Physical Fitness and Psychological Benefits of Strength Training in Community Dwelling Older Adults

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Abstract. Previous studies concerning psychological benefits of exercise among the elderly has focused predominantly on the effects of aerobic exercise. In the present study, psychological and behavioral adaptations in response to 12-weeks of strength training were examined in medically healthy but sedentary 42 older adults (mean age = 68 years). The purpose of this study was to evaluate the effects of high and low intensity resistance training intensity on a) muscular fitness, b) psychological affect, and c) neurocognitive functioning. Subjects were randomly assigned to high intensity/low volume (EXH: 2 sets of 8 to 10 repetitions for 75 to 85% of 1 RM), low intensity/high volume (EXL: 2 sets of 14 to 16 repetitions for 55 to 65% of 1 RM), or no exercise control programs. Prior to and following the 12-week program, subjects underwent comprehensive physiological and psychological evaluations. Physiological assessment included measurements of blood pressure, heart rate, arm and leg muscle strength, body composition, and oxygen consumption (VO₂max). Psychological measures included evaluations of mood, anxiety, and physical self-efficacy as well as cognitive functioning. The results of this study indicated that both high and low intensity strength programs were associated with marked improvements in physiological fitness and psychological functioning. Specifically, subjects in the strength training programs increased overall muscle strength by 38.6% and reduced percent body fat by 3.0%. Favorable psychological changes in the strength-trained subjects included improvements in positive and negative mood, trait anxiety, and perceived confidence for physical capability. The treatment effects of neurocognitive functioning were not significant. In summary, this study demonstrated that participation in 12-weeks of high or low intensity strength training can improve overall physical fitness, mood, and physical self-efficacy in older adults while cognitive functioning remains constant.

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Keywords: older adults, strength training, mood, self-efficacy

Introduction

Health issues for the elderly are becoming increasingly important due to dramatic increases in life expectancy rates and the fact that the percentage of individuals over the age 65 is the fastest growing segment of the population. In the beginning of the 20th century only 4% of the population was over 65 years, currently 13% are over 65 years, and estimates state that this statistic will grow to nearly 20% by the year 2025 (U.S. Bureau of the Census, 1995). Elderly health issues are of unequivocal importance when one considers that 80% of those over 65 years old are currently suffering from one or more chronic health condition including arthritis, hypertension, hearing loss, heart problems, or diabetes (U.S. Department of Health and Human Services, 1984).

Recent scientific evidence has shown that the benefits of exercise may potentially contribute to the modification of age associated declines in numerous physical and psychological functioning (Blumenthal et al., 1989; Dishman, 1992; Hagberg 1990; King et al., 1989; Paffenbarger et al., 1986). For example, there is considerable support that exercise can reverse a decline in cardiovascular functioning associated with physical reconditioning (Blumenthal et al., 1989; Bortz, 1982). It has also been shown that aerobic exercise can modify parameters of cardiovascular performance except for peak heart rate (Adams and de Vries, 1973; Bortz, 1982; Cunningham et al., 1987; Kavanaugh and Shepherd, 1978).

In addition, exercise may prevent or slow the functional impairment of skeletal muscle. Muscle strength may be particularly crucial for this population, because lack of muscle strength appears to be a major contributor to frailty and institutionalization in the elderly (King, 1991). Recent findings have indicated that older adults can achieve many of the muscular fitness results as younger adults by performing strength training (Fiatarone et al., 1990). It has also been demonstrated that strength training can help older adults to modify
physical impairments by improving muscular fitness (Frontera et al., 1988).

In addition to physiological benefits, exercise training may also improve mental health. Many studies have demonstrated that aerobic exercise may ameliorate psychological impairments, such as mood (Folkens and Sime, 1981; Greist et al., 1979), and cognitive performance (Elsayed et al., 1980). Findings in strength training in younger and middle-adults have also shown positive psychological effects. Tucker et al. (1986) found that middle-aged males with poor musculoskeletal fitness demonstrated greater levels of perceived stress than did physically fit subjects. Further, some investigators have subsequently reported reduced symptoms of clinical depression in middle-aged men and women (Ossip-Klein et al., 1989; Martinsen et al., 1989).

Stewart et al.’s (1988) three year intervention study demonstrated positive psychological effects of strength training in male cardiac patients. All of their subjects performed aerobic exercise, but one group engaged in strength training as well. Results showed that only subjects who performed strength training reported significant increase in physical self-efficacy for arm and leg activities, suggesting strength training can influence psychological outcomes. Ewart (1989) also reported that a 10-week combined strength training and aerobic exercise significantly increase arm and leg self-efficacy, as well as corresponding increases in positive mood and decreases in negative mood.

Age-related declines in cognitive functioning are also observed among the elderly. While crystallized intelligence such as acquired knowledge, experience, or learning, appears to be relatively preserved among the healthy older adults, fluid intelligence such as problem solving or ability to integrate new information has been found to decline with age (Elsayed et al., 1980). It has also been suggested that exercise training has beneficial effects on modifying declines in the neuropsychological or cognitive functioning (Dustman et al., 1984; Molloy et al., 1988).

In the first well-controlled investigation, Dustman et al. (1984) examined the effects of exercise on cognitive functioning in older adults aged 55 to 70. Subjects were evaluated with a battery of neuropsychological tests designed to tap a range of cognitive functioning, including short-term memory, reaction time, and other indicators of fluid intelligence. The results indicated that trained subjects improved significantly on reaction time and problems solving, including the Digit Symbol from the Wechsler Adult Intelligence Scale-Revised (WAIS-R) and Stroop Word-Color test. However, several recent studies have failed to find that exercise mediates these functions (Blumenthal et al., 1989; Emery and Gatz, 1990). Therefore, the effects of exercise on age-related cognitive functioning remains inconclusive.

Despite the potential benefits of strength training on various health variables for the elderly, unfortunately strength training has often been underestimated or ignored in community setting exercise programming for older adults (King, 1991). The present study was conducted to explore the possible benefits of strength training on various health variables in older adults. High and low intensity strength training programs were employed in this study to reveal training regimes that are both suitable for the aging population and to maximize objectives. This study was designed to comprehensively assess muscular fitness and psychological variables including mood, anxiety, self-efficacy, and cognitive or neuropsychological functioning in community dwelling older adults who were aged from 60 to 86 years old. Results from the present study may help to provide greater insight towards understanding cognitive-behavioral factors that underlay improvements in mental health following strength training in the older population.

Method

Participants
Forty-five subjects (male=9, female=36) were recruited for this study through advertisement. Subjects were eligible for this program if they were a minimum of 60 years, medically healthy, and sedentary (defined as having no involvement in any regular exercise for the previous 6 months). The subjects ranged in age from 61 to 86 years (mean=68.8 ± 5.7 years). This study was approved by the Research Review Committee of the School of Education at Boston University. All subjects were free of cardiovascular disease or not currently taking medication for the treatment of hypertension. Two subjects withdrew from the program during instruction sessions due to scheduling conflicts and one due to commuting problems. Thus, a total of 42 subjects participated in this study. All subjects had achieved at least a high school education and 96% were Caucasian.

Procedures
Subjects were randomly assigned into three groups: 1) high intensity strength training (EXH) (n=14); 2) low intensity strength training (EXL) (n=14); 3) non-exercise control (n=14) following the completion of an extensive assessment battery.

Subjects in the EXH and EXL groups attended three supervised strength training sessions per week for 12 consecutive weeks. The following 12 exercises were used for training by using dynamic variable resistance weight machines (weight machines): leg extension, leg curl, shoulder press, bench press, lateral pull-down, fly, triceps press-down, arm curl, back extension, seated row, and abdominal flexion. These exercise were chosen to train the major muscles based on the American College of

The protocols in this study differed as follows: the EXH group performed 75 to 85% of estimated 1 RM (one repetition maximum: the maximum strength that the subject was able to complete 1-repetition through a full range of motion) with 8 to 12 repetitions; while the EXL group performed 12 to 16 repetitions at 55 to 65% of estimated 1 RM. Each repetition took 6 to 8 seconds per repetition with 1 to 2 minute rest periods between sets. Training intensity was adjusted every 4 to 6 sessions to maintain the appropriate training load. For example, when the subjects in the EXH group were able to perform two sets of 12-repetitions with the original 8-repetitions in correct form, the load was increased within 5 to 20 percent to maintain training load and started with 8-repetitions.

All physiological and psychological measures were obtained at baseline except for muscle strength which was obtained after 4 instruction sessions. These measures were obtained within 8 days after the subjects’ completion of the training sessions.

Physiological measurements

Muscle strength: For the strength training groups, the first 4 sessions were devoted to instruction, which included machine use, correct body position during exercise, and proper movement, speed of movement, range of motion and breathing technique. After this instruction phase, maximum muscle strength was assessed by a 10 RM maximum method for each of the exercise machines (the maximum load the subject could lift through the full range of motion for 10 repetitions). After 5 minutes of warm-up, the first set was performed for 10-repetitions with a light weight. This weight was determined for each subject during the instruction period. After a 3 to 4 minute rest interval, a second set of 10-repetitions was performed with a weight increase of 2.5 to 20 pounds according to the subject’s ability. This procedure was repeated for a third set; and if necessary, a fourth set of 10-repetitions with gradually increasing weight until the subjects reached the 10 repetition maximum.

Oxygen uptake: Assessment of VO₂max was conducted by using bicycle ergometer testing recommended by ACSM (1995). Briefly, the subjects started at 60 revolutions/minute (for three minutes) at an initial power output of either 30 Watts or 60 Watts according to the subject’s ability. The power output was increased by 30 Watts until the subjects reached an 80% of age-predicted maximum heart rate formula (220 - age). During this submaximal test, Favor Heart Rate Monitors (Polar CIC, Inc.) monitored heart rates and at the final 15 seconds of each minute the rate was recorded. Blood pressure was measured with a standard stethoscope, cuff, and sphygmomanometer with recordings at 150 seconds into each stage.

Body composition: Percent (%) body fat was estimated from the sum of four sites of skinfold measurements (triceps, subscapular, suprailiac, and biceps).

Resting heart rate and blood pressure was obtained with the subjects in a sitting position by the MEDAC 3 system (DAVICON, Inc. of Boston, MA) and by standard cuff sphygmomanometer. Body weight was measured by a standard balance scale.

Psychological measurements

Mood and anxiety: The Profile of Mood States (POMS: McNair et al., 1981) was used to evaluate self-reported mood states. It consists of 65 items which are related on seven dimensions of mood state including tension/anxiety, depression/dejection, anger/hostility, vigor/activity, fatigue/inertia, confusion/bewilderment, and a total mood disturbance (TMD). TMD was calculated by summing the scores across 6 negative subscales and subtracting the scores for one positive mood (vigor). Anxiety was assessed by the State-Trait Anxiety Inventory (STAI), a 40-item questionnaire measuring levels of anxiety at the time of assessment and in general (Spielberger et al., 1970).

Physical self-efficacy scale: Two sets of efficacy measures were assessed: physical activity efficacy and physical competence efficacy. The former, which Ewart and Taylor (1985) originally developed for use with cardiac patients, is comprised of four measurements designed to determine subjects' beliefs in their abilities with respect to lifting objects, walking, climbing stairs, and push-ups. For each activity, subjects select percent confidence scores from 0 (not at all) to 100% (completely confident) that correspond to a given range of performance levels. The physical competence efficacy was assessed by using the Physical Self-Efficacy Scale (Ryckman et al., 1982). This scale consists of two factor subscales (a) perceived physical ability (PPA) and (b) physical self-presentation confidence (PSPC). The PPA is designed to measure an individual’s belief in components of physical capability, while the PSPC attempts to assess the individual’s confidence in the presentation of physical skill. The subjects were asked to indicate their level of confidence on a 6-point Likert scale ranging from 1 (strongly disagree) to 6 (strongly agree). The PPA subscale consists of 10 items with a possible range of 10 to 60 and a 12-item PSPC subscale with a range from 12 to 72.

Neurocognitive functioning: Neurocognitive functioning was assessed by mental arithmetic (MA) and a computerized mirror drawing (MD) task. In the MA task, subjects were given three-digits and told to count backwards by 7's from the number with the greatest degree of speed and accuracy as possible in 2 minutes. The number of correct answers were recorded as a
dependent measure for this task.

The MD task is a software program specially developed to simulate a traditional star tracing task. The subjects used their nondominant hand to track the cursor around an octagonal star displayed on a computer screen by staying within a narrow outline as many times as possible in two minutes. To increase the task difficulty a mirror effect was created, whereby the mouse direction of movement was opposite to the cursor's direction of movement of the computer screen. For example, to direct the cursor right, the mouse must move left. If the cursor was moved outside of the double lines, a beep sounded, and the computer automatically recorded an error.

The time and distance traveled within the narrow outlines were recorded along with the total number of the errors as determinants of performance on this assessment.

Statistical analysis

To accommodate the numerous instruments and subscales that were used, variables were often clustered into various conceptual units. Hence, data were principally analyzed with a repeated multivariate measures analysis of variance (MANOVA). The conceptual units were physiological variables, mood and anxiety, physical self-efficacy, and cognitive functioning. When the MANOVA was significant, follow-up univariate tests were employed on the pre- and post-training measures to determine the variable on which groups differed. In cases where variables could not be clustered into the multivariate analysis (e.g., body weight), the data were analyzed by analysis of variance (ANOVA).

Results

Group characteristics

Of the 42 subjects who participated in this study, all subjects completed their respective programs. One woman in the EXH program was not available for post-training assessment, so her data were excluded. The remaining data from 41 subjects were analyzed. The characteristics of the three groups of subjects are presented in Table 1. There were no significant group and sex differences in physiological or psychological characteristics at baseline.

Changes in physiological measures

Physiological measures, including arm and leg strength, VO2max, and % body fat were clustered into a MANOVA. The MANOVA for physiological measures revealed significant multivariate main effects for time, Wilks' lambda=31.73, p<0.001, and group x time interaction effects, Wilks' lambda=8.58, p<0.0001. Because of the nature of this study design, only interaction effects were analyzed as treatment effects.

Univariate analysis of muscle strength revealed significant group x time interaction effects for arm strength, F (2, 38)=14.1, p<0.0001, and leg strength, F (2, 38)=13.1, p<0.0001. At post-training testing, the EXH group improved arm strength by 9.5 kg (48.2%), from 19.7 kg to 29.2 kg, and the EXL group improved the strength by 7.2 kg (39.7%), from 18.9 kg to 27.0 kg. In contrast, subjects in the control group experienced 1.0% reduction in arm strength, while they experienced a non-significant 4.0% increase in leg strength. Thus, as illustrated in Fig. 1, both high and low strength training groups significantly improved their arm and leg muscle strength while the control group had little changes.

Also, univariate analysis of % body fat revealed a significant group x time interaction, F (2, 38)=6.56, p<0.01. Subjects in the high and low intensity programs decreased % body fat by 2.8% and 3.2%, respectively, while subjects in the control group showed non-significant 0.1% increment.

An ANOVA for VO2max revealed only significant main effect for time, F (1, 29)=4.58, p<0.05. All three groups experienced a increment of 0.2 to 2.9 ml/kg/min.

An ANOVA for body weight or resting heart rate revealed no significant changes across groups. But MANOVA for resting systolic (SBP) and diastolic blood

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Basic characteristics for high intensity (EXH), low intensity (EXL), and Control groups</th>
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<tbody>
<tr>
<td></td>
<td>EXH</td>
</tr>
<tr>
<td>Age (yr.)</td>
<td>67.8 (4.9)</td>
</tr>
<tr>
<td>N (Male/Female)</td>
<td>13 (27/17)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>61.0 (9.8)</td>
</tr>
<tr>
<td>Resting HR (bpm)</td>
<td>69.8 (11.4)</td>
</tr>
<tr>
<td>Resting SBP (mmHg)</td>
<td>109.8 (18.8)</td>
</tr>
<tr>
<td>Resting DBP (mmHg)</td>
<td>65.0 (9.9)</td>
</tr>
<tr>
<td>Arm strength (10 RM-kg)</td>
<td>19.7 (5.5)</td>
</tr>
<tr>
<td>Leg strength (10 RM-kg)</td>
<td>23.4 (6.4)</td>
</tr>
<tr>
<td>VO2max (ml/kg/min)</td>
<td>21.0 (6.1)</td>
</tr>
<tr>
<td>% body fat (%)</td>
<td>30.3 (7.2)</td>
</tr>
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Values are means (SD).
pressure (DBP) revealed a significant group x time interaction effect, Wilks’ lambda=2.75, p<0.05. The univariate ANOVA revealed that both SBP and DBP contributed to the multivariate effect, F (2, 38)=2.70, p<0.05, and F’ (2, 38)=5.62, p<0.01, respectively. Subjects in both high and low intensity program decreased resting SBP by 6.1 mmHg (5.5%) and by 13.4 (10.8%), respectively, while the control subjects experienced non significant increase. Subjects in the low intensity program reduced their DBP by 2.1 (3.0%) mmHg, while subjects in the high intensity program experienced non significant increases. The control subjects showed no changes.

Changes in mood and anxiety

Seven scales from POMS and STAI were considered together in a MANOVA.

Results of the MANOVA revealed a significant main effect for time, Wilks’ lambda=16.30, p<0.001 and a group x time interaction effect, Wilks’ lambda=2.13, p<0.05. Examination of the univariate effects revealed that there were significant group x time interaction for tension, F (2, 38)=4.25, and p<0.05, vigor, F (2, 38)=7.25, p<0.001. The univariate ANOVA also revealed a marginally significant group x time interaction for total mood disturbance (TMD), F (2, 38)=2.67, p<0.10. As illustrated in Fig. 2, subjects in both intensity programs showed marked reduction in tension while subjects in control group experienced no significant changes. Figure 2 also shows that subjects in both experimental programs improved vigor scores while subjects in the control group increased their scores (a lower score is better).

The univariate ANOVA for trait anxiety revealed a significant group x time interaction, F (2, 38)=10.31, p<0.001. Subjects in the EXH and the EXL groups lowered trait anxiety scores from 41.8 to 39.5, and from 40.8 to 34.6 respectively. But subjects in the control groups increased their scores from 35.6 to 38.8.

Changes in physical self-efficacy

Physical self-efficacy scales for lifting, walking, climbing stairs, push-ups, PPA, and PSCS were evaluated together in a MANOVA. The MANOVA revealed a significant main effect for time, Wilks’ lambda=5.67, p<0.001 and a group x time interaction, Wilks’ lambda=3.11, p<0.01.

The univariate ANOVA for lifting and push-ups revealed significant group x time effects, F (2, 38)=6.29, p<0.01, and F (2, 38)=3.29, p<0.05. Examination of Fig. 3 (a) indicates that subjects in high and low intensity program experienced improved lifting and push-up efficacy by 15.1% and 28.5%, and by 10.5% and 28.6%, respectively, while subjects in the control group slightly reduced both scores.

The results of univariate ANOVA for PPA and PSPCS also indicated group x time interaction effects, F (2, 38)=10.55, p<0.001, and F (2, 38)=5.31, p<0.01. As illustrated in Fig. 3 (b), PPA and PSPCS increased 25.3% and 12.2%, respectively for the high intensity group, and 20.9% and 12.4%, respectively for the low intensity group. These results were unchanged in the control group.

Changes in cognitive functioning

An assessment of cognitive function was compiled from performance on the MA task (serial 7’s) and the MD task. Results of the MANOVA revealed only a significant time main effect, Wilks’ lambda=7.86, p<0.001. As indicated in Table 3, both men and women in all groups display better scores on all cognitive tests (number of correct answers on the MA task and time, distance, and
the total number of errors on the MD task) at post-assessment compared to pre-test. Therefore, no treatment effects were found in neurocognitive functioning.

Discussion

The results of this study demonstrate that 12-weeks of strength training elicited significant increase in muscular fitness in healthy, but sedentary older men and women. Both high and low intensity programs were associated with improvements in muscle strength at a significant level. Both male and female subjects in the two experimental groups increased overall muscle strength while subjects in the control group experienced little changes although there were no significant differences in improvements between men and women.

The level of improvement in muscle strength in this study was much lower than some studies where over 100% muscle strength increase was found in older adults. For example, Fiatarone et al. (1990) reported that 9 frail institutionalized elderly men and women (mean age 90)
who performed high intensity (80% of 1 RM) knee extension exercise gained 174% in the knee extensors. Nevertheless, the present findings are consistent with earlier reports in which untrained college age women increase their average 19-33% after 10 weeks of low to high intensity weight training (Gettman et al., 1982). While it is possible to produce higher improvements in muscle strength, perhaps, the gains of 30% to 50% which were produced in the present study may be a more realistic goal in order to minimize the risk injury in a recreational type of strength training for the elderly.

Another effect associated with both high and low intensity training programs was a significant decrease in % body fat. The percentage of body fat in the high intensity group decreased from 30.3% to 27.5%, and the low intensity group decreased from 32.9% to 29.7% without changing body weight. Subjects in all three groups improved \( \dot{V}O_2 \)max by 0.2 to 2.9 ml/kg/min at the post-training assessment compared to the pre-test. Since all subjects had been sedentary, they may have not been familiar with pedaling a stationary ergometer at the pre-test; therefore, at the post-training assessment they may have felt more comfortable with the ergometer which resulted in the longer pedaling performance. It was concluded that there were no treatment effects in oxygen consumption after the 12-week strength training program.

Along with physiological improvements, subjects in both intensity strength training groups reduced tension and trait anxiety as well as increased vigor. These findings are consistent with previous reports that have demonstrated that strength training can yield significant improvements in mood and anxiety. In early investigations, Dishman and Gettman (1981) reported that strength-trained subjects significantly improved in measurements of vigor. Also, Fuchs and Zaichkowsky (1983) found that male and female bodybuilders with a long-term history of strength training scored below the norm on anxiety, tension, depression, and anger and above the norm on vigor measurements. Further, when Stewart et al. (1994) trained mild hypertension men with low intensity weight training combined with aerobic training, subjects reduced tension-anxiety and total mood disturbance (TMD) and improved vigor. Finally, results of the present study are also consistent with a recent study done by Don et al. (1996) that strength training programs resulted in significant reductions in multiple measures of negative affect and increase in positive feeling of vigor after 10-weeks of high and moderate intensity of strength training in college women.

Another psychological characteristic that was influenced by the present exercise programs was self-efficacy. Both strength training groups demonstrated significant improvements in perceived physical efficacy for lifting, push-ups, perceived physical ability, and physical self-presentation confidence. The control subjects had no significant changes on these measures. These results may be explained from a social cognitive perspective (Bandura, 1986): the experience of mastery associated with participation in a regular strength training program resulted in enhanced perceptions of physical self-efficacy.

As for physical self-efficacy, many researchers have found that self-efficacy has far-reaching implications for a variety of mental health variables. Bandura (1986) poised self-efficacy perception as a precursor to other cognitions. Ewart (1989) and Stewart et al. (1994) found enhanced physical self-efficacy was associated with improved positive and negative mood. Norvell and Belles (1988) found that regular circuit strength training may affect an individual's self-efficacy and self-esteem along with improvements in mood and job satisfaction. In addition, research on the relationship between self-efficacy and exercise in clinical settings has found that self-efficacy can reliably predict health behaviors (Ewart, 1989; Ewart et al., 1988; Lox et al., 1995). Lox, McAuley, and Tucker's (1995) trained HIV-1 patients aerobically and anaerobically demonstrated that self-efficacy was correlated with global constructs such as life satisfaction. Based on the positive correlation between physical self-efficacy and functional status of cardiac patients, Allen et al. (1990) suggest that a cardiac rehabilitation program's main goal should be to improve self-efficacy.

Ewart maintains that there are two principal mechanisms by which self-efficacy is enhanced by exercise: 1) individuals alter their perception of their physical competence by comparing their current performance to past performance as well as to the performance of their peers and 2) internal feedback from exercise-induced sensations can alter one's self-efficacy. Based on these mechanisms, self-efficacy may be dramatically improved when older adults perform strength training. Further, due to the novelty of the exercise since this type of activity is quite uncommon for this age group, self-efficacy for physical ability and self-presentation effects may be quite powerful. According to Ewart (1992), when self-efficacy failed to change after participation in an exercise program, the subjects experienced few psychological benefits. Then, positive psychological changes, yielding reduced anxiety and increased positive mood in the present study seemed to be influenced by enhanced physical self-efficacy.

Another provoking finding from studies is that psychological changes do not necessarily correlate with improvements in \( \dot{V}O_2 \)max. Blumenthal et al. (1989) reported that while both older men and women improved mood after 4-month aerobic exercise, the improvements in psychological variables were unrelated to physiological gains. The present study's findings add to their findings. Also, in the present study, no differences in psychological
improvements were found between high and low intensity strength training programs. The failure of training intensity levels to correlate with psychological outcomes may indicate that cognitive-behavioral mechanisms such as enhanced self-efficacy influence psychological variables more than physiological mechanisms.

It should be noted that the strength-trained subjects failed to enhance self-efficacy for leg activities such as walking and climbing stairs. This might be explained by two speculations. First, both walking and climbing stairs require aerobic power rather than muscular strength. In previous research, these leg tasks were found to be associated with aerobic power (Ewart et al., 1986). Second, the training protocol involved fewer exercises to train leg muscle (leg extension and leg curl) than arm-related exercises. Subjects improved arm strength disproportionately to leg strength.

Researchers have reported that with increased cognitive functioning increases as physiological functioning improves (e.g., Dustman et al., 1984; Perri and Templar, 1986; Stacey et al., 1985). Dustman et al. (1984) suggest that improved cognitive functioning may be mediated by the enhanced cerebral metabolic activity that results from exercise training. Other researchers, however, have found that exercise has no effect on cognitive functioning (e.g., Blumenthal et al., 1989; Emery and Gutz, 1990). After 4-months of aerobic exercise training, Blumenthal et al. (1989) failed to find changes in neuropsychological functioning in healthy older men and women (mean age-67 years). The results of the present study also observed only slight cognitive changes associated with physiological functioning.

To our knowledge, this is the first study to document the effects of strength training on psychological and cognitive functioning as well as physiological functioning. The results indicate that there are many benefits of 12 weeks of strength training for older adults. Physiologically, strength training improved their muscle strength, body composition and lowered resting systolic blood pressure. Psychologically, strength-trained subjects had positive effects in mood and trait anxiety. Marked improvements in physical self-efficacy seem to be particularly important for this population due to gradual declines in both real and perceived physical capabilities.

Interpretations of the present study, however, must be made with caution for several reasons. First, it has been reported that 85% of older adults are experiencing at least one chronic health condition. Subjects in the present study, however, were healthy and free from concomitant diseases. Also, our subjects were educated, highly motivated individuals who were self-selected to train themselves with an adherence rate of nearly 100%. These factors may have had important influences on outcomes. Perhaps, for example, the lack of significant change in cognitive function was due to the already relatively high level of functioning of the participants. In addition, the results must be considered along with the limitations of the study's duration and the small sample size employed. Finally, the majority of the participants were Caucasian females. These factors may limit the extent to which these findings can be generalized.

In summary, the results of the present study suggest that older adults can benefit both physiologically and psychologically from participation in strength training. Importantly, subjects in both high and low intensity of strength programs produced marked muscle strength gains. Along psychological dimensions, they improved in positive and negative mood as well as experienced an increase in self-efficacy. These results clearly suggest that psychological changes do not necessarily correlate to the intensity of the training program. Even a low intensity strength program can have a strong impact on an older individual's physical and mental health. Further empirical study is necessary to define the characteristics of more effective strength training protocols. But the benefits of regular exercise among the elderly must be promoted by emphasizing that they can improve their ability to manage the activities of daily living, increase their perceived efficacy for physical capability, and heighten their psychological well-being.

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