Muscular Endurance and Physical Capacity to Perform Work of Adolescents With Mental Retardation

Christine B. Stopka, Kimberly L. Zambito, David G. Suro, Kevin S. Pearson, Ronald A. Siders, and Buffy H. Goff

The purpose of this study was to evaluate gains in muscular endurance and physical capacity to perform work in 22 adolescents and young adults (ages 13–22 years) with MR. The participants were tested before and after two consecutive 3-week sessions of supervised resistance training. Specific muscle strength was evaluated using a three repetition maximum (3RM) test, and muscular endurance was assessed using a repetition to failure (RF) test at 60% of the 3RM. The chest press, leg extension, and torso arm exercises were tested. Participants trained twice per week during the training intervals. The data were analyzed using a one-way ANOVA for repeated measures. Significant increases (p ≤ .05) in 3RM, RF, and total work performed during the RF test were found for the leg extension and torso arm exercises. Significant increases (p ≤ .05) in RF performance and total work performed during the RF test were found in the chest press. These results demonstrate that adolescents and young adults with MR can experience significant gains in muscular strength and endurance through a supervised resistance training program.

The 1996 Surgeon General’s Report on Physical Fitness recommends an exercise program for all Americans (18). A major public health goal is to get more people of all ages motivated and involved in physical activities (7). A number of studies on the general adult population have demonstrated that resistance training programs can improve muscular strength and endurance, aerobic capacity, and body composition (1–3, 7–9, 17, 18). In addition, resistance training programs have been shown to decrease the risk of suffering a serious injury from a fall or other accident in this population (3). Although some researchers have recently examined the cardiorespiratory endurance levels of individuals with mental retardation (MR) (2, 4, 5, 13, 10), few studies have focused on resistance training for individuals with MR (11, 12, 14, 17), especially adolescents with MR (17).

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The purpose of this study was to document changes in muscular endurance and physical ability to perform work in adolescents with MR. Subjects participated in two continuous 3-week sessions of supervised resistance training. The chest press, leg extension, and torso arm exercises were evaluated.

**Methods**

Twenty-two adolescents/young adults with mental retardation, ages 13–22, volunteered with approval of their parents or legal guardians to participate. All of the participants were diagnosed with MR as defined by the American Association of Mental Retardation in 1993 (16). Each subject and parent or guardian signed the appropriate institutional review board consent forms for human research participation, as well as the Florida Special Olympics Medical Release Form. Of the 22 participants (7 females, 15 males), 17 completed this study. One male subject had spastic hemiplegia and another had Prader-Willi syndrome, which precluded them from participating in the chest press exercise.

The experiment was carried out using a single-group, repeated-measures design (Figure 1). The participants completed two sets of pretests. Pretest 1 was followed by a 3-week period of nonspecific exercise. During this period, the subjects participated in a recreational swim program twice per week. Following this period, the participants completed a second set of pretests (Pretest 2). By conducting two separate pretests, participants could serve as their own control group in this dependent-measures design. Pretest 2 was followed by 3 weeks of specific resistance training. The participants then underwent a series of midtests. Following these midtests, the participants underwent 3 more weeks of specific training and then were given a final set of tests (posttest). Each test session was identical.

The protocol for each test session included anthropometric measurements as well as fitness tests. Each participant’s height, weight, and body composition were measured during test sessions. General fitness was assessed during each test session using the sit-and reach test for hamstring and low back flexibility, the 50-yard dash for speed and power, and the 30-s sit-up test for abdominal muscle endurance (17). Specific muscle strength was assessed using a three repetition maximum (3RM) test, and muscular endurance was assessed using a repetition to failure (RF) test at 60% of the 3RM (5) for the chest press, leg extension, and torso arm exercises during each test session. The Nautilus chest press (CP), Nautilus leg

![Figure 1 — Experimental design. The nonspecific exercise was a recreational swimming program.](image-url)
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extension (LE), and Nautilus torso arm (TA) machines were used to measure muscular performance. Total work (TW) performed during the RF tests was calculated by multiplying the number of repetitions with proper form by the amount of resistance the participants were moving per repetition. This product was then multiplied by the distance the resistance was moved per repetition to calculate the total work performed for each exercise (9).

A period of 48 hr separated the 3RM tests from the RF tests. This was to ensure that muscle fatigue from the 3RM test did not affect the RF test performance (8). The anthropometric measurements and the tests for general fitness followed the specific tests for muscle performance to ensure that there was no effect of fatigue from these tests on the 3RM or RF performances (12).

The participants trained twice per week during the training intervals. The protocol for training sessions consisted of a brief warm-up and stretching period that included calisthenics, specific muscular training, and recreational sport. The specific muscular training portion of each session consisted of one set of repetitions on each of the seven Nautilus machines. The machines were as follows: chest press, lat pulldown, leg extension, leg curl, biceps curl, triceps curl, and pullover. The exercises other than those tested were incorporated to provide a comprehensive, well-rounded resistance training program.

All pretest, posttest, and training sessions were administered by student volunteers who had been instructed in correct testing and training protocols; they were supervised by the principal investigators and comprised the staff administering the training to the subjects throughout the program.

The resistance was set for each participant so that he or she could perform 25 to 30 repetitions with proper form. If a participant could perform more than 30 repetitions, the resistance was increased for the following training session. Each participant’s performance was recorded on a daily workout chart. The training sessions were concluded with a recreational sport activity. Sports played during the experiment included flag football, softball, and basketball.

The data from the two pretests were correlated using a Pearson product-moment correlation. This was to determine the effect of maturation or other uncontrollable factors on participant performance. The data collected from all four tests were analyzed with a one-way analysis of variance (ANOVA) for repeated measures. The results of the ANOVAs were analyzed with a Sheffé post hoc test to determine which interval, if any, significantly changed subject performance. The significance level for the experiment was set at \( p \leq .05 \).

Results

Anthropometric Measurements

There were no significant changes in mean participant weight or body composition during the course of the study. There was a significant change in mean participant height between the first pretest and the final posttest.
The data for the 3RM tests and the TW performed during the RF tests were expressed as resistance relative to the participants' body weights (RBW). This method was used to reduce or nullify the impact of physical maturation (e.g., weight) should weight change during the study as a result of maturation, training, or both (Tables 1-3).

There were no significant changes in test performance, seen between Pretest 1 and Pretest 2, following the period of nonspecific exercise. Correlations between the data collected during the two pretest sessions (before and after the period of nonspecific exercise) were very high for the 3RM test, RF test, and TW performed for all muscle groups tested. Since a high correlation between the first two tests was found ($r = .97$), we ascertained that confounding variables had no effect on test performance, thus allowing participants to serve as their own controls.

Chest Press

For the chest press, usable data were collected for 15 of the 17 participants who completed the study. One participant was unable to perform a set of three repeti-

<table>
<thead>
<tr>
<th>Test</th>
<th>Total work during RF test (RBW) (J)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
</tr>
<tr>
<td>Test 1</td>
<td>8.138</td>
</tr>
<tr>
<td>Test 2</td>
<td>8.405</td>
</tr>
<tr>
<td>Test 3</td>
<td>11.719</td>
</tr>
<tr>
<td>Test 4</td>
<td>15.840</td>
</tr>
</tbody>
</table>

Table 1  Chest Press Test Performance

Table 2  Leg Extension Test Performance

<table>
<thead>
<tr>
<th>Test</th>
<th>Total work during RF test (RBW) (J)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
</tr>
<tr>
<td>Test 1</td>
<td>17.198</td>
</tr>
<tr>
<td>Test 2</td>
<td>17.541</td>
</tr>
<tr>
<td>Test 3</td>
<td>28.371</td>
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<tr>
<td>Test 4</td>
<td>42.894</td>
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</tbody>
</table>
Table 3 Torso Arm Test Performance

<table>
<thead>
<tr>
<th></th>
<th>3RM test (RBW)</th>
<th>RF test (repetitions)</th>
<th>Total work during RF test (RBW) (J)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Test 1</td>
<td>0.771</td>
<td>0.264</td>
<td>18.353</td>
</tr>
<tr>
<td>Test 2</td>
<td>0.767</td>
<td>0.265</td>
<td>18.000</td>
</tr>
<tr>
<td>Test 3</td>
<td>0.788</td>
<td>0.271</td>
<td>24.176</td>
</tr>
<tr>
<td>Test 4</td>
<td>0.842</td>
<td>0.282</td>
<td>28.706</td>
</tr>
</tbody>
</table>

There were no significant changes in 3RM test performance for the chest press. There were significant increases in both the RF test performance and TW performed during the RF tests. Uniform, significant increases followed each period of specific training.

**Leg Extension**

Significant increases in mean participant performance were noted for the 3RM test, the RF test, and TW for the leg extension exercise. The increases in 3RM test performance were not consistent during the study; however, each significant increase followed a period of specific training. There were significant increases in RF test performance and TW performed during the RF tests following each period of specific training. The mean TW performed by the participants more than doubled from the pretest, midtest, and posttest for the knee extension exercise.

**Torso Arm**

Significant increases in mean performance were noted for the 3RM test, the RF test, and TW for the torso arm exercise. The increases in 3RM test performance were not consistent during the study; however, each significant increase followed a period of specific training. There were significant increases in RF test performance and total work performed during the RF tests following each period of specific training.

**Discussion**

The period of nonspecific exercise served as the control interval for this study. During this interval there were no significant changes in performance for any of
the specific resistance exercise tests as measured by a set of pretests before and after this interval. The correlation between the performance on these pretests was very high \( r = .97 \), therefore substantiating this interval as a control period.

**Anthropometric Data**

The subjects' height significantly increased during the course of the study. The significant interval was found between Pretest 1 and the posttest, which were separated by 11 weeks. The increase in height is the result of the adolescent participants' rapid growth.

Although mean participant weight did not change during the course of the study, minor fluctuations were noted. These minor fluctuations could be the result of inconsistent diet and fluctuating levels of hydration of the subjects. The increase in weight noted for the last test session could be the result of an increased amount of clothing worn by the subjects, because weather conditions were colder during the final test session than in previous test sessions. There were likely some changes in lean body weight due to hypertrophy as a result of the resistance training. One subject showed dramatic weight loss during the study. That particular subject had Prader-Willi syndrome, a compulsive eating disorder. During the study, he was on a restricted diet designed by a physician to decrease his percent body fat.

Although mean percent body fat did not change during the study, minor fluctuations were noted. The fluctuations could have been the result of the subjects' varying levels of hydration. Another factor that may have caused the fluctuations was intratester variability. The same tester collected skinfold data for all four tests sessions, but some variability was still likely to occur. The participant with Prader-Willi syndrome showed dramatic decreases in percent body fat during the course of the study.

**Resistance Test Data**

3RM Tests. There were no significant increases in mean 3RM chest press during the study. In fact, mean 3RM chest press decreased slightly following the first period of specific training. The increase in the 3RM chest press following the second period of training, though not significant, could be the result of increases in muscular strength due to neural adaptations (1, 6) as a result of the training or could have been due to subjects learning the technique.

For the chest press exercise, 15 of the 17 subjects completed the test. One subject had spastic hemiplegia due to cerebral palsy and could not perform the chest press exercise properly. Another subject was not strong enough, due to Prader-Willi syndrome, to move the resistance arm on the chest press machine three times while the machine was set at the lowest possible resistance. Thus, these 2 subjects were excused from the chest press portion of the study.

There were significant increases in leg extension performance for the 3RM test during the study. The significant increase followed the second period of spe-
specific training. The subjects also showed significant increases in the 3RM torso arm test during the study. These significant increases were noted following the periods of specific training.

The increases in 3RM test performance for the leg extension and the torso arm tests were most likely the result of increases in muscular strength as a result of the training. Since the training interval was too brief to result in muscle fiber hypertrophy, the observed strength gains were likely due to neural factors such as enhanced fiber recruitment (1, 6). Simple learning of the technique could have contributed to the increase in performance. That the subjects did not show significant changes for the 3RM chest press performance suggests that the effects of learning were minimal.

The correlations between the initial pretest data and the data from the test following the period of nonspecific exercise were very high for all three resistance exercises. This shows that the period of nonspecific exercise acted as a control interval for 3RM test performance.

**RF Tests.** The subjects showed significant improvements in RF test performance for each resistance exercise following each period of specific training. The subjects did not show significant changes in RF test performance for any of the three resistance exercises following the period of nonspecific exercise. The correlations for the RF test data for the initial pretest and the test following the period of nonspecific exercise were very high for each resistance exercise, which indicates that the period of nonspecific exercise acted as a control interval for the RF tests.

The increases in RF test performance were a result of increased muscular endurance following training. Effects of learning could have added to the increases in RF test performance, but the fact that there were such small changes in RF test performance between the pretest and the test following the period of nonspecific exercise suggests that the effects of learning were minimal.

**Total Work.** As with the RF tests, mean TW increased significantly following each period of specific training. There were no significant changes in TW performed following the period of nonspecific exercise. The correlations between the data from the pretest and the data from the test following the period of nonspecific exercise were very high for each of the three resistance exercises, which suggests that the period of nonspecific exercise served as a control interval for the measurements of TW. Since work is calculated by multiplying the number of repetitions by the amount of resistance and the distance the weights travel per repetition, a significant increase in resistance or a significant increase in the number of repetitions would significantly increase TW. The distance the weights traveled per repetition was constant for each subject on each machine. The significant increases in work were primarily due to increases in RF test performance. RF test performance improved much more dramatically than 3RM test performance for each of the three resistance exercises. However, the significant improvements in leg extension and torso arm performances contributed to the significant increases in TW performed for these two exercises.
Summary

The period of nonspecific exercise served as the control interval for this study. During that interval there were no significant changes in performance for any of the resistance exercise tests. The correlations between performance on the pretest and the test following the period of nonspecific exercise were very high for the 3RM test, the RF test, and TW performed for each of the three resistance exercises.

Mean performance on the 3RM tests for the resistance exercises changed significantly following some specific training intervals. The fact that there was not a uniform significant increase in 3RM performance for each resistance exercise suggested that the training sessions were not specific to increase muscular strength.

Mean performance on the RF test and TW performed during the RF test increased significantly following each specific training interval. The subjects showed uniform significant increases in muscular endurance and physical capacity to perform work following the specific training periods.

Conclusions and Practical Applications

After participating in a supervised resistance training program using sophisticated weight training machines for two 3-week sessions, the adolescents with MR experienced significant gains in muscular endurance and physical capacity to perform work for the chest press, leg extension, and torso arm exercises. In addition, some significant increases in leg extension and chest press strength were also found.

It appears that adolescents with moderate to severe MR can significantly improve muscle endurance and work capacity by participating in a physical fitness program that emphasizes resistance training. This population can experience muscle endurance and physical work capacity gains similar to their nondisabled peers when given a supervised program of resistance training (4, 14, 17). Participants who also had physical limitations such as cerebral palsy or orthopedic challenges realized muscular endurance and work capacity gains. These gains had direct benefits in their activities of daily living, special education, and vocational pursuits.

Individuals with disabilities must not be excluded from physical fitness programs; all persons, regardless of their limitations, have the right to a lifestyle of health and physical fitness (7, 15, 17). Arguably, these individuals benefit from and need such programs perhaps even more than their nondisabled peers.

References