The Effects of Aerobic Training and Nutrition Education on Functional Performance in Low Socioeconomic Older Adults

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ABSTRACT

Purpose: To describe the population in terms of risk for disability and compare the effects of a walking intervention and nutrition education intervention on risk modification and functional performance in lower socioeconomic older adults using a randomized controlled study. **Methods:** Twenty-six community-dwelling older adults aged 60 and older were randomly assigned to a 16-week walking exercise group or a nutrition education control group. Peak aerobic capacity and physical function were measured at baseline and post intervention. Physical function was measured using the Medical Outcomes Study Short Form Health Survey Physical Function subscale, Short Physical Performance Battery, Physical Performance Test, and Continuous Scale Physical Functional Performance 10 item test (CS-PFP10). **Results:** Eighty-five percent of the participants were at risk for preclinical disability of which 50% were at risk for moderate disability. The walking exercise group significantly improved in peak aerobic capacity (18.9%), physical function (25%) using the CS-PFP10 compared to the control group. **Conclusion:** These findings highlight the importance of physical activity and indicate that walking, a simple exercise that can be done without specialized exercise leader or equipment can significantly increase peak aerobic capacity and physical function in just 4 months.

Key Words: physical function, preclinical disability, low socioeconomic older adults, aerobic capacity

INTRODUCTION

With the older adult population steadily increasing in number, researchers are focusing on quality as well as quantity of life.[1] Quality of life of an older adult is influenced by not only specific disease processes but also the level of functioning.[2] This level of functioning can mean the difference between independent and dependent living. Accurate assessment of physical function can be used to evaluate change in functional capacity, health status, and risk prediction to prevent future adverse events. Valid and reliable measures of physical function are important for accurate assessment of functional risk and strategizing interventions to maintain independence.

Self-report and performance-based physical function assessments provide valuable information about functional limitations and predict health-related outcomes in older adults.[2,3] Self-report combined with performance-based measures of physical function have been shown to predict preclinical disability.[4] Since 1990, several performance-based measures have been developed to quantify functional performance, a shift in focus from functional limitation as measured in self-report questionnaires to observed ability.[4-6] Performance-based measures range from a single item such as the 6-minute walk to multi-item tests such as the Physical Performance Test, and from measures with a single focus such as the Short Physical Performance Battery which evaluates mobility, to multidimensional concepts such as the Continuous Scale Physical Functional Performance 10 item test (CS-PFP10), a global measure of physical function with subscales for strength, flexibility, balance & coordination, and endurance. Objective performance assessment is relatively independent of educational, cognitive, and cultural bias.[2] These performance-based and self-report measures have established benchmarks for preclinical disability and risk of disability. Preclinical disability is defined as functional loss before the recognition of difficulty performing tasks.[7]

Older adults with low income, low education, and low physical reserves are at disproportional higher risk for chronic disease burden, functional limitations, and disability[8] due to poor health and lifestyles that occur more frequently among individuals of low socioeconomic status.[9] Physical inactivity is more prevalent among women, minorities, older adults, and the less affluent.[10]

Regular physical activity, a proven public health strategy to reduce disease, disability, and improve quality of life for older persons, is a nonpharmacological intervention for management of chronic disease.[11] These benefits are particularly important for low socioeconomic older adults who are more apt to lack health care coverage and financial resources for assistance with disability.[12]

The key to late life independence may lie in midlife strategies that preserve physiologic capacity and maintain physical reserve. Physical reserve, physiological capacity in excess of that required for the performance of activities of daily living, can be increased through endurance training. Walking, a popular and effective method of increasing peak aerobic capacity is easily implemented in populations with limited resources for an exercise leader or facilities. This study was designed to characterize the population in terms of risk for disability and compare the effects of a walking intervention and nutrition education on risk modification and functional performance in lower socioeconomic older adults. It was hypothesized that the walking exercise group would demonstrate significant improvements compared to the control group in risk modification and functional performance after the intervention.

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METHODS

Subjects

Forty men and women aged 60 and older were recruited from the Athens, Georgia community. Twenty-six volunteers (22 women and 4 men) received medical clearance from their physician and signed a written informed consent approved by University of Georgia's Institutional Review Board. Subjects were excluded from the study if they met the following criteria: poorly controlled or unstable cardiovascular disease, unstable angina pectoris as characterized by an abrupt increase in the frequency of angina pectoris or angina pectoris at rest or angina pectoris symptoms of greater than 2 on a scale of 1 to 4, heart failure, uncontrolled arrhythmias, severe and symptomatic aortic stenosis, uncontrolled casual blood glucose >200 mg/dl (casual is defined as blood glucose taken at any time of day without regard to the time of the last meal), severe psychiatric illness that limits cooperation in general and the ability to follow directions or keep appointments, uncontrolled hypertension or a blood pressure of >140/90 at rest, leg or arm amputation, excessive alcohol intake defined as greater than 3 drinks/day, terminal illness (life expectancy less than 1 year), and other conditions that are aggravated by exercise as identified by their physician.

Experimental Design

The study uses a pretest/post-test repeated measures design. The participants were randomized into a control or a walking exercise group. Baselines measures were evaluated before and after the 16-week intervention. Health status questionnaires were completed prior to performance tests so participants did not gain insights from their performance. Peak oxygen consumption testing and physical function tests took place on different days within a week time period. The participants were characterized for risk of disability using physical function measures. The control group was given the opportunity to join the walking program after completion of exit testing.

Self-Reported Physical Function

Medical Outcome Survey

The Medical Outcomes Study Short Form Health Survey (SF36) is a reliable and valid self-report questionnaire that assesses 8 health domains: physical functioning, role-physical, bodily pain, general health, vitality, social functioning, role-emotional, and mental health.[13,14] The SF36 physical function (SF36PF) subscale uses a 3-level response: (limited a lot, limited a little, or not limited at all) to assess 10 physical limitations.[3] Adjusted scores range from 0 to 100, with 0 reflecting poorer self-rated health status. An adjusted score of <65 indicates low probability of independence.[4] The SF36PF was administered prior to the performance-based physical function measures so participants did not gain insights from their performance.

Functional Performance Measurements

Short Physical Performance Battery (SPPB)

The Short Physical Performance Battery of lower extremity function is a valid measure that predicts mortality and institutionalization in community-dwelling older adults with a broad range of abilities.[15] The SPPB consists of: (1) 3 standing balance measures (tandem, semi-tandem, and side-by-side stands), (2) 5 continuous chair stands, and (3) an 8-foot walk. The 3 balance tests are considered a hierarchy of difficulty when assigning a single score of 0 to 4 for standing balance.[15] Individuals who cannot complete the tasks are given the score of 0. Individuals who complete the tasks are assigned scores of 1 to 4 based on their time and best ability, with the fastest time being scored as a 4. The scores for the 8 foot walk, chair stands, and balance measures are summarized to get a total score ranging from 0 to 12.[15] Epidemiological studies indicate that older adults with total scores of 4 to 6 have a high risk, scores of 7 to 9 have a moderate risk, and scores of 10 to 12 have a low risk of nursing home admission, incident disability, and mortality.[5,16]

Physical Performance Test (PPT)

The Physical Performance Test is a reliable and valid measure that assesses multiple aspects of physical function using observed performance of tasks that simulate activities of daily living of various degrees of difficulty.[17] The 7-item test consists of (1) writing a sentence, (2) simulated eating, (3) lifting a book, (4) putting on and removing a jacket, (5) picking up a penny from the floor, (6) turning 360°, and (7) walking 50 feet. The 9-item test includes the 7-item tasks with the addition of (8) climbing 1 flight of stairs and (9) the number of flights of stairs climbed. Each item is scored based on a 5-point scale (0-4) in which 0 is unable to complete and 4 is most capable or fastest. The best possible score on the 7-item test is 28 and 36 on the 9-item test.[17] A PPT score of 15 to 18 has been reported to be predictive of death or nursing home placement in older adults.[6]

Continuous Scale Physical Functional Performance 10 item test (CS-PFP10)

The Continuous Scale Physical Functional Performance 10 item test, a shortened version of the Continuous Scale Physical Functional Performance (CS-PFP) test,[18] is a reliable and valid measure of physical function that preserves the important information provided by the CS-PFP.[19] The CS-PFP10 is comprised of 10 household tasks performed sequentially where time, distance and weight are used to evaluate functional ability. The CS-PFP10 is a reflection of the person's functional capacity, as each task is performed at maximal effort within the person's judgment of comfort and safety. Tasks that are quantified using both weight and time include: (1) carrying a pot of weight from 1 counter to another; and (2) carrying groceries onto and off a 4-step platform. Tasks that are quantified by time alone include: (1) transferring laundry, (2) donning and removing a jacket, (3) sweeping kitty litter into a dustpan, (4) climbing stairs; (5) sitting down and getting up from the floor; and (6) picking up 4 scarves from the floor. Tasks that are quantified by distance include: (1) a 6-minute walk and (2) a maximal reach using an adjustable shelf. A detailed description of the tasks and test set-up is available at www.coe.uga.edu/cs-pfp. The test is administered in a standardized environment with a set dialogue. The raw scores for each task are adjusted to a scale of 0 to 100, where 0 is the poorest performance. The average of all scores is used to determine the CS-PFP10 total score and the average task scores for each domain determine each total domain score. Physical domain scores include upper body strength (UBS), upper body flexibility (UBF), lower body strength (LBS), balance and coordination (BALC), and endurance (END). A score of <57 (55-58) indicates decreased probability of living independently or preclinical disability.[4]

Peak Aerobic Capacity

Peak aerobic capacity (VO_{2peak}) was assessed using a modified Balke treadmill protocol.[20] During a 2 minute warm-up, the fastest, most comfortable walking speed was determined and then maintained throughout the test while elevation was increased 2% every 2 minutes until participants reached volitional exhaustion or until the physician terminated the test in accordance with American College of Sports Medicine Exercise Testing Guidelines.[21] A 12-lead electrocardiogram (Q-Stress® Exercise Test Monitor, Quinton. Inc., Bothell, WA) was continuously monitored by a physician. Heart rate and blood pressure were recorded each minute. Oxygen consumption measurements were collected at 30 second intervals using the Parvo Medics TrueOne 2400 Metabolic Measurement System (Parvo Medics, Inc., Salt Lake City, UT). Using the Borg scale (6-20 scale), rating of perceived exertion was recorded at the end of each stage.[22] Peak aerobic capacity was defined as the highest value of oxygen consumption attained during the treadmill test. Criteria for meeting maximal effort have been established as meeting least 2 of the following 3 criteria: (1) maximum achieved heart rate within 10 beats/min of age-predicted maximum heart rate,[23,24] (2) respiratory exchange ratio of greater than 1.0,[2] or (3) rating of perceived exertion of at least 18 on the Borg 6-20 Rating of Perceived Exertion Scale.[23] Participants' data were not excluded if maximal effort criteria were not met.

Lower Limb Extension Strength

Lower limb extension strength was assessed from a 1-repetition maximum (1RM) using the leg press machine (Alliance Rehabilitation System, Chattanooga Group, Inc., Hixson, TN), where 1RM is the maximal amount of weight that can be lifted once through the full range of motion while holding to good form.[25] After 4 to 5 warm-up repetitions, resistance was added until a maximal weight could be lifted. Participants were given 30 second rest periods between each lift.

Exercise Intervention

The supervised walking classes met 3 times a week for 16 weeks. The program consisted of a 10-minute warm-up, 10 to 40 minutes of walking, followed by a 10-minute cool-down. Initially, participants were encouraged to walk for 10-minutes continuously. The duration of continuous walking was increased to 40-minutes by week 8. An exercise intensity of 60% to 75% of heart rate maximum (HRmax) was monitored using heart rate monitors (Polar A series) and also by Borg's 6 to 20 self-rated perceived exertion (RPE) scale.[22] The participants were taught to identify a RPE of 12 to 14, which is considered as moderate intensity.[26] While the walking program focused on endurance, balance and flexibility exercises were also included in the warm-up and cool-down segments of the class. Participants were encouraged to attend all exercise classes (48 sessions) with make-up classes arranged as needed for those who missed classes. All participants were required to attend 2 consecutive weeks of classes before exit testing. The classes were held at Denney Tower which is a predominantly older adult public housing apartment complex in Athens, GA, along a cityscape walking path.

Nutrition Intervention Control

The control group was given information about the benefits of nutrition with a focus on fruits and vegetables using the lessons from Nutrition for Older Adults' Health developed by the Department of Foods and Nutrition, The University of Georgia (http://noahnet.myweb.uga.edu/plansfv.html) during presentations every 2 weeks. Participants were given the opportunity to join the walking program after the 16-week intervention.

Data Analysis

Data were analyzed using the SPSS (version 14.0, SPSS Inc., Chicago, Ill) statistical software package. Descriptive statistics were calculated to obtain the means and standard deviations of each group. Analysis of covariance was used to compare groups on physiological capacity and functional measures following the intervention while controlling for preintervention performance. If a measure showed significant change, Pearson product moment correlations were used to quantify the relationships between the change in physiological capacity (VO_{2peak} & 1RM) and the change in physical function (SF36PF, SPPB, PPT, & CS-PFP10) measures. Effect size was calculated to assess the size of the observed effects the exercise training had on the physiological capacity and functional measures. Linear regression was used to determine the contribution of change in physiological capacity (VO_{2peak} and 1RM) to change in function (CS-PFP 10). Statistical significance was set at $P < .05$. Results were reported as means ± standard deviations, unless otherwise noted.

RESULTS

Selected characteristics are listed in Table 1. Twenty-six of forty volunteers were enrolled in the study. Sixteen volunteers were either unable to obtain physician clearance (n=7), or denied by their physician (n=4), or decided not to participate in the study (n=3). Two volunteers, one from the control and one from the walking exercise group were not entered into the intervention programs due to the inability to complete the peak aerobic capacity test. Twenty-four older adults completed the study. The participants were predominantly low socioeconomic older adults. Thirty-eight percent of the participants' annual income fell below poverty level ($9,570 annually).[27] Using the CS-PFP10, 85% of the participants (n=22) were at risk for preclinical disability of which 50% were at risk for moderate disability using the SPPB. There were no floor effects, meaning there were no individuals unable to perform at least 1 of the tasks on any of the physical function measures. However, ceiling effects, individuals clustered at the top of the range, were found on the SPPB (8.3%), PPT 7-item (8.3%), and the SF36PF (12.5%). No ceiling effects were found on the CS-PFP10 and PPT 9-item. At baseline, no significant differences were found between the groups in physical characteristics, physical function, peak aerobic capacity, leg strength, and self-reported health status. Eighty-eight percent (n = 21) of the participants met at least 2 of the 3 criteria for peak aerobic capacity at baseline and postintervention testing. Participant's compliance with attending the exercise class was 88.5%. At post-testing all domains of the CS-PFP10 in the walking exercise group were significantly different from the control (Table 2). The CS-PFP10 total score increased significantly by 25% (effect size = 0.75) compared to the 8.3% decline in the control group (Figure 1). Peak aerobic capacity increased significantly by 18.9% (effect size = 0.46) in the walking exercise group compared to the control group which experienced a 9.2% reduction in peak aerobic capacity (Figure 2). The correlation between the change in peak aerobic capacity and the change in physical function was r = 0.85. Both

Table 1. Selected Baseline Characteristics

Characteristics	Total (n=26)	Walking Exercise (n=12)	Control (n=12)
Age (years, mean ± Standard Deviation (SD))	71.5±8.1	68.6±7.6	72.3±6.8
Gender (percent (%) females)	84.6%	83.3%	83.3%
Race (% African American)	34.6%	41.7%	16.7%
Education (% ≤12 years)	61.5%	33.3%	33.3%
Annual Income (% ≤ $20,000)	80.8%	75.0%	83.3%
Weight (kilogram, mean ± SD)	76.7±15.1	79.5±17.0	72.5±15.6
Height (centimeters, mean ± SD)	164.6±10.6	167.4±10.9	164.2±8.9

groups demonstrated nonsignificant improvements (7% control group and 6.6% walking exercise group) in 1RM. The change in peak aerobic capacity accounted for 87% (Beta = .873) of the variance in the change in CS-PFP10 total. The walking exercise group showed a trend toward improvement in 7 of health concepts of the SF36 while the SFPF demonstrated significant improvement after the intervention (Table 3).

DISCUSSION

Most exercise intervention studies have used samples that are predominately affluent, well educated, and Caucasian. This research is important because it is one of the few randomized controlled trials to focus on improving function in lower socioeconomic older adults.

In the baseline sample (n=26) using the > 57 benchmark on the CS-PFP10, 85% of the participants did not have a physical reserve and were at risk of preclinical disability. In the walking exercise group at baseline, 66% (n = 8) were below the benchmark of 57 on the CS-PFP10 for loss of independence and following the intervention, only 25% of the walking exercise group was below the benchmark for loss of independence (CS-PFP10 <57). At baseline, approximately 50% (n =13) of the participants were at moderate risk for disability using the 7 to 9 benchmark on the SPPB. In the walking exercise group the prevalence of moderate risk of disability was 42% (n = 5) before the intervention and 25% (n = 3) following the 16-week walking program. Twenty-seven percent of the participants were determined to be at risk for dependency using the benchmark of < 65 on the SF36PF. All study participants were found to be above the benchmark established for risk of nursing home placement and death using the PPT 7 item (<15).

The results of this study indicate that peak aerobic capacity improved by 18.9% (effect size = 0.46) in this population after the 16-week walking program (Figure 2). These findings are similar to previous studies on older adults where the aerobic capacity increased by 11% to 30%.[28-31] Most (n =21) participants achieved their peak aerobic capacity based on meeting 2 out of 3 of the following criteria: (1) maximum achieved heart rate within 10 beats/min of age-predicted maximum heart rate,[23,24] (2) respiratory exchange ratio of greater than 1.0,[2] or (3) rating of perceived exertion of at least 18 on the Borg 6-20 Rating of Perceived Exertion Scale.[23] All subjects met at least 1 criterion. Physical function improved in these study participants by 25% (effect size = 0.75) using CS-PFP10 total score (Figure 1). These improvements in function are similar to those found in other studies that used exercise training as an intervention (14-24%).[32-34] This study adds to the literature by showing a causal relationship between change in peak aerobic capacity and change in physical function (r = 0.85). For each unit improvement in peak aerobic capacity the average improvement in CS-PFP10 was 4 units. Previous work from this laboratory has determined 20 ml·kg·min^{-1} (C.I.: 17.33-22.92 ml·kg·min^{-1}) as the threshold between physical function and aerobic capacity above which increases in aerobic capacity are a physical reserve.[4] The improvement in peak aerobic capacity provided the walking exercise group with a physical reserve of 3.6 ml·kg·min^{-1}. A physical reserve can make the difference between independent daily living and reliance on some form of assistance.[35] The reduction in peak aerobic capacity (9.2%) left the control group without the benefit of a physical reserve.

The findings indicate that the CS-PFP10 was able to detect a greater change in physical function than the SPPB or the PPT 9-item after the intervention. A possible explanation for the inability to detect change maybe the need for a larger sample size due to ordinal scaling of the SPPB and PPT 9-item measures. While the walking program mainly focused on endurance and lower body strength, compared to the control group the walking

Table 2. Baseline and Post Intervention Continuous Scale Physical Functional Performance 10 Item Test (CS-PFP 10) Scores (n=24)

	Walking Exercise		Control		
CS-PFP 10 Scores	Baseline	Post Intervention	Baseline	Post Intervention	P value
CS-PFP10 total score	51.5±9.8	64.3±11.9*	44.7±9.3	41.0±8.1	.001
Upper Body Strength	52.1±17.2	63.9±13.8*	42.1±11.7	38.7±11.9	.001
Upper Body Flexibility	72.2±9.7	82.3±9.1*	66.7±16.6	61.4±14.2	.001
Lower Body Strength	42.3±11.9	55.5±14.1*	34.8±8.2	31.9±8.2	.001
Balance & Coordination	51.9±9.8	64.8±12.4*	46.6±9.7	42.4±8.4	.001
Endurance	53.0±9.9	66.7±12.5*	46.5±10.0	42.8±8.0	.001

Values are mean ± standard deviation.
*Significantly different (P<.05) from control at post intervention time point.

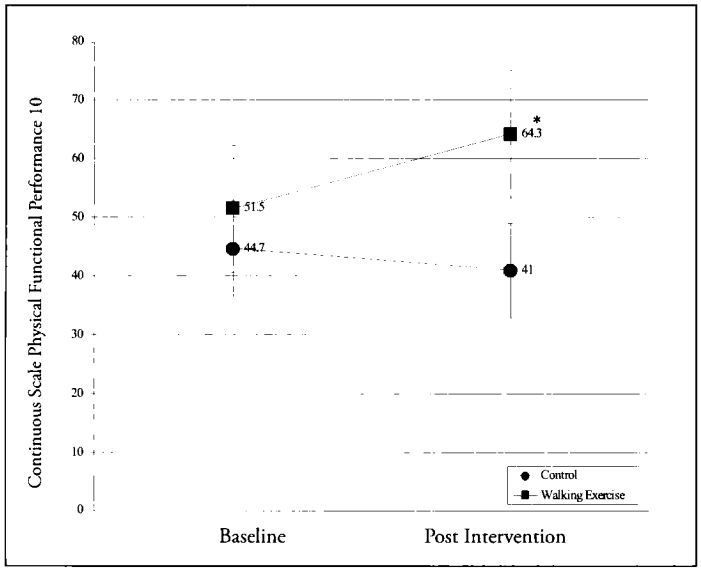

Figure 1. Continuous scale physical functional performance 10 item test total baseline and post intervention scores expressed as means ± standard deviation. *Significantly different after the intervention ($p < .05$). n=24.

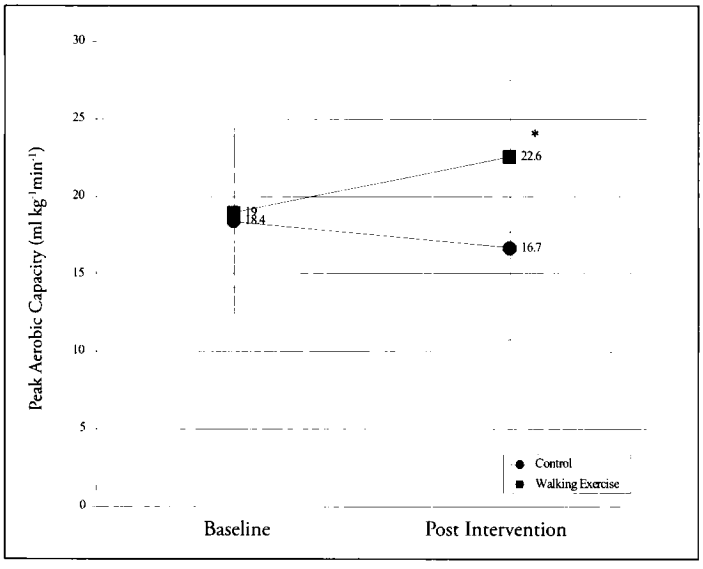

Figure 2. Peak aerobic capacity baseline and post intervention values expressed as mean ± standard deviation. *Significantly different after the intervention ($P < .05$). n=24.

exercise group showed significant improvements in the upper body strength, upper body flexibility, balance, and coordination domains of the CS-PFP10. These improvements may have come about from participants feeling more confident with upper body activities that were then incorporated into the routine activities of daily living resulting in overall improvements in all domains. Previous studies have shown that walking is convenient and easily accommodated into any daily routine.[36] Compliance with the program was 88.5% indicating that the participants tolerated a walking program held in Georgia in the months of May – September. Program satisfaction can be gauged by the 100% retention rate from both the control group and the walking exercise group. Walking in pairs and program leadership may have also contributed to the compliance and satisfaction with the walking program. The walking exercise program was continued following the post-testing for those in the both groups, particularly the control group who wished to participate.

This study has several limitations. The assessors were not blinded to the treatment groups. The sample size was small. Twenty-seven percent (11 of 40) who volunteered were unable to get physician's clearance required by the University of Georgia Institutional Review Board. This limits the generalizability of this study. Further research is warranted to determine if walking programs that are low cost and easily implemented could lead to public health strategies that decreased health care utilization and delay dependency. Continued research is needed in lower socioeconomic populations to gather more information on interventions that preserve function.

CONCLUSION

The findings of this study highlight the importance of physical activity and indicate that walking, a simple exercise that can be done without specialized exercise leader or equipment can significantly reduce risk for preclinical disability and increase peak aerobic capacity and physical function in just 4 months.

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Table 3. Baseline and Post Intervention SF36 Scores (n=24)

	Walking Exercise		Control		
SF36 Concepts	Baseline	Post Intervention	Baseline	Post Intervention	P value
Physical Functioning	81.7±18.6	85.8±13.6	69.6±18.3	65.0±16.4	.014*
Role-Physical	77.1±39.1	81.3±21.7	85.4±16.7	83.3±32.6	.879
Bodily Pain	68.1±17.5	69.3±25.2	61.9±19.7	60.7±20.2	.562
General Health	70.7±13.0	74.8±13.1	74.3±11.8	71.6±11.8	.423
Vitality	66.3±17.1	66.7±15.1	66.3±12.6	60.0± 9.8	.148
Social Functioning	89.6±12.9	89.6±14.9	92.7±15.5	82.3±22.3	.228
Role-Emotional	75.0±35.2	83.3±33.3	88.9±21.7	88.9±29.6	.925
Mental Health	78.0±14.2	82.0±12.9	87.3±06.8	82.7±11.9	.313

Values are means ± standard deviation.
*Difference from control at post intervention time point.

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