resulted in greater strength gains than training twice per week, yet no significant differences in strength development were observed between groups who trained once or twice per week (Gillam, 1981). However, the training program in the later study consisted of an unusually large number of intense sets (18 sets of 1RM).

Upper Body Strength

In the present study, training twice per week resulted in more favorable changes in upper body strength as compared to training only once per week. It is reasonable to conclude, although not with complete confidence, that training twice per week during the initial adaptation period may have provided a better opportunity for improved coordination or learning and increased the activation of the prime movers (i.e., increased number of motor units recruited and increased discharge frequency). Because it has been suggested that untrained children are less able to potentiate muscle activity during strength training than untrained adults (Sale, 1989), strength training only once per week may not be ideal for enhancing the upper body strength of untrained children. It should be noted that in our study training occurred on the same equipment used for testing. Thus, issues related to testing-training specificity cannot explain the relatively small gains in upper body strength in response to the once per week training program.

The observed gains in 1RM chest press strength following our short-term strength training program were less than previous reports involving children (Faigenbaum et al., 1993; Faigenbaum, Westcott et al., 1996; Sailors & Berg, 1987). Upper body strength gains of 19.6% (Sailors & Berg, 1987) to 64.1% (Faigenbaum et al., 1993) have been observed on similar exercises in children following the first 8 weeks of a strength training program. The absolute increase in chest press strength by participants who trained once or twice per week (2.0 and 2.5 kg, respectively) were also less than previously reported upper body strength gains in children of 5.2 kg (Sailors & Berg, 1987) and 9.8 kg (Faigenbaum et al., 1993).

It is likely that the greater gains in upper body strength in previous investigations, as compared to the present study, may be due to differences in training frequency and training volume (i.e., the total amount of work performed per training session and per week). It appears that more frequent training programs (e.g., 2–5 times per week) and higher volume training programs (e.g., three sets of 10–15 repetitions per exercise with a moderate load) result in greater gains in upper body strength than less frequent and lower volume training programs during the initial adaptation period. Others have reported that the development of upper body strength in adults responds more favorably to higher training frequencies (Hoffman et al., 1990; Hunter, 1985; McLester et al., 2000). Westcott (1995) observed no significant differences in upper body strength gains in adults who trained one, two, three or five times per week, provided that the volume of work was kept constant. The effects of different training frequencies on strength development while maintaining the weekly training volume constant have not been studied, nor have the effects of high volume training performed only once per week been explored in children. In the present study, the 1-day group exercised at a weekly volume half that of the 2-day group. In the short-term, performing one set of 10–15 repetitions only once per week may be suboptimal for increasing children’s upper body strength above and beyond growth and maturation.

During childhood, there is a gradual increase in height and weight, yet the legs grow at a faster rate than the trunk (Brooks, Fahey, & White, 1996; Malina & Bouchard, 1991). Although speculative, this developmental lag in upper body maturation may influence the functional development of muscle tissue. While more data on the dynamics of upper body strength development in children are needed, it is possible that training-induced gains in upper body strength during childhood may be relatively slow to develop, and, if a 1-day protocol is followed, gains may not become apparent until later in a training program.

It has been suggested that the upper body of adults may be able handle more frequent training sessions than the lower body (Stone & O’Bryant, 1987); and it seems that additional training sessions may be needed to enhance the upper body strength of children. The smaller muscles of the upper body produce smaller gains (as compared to the lower body) and may need higher volumes and more frequent training sessions before strength gains become statistically significant. Further, the upper body muscles of children in our study may have been at
a higher level of conditioning than those in other reports, because 28% of the children who strength trained in this study regularly participated in a competitive swim program. However, the validity of these contentions is clouded by our limited understanding of the precise physiological determinants of training-induced strength gains in children.

One could speculate that handgrip strength should be enhanced following several weeks of progressive strength training, because several exercises (e.g., seated row and lat pull down) placed increasing demands on the wrist flexors. In our study, no significant differences in handgrip strength were noted between groups after the training period. This suggests that specific exercises (e.g., wrist curl) for enhancing handgrip strength may be needed, if this is a desired outcome of the training program.

Lower Body Strength

In the present investigation, leg press strength gains by participants who trained once or twice per week (14.2 and 24.9%, respectively) were significantly greater than control group values. Our results are less than lower body strength gains observed in similar age groups who followed twice or thrice weekly strength training programs (Faigenbaum et al., 1993; Faigenbaum, Westcott et al., 1996; Sailors & Berg, 1987). The absolute increase in leg press strength resulting from 1 and 2 days per week of training in our study (8.6 and 14.2 kg, respectively) were also less than the reported gains of approximately 16 kg (Ramsay et al., 1990) and 22 kg (Sailors & Berg, 1987) on similar exercises following 8–10 weeks of strength training. The higher training frequencies and training volumes used in other studies may explain these findings. However, when compared to the development of upper body strength, the minimum training frequency required to increase the lower body strength of children may be less than previously thought, provided the exercise is of sufficient intensity.

Motor Performance and Flexibility

Strength training has been shown to improve the adults’ motor performance (Fleck & Kraemer, 1997), and it’s reasonable to assume that children should receive similar benefits. Several studies involving children have reported significant improvements in selected motor performance skills (e.g., vertical jump and sprint speed) following 12 to 14 weeks of strength training (Lillegard, Brown, Wilson, Henderson, & Lewis, 1997; Weltman et al., 1986). However, despite significant improvements in lower body strength, the results of our investigation do not support these findings. Anecdotally, however, parents continually reported improvements in sports performance of the strength trained participants, particularly age-group swimmers.

Participants in our study performed one set of 10–15 repetitions on selected weight machine exercises for 8 weeks using slow, controlled movements. It is possible that longer study durations, more frequent training sessions, higher training intensities, more advanced strength training exercises (e.g., barbell squat), or exercises requiring faster training velocities (e.g., plyometrics or Olympic-style lifting) may result in more favorable findings. In general, it seems that common field-based measures, such as the vertical jump and long jump, may not relate to maximal leg strength in children. While tests for local muscular endurance (e.g., curl-up and push-up) are available, tests for maximal muscle strength are not typically included in youth fitness test batteries. Additional studies are needed to identify in children simple field-based measures that relate to maximal muscle strength. Because lower back and hamstring flexibility improved in all groups, it appears that strength training will not result in a loss of flexibility in children, provided that stretching exercises are incorporated into the training program. Others have reported similar findings in children (Lillegard et al., 1997; Weltman et al., 1986).

The magnitude of muscular strength development in the present study resulting from training twice per week was greater than for those training only once per week. These observations, however, should not overshadow the practical importance of prescribing a training frequency of once per week for children participating in an introductory program. For some children, large time commitments are not possible, and less frequent training programs are more desirable. While trained, young athletes may make greater gains from more frequent training sessions, participants who strength trained once per week significantly enhanced 1RM leg press strength as compared to the control group, and, perhaps equally as important, children in this group had an opportunity to learn proper strength training procedures and develop an interest in a form of exercise that can be continued into adulthood. In some cases (e.g., physical education classes), the rate of strength gain may be secondary in importance to a positive educational experience. Following the initial adaptation period (i.e., 8–12 weeks), varying the training frequency (as well as other program variables) may be warranted to make continual gains.

In this investigation, the weekly training volumes for participants who exercised once or twice per week were not equal. The weekly volume for the those who strength trained twice per week was double that of those who trained only once per week. Admittedly, differences in the weekly training volume as well as training frequency may have influenced the results. However, because no study involving children has explored the effects of different training frequencies with a single set performed to volitional
fatigue, beginning a strength training program with one set per exercise for both training groups appeared to be safe, effective, and potentially more enjoyable for the participants than higher volume protocols.

Also, because we did not assess biological maturation before the start of the study, it is possible that older participants may have entered their pubertal years. For the purpose of this study, we contend that this limitation is minor, because relative strength gains achieved during prepubescence are comparable with relative gains observed during adolescence (Pfeiffer & Francis, 1986). During and after puberty, however, training-induced strength gains in boys may be associated with changes in hypertrophic factors, because hormonal influences on muscle hypertrophy would be operant (Faigenbaum, Kraemer et al., 1996). Finally, our results may not be applicable to trained young athletes in whom the relationship between training frequency and magnitude of strength gain may be different.

In summary, the results from this investigation suggest that if untrained children begin strength training with one set of 10–15 repetitions per exercise, a training frequency of at least twice per week should be recommended (assuming that repetitions are performed to the point of temporary fatigue). These findings are consistent with current recommendations from the American College of Sports Medicine (2000) and the National Strength and Conditioning Association (Faigenbaum, Kraemer et al., 1996). Additional youth strength training guidelines, which include close supervision, knowledgeable instruction, and an appropriate progression of training loads, are available elsewhere (Faigenbaum & Westcott, 2000). Owing to the growing popularity of youth strength training, future long-term studies should evaluate the effects of different training frequencies on other health and fitness measures in children and should explore the precise physiological determinants of training-induced strength gain in younger populations.

References


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