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Differential Exercise Effects on Quality of Life and Health-Related Quality of Life in Older Adults: A Randomized Controlled Trial

Elizabeth A. Awick, Thomas R. Wójcicki, Erin A. Olson, Jason Fanning, Hyondo D. Chung, Krystle Zuniga, Michael Mackenzie, Arthur F. Kramer, and Edward McAuley

University of Illinois at Urbana-Champaign

Abstract

Purpose—Maintaining quality of life (QOL) and physical and mental health status are important outcomes throughout the aging process. Although cross-sectional studies suggest a relationship between global QOL and physical activity, it is unclear whether such a relationship exists as a function of exercise training.

Methods—We examined the effects of two exercise intervention arms on health-related quality of life (HRQL) and global QOL. Low-active, older adults (N=179) were randomly assigned to either a 12-month aerobic walking group or a stretching and toning group. HRQL and QOL were measured at baseline, 6, and 12 months.

Results—There was a significant group by time effect on QOL [$F(2,176)=3.11$, $p=0.047$, $\eta^2=0.03$]. There was also a significant overall group by time effect for HRQL [$F(4,174)=2.46$, $p=0.047$, $\eta^2=0.05$], which was explained by the significant group by time interaction for mental health status ($p=0.041$, $\eta^2=0.02$) favoring the walking condition. Further analyses using latent class analysis revealed three classes of individuals with differential patterns of change in QOL and HRQL across time. These classes reflected no change, declines, and improvements in these constructs across time.

Conclusions—Walking appears to enhance the mental aspect of HRQL and global QOL when compared to a non-aerobic intervention. Additionally, the patterns of change in QOL and HRQL were not linear over time. Our findings are in contrast to previous reports that these outcomes change a little or not at all in randomized trials.

Keywords

Older adults; physical activity; aging; quality of life; randomized controlled trial

Address all correspondence to: Edward McAuley Department of Kinesiology and Community Health University of Illinois 906 S. Goodwin Ave Urbana, IL 61801 emcauley@illinois.edu Tel: 217-333-6487 Fax : 217-244-7322.

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Ethical Standards

All participants provided their informed consent before participation in the study, and a university Institutional Review Board approved all study procedures.

Introduction

A rapidly changing demographic landscape will result in a doubling of the US adult population over 65 years of age, and reach 71 million by 2050 [1]. Such figures have important medical, societal, and economic implications given that these individuals are at an increased risk of chronic disease, disability, and compromised global quality of life (QOL). Global QOL is an overall, affective judgment of one's satisfaction with life compared to health-related quality of life (HRQOL), which assesses physical and mental health status [2]. Given the connection between these constructs and traditional medical health outcomes such as morbidity, clinicians regularly use global QOL and HRQOL status to gain a more complete understanding of the process of disease and general care in older adults [2]. Physical activity is a behavioral modality associated with reduced disease risk and enhanced physical function and quality of life in older adults. Reviews of the physical activity and QOL literature are quite consistent in their conclusions that being more active is associated with greater global QOL [2-3], although these conclusions have their foundation largely in cross-sectional and observational studies. The evidence from randomized controlled trials is both limited and equivocal [3-4]. A recent study assessing physical activity and HRQOL in older adults reported a positive dose-response relationship with HRQOL outcomes improving with increasing levels of physical activity [5]. However, a recent meta-analysis examined exercise intervention effects on HRQOL, as measured by the Short-Form (SF)-36 [6], in community-dwelling older adults [7] and found differing results. The authors concluded that exercise had a significant effect only on physical functioning but little effect on other components of HRQOL. All 11 studies included in the meta-analysis compared either supervised or non-supervised exercise with a no-contact usual care control condition. Additionally, the longest intervention was 6 months with the majority lasting 3 months or less. Moreover, few interventions compared different types of exercise intervention (aerobic vs. anaerobic) in terms of improving HRQOL.

Although well-designed randomized controlled exercise trials may help further understand the exercise-HRQOL relationship in older adults [7], it may be more appropriate to assess global QOL and HRQOL as part of large-scale, randomized controlled, exercise trials which incorporate extended treatment time-frame with multiple assessment periods to examine the temporal trajectory of any effects. Furthermore, exercise mode (i.e., aerobic vs. anaerobic) and the specificity of the training may influence different health outcomes, making it important to move beyond usual care as a control group and examine changes in components of HRQOL over time in varying types of physical activity.

Another possible reason for the null findings from previous studies is that mean level data are typically reported with little attempt to examine whether participants display differential patterns of change across time. Herein, we report secondary outcomes data from a randomized controlled trial designed to assess the effects of a 12-month exercise intervention on brain structure and function in community-dwelling older adults. The purpose of the present study was to examine the differential effects on global QOL and HRQOL of two exercise training conditions, an aerobic walking group and a strengthening and flexibility active control group, across a 12-month intervention period. Furthermore, we

conducted exploratory analyses to determine whether there were differential patterns of change in these patterns across the trial.

Methods

Participants, Design, and Procedures

Primary outcomes, study design details, and participant flow have been reported elsewhere [8-10]. Briefly, participants (N=179) were community-dwelling older adults who volunteered to participate in a 12-month exercise program. Recruitment took place via local media outlets, including television, radio, and print media advertisements. Eligibility criteria included being 60 to 80 years of age, low active as defined as less than 2 days per week of physical activity, free of medical contraindications to physical activity (able to get up and down off the floor easily, no medical condition that may be exacerbated, etc.), obtaining physician clearance, and willingness to be randomized. Further inclusion criteria were related to the neurocognitive and brain structure primary outcomes. Thus, participants had to be right-handed, cognitively unimpaired [11], have normal color vision and normal or adjusted visual acuity, as well as not clinically depressed or suffering from claustrophobia.

Interested participants contacted a research coordinator by telephone and subsequently completed a pre-screening interview to determine whether they met initial inclusion criteria. Following entry into the trial, participants completed an informed consent and a battery of questionnaires including measures of global QOL and HRQOL. Once all baseline testing data were collected, participants were randomized using a computer-generated random allocation sequence into one of the two exercise conditions: a walking group (n = 90) or a strengthening and flexibility group (n = 89). Each group met three times a week for approximately one hour over the 12-month intervention period. Participants completed all measures again at 6 and 12 months. A university Institutional Review Board approved all study procedures. Subject flow through the study is shown in Figure 1 [8].

Measures

Demographics—Basic demographic information relative to marital status, education, age, gender, and household income was assessed via questionnaire during screening.

Global Quality of Life—Global QOL was assessed with the 5-item Satisfaction With Life Scale (SWLS; [12]). Pavot and Diener [13] have reported that the SWLS is sensitive enough to detect changes in life satisfaction across the course of a clinical intervention and has good psychometric qualities in older adults [12, 14]. Furthermore, Rejeski and Mihalko [2] reviewed the literature on physical activity and quality of life in older adults, and concluded that global quality of life when defined as a psychological construct is best represented by satisfaction with life. Each item is scored on a 7 point Likert scale from strongly disagree (1) to strongly agree (7), with higher scores reflecting greater satisfaction with life. Possible range of scores is from 5 – 35. Internal consistency in the present study was acceptable ($\alpha = .80 - .87$).

Health-Related Quality of Life—HRQOL was measured with the SF-12 Health Survey [15]. The SF-12 is an abridged version of the Medical Outcomes Study SF-36 [16] and has well-documented psychometric qualities across multiple populations. The SF-12 provides a summary assessment of both physical and mental health status and scores which can range from 0-100, with a higher score indicating greater health status. The mean (SD) normative score for physical health status in older adults is 44.29 (10.87). For mental health status, the mean (SD) normative score is 52.26 (10.07) [17].

Interventions

Walking—The walking group was led and supervised by a trained exercise specialist. Each session included a 5-10 minute stretching period for the purpose of warming-up and cooling down. For the first seven weeks of the program, participants slowly progressed from 10 minutes of walking to 40 minutes, increasing duration by a 5-minute increment each week. Upon achieving this duration, participants maintained 40 minutes of brisk walking for the remainder of the program. All participants wore heart rate monitors and were encouraged to stay within 50-60% of their maximum heart rate reserve for the first 7 weeks and thereafter to maintain a heart rate within 65-75% of their heart rate reserve.

Strengthening and flexibility—A trained exercise specialist supervised the strengthening and flexibility condition exercise sessions, which began and ended with a 5-10 minute warm up and cool down. Participants completed 4 muscle toning exercises using dumbbells or resistance bands, 2 exercises to improve balance, 1 yoga sequence, and 1 exercise of their choice in each session. A new group of exercises was introduced every four weeks to prevent boredom and preserve interest. Both the walking and strengthening and flexibility groups were prescribed the same Rating of Perceived Exertion (RPE) range of 13-15.

Data Analysis

Correlational analyses initially examined relationships among the global QOL and HRQOL measures. For the primary analyses, an initial set of analyses used a two (group) by three (time) mixed model repeated measures analyses of variance using general linear models to examine the effects of the 12-month exercise intervention on global QOL and HRQOL. These models included tests of within subject contrasts to examine both linear and quadratic effects. Missing data for these analyses were imputed using the multiple imputation feature in SPSS version 22 [18]. Next, we conducted a latent class analysis (LCA) to determine whether there were different initial levels and different patterns of growth in global QOL and HRQOL over time. We tested the simple position that three classes could exist in the data with individuals demonstrating no change, increasing their levels of global QOL and HRQOL, or showing declines in global QOL and HRQOL across the trial. The data were analyzed using *Mplus* version 6.0 with the robust full information likelihood estimator [19]. The final class solution was based on the Bayesian Information Criterion (BIC) and the sample-size adjusted-BIC (ABIC) following the guidelines provide by Burnham & Anderson [20]. In addition, entropy values and most likely class membership probabilities were computed with a value range between 0 and 1, with higher values indicating greater

likelihood of replication. We report the means for intercept (M_i), slope (M_s), and accuracy of class assignment.

Results

Table 1 details descriptive statistics for the global QOL and HRQOL variables at baseline, 6, and 12 months within each intervention group. The mean age of participants at baseline was 66.43 years, 88.3% were White, 3.4% were Asian, and 8.4% were African-American. Participants were generally well educated, 48.6% had at least a college degree, and 59.8% were married. Furthermore, participants were low fit ($M = 21.04 \text{ ml/kg} \pm 4.75$) and overweight ($M \text{ BMI} = 28.88 \pm 4.42$) with 11.20% reporting diabetes and 13.4% reporting heart conditions. We had 84% retention with 144 participants completing all three assessment time points. Study “dropouts” showed no significant differences at baseline in global QOL and HRQOL constructs relative to “completers”. The average adherence to the exercise programs was 72.56% (i.e., percentage of classes attended. There was no statistically significant difference in adherence levels between the walking condition (73.38%) and the strengthening and flexibility condition (71.75%). Additionally, participants in both groups reported enjoying the exercise programs equally well (Walking = 5.23; Strengthening and flexibility = 5.37; Enjoyment measured on a 1-7 scale with higher numbers reflecting greater enjoyment).

Finally, no significant differences were present at baseline when comparing walking and strengthening and flexibility groups on global QOL and HRQOL variables (p 's $\geq .65$) and demographic measures (i.e., age, gender, education, p 's $\geq .14$). Thus, demographic measures were omitted from further analyses.

Correlations between Global QOL and HRQOL

Global QOL was significantly associated with the mental health status aspect of HRQOL, $r = .41, .48$, and $.57$ ($p < .001$), at baseline, 6, and 12 months. However, Global QOL was only significantly associated with the physical health status aspect of HRQOL at month 6 ($r = .16, p < .05$).

Intervention Effects on QOL and HRQOL

Analysis of the intervention effects on global QOL revealed a significant group by time effect [$F(2,176)=3.11, p=0.047, \eta^2=0.03$]. Decomposition of the interaction effect revealed a significant quadratic effect ($p=0.040, \eta^2=0.02$) for global QOL, whereby the walking condition demonstrated a linear increase across the trial and the strengthening condition increased global QOL above baseline at 6 months and then declined but remained slightly above baseline levels at 12 months.

The analysis comparing intervention effects on HRQOL revealed a significant group by time interaction [$F(4,174)=2.46, p=0.047, \eta^2=0.05$]. The overall multivariate effect was driven by the significant group by time interaction for mental health status ($p=0.041, \eta^2=0.02$) in which the walking group demonstrated a modest increase across the 12-month period while the strengthening and flexibility group had a significant linear decline in mental health status over the course of the intervention ($p=0.016, \eta^2=0.03$). The mental health status trajectories

were significantly different between the walking and strengthening conditions, however within each exercise condition there was no significant change in trajectory throughout the intervention period. Physical health status remained relatively stable across the trial for both groups.

Latent Class Growth Modeling

Our attempt to fit a three-class model for global QOL was successful and extracted one large class of cases (C1; $n = 147$) and two smaller classes, (C2; $n = 2$ and C3, $n = 30$). These three classes reflected no change, declines, and increases in global QOL, respectively. Individuals in C1 began with higher levels of QOL at baseline ($M_i = 28.03$, $p < .001$) and demonstrated no discernable change across time ($M_s = 0.13$, $p = .53$). The second class (C2) also began with higher levels of global QOL ($M_i = 30.94$, $p < .001$) and demonstrated a large but non-significant decrease across the trial ($M_s = -8.88$, $p = .22$). Participants in the third class (C3) began the trial with lower values of QOL ($M_i = 16.82$, $p < .001$) and showed significant increases in global QOL across the trial ($M_s = 2.88$, $p < .001$). For this 3-class model, entropy was .90 and most-likely class member probabilities were .97 (C1), .98 (C2) and .92 (C3). These figures suggest that the model could be replicated 90% of the time and that accuracy of class assignment was between 98% and 92%.

The model for the physical health status component of HRQOL also revealed three classes with one large class (C1; $n = 140$) and two smaller classes (C2; $n = 2$ and C3, $n = 37$). Participants in C1 began with higher than average [17] levels of physical status ($M_i = 51.30$, $p < .001$) and demonstrated small declines over time ($M_s = -1.76$, $p = .07$). The pattern for C2 began with low [17] physical status scores ($M_i = 19.95$, $p < .001$) and increased significantly over time ($M_s = 3.56$, $p = .01$). The third class also began with slightly lower than average [17] baseline scores ($M_i = 38.25$, $p < .001$) and experienced small but non-significant increases over time ($M_s = 1.11$, $p = .35$). Entropy was .85 and most-likely class member probabilities were .95 (C1), .98 (C2) and .86 (C3). Thus, the model could be replicated 85% of the time and class assignment was between 86% and 98% accurate.

The mental health status model of HRQOL also provided a three-class solution with one large class (C1; $n = 150$) and two smaller classes (C2; $n = 17$; C3; $n = 12$). In the larger class, participants began with higher than average [17] levels of mental health status ($M_i = 56.30$, $p < .001$) but with little change over time ($M_s = -0.27$, $p = .33$). Those individuals in C2 had below average [17] baseline values ($M_i = 44.23$, $p < .001$) with significant declines over time ($M_s = -5.60$, $p = .006$). Finally, members of C3 had considerably lower [17] baseline values ($M_i = 34.76$, $p < .001$) and significant increases over the trial period time ($M_s = 10.39$, $p < .001$). Entropy was .93 and most-likely class member probabilities were .98 (C1), .91 (C2), and .93 (C3). Thus, the model could be replicated 93% of the time and class assignment was between 91% and 98% accurate.

Discussion

There is substantial support in the literature for the assessment of health-related constructs such as global QOL and HRQOL as primary or secondary health research outcomes [21]. However, the effects of exercise training on global QOL and HRQOL in generally healthy

older adults are equivocal. Kelley et al. [7] have suggested that this may be a function of few and poorly designed trials, as well as the majority of studies having relatively short intervention periods. The purpose of this study was to examine the effects on global QOL and HRQOL between two exercise training conditions, an aerobic walking group and a strengthening and flexibility active control group, across a 12-month physical activity intervention period. We further conducted exploratory analyses to determine whether clear differential patterns of change existed in global QOL and HRQOL across time. In the present study, both exercise groups evidenced an increase in global QOL, however the walking group had a linear increase across the trial whereas the strengthening and flexibility group showed improvements from baseline to 6 months followed by declines from 6 to 12 months, although values still remained above baseline scores. With regard to HRQOL, the walking group demonstrated an increase in mental health status whereas the strengthening and flexibility group declined significantly. However, improvements in mental health outcomes following exercise interventions have previously been demonstrated in older adults in the absence of compromised mental health [22]. This finding may well be a reflection of the participants coming to the end of a professionally dispensed, socially supportive exercise program and having to begin to exercise on their own. That is, an affective response. Values for the physical health status component of HRQOL remained stable across the trial. This is perhaps understandable, given that our sample was comprised of relatively healthy older adults and it is likely that the interventions served to maintain these levels of physical health status, which is promising given the high costs associated with aging.

Findings from the present study suggest that exercise interventions and, in particular, aerobic activity have modest effects on global QOL and HRQOL and that the size of these effects may well be due to the participants (i.e., healthy, community-dwelling older adults) already having moderate to high levels of these constructs at baseline. At worst, one might conclude that exercise-training interventions may well preserve and maintain global QOL and HRQOL, which is an important outcome in and of itself. Well-designed prospective trials are required to determine the veracity of this position [3]. However, whether the pattern of change in global QOL and HRQOL across the length of exercise trials is consistent for all participants is debatable. Most conclusions about exercise training effects on these variables are based upon examination of mean level data. We conducted exploratory analyses to examine whether our data had classes of individuals who did not change, increased, or declined in global QOL and HRQOL across the trial. The pattern was very similar for global QOL and the physical and mental health status outcomes with the majority of the sample having moderate to high baseline levels of these constructs with maintenance across the trial. The two other classes, both relatively small, showed patterns of change that reflected either higher levels of global QOL and HRQOL at baseline and declines across the trial or moderate to low levels at baseline followed by significant increases across the 12-month period.

These findings suggest several avenues to pursue. First, examination of baseline levels of global QOL and HRQOL would allow interventionists to identify those individuals who may need different levels of attention in order to maximize the mental and physical health benefits of the intervention. Second, educating participants within the trial, particularly older

adults, about the importance of exercise effects in leading a healthy and functional life may lead to a greater sensitivity to even subtle changes of global QOL and HRQOL [23]. Additionally, it is quite possible that those individuals with low levels at baseline had chronic health conditions that were not exclusionary criteria and subsequently there was likely greater room for improvement. Unfortunately, sample size restrictions do not permit further examination of this position. Nevertheless, differences in how individuals respond within the exercise trial represents new and important data, and further examination of such classes of individuals is warranted.

This study has several strengths. First, we used a relatively large, 12-month, randomized controlled trial design with an active control. The use of this active control group serves as an attentional control for potential psycho-social benefits of interacting with peers and staff members. Second, we had multiple measurement points in the intervention rather than a standard pre-post design. Further, using contemporary statistical methods, we were able to examine the possibility that different groups of participants had differential patterns of change in global QOL and HRQOL. Previous studies examining the global QOL, HRQOL, and exercise relationship have primarily used cross-sectional and observational designs, with the conclusions drawn from randomized controlled trials being quite mixed [2-5, 7]. This pattern of results is rarely reported in the results of intervention trials with the main focus on mean level change of groups. We believe that drawing attention to these differential patterns within groups is valuable. We do note several limitations that need to be considered in the interpretation of the data. Participants were relatively well educated and in good health, potentially limiting the generalizability of the results. Furthermore, although statistically significant these findings are not clinically significant which should be interpreted with caution due to the relatively healthy nature of this sample of older adults. Additionally, in the assessment of HRQOL, we used the SF-12 [15], a shorter version of the Medical Outcomes Study SF-36 [6], which provides a physical and mental health status score. However, using the SF-36 would allow a more fine-grained assessment of the subdomains of HRQOL that may evidence greater change, as a function of exercise intervention. It is noted that the global QOL measure may also be affected by transient mood shifts. As Krueger and Shkade [24] have previously mentioned, completing a global QOL measure such as the life satisfaction scale amounts to one conducting an unplanned review of one's life and is thereby susceptible to influence by any number of personal or environmental influences. Finally, one might question examination of the three-class solution when one class consisted only of two cases. We followed the example of Muthen [19] and Mullen [25] in choosing to keep the class on substantive grounds. That is, it was possible to have classes of participants who might increase, decline, or stay the same across the intervention period.

In closing, we provide data supporting modest effects of a 12-month randomized controlled exercise training study on global QOL and HRQOL. The aerobic activity condition (walking) appeared to benefit slightly more than the strengthening and flexibility condition, however maintenance in both conditions is promising. In addition, exploratory analyses uncovered differential patterns of change in global QOL and HRQOL trajectories across the trial. Our findings are in contrast to previous reports that these outcomes change a little or not at all in randomized trials.

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Figure 1.
CONSORT

Table 1

Means and standard deviations of QOL outcomes across time points

	Total Sample	Walking Condition	Strengthening and Flexibility Condition
Global QOL			
month 0	26.09 ± 5.72 (n=179)	26.01 ± 5.28 (n=89)	26.16 ± 6.15 (n=90)
month 6	26.64 ± 5.23 (n=151)	26.18 ± 5.33 (n=76)	27.10 ± 5.21 (n=75)
month 12	26.87 ± 5.49 (n=145)	27.17 [*] ± 5.14 (n=72)	26.57 ± 5.83 (n=73)
HRQL - Mental Health Status			
month 0	53.62 ± 8.27 (n=179)	53.90 ± 8.16 (n=89)	53.34 ± 8.41 (n=90)
month 6	53.70 ± 7.65 (n=151)	54.74 ± 6.56 (n=76)	52.67 ± 8.50 (n=75)
month 12	53.16 ± 8.40 (n=145)	54.98 ± 6.11 (n=72)	51.36 [*] ± 9.88 (n=73)
HRQL - Physical Health Status			
month 0	48.00 ± 8.43 (n=179)	48.23 ± 7.94 (n=89)	47.79 ± 8.92 (n=90)
month 6	47.69 ± 8.13 (n=151)	47.08 ± 8.36 (n=76)	48.29 ± 7.90 (n=75)
month 12	47.22 ± 8.35 (n=145)	47.38 ± 7.61 (n=72)	47.06 ± 9.06 (n=73)

Note: QOL = Quality of Life, HRQL = Health-Related Quality of Life

* significant at alpha=0.05 over time