Does Participation in Light to Moderate Strength and Endurance Exercise Result in Measurable Physical Benefits for Older Adults?

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ABSTRACT

Purpose: This study investigated the impact of a light to moderate intensity combination strength and endurance exercise program on various physical parameters in older individuals. **Methods**: Forty-seven volunteers that were 50 years of age or older were assigned to either a control group (n=22) or to an exercise group (n=25). Data were collected from both groups in a pretest/post-test format as follows: (1) resting blood pressure and heart rate, (2) body weight, (3) body composition via bioelectric impedance, (4) flexibility via the sit-and-reach test, (5) cardiorespiratory endurance via a timed one-mile walk on an indoor track, (6) pulmonary function via spirometry testing (forced vital capacity and forced expiratory volume in 1 second), and (7) upper/lower extremity strength testing using Nautilus equipment (supine bench press and supine leg press). Between measurements, participants in the exercise group attended a supervised, light to moderate intensity strengthening/endurance program at the Medical University of South Carolina's Harper Student Wellness Center 3 times per week for 12 weeks. Each exercise session lasted approximately 90 minutes, and consisted of light resistive exercises, flexibility exercises (ie, stretching), and self-paced walking. **Results**: The findings showed no significant differences in the variables tested. **Conclusion**: The results of our study failed to show conclusive evidence that light to moderate exercise produces significant measurable benefits. The findings suggest that further work is needed to better clarify whether light to moderate exercise is of use in helping older individuals achieve significant health benefits.

Key Words: exercise, aging, activity

INTRODUCTION

Improvement in both physical function and general health for older patients has been a concern for health practitioners in geriatrics for many years.[1-4] As individuals age, a decline in physical activity and reduction in muscle mass generally occurs, which can lead to weakness,[5] loss of mobility,[6] and gradual susceptibility to falls and loss of functional abilities.[7] Such outcomes have potentially serious pathophysiological consequences, and may further lead to muscle atrophy, impaired balance, orthostatic hypotension, cardiorespiratory and gastrointestinal problems, along with development of pressure sores and urinary tract infections.[8] Individually or in combination, these outcomes can contribute to a serious decline in health, with loss of function and independence, and in some cases, even death.[9,10] Furthermore, such outcomes may result in admission to a long-term care facility, causing further decline in function.[11] Although a decline in physical function is common and inevitable as individuals age, there is evidence that regular participation in an exercise program can be very beneficial. In support of this claim, a report by the US Surgeon General suggested that a healthy lifestyle should include regular physical exercise, which may contribute significantly to the reduction of the functional decline that is associated with aging.[12]

Exercise for older individuals has also been recommended by such national health policy directives as Healthy People 2010 (in its section on physical activity and fitness)[13] and the US Surgeon General's Workshop on Health Promotion and Aging.[14] Each of these reports suggest that many disorders associated with aging, both physical and psychological, may be delayed and/or prevented. In some cases, even persons that are symptomatic may achieve benefits, so that loss of function, recurrence of symptoms, and the eventual onset of disability may be prevented.[15-17]

When prescribing fitness programs for older individuals, the use of multiple exercise approaches is often recommended in order to achieve significant overall health benefits.[18] Such a format may be referred to as a balanced fitness program, and generally emphasizes activities that increase strength, flexibility, and cardiorespiratory endurance.[1] While participation by older individuals in a fitness program of this nature is associated with better health, the optimal level of exercise intensity is unclear and has been debated in the literature for several years.

In 1990, Fiatarone et al suggested that high-resistance weight training led to significant gains in muscle strength, size, and functional mobility among frail residents of nursing homes up to 96 years of age.[19] In a more recent study, Lee and Paffenbarger compared mortality rates of a large number of older males (n=13,485, mean age 57.5 years) who had engaged in light, moderate, and vigorous activity over a 15-year time span and found that men who had regularly engaged in vigorous activity ($\leq$ 6 METs) experienced significantly lower mortality rates than those who had regularly engaged in light to moderate activity.[20] Cress et al compared the effects of endurance and strength training performed at relatively high intensity (75%-80% of maximum effort) among independent older adults, and found that the participants showed marked and significant increases in VO_{2max} and muscle strength.[21]

Alternatively, other researchers have advanced an argument in favor of light to moderate exercise for achieving satisfactory benefits in older individuals. The benefits proposed have been numerous, and have included: (1) improvements in mobility and orthopedic conditions;[22,23] (2) improved sleep;[24] (3) augmented

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immunity;[25] (4) enhancement of insulin sensitivity;[26] (5) increased peripheral blood flow;[27] and (6) reduction of age-related declines in balance, muscle, power, and gait.[22,28] Other researchers have concluded also that moderate activity will decrease cardiovascular disease risk factors, and suffice to produce overall health improvements in older individuals.[29] Presently, the debate is unresolved, and exercise programs for older individuals appear to have adopted numerous protocols and philosophies for achieving the levels of exercise intensity that they believe to be appropriate for their clientele.

In order to develop more insight into optimal levels of intensity required to achieve significant health benefits in older individuals, our study monitored individuals that were participating in an ongoing strengthening/endurance exercise program and compared them to a non-exercising control group. The program used a light to moderate intensity approach, was considered to be a balanced program (ie, emphasizing strength, flexibility, and cardiorespiratory fitness), and attempted to individualize activities in accord with each participant's physical abilities. Participants entered the program as volunteers, and were asked to attend sessions on a regular basis.

The purpose of our study, therefore, was to examine the effects of a light to moderate exercise program on strength, flexibility, and cardiorespiratory fitness in a group of older individuals. We anticipated that individuals ($\geq$ 50 years) who exercised would show better performance on several fitness variables than individuals who did not exercise.

METHODS

Participants

Screening and selection

The participants in the study were recruited via newspaper advertisement, and consisted of healthy individuals that were 50 years of age or older (the range was 50 years of age to 76 years of age). The participants were generally novice exercisers, although 4 individuals noted that they had been a part of a structured exercise program formally, but had not taken part in the program for several months. All were independently living and functioning in the community. Mean age for the participants was 63.6±8.1 years of age, and none were taking medications that might potentially alter cardiovascular response to exercise (ie, beta blockers).

Screening and selection of the participants was done at the Harper Student Wellness Center (HSWC) at the Medical University of South Carolina (MUSC) in Charleston. All of the participants volunteered for the study, and each was assigned to either the control group (CON) or to an exercise group (EXE) (the researchers were not blinded as to which group each participant was assigned). Initially, the investigators intended to randomly assign subjects to CON or EXE; however, strong preferences expressed by some of the participants for joining one group or the other made such assignments difficult, if not virtually impossible to totally achieve.

Each participant was informed that the length of the study would be 12 weeks, and each was asked to report to the HSWC for testing before and after the 12-week period. Individuals who joined EXE agreed to regularly attend a structured, supervised, and ongoing exercise program that lasted for 12 weeks. The researchers noted that other investigators had presented evidence that 12 weeks of regular light to moderate exercise would be sufficient time to allow the participants to demonstrate improved performance on the fitness variables that were evaluated in the present study. Participants began the study on different dates, and the investigators followed each individual over the ensuing 12 weeks so as to note when his/her involvement in the study had expired. Overall, 47 individuals began the study, with CON having n=22 and EXE having n=25. In both the CON and EXE groups, gender was mixed (Table 1).

Before the pretest, all participants (both CON and EXE) were screened for inclusion in the study via a questionnaire created by the investigators. The questionnaire asked for demographic background and health history and was designed specifically for the present study. Since the questionnaire had not been used in any previous studies, no data description of reliability or validity could be determined. The questionnaire asked about participants' history of cardiopulmonary disease, bone and joint disease, cancer, and diabetes mellitus. Participants were also asked to list current prescription medications, including drugs in the beta-blocker class. During the screening and prior to joining the study, each participant read and signed a consent form that had previously been approved by the MUSC Office of Research Integrity and Risk Protection. The consent form explained the nature and methods of the study, and listed possible risks and/or adverse effects that might occur.

In addition to being 50 years of age and/or older, participants in EXE had to meet certain requirements to be included in the study, as follows: (1) have no illness or medical diagnosis that would prevent their participation in light to moderate exercise on a regular, ongoing basis, including ambulation; (2) receive and present written permission from his/her physician; and (3) agree to participate in the exercise program 3 times per week for 90 minutes per session for 12 weeks. Exclusionary criteria that were applied to both CON and EXE included diseases such as diabetes mellitus, osteoporosis, emphysema or other significant respiratory disease, arthritis, and heart disease (cardiomyopathy, angina pectoris, or previous myocardial infarction). Volunteers were also informed that they would be asked to perform a timed, 1-mile walk on an indoor, level surface. Each person was told that he/she could stop and rest if needed during the 1-mile walk, but that the timer would continue to run. Of the volunteers screened for the study, all completed the 1-mile walk, although some took rest stops before completion.

Participants were advised before coming to the testing sessions that they would be exercising, and were instructed to wear light clothing or a sweat suit and sneakers. Participants' anonymity was kept secure during data analysis by assigning each individual an identification number that was recorded on his/her data collection sheet. Data sheets were then kept separate from informed consent statements and demographic information/health history forms.

Attrition

Attrition occurred in both CON and EXE. Preliminary attrition occurred in CON, as 3 participants that initially agreed to be in this group declined to begin the study, citing personal reasons. Of the 22 individuals that received pretest measures for inclusion in CON, 8 declined to participate in 12-week post-test measurements for various personal reasons that generally involved their availability. Attrition also was noted in the EXE, with 3 participants declining to complete the 12-week testing period. As in CON, individuals gave various personal and family reasons for their withdrawal from the

Table 1. Comparison of Measurements (mean; standard deviation [median]) Obtained 12-Weeks Post from Subjects in an Experimental or Control Group (p values are for ANCOVAs in which total fat percentage and age were covariates).

12 Week measures	Experimental Group N=20	Control Group N=14	p value
Systolic blood pressure (mm Hg)	126; 14.4 (124)	131; 18.9 (130)	0.44
Diastolic blood pressure (mm Hg)	75; 9.0 (75)	77; 10.2 (75)	0.22
Resting heart rate (BPM)	71; 9.8 (70)	2.58; 1.2 (2.28)	0.15
FEV_1(liters)	2.03; 1.0 (1.94)	1.81; 0.9 (1.58)	0.19
Upper extremity strength (pounds)	52.9; 18.8 (48.5)	69.3; 39.3 (50.2)	0.61
Lower extremity strength (pounds)	181; 70.8 (161)	217; 130.3 (179)	0.33
Weight (pounds)	165; 42.2 (152)	196; 58.1 (188)	0.24
Total fat (pounds)	52.5; 20.0 (46.8)	69.5; 34.0 (57.2)	0.27
One mile walk (minutes)	16.2; 3.1 (15.3)	17.0; 4.0 (15.8)	0.19
Flexibility (inches)	14.5; 4.2 (14.5)	14.8; 3.6 (14.5)	0.41

study. To the best of the investigators' knowledge, none of the participants who dropped out of either CON or EXE did so as a result of a serious loss in health or physical function, nor were there known significant differences between those that remained and those that dropped out. Also, all were of apparent normal functional and physiological status at the point of their entrance into the study.

No adverse events occurred or were cited during the course of the study in association with attrition from either group. The number of participants in each group was thus reduced at the conclusion of the study, with CON having n=14 and EXE having n=22. In all cases, withdrawal from the study by participants was voluntary, and none was asked to withdraw by the investigators. While there can be no assurance as to the comparability of participants that completed the study to participants who dropped out, the investigators observed no unusual characteristics that were particularly noteworthy in this regard among the attrition group.

Procedures

Exercise sessions

All testing occurred at the HSWC, and was carried out by an exercise physiologist with 10 years experience in designing and implementing exercise programs for older adults. Individuals in CON were instructed, both verbally and via the consent form, to perform no exercises (other than normal, routine activities of daily living) for 12 weeks. As mentioned previously, individuals in EXE agreed to regularly attend a structured, supervised, and ongoing exercise program, which lasted for 12 weeks. The researchers estimated that the program required intensity levels on the part of participants within the range of $\leq$4 to <6 METs, thus placing the activities in the light to moderate range of exertion.[20]

Each exercise session lasted 90 minutes, and took place on Mondays, Wednesdays, and Fridays. On each of these days, participants were given their choice of exercising either in a 9:00 A.M. to 10:30 A.M. session, or in a 10:30 A.M. to 12:00 P.M. session. No other sessions were offered to the participants, and all were asked to refrain from exercising on their own or within other programs.

Each exercise session started with a warm-up routine of stretching and flexibility exercises, followed by approximately 30 minutes of ambulation on an oval indoor track 1/6 mile in length. After ambulation activities, the participants then performed approximately 30 minutes of resistance/strength training, using free weights and/or Nautilus machines. In each case, appropriate resistance levels for participants to use during exercise sessions were individualized according to baseline strength evaluations. In general, resistance levels were kept between 0.25-repetition maximum (RM) and 0.50-RM, with participants being asked to perform a minimum of 8-12 repetitions, or until they felt a subjective sense of fatigue in the exercising muscle group. Participants were neither encouraged nor pushed to perform repetitions to the point of muscle failure.

The resistance/strength training activities were performed in a circuit training fashion, in which participants moved between exercises in sequential fashion. Each exercise session then ended with cool-down exercises, which consisted of more stretching, along with verbal cues for relaxation given by the supervising exercise physiologist and/or his assistants.

All participants in both the CON and the EXE groups were given pretest measures for estimating blood pressure and heart rate, strength, body weight and body composition, pulmonary functions, flexibility, and cardiorespiratory endurance. After 12 weeks, the measures were repeated as a post-test on all participants in both groups.

Pretest/post-test measures

Resting systolic blood pressure (SBP), resting diastolic blood pressure (DBP), and resting heart rate (RHR). These measurements were taken via auscultation with a stethoscope. Resting heart rate was auscultated over the mitral valve at the left anterior mid-chest area. The SBP and DBP (mm HG) were taken using a sphygmomanometer and auscultation with a stethoscope over the brachial artery at the cubital fossa. Body weight (pounds) was measured by having the patient stand (clothed in a sweat suit and sneakers) on a calibrated weight scale.

The remaining pretest/post-test measures employed specific techniques as noted below to determine the effects of the exercise program. Each measure has been demonstrated in previous research to have reliability and validity for quantifying the variables noted.

Body composition in total percent body fat and total fat pounds. Total percent body fat and total fat pounds were estimated by using bioelectrical impedance analysis, a reliable and valid measure for determining these parameters.[30] For this technique, voltage electrodes were attached to each participant at the right wrist and right ankle with the participant in a relaxed supine position on a padded wooden table, and with upper extremities and lower extremities in a slightly abducted position. Pregelled ECG tab type monitoring electrodes, cut in half longitudinally, were used for the voltage electrodes. Because of the high frequency used (50 kilohertz), skin preparation was not required because skin interface impedance was very low. Bioelectrical impedance was measured with a Naparima, Inc. battery operated instrument capable of delivering a sinusoidal constant current of 500 microamperes (baseline to peak) at a frequency of 50 kilohertz. These are standard range parameters that have been used in practice for more than a decade, are well below the sensory level, and are considered to be completely innocuous.[30]

Following measurement of bioelectric impedance, each participant's date of birth, gender, weight, height, and the bioelectrical impedance resistance in ohms were entered into a BioZ computer program by Naparima, Inc. Using the calculations discussed by Lukaski et al, the software used participants' height, weight, and impedance measurement to find fat-free mass (FFM).[31] The calculations employed the formula Ht^2/Z as a predictor of total body water (TBW) and FFM, where Ht was the subject's height, and Z was the bioelectrical impedance. Subsequently, once FFM is known, the value can be subtracted from total body weight to give fat mass and percent body fat. These authors suggested that the technique was a reliable and valid approach for the estimation of human body fat composition.

Pulmonary Functions: Forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV$_1$). Each participant's FVC and FEV_1 was determined using a Vitalograph spirometer with a disposable mouthpiece. Spirometery is a time-honored method for determining pulmonary functions, noted for its validity and reliability.[32] The electronic readout was zeroed prior to each test, and calibrated using a 3-liter syringe. To perform these tests, the participants were instructed to stand facing the spirometer, holding the mouthpiece and expired air tubing leading to the spirometer in one hand. Each participant was then asked to inhale as deeply as possible, pinch both nostrils closed with his/her free hand, and forcefully exhale into the mouthpiece until he/she could no longer exhale. Participants were allowed to bend forward at the waist during the exhalation phase, if they desired. When finished exhaling, the participants were instructed to remove the mouthpiece from their mouths and inhale freely. FVC and FEV_1 were recorded from the digital readouts and reset prior to the next trial. Each participant completed 3 trials, and the highest values for FVC and FEV_1 from the 3 tests were used for comparison.

Upper and lower extremity strength. Using Nautilus equipment, upper and lower extremity strength was assessed by estimating 1-RM (ie, the maximum amount of weight in pounds that can be lifted through a complete joint range of motion one time), a method cited as being both reliable and valid.[33] To estimate upper extremity 1-RM, participants performed a supine bench press; to estimate lower extremity strength 1-RM, participants performed a supine leg press. Estimated 1-RM was then calculated via methodology proposed by Allaire, in which the maximum number of repetitions performed with a given amount of weight is divided by a predetermined constant.[34]

Flexibility. A sit-and-reach test was done to examine flexibility. Measurements were obtained by using a sit-and-reach box, a generally reliable and valid technique for evaluating flexibility in older, healthy adults as described by the American College of Sports Medicine.[33] Health and Education Services, a division of Novel Products, manufactured the sit-and-reach box used in the present study. The participants removed their shoes, sat on a mat on the floor, and were instructed to move backward until their hips and shoulders were against the wall behind them. The sit-and-reach box was then placed flatly against their feet at a point that corresponded to a visible '15-inch mark' on the sit-and-reach box's measurement scale. Next, the participants were instructed to extend their lower extremities until their knees were straight, and were told to place one hand on top of the other, inhale, and exhale as they slowly reached forward with both hands. During this maneuver, they were told to keep their knees straight and reach as far forward as they could, pushing the slide on the sit-and-reach box with their fingertips as they bent forward. When their maximum forward trunk flexion was reached, the participants returned to the starting position. The slide's position on the measurement scale was then recorded and reset to the starting position. Three trials were performed and recorded, and the best trial was used for scoring. The investigators did not observe any participants to have significant kyphosis or other defects that might result in an exaggerated or biased outcome.

Walking endurance. Cardiorespiratory endurance was estimated by having each participant complete a timed 1-mile walk, a procedure that has been noted to be both valid and reliable.[35] To perform the test, participants were instructed to walk as rapidly as they felt they could continuously around an oval indoor, level track. Six complete trips around the track constituted a distance of 1.0 mile. In each case, the time required to complete the mile walk was recorded with a stopwatch. Rest stops were allowed as needed, but the time taken at each rest stop was added to the total time taken to complete the exercise.

Statistical Analysis

All data were analyzed using the Minitab (Minitab, Inc., State College, Pa) and MS Excel software programs. Statistical methods appropriate for a pretest/post-test experimental-control group design were used. Students t-tests were used to compare pretest values. Analysis of covariance (ANCOVA) procedures were employed to look for differences in 12-week values between EXE and CON (while controlling for variables that differed pretest). The Anderson-Darling procedure was used to assess normality. Type I error was set at 5% and all tests were 2-sided.

RESULTS

Descriptive statistics for the 10 dependent variables are presented by groups in Table 1. Significant differences (CON vs. EXE) in baseline measures were found for 3 variables: total fat percent ($t=-2.18$, $p=0.03$), total fat pounds ($t=-2.51$, $p=0.02$), and age ($t=2.28$, $p=0.03$). CON had greater total percent body fat and total fat pounds, but were younger by 5 years compared with the EXE. Since total fat percent and total fat pounds were highly correlated, only one, total fat percent, was used in the analysis of covariance (ANCOVA). Thus, the variables used as covariates in the analysis of data at 12 weeks were total fat percent and age.

Results of the ANCOVA are also reported in Table 1. There were no significant differences ($p = .15$ to $.61$) in any of the 12-week measurements between CON and EXE.

DISCUSSION

The findings in this study failed to demonstrate significant differences among the variables measured. Possibly, given a longer exercise period between pre- and post-test measurements and/or greater exercise intensity, these variables may have shown significant differences. Employment of a larger sample than that studied in this investigation may have also yielded definitive results.

Although overall improvements were not generally detected by our measures during the 12-week exercise program encompassed by this study, psychological improvements may have taken place among the participants. For example, King et al[36] reported that regularly exercising adults demonstrate outcomes that are more associated with psychological improvements than with physical fitness improvements. These authors also wrote that perceptions of such improvements likely develop early in the course of an exercise program (4 weeks). Other researchers have also promoted the view that many of the positive results from exercise may be due to psychological gains rather than gains ascribed to physical fitness. The belief that exercise may improve longevity, health, and quality of life suggest a sense of personal accomplishment and well being, so that the perception of fitness becomes important in terms of overall satisfaction and health benefits.[37,38]

Missed sessions were a concern as we planned the implementation of the study. At each exercise session, roll was taken, and in general, the participants were compliant and regular in their attendance, with participants in EXE collectively having a compliance level of approximately 66.0% attendance at the exercise sessions over the 12-week period. The impact of missed sessions on outcomes for studies of this nature is somewhat speculative and merits further investigation. In a previous study, Thomas et al[39] found no significant correlation between missed sessions and elderly participants' perceptions of improvement during a 6-week course of exercise.

There are a number of limitations to the study that should be recognized. First, all participants were volunteers, and the researchers were not blind as to which participants were in each of the 2 groups. Furthermore, the group sample sizes were relatively small and unequal, with CON having n=22 and EXE having n=25. The sample compositions were also limited by gender composition, with the comparison groups having fewer males than females. Limitations in sample size may have limited statistical power for showing significant changes. Furthermore, gender composition may have introduced variable and unaccounted for bias.

Second, as noted previously, attrition occurred in both groups. There can be no assurance that attrition occurred on a random basis, thus adding further potential limitations to the study.

Third, was the decision to use 12 weeks as the exercise time period. Rimmer and Hedman, however, noted improvements in both physical and psychological measures in older stroke survivors after participating in a health and wellness program that included exercise 3 times per week for 12 weeks.[40] Other investigators have also observed significant changes in physical measures among individuals that have participated in exercise programs for similar time periods. For example, Agre et al reported increases in quadriceps strength in adults with post-poliomyelitis following a 12-week home exercise program.[41] Also Jette and colleagues described improvement in lower limb strength at 12 weeks among a sample of older adults (age >60 years) after participation in a physical therapist initiated home exercise program.[42] Finally, Midha et al determined that wheelchair bound individuals gained improved perceptions of well being as well as lowered resting heart rate, decreased upper limb fat, and decreased serum cholesterol after 10 weeks of participating in an aerobic program that was supervised by a wheelchair aerobic fitness trainer.[43] In the same study, significant improvements were also noted in peak oxygen consumption, midarm circumference, and free thyroxine index.

CONCLUSION

Loss of mobility and functional decline occur with aging, but may be at least partially offset by exercise. Whether older individuals show significant physical benefits from light to moderate intensity exercise has been an issue of debate in the literature. The results of the present study, while exploratory, suggest that such exercise programs may not be sufficient to produce widespread measurable physical benefits, at least in well-elderly individuals. Given some of the limitations as noted above, the investigators feel that the study could be improved.

While our study yielded results that were not strongly supportive of light to moderate exercise programs for healthy, older adults to achieve measurable benefits, interest in the exercise program among the participants was high throughout the 12-week time period. Also, participant attendance was generally regular and compliant, and verbal feedback from each participant regarding his/her impressions of benefits gained from engaging in the program was favorable. Furthermore, during the study, we collected questionnaire data to evaluate the participants' perceptions of benefits gained from taking part in the exercise program, and we plan to publish the results in a follow-up report. We anticipate that perceptions have a marked influence on behavior, as manifested by the degree of willingness to regularly exercise.

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