# Metabolic health and perceived quality of life in older adults after a 16-week exercise programme

ORIGINAL ARTICLE

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## ABSTRACT

**Purpose.** This study examined the effects of a 16-week exercise programme on older adult´s metabolic markers and quality of life (QoL).

**Methods.** 65 participants (mean age, 69.2 years) were randomly assigned to an intervention (n=38) or control (n=27) group. The intervention group attended hydro-gymnastic and group gym sessions that included strength, resistance, and flexibility training 4 times a week. The control group did no exercise. All participants were assessed before and after intervention using anthropometric measurements, blood tests, and the World Health Organization's WHOQOL-BREF and -OLD questionnaires.

**Results.** There was a decrease in waist circumference, waist circumference to height ratio, and glucose ($p<0.01$) and an increase in high-density lipoprotein cholesterol ($p<0.01$) in response to exercise. There was an overall reduction in the psychological domain in both groups. Total WHOQOL-OLD and intimacy sub-scale scores were higher in the control group ($p<0.01$).

**Conclusion.** Regular exercise positively affected older people's metabolic markers, in particular increasing HDL cholesterol levels and decreasing glucose levels, but not QoL parameters.

**Key words:** Aerobic exercise, strength exercise, aging, biomarkers, quality of life

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## INTRODUCTION

The metabolic syndrome (MetS) is a cluster of common cardiovascular risk factors that include hypertension, glucose intolerance, dyslipidaemia, and visceral fat obesity.[1] These factors increase the risk of heart disease and health problems such as obesity, diabetes, accelerated atherosclerosis, and other complications including stroke and myocardial infarction.[2] MetS is increasingly recognised in geriatric populations.[3] Obesity is considered the central element of MetS, even more relevant in older people because general and abdominal obesity increases with ageing.[4]

In adults, waist circumference (WC) and body mass index (BMI) as markers of total adiposity are strongly correlated with fat mass.[5] Nonetheless, they may underestimate body fat in older people who have a high proportion of lean muscle mass[6] or loss of muscle mass tissue due to ageing. Moreover, the WC is the most important risk factor for metabolic complications, and the more accurate anthropometric measure of body fat distribution[7] rather than abdominal visceral fat *per se*[8] has been associated with morbidity and mortality.[9] Women with a WC ≥88 cm should avoid gaining further weight and those with a WC ≥98 cm should try to lose weight. The corresponding cut-off values for

men are 97 and 110 cm.[10]

Exercise may ameliorate health risk factors including those that comprise MetS and may contribute to a reduction in abdominal visceral fat.[11] Exercise refers to planned, structured, and repetitive movement that aims to improve or maintain one or more components of physical fitness.[12] Inactivity is associated with cardiovascular risk factors such as hypertension, insulin resistance, diabetes, dyslipidaemia, and obesity.[13] The longer older people are inactive, the more likely they are to have MetS, even taking into account age, sex, education, alcohol consumption, smoking, BMI, diabetes, and heart disease.[14]

Maintaining global quality of life (QoL) and physical and mental health status are important throughout the ageing process. Negative variation of biological markers as a result of higher levels of inactivity may have a strong influence on old people's health-related QoL (HRQoL). Although cross-sectional studies suggest a relationship between global QoL, HRQoL, and physical activity, it remains unclear whether such relationship exists with exercise training.[15]

This study analysed the effects of a 16-week structured exercise programme on a set of MetS markers in older participants' perceived QoL. It was hypothesised that older participants would achieve better values for BMI and WC, MetS markers, and a higher level of perceived QoL after participating in the 16-week exercise programme.

## METHODS

### Participants

This study was approved by The Ethics Committee of Sport Sciences and Physical Education Faculty – University of Coimbra, Portugal. Informed consent was obtained from each participant. 65 older adults aged 65 to 75 (69.2±4.0) years were recruited from the Funchal City Council Exercise and Health Program, in Madeira Island, Portugal. Those diagnosed with chronic ischaemic heart disease or chronic coronary artery disease were excluded. Participants were randomly assigned to the intervention/exercise group (n=38, 68.5±3.6 years) or the control group (n=27, 70.3±4.4 years). All participants obtained medical permission to participate in the exercise programme and were cognitively able.

### Parameters

The participants' general health status was assessed using a clinical questionnaire. Perceived QoL was assessed using the World Health Organization's WHOQOL-BREF and -OLD questionnaires. The Portuguese version of the WHOQOL-BREF includes 26 items across 4 dimensions (social, environmental, physical, and psychological) measured on a 5-point Likert scale. Its internal consistency was confirmed using Cronbach's Alpha coefficient ($\alpha$=0.77).[16] The Brazil version of WHOQOL-OLD[17] was administered to obtain complementary information about older participants' QoL. This questionnaire includes 6 dimensions measured on a 5-point Likert scale: (1) sensory abilities, (2) autonomy, (3) past, present and future activities, (4) social participation, (5) death and dying, and (6) intimacy. Its internal consistency varies from $\alpha$=0.67 to $\alpha$=0.90.[17] It has good reliability (r=0.82) and internal consistency ($\alpha$=0.71) for use with older people.[18]

Participants'weight (kg), height (cm), BMI (kg/m$^2$), and WC (cm) were measured, as were serum triglycerides, glucose, and total and high- and low-density lipoprotein (HDL and LDL) cholesterol.

### Procedures

All questionnaires were administrated by the same research assistant using standardised instructions. In some situations where the participant had a poor understanding of the questionnaires, interviewing techniques were used. All anthropometric measurements were obtained according to the guidelines of the International Society of Advanced Anthropometry.[19] Intra-observer variation was calculated based on 15 participants measured twice within a one-week interval (0.27 kg for weight, 0 cm for height, and 0.17 cm for WC). All participants were assessed at baseline (T0) and after the exercise programme (T1).

### Intervention

The 16-week standardised aerobic and strength training programme (4 times per week) was held in the gym and swimming pool, prescribed and implemented by a sport sciences professional. Each session lasted 45 minutes and included a warm-up, main session, and cool-down. The main session comprised exercises to improve aerobic capacity,

endurance strength, and flexibility. Exercise intensity was indirectly predicted using Karvonen's formula to predict target heart rate (HR), with the maximum HR being calculated using a specific formula (207 beat/min – 0.7 x age) for old people for safety reasons.[20] Aerobic work intensity was targeted to be 55-75% of the participant's maximum HR. The programme intensity increased from 55-65% during weeks 1-7 to 65-75% during weeks 8-16. Session intensity was monitored using HR monitor (POLAR RCXS) in 6 random participants *per* session and at least twice in all participants during each session using the Perceived Exertion Borg Scale.[21]

Exercise compliance was recorded. When a participant had 2 consecutive absences, he/she was contacted by a research team member to enquire about the reason, and motivational strategies were used to stimulate the participant to return. No participant dropped out during the 16-week exercise programme.

**Statistics**

Normality was checked using the Kolmogorov-Smirnov test, with Lilliefors' significance correction, and using visual inspection of normality plots. Changes to body dimensions, metabolic health indicators, and QoL sub-scales were examined as a consequence of the exercise intervention using multilevel modelling, based on a pre- and post-intervention design (unconditional linear model). Each participant's successive measurements over time were defined as individual response change and random error (level 1). Differences in response change between groups of individuals were examined (level 2).

Changes across the period in the intervention and control groups were examined by adding a dummy variable as 2-level explanatory variable (0 for control group; 1 for intervention group) and an interaction term between the group dummy variable and change across the experimental period, i.e. slope, using conditional linear models. All parameters were fixed with the exception of the constant (intercept term) and changes across the experimental period (slope) parameters, which were allowed to vary randomly at level 2 (between individuals).

Akaike information criterion takes into account the different number of fitted parameters in the different model structures to be compared. Visual inspection of residual plots were performed to determine the final models' validity to fit responses of the dependent variables as a consequence of training, considering the effects of the predictor variables. Significance was set at $p<0.05$. Multilevel regression models were obtained using the 'nlme' package[22] in the R statistical language (http://cran.r-project.org).

## RESULTS

Baseline characteristics of the intervention and control groups were comparable, except for height (158.7 vs. 154.3 cm, p=0.03), WHOQOL-BREF sub-scale of physical (14.1 vs. 12.6, p=0.02), WHOQOL-OLD sub-scale of social participation (15.8 vs. 14.5, p=0.04) and intimacy (14.4 vs. 7.8, p=0.001), and total WHOQOL-OLD score (86.8 vs. 76.7, p=0.001) [**Table 1**].

Changes before and after intervention in terms of morphology, metabolic health, and WHOQOL-BREF and -OLD sub-scales are presented in **Table 2**.

The multilevel regression models (**Table 3**) showed a significant decrease for WC and WC to height ratio in the intervention group (i.e. interaction between changes and intervention group exponent), compared with no changes in the control group ($p<0.01$). No significant difference was noted after exercise in the intervention group for weight or BMI. The intervention group showed a significant decrease in glucose levels in response to the exercise programme, compared with the control group ($p<0.01$). No significant change was noted for other metabolic health indicators in response to exercise. In the WHOQOL-BREF questionnaire, a significant decrease in the psychological dimension was noted in all participants ($p<0.01$). In the WHOQOL-OLD questionnaire, intimacy and total WHOQOL-OLD score were higher in the control than intervention group ($p<0.01$), but no significant change was noted in response to exercise.

## DISCUSSION

There was a significant reduction in WC, WC to height ratio, and glucose from pre- to post-intervention in the intervention group, compared with the control group. This partially supports the

**Table 1**
**Baseline characteristics of intervention and control groups***

| Characteristic | Intervention group (n=38) | Control group (n=27) | p Value |
|---|---|---|---|
| Age (years) | 68.5±3.6 | 70.2±4.4 | 0.09 |
| Height (cm) | 158.7±8.2 | 154.3±7.6 | 0.03 |
| Weight (kg) | 76.3±12.9 | 74.3±14.3 | 0.57 |
| Body mass index (kg/m$^2$) | 30.2±4.0 | 31.2±5.4 | 0.45 |
| Waist circumference (cm) | 102.9±11.1 | 104.9±12.8 | 0.53 |
| Waist circumference to height ratio | 0.7±0.1 | 0.7±0.1 | 0.14 |
| Total cholesterol (mg/dl) | 183.5±33.7 | 177.9±43.3 | 0.57 |
| High-density lipoprotein cholesterol (mg/dl) | 58.5±16.0 | 52.0±14.5 | 0.10 |
| Low-density lipoprotein cholesterol (mg/dl) | 101.7±27.5 | 97.8±36.4 | 0.64 |
| Triglycerides (mg/dl) | 118.9±73.3 | 140.4±67.2 | 0.23 |
| Glucose (mg/dl) | 107.0±21.2 | 106.7±23.9 | 0.95 |
| WHOQOL-BREF sub-scale | | | |
| Physical | 14.1±2.3 | 12.6±2.7 | 0.02 |
| Psychological | 14.9±2.4 | 14.1±2.8 | 0.20 |
| Social | 15.2±2.8 | 13.9±3.1 | 0.10 |
| Environmental | 14.4±1.8 | 14.2±2.2 | 0.70 |
| WHOQOL-OLD sub-scale | | | |
| Sensory abilities | 15.3±2.9 | 14.5±3.5 | 0.32 |
| Autonomy | 14.4±2.1 | 14.6±2.3 | 0.64 |
| Past, present and future | 13.9±2.2 | 13.2±2.9 | 0.28 |
| Social participation | 15.8±2.1 | 14.5±2,7 | 0.04 |
| Death and dying | 12.8±3.8 | 12.0±4.9 | 0.50 |
| Intimacy | 14.4±4.2 | 7.8±4.7 | 0.001 |
| Total WHOQOL-OLD score | 86.8±9.4 | 76.7±11.7 | 0.001 |

* Data are presented as mean±SD

positive effects of exercise to reduce some risk factors that may contribute to metabolic complications such as diabetes.[7] Another study has reported a reduction in WC in older participants following aerobic and strength training sessions for 16 weeks.[23] Furthermore, positive effects of physical activity (Tai Chi and dance) have been reported in older adults aged 50-70 years with a decrease in WC, compared with a sedentary age-matched group.[24] Nonetheless, no difference in WC has been reported in older participants after dance sessions twice a week for 6 months,[25] or in old sedentary participants using Go4Life educational material (www.Go4life.nia.nih.gov) for a exercise-based counselling programme for 24 weeks.[26]

The intensity and the type of exercise programme are important to achieve WC reduction. In the present study, the intensity of the exercise programme was 55 to 75% of the maximum HR and there was a significant difference in WC between the intervention and control group. In another study, despite the positive results for overall fitness condition in older women who exercised regularly for 8 weeks, no significant change in weight or BMI was noted compared with a control group.[27] In addition, a dance exercise programme showed no significant difference between weight and BMI in older active individuals and controls.[25] These studies had a limited duration (8 weeks) for the exercise programme[27] or a wide range of exercise intensity (50-80%).

Nevertheless, positive results are associated with

**Table 2**
**Change in mean pre- and post-intervention**

| Characteristic | Intervention group (n=38) | | | |
|---|---|---|---|---|
| | Pre-intervention* | Post-intervention* | Change in mean (95% CI) | Within-subject variation (level-1 residuals) [95% CI] |
| Age (years) | 68.5±3.6 | - | - | - |
| Height (cm) | 158.7±8.2 | - | - | - |
| Weight (kg) | 76.3±12.9 | 74.5±13 | -1.8 (-2.5 to -1.0) | 2.7 (1.8 to 4.4) |
| Body mass index (kg/m$^2$) | 30.2±4.0 | 29.5±3.8 | -0.7 (-1.0 to -0.4) | 0.5 (0.3 to 0.7) |
| Waist circumference (cm) | 102.9±11.1 | 98.4±10.4 | -4.5 (-6.1 to -2.9) | 12.0 (7.6 to 19.0) |
| Waist circumference to height ratio | 0.7±0.1 | 0.6±0.1 | -0.0 (-0.0 to -0.0) | 0.0 (0.0 to 0.0) |
| Total cholesterol (mg/dl) | 183.5±33.7 | 189.2±31.7 | 5.7 (-2.5 to 13.9) | 313.2 (198.5 to 493.9) |
| High-density lipoprotein cholesterol (mg/dl) | 58.5±16.0 | 65.3±16,8 | 6.8 (4.4 to 9.2) | 26.2 (16.6 to 41.4) |
| Low-density lipoprotein cholesterol (mg/dl) | 101.7±27.5 | 102.4±29.6 | 0.7 (-6.9 to 8.4) | 274.2 (173.8 to 432.5) |
| Triglycerides (mg/dl) | 118.9±73.3 | 107.9±51.6 | -11.0 (-22.2 to 0.2) | 583.5 (369.3 to 920.3) |
| Glucose (mg/dl) | 107.0±21.2 | 104.7±20.4 | -2.3 (-6.4 to 1.8) | 79.3 (50.6 to 125.0) |
| WHOQOL-BREF sub-scale | | | | |
| Physical | 14.1±2.3 | 13.9±1.5 | -0.1 (-1.0 to 0.7) | 3.3 (2.1 to 5.3) |
| Psychological | 14.9±2.4 | 13.9±1.8 | -1.0 (-1.9 to -0.1) | 3.6 (2.3 to 5.7) |
| Social | 15.2±2.8 | 15.1±2.4 | -0.1 (-1.3 to 1.1) | 6.5 (4.1 to 10.3) |
| Environmental | 14.4±1.8 | 14.2±1.9 | -0.2 (-1.0 to 0.6) | 2.8 (1.8 to 4.5) |
| WHOQOL-OLD sub-scale | | | | |
| Sensory abilities | 15.3±2.9 | 14.9±2.9 | -0.4 (-1.3 to 0.5) | 3.9 (2.4 to 6.2) |
| Autonomy | 14.4±2.1 | 13.9±2.0 | -0.5 (-1.3 to 0.3) | 2.8 (1.8 to 4.5) |
| Past, present and future | 13.9±2.2 | 13.9±2.1 | -0.0 (-0.9 to 0.8) | 3.5 (2.2 to 5.6) |
| Social participation | 15.8±2.1 | 15.6±2.3 | -0.2 (-1.1 to 0.7) | 3.7 (2.3 to 5.8) |
| Death and dying | 12.8±3.8 | 13.7±4.0 | 0.9 (-0.6 to 2.4) | 10.2 (6.5 to 16.1) |
| Intimacy | 14.4±4.2 | 14.2±4.3 | -0.3 (-1.5 to 0.9) | 7.0 (4.5 to 11.1) |
| Total WHOQOL-OLD score | 86.8±9.4 | 86.2±10.3 | -0.5 (-3.8 to 2.8) | 50.0 (31.7 to 78.9) |

* Data are presented as mean±SD

combined physical activity and dietary intervention in decreasing BMI in older postmenopausal women.[28] Physical activity is inversely associated with BMI at baseline; an increase in physical activity from baseline to 5 years is associated with a decrease in BMI.[29]

In the present study, HDL cholesterol increased 11.6% and fasting glucose level decreased 2.14% as a result of exercise. Physical activity for older people (such as 30-minutes of walking 6 times a week) reduces fasting glucose level after a period of 12 weeks.[6] Strength training sessions over a period of 12 weeks also reduce glucose levels.[30] In a study of the effects of moderate-intensity aerobic and strength training in older individuals over a period of 16 weeks, a 5% increase in HDL cholesterol levels has been reported.[23]

It remains unclear whether there is an association between QoL, HRQoL, and physical activity.[15] In the present study, there was a global small but not significant increase in most QoL dimensions and a significant decrease in the psychological domain (WHOQOL-BREF) over a period of 16 weeks. There was also a global small positive but not significant effect of exercise on the participant's QoL. A significant increase was noted in the control group in terms of intimacy and total WHOQOL-OLD scores after a period of 16 weeks.

**Table 3**
**Multilevel regression analysis of older people in response to exercise**

| Characteristic | Constant | Changes with intervention (slope) | Intervention group (control group as reference) | Interaction between changes and intervention group |
|---|---|---|---|---|
| Weight (kg) | 75.00 (2.54)* | 6.77 (7.07) | - | - |
| Body mass index (kg/m$^2$) | 31.42 (0.87)* | 2.98 (3.10) | -0.94 (1.17) | -8.93 (6.21) |
| Waist circumference (cm) | 104.89 (2.28)* | 0.70 (0.91) | -1.94 (2.98) | -5.23 (1.19)* |
| Waist circumference to height ratio | 0.68 (0.01)* | 0.00 (0.01) | -0.03 (0.02) | -0.03 (0.01)* |
| Total cholesterol (mg/dl) | 5.17 (0.04)* | 0.04 (0.02) | 0.04 (0.05) | -0.03 (0.03) |
| High-density lipoprotein cholesterol (mg/dl) | 3.89 (0.05)* | 0.09 (0.02)* | 0.11 (0.07) | 0.06 (0.03) |
| Low-density lipoprotein cholesterol (mg/dl) | 4.54 (0.06)* | 0.03 (0.03) | 3.87 (7.92) | -3.66 (5.99) |
| Triglycerides (mg/dl) | 4.91 (0.09)* | -0.01 (0.03) | -0.22 (0.12) | -0.12 (0.06) |
| Glucose (mg/dl) | 4.65 (0.03)* | 0.03 (0.02) | 0.01 (0.04) | -0.12 (0.04)* |
| WHOQOL-BREF sub-scale | | | | |
| Physical | 12.95 (0.36)* | 0.24 (0.33) | 1.54 (0.62) | -0.89 (0.66) |
| Psychological | 14.19 (0.39)* | -0.91 (0.31)* | 0.86 (0.65) | -0.25 (0.64) |
| Social | 13.64 (0.46)* | -0.47 (0.43) | 1.25 (0.74) | 0.88 (0.87) |
| Environmental | 14.36 (0.32)* | 0.02 (0.27) | 0.20 (0.49) | -0.54 (0.55) |
| WHOQOL-OLD sub-scale | | | | |
| Sensory abilities | 14.64 (0.59)* | -0.18 (0.35) | 0.82 (0.80) | -0.57 (0.70) |
| Autonomy | 14.74 (0.36)* | -0.37 (0.31) | -0.26 (0.55) | -0.31 (0.62) |
| Past, present and future | 13.24 (0.41)* | 0 (0.34) | 0.73 (0.63) | -0.06 (0.70) |
| Social participation | 14.28 (0.40)* | -0.46 (0.34) | 1.33 (0.59) | 0.67 (0.70) |
| Death and dying | 12.00 (0.73)* | 0.89 (0.51) | 0.82 (1.09) | 0.01 (1.05) |
| Intimacy | 8.20 (0.80)* | 0.35 (0.55) | 6.66 (1.11)* | -1.55 (1.11) |
| Total WHOQOL-OLD score | 77.18 (1.86)* | 0.23 (1.29) | 10.10 (2.62)* | -1.82 (2.61) |

* $p<0.01$

Exercise training programmes have a positive impact on older people's QoL. A 12-week Pilates training programme significantly decreased depression symptoms in older people.[31] An aqua fitness and Pilates training programme improved WHOQOL-BREF and -OLD scales for physical fitness, autonomy, and social participation.[32]

Despite the limited evidence for the impact of exercise training on QoL, the reduction of the psychological sub-score in all participants may have been influenced by the economic crisis between 2012 and 2015. Adults over 65 years faced a reduction in social and health care support, including cuts to retirement pensions and an increase in direct and indirect taxes. Older people tended to feel disgusted and neglected and showed higher levels of perceived stress and lower levels of self-esteem and self-confidence that may have influenced their perceived QoL.

Evidence for such an impact has been described in a study of a dance programme in older women.[33] The overall QoL score was significantly higher in married women, with a good financial position and without chronic diseases.[33] Additionally, no substantial improvement was noted in women living alone or with low health and economic status.[33] Psychosocial interventions, not just physical activity by itself, can improve QoL in specific contexts, increase social interaction, self-esteem, self-confidence, and avoid social withdrawal.[33]

A limitation to our study was that it was not representative of the entire population of Portugal. Only older participants from Funchal City, Madeira

Island were included. The limited results in QoL dimension may have been influenced by the various levels of literacy in the community. The older adult literacy rate is relatively low in Madeira and may have influenced the answers to the questionnaires.[34]

## CONCLUSION

Regular exercise positively affected older people's MetS markers, in particular increasing HDL cholesterol levels and decreasing glucose levels. In the intervention group, the psychological domain of WHOQOL-BREF decreased and the intimacy domain and the total WHOQOL-OLD score increased but the differences were not only due to exercise participation.

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