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Correlates of health-related quality of life in young-old and old–old community-dwelling older adults

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Abstract
Purpose This study aimed (1) to examine the role of potential correlates of HRQoL in a large representative sample of older adults, and (2) to investigate whether the relationships between HRQoL and potential factors differ as a function of HRQoL component (physical vs. mental) and/or age cohort (young-old vs. old–old).
Methods This cross-sectional study included 802 older adults aged 60–79 years old. HRQoL was assessed using the SF-36 questionnaire. Functional fitness was assessed using the Senior Fitness Test. Physical activity was measured via the Baecke questionnaire. Demographic information, mental and health features were obtained through questionnaires.
Results A multiple regression analysis showed that BMI ($\beta = -0.15$, $p = 0.001$), body strength ($\beta = 0.21$, $p < 0.001$), aerobic endurance ($\beta = 0.29$, $p < 0.001$), physical activity ($\beta = 0.11$, $p = 0.007$), depressive symptoms ($\beta = -0.19$, $p < 0.001$), falls ($\beta = -0.19$, $p < 0.001$), and living alone ($\beta = -0.16$, $p < 0.001$) were all significantly related to HRQoL-SF-36 total score. The positive relation with aerobic endurance was significantly higher for the physical component of HRQoL, while the negative relation with living alone was significantly higher for the mental component. The positive relation of HRQoL with physical activity was significantly higher in old–old compared to young-old adults.
Conclusion This data suggest that body composition, functional fitness, psycho-social factors, and falls are important correlates of HRQoL in old age. There are HRQoL-component and age-cohort differences regarding these correlates, underlying the need for specific strategies at the community level to promote HRQoL in older adults.

Keywords Health · Quality of life · Functional fitness · Lifestyle · Old age

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Introduction

Over the past decades, quality of life has been assumed as a critical predictor of successful aging in gerontological research [1, 2]. However, its definition is not consensual. Various constructs of quality of life as well as different core dimensions have been addressed in the literature [3].

In this study, we approach quality of life from a health perspective, focusing on health-related quality of life

(HRQoL). Two major domains underpin HRQoL research: functioning and subjective wellbeing [4], however, different sub-dimensions have been considered. The Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36) [5] is the most widely used HRQoL assessment instrument, in both large population-based surveys and clinical settings [6], and is reported to have a strong relationship to global measures of life satisfaction [7]. Two main components of this multidimensional scale are described: physical and mental. The physical component includes the physical function, role physical, bodily pain, and general health dimensions. The mental component includes the vitality, social function, role emotional, and mental health dimensions [5]. A global score is derived from the sum of these two components, estimating an individual's perception of global HRQoL.

Many factors are known to affect HRQoL. First, cross-sectional and longitudinal studies have identified several factors that play a detrimental role for HRQoL in older adults. For instance, obesity [characterized by the excessive body weight (Body Mass Index (BMI) $\geq$ 30 kg m^2)] is associated to numerous chronic diseases, including cardiovascular disease [8], type 2 diabetes mellitus [9], many forms of cancer [10], and numerous musculoskeletal problems [11]. Overall, obesity is known to have a great impact on both physical function and quality of life [12–16]. Likewise, significant associations between depressive symptoms [17, 18] and social isolation (living alone) [19] with a poorer quality of life in older adults have been found, independently of the assessment instrument used. Yet, within the detrimental factors for HRQoL in older adults, falls and its derived consequences have been considered as major health problems, predicting a long-term reduction in HRQoL, independently of a variety of coexisting conditions and chronic diseases [20, 21]. Another risk factor for physical and mental components of HRQoL is sedentary behaviour, which refers to activities that do not increase energy expenditure substantially above the resting level (i.e. 1.0–1.5 metabolic equivalent units, such as sleeping, sitting, lying down, and watching television or other forms of screen-based entertainment) [22]. As people grow older, they generally become less active due a large of variety of clinical factors. This represents a negative spiral leading to an increase in sedentary behaviours, loss of autonomy and reduction in the quality of life [23–25].

With respect to beneficial factors for self-reported HRQoL, several studies have shown positive effects of high levels of physical activity [3, 26–28] and better functional fitness, such as aerobic endurance [26, 28, 29], muscular strength/endurance [26, 27, 30], and motor ability (i.e., power, speed, agility, balance) [27, 29–31]. Both physical activity and functional fitness are linked to the older adults' ability to safely and independently perform their activities of daily living (e.g., walking, bathing, dressing, shopping, and participation in sports and recreational activities) and to the ability to do the things they want, without pain, for as long as possible [32]. Since physical activity and functional fitness are considered two of the most important factors affecting HRQoL of older adults [1] and they are modifiable, a detailed knowledge about these associations is important, as basis for designing effective intervention programs in the prevention of HRQoL decline.

Although several studies have addressed HRQoL, a better understanding of its relationships is still needed. First, the relationships between HRQoL and several modifiable risk factors are still under discussion due to the complexity of the concept and to the use of different instruments, expressing different views of HRQoL core dimensions [3]. Second, besides the frequent approach to HRQoL core dimensions, the relationships between correlates of HRQoL and its sub-components have been rarely examined. A third point is related to age-specific trajectories of HRQoL. Since steeper declines in HRQoL have been identified in the oldest old [18], detailed knowledge on the moderating effect of age in HRQoL is important to design effective interventions, specially tailored for young-old or old–old adults. On this basis, age-specific correlates of HRQoL need to be further studied.

To contribute to a deeper understanding of these points, our main objectives were: (1) to examine the role of potential correlates of HRQoL in a large representative sample of older adults, and (2) to investigate whether the relationships between HRQoL and potential factors differ as a function of HRQoL component (physical vs. mental) and/or age cohort (young-old vs. old–old).

Methods

Participants

This cross-sectional study included 802 participants, similarly distributed over two age cohorts (60–69 years, young-old group, and 70–79 years, old–old group). The age cohort classification was based on life expectancy in the Autonomous Region of Madeira, which was between 72.67 for men and 79.74 years for women, and 76.54 for both [33]. Proportional regional (geographic) representation was determined by stratified sampling based on Census 2001 data from the Portuguese Statistics National Institute [34] with age cohort and sex serving as stratification variables. In this study, the total sample comprised 2.1% of the older adults residing in the Autonomous Region of Madeira (60–79 years). Participants were volunteers recruited between August and December 2008 through direct contacts carried out in day-care and social centres,

cultural and sport clubs and associations, and residential and public places (e.g., open markets, municipal gardens, and churches). The study was also advertised in the daily newspaper and on local radio and television.

Inclusion criteria were: (1) being community-dwelling; (2) age between 60 and 79 years; and (3) to be able to walk independently. Exclusion criteria were: (1) any medical contraindications to sub-maximum exercise according to the guidelines of the American College of Sports Medicine [35]; and (2) inability to understand and follow the assessment protocol of the study. The study was approved by the Scientific Commission of the Department of Physical Education and Sports of the University of Madeira, the Regional Secretary of Education and Culture, and the Regional Secretary of Social Affairs. Informed consent was provided by all participants before the assessments and this study included adherence to the declaration of Helsinki. All assessments were conducted between September 2008 and July 2009 in the Laboratory of Human Physical Growth and Motor Development at the University of Madeira.

Materials

HRQoL

HRQoL was assessed using the 36-item Short-Form Health Survey (SF-36; Ware and Sherbourne [5]; Portuguese version by Ribeiro [7]). The SF-36 includes eight dimensions: physical functioning (PF), role physical (RP), bodily pain (BP), general health (GH), vitality (VT), social functioning (SF), role emotional (RE), and mental health (MH). Scores of each dimension range from 0 to 100, with higher scores indicating better HRQoL. Two major components can be obtained by sum scores: (1) physical component (PF + RP + BP + GH) and (2) mental component (VT + SF + RE + MH), with scores ranging from 0 to 400. In this study, the Cronbach's alpha coefficient was 0.728 and 0.729 for the physical and the mental component, respectively. Total SF-36 score can be obtained by a sum score: physical component + mental component, with scores ranging from 0 to 800.

Physical activity

Physical activity was assessed in face-to-face interviews using the Baecke questionnaire [36]. This questionnaire includes a total of 16 questions classified into three specific domains: physical activity at work/household activities (HS), sport, and leisure time. Composite indices for physical activity were calculated for the three domains as well as an overall physical activity composite measure that was used for further analysis.

Functional fitness and body composition

Functional fitness components were assessed using the Senior Fitness Test (SFT). Body strength was assessed using the arm curl test and aerobic endurance was assessed using the 6-min-walk test [32]. Participants completed one trial to become familiarized with the tasks. The 6-min-walk test was administered after all other tests and questionnaires had been completed. Body mass index was calculated from weight and height (kg/m^2). Height was recorded accurate to 1 mm with a portable stadiometer (Siber-Hegner, GPM). Body mass was measured on a balance-beam scale accurate to 0.1 kg (Seca Optima 760, Germany).

Health and demographic questionnaires

Health (history of depression and falls during the last year) and demographic information (age, living alone) were obtained with a sociodemographic questionnaire.

Statistical analyses

The SF-36 scale's internal consistency was verified using the Cronbach's alpha coefficient. Descriptive characteristics of participants were reported as means ± SDs, for the two age groups: 60–69 years (young-old); and 70–79 years (old–old). Independent-samples *t* tests were used to compare the mean scores of the two age groups and chi-square tests to compare sample proportions.

Bivariate relations of physical and mental components of HRQoL and SF-36 total score to health-related parameters and lifestyle variables were investigated (for the overall sample) using Pearson product-moment correlation coefficients *r*.

We used Standard multiple regression (MLR) analysis to examine the independent contribution of the predictors (BMI, body strength, aerobic endurance, physical activity, falls, depressive symptoms, and living alone) to HRQoL measured with SF-36 total score. To investigate relationships in subsequent analyses, we additionally entered age group (young-old vs. old–old) and HRQoL component (physical vs. mental) as moderators and investigated interactive effects of these moderators with the predictors. These additional analyses allowed knowing whether the relationships between HRQoL and the predictors differ between young-old and old–old age groups and between the physical and mental component. All analyses were performed with the R environment [37].

Results

Descriptive statistics

In this study, the total sample comprised 401 males and 401 females, mean age = 69.8 years, SD = 5.6, similarly distributed over the two age cohorts (young-old group, mean age = 65.1 years, SD = 2.9; and old–old group, mean age = 74.8 years, SD = 2.8).

Means and standard deviations for HRQoL, health-related parameters, lifestyle variables, and clinical co-morbid conditions by age group (young-old vs. old–old) are presented in Table 1. We found a significantly lower score in old–old compared to young-old adults in the physical component of HRQoL (physical function, role physical, and general health; $p < 0.001$), in the mental component of HRQoL (vitality, role emotional, and mental health; $0.001 < p < 0.041$), and SF-36 total score ($p < 0.001$). Similar results were found for the physical activity dimensions (work/household; sport, and leisure time) and the physical activity total score ($0.001 < p < 0.038$), as well as for functional fitness parameters (body strength and aerobic endurance; $p < 0.001$). Additionally, old–old adults took more medication ($p = 0.007$) and had more CVD risk factors in comparison to the young-old group ($p < 0.001$). In old–old compared to young-old adults, the proportion of individuals living alone was significantly higher ($p < 0.001$). No other significant differences were found between age groups (see Table 1).

Bivariate relations of physical and mental components of HRQoL and SF-36 total score to health-related parameters and lifestyle variables

As apparent in Table 2, there was a significant negative correlation between HRQoL and age, BMI, depressive symptoms, falls, and living alone in both physical ($-0.24 < r < -0.14$, $ps < 0.001$) and mental ($-0.24 < r < -0.19$, $ps < 0.001$) components. There was also a significant positive correlation between HRQoL

Table 1 Descriptive statistics and age group (young-old vs. old–old) differences in HRQoL, health-related parameters, and lifestyle variables

	Young-old $M \pm SD$ ($N = 412$)	Old–old $M \pm SD$ ($N = 390$)	p
Age (years)	65.1 ± 2.9	74.8 ± 2.8	<0.001
PF (0–100)	75.3 ± 23.0	66.1 ± 24.3	<0.001
RP (0–100)	80.0 ± 37.3	69.1 ± 41.6	<0.001
BP (0–100)	66.5 ± 30.0	62.6 ± 29.3	0.066
GH (0–100)	54.4 ± 16.7	49.5 ± 15.4	<0.001
PC (0–400)	276.1 ± 83.0	247.3 ± 85.4	<0.001
VT (0–100)	59.0 ± 19.2	53.8 ± 17.8	<0.001
SF (0–100)	89.2 ± 18.4	88.3 ± 18.8	0.479
RE (0–100)	82.2 ± 35.1	76.9 ± 37.9	0.041
MH (0–100)	63.0 ± 19.1	60.1 ± 17.7	0.029
MC (0–400)	293.4 ± 71.7	279.1 ± 72.3	0.005
SF-36 total score (0–800)	569.5 ± 140.8	526.5 ± 143.7	<0.001
BMI (kg/m^2)	29.5 ± 4.5	29.5 ± 4.2	0.898
ACT (n)	17.1 ± 4.2	15.4 ± 3.8	<0.001
MWT6 (m)	521.2 ± 108.0	456.9 ± 115.6	<0.001
PA work/household index (1–5 units)	2.7 ± 0.6	2.6 ± 0.5	0.001
PA sport index (1–5 units)	2.2 ± 0.6	2.1 ± 0.6	0.009
PA leisure time index (1–5 units)	2.5 ± 0.6	2.4 ± 0.6	0.038
PA total score (3–15 units)	7.5 ± 1.2	7.1 ± 1.2	0.001
Medication (n)	3.3 ± 2.6	3.8 ± 2.4	0.007
CVD risk factors (n)	1.9 ± 1.3	2.5 ± 1.4	<0.001
Depression (%)	26.3	20.5	0.105
Fallers (%)	36.0	36.7	0.928
Liv. Alone (%)	11.9	22.8	<0.001

p values are results from independent-samples t tests comparing the mean scores in young-old vs. old–old adults and of chi-square tests comparing sample proportions

PF physical function, *RP* role physical, *BP* bodily pain, *GH* general health, *PC* physical component, *VT* vitality, *SF* social function, *RE* role emotional, *MH* mental health, *MC* mental component, *BMI* body mass index, *ACT* arm curl test, *MWT6* 6-miniute walk test, *PA* physical activity, *Liv. Alone* living alone

Table 2 Pearson correlations between HRQoL, health-related parameters, and lifestyle variables

HRQoL	PC	MC	Total score
Age (years)	−0.21***	−0.13***	−0.19***
BMI (kg/m^2)	−0.20***	−0.15***	−0.19***
ACT (*n*)	0.36***	0.29***	0.36***
MWT6 (m)	0.51***	0.37***	0.49***
PA total score (3–15)	0.28***	0.20***	0.27***
Depression (0/1)	−0.19***	−0.22***	−0.22***
Fallers (0/1)	−0.24***	−0.19***	−0.24***
Living Alone (0/1)	−0.14***	−0.23***	−0.20***

PC SF-36 physical component, *MC* SF-36 mental component, *Total score* SF-36 total score, *BMI* body mass index, *ACT* arm curl test, *MWT6* 6-min-walk test, *PA* physical activity, *Fallers (0/1)* 0 = no falls, 1 = falls, *Depression (0/1)* 0 = no depressive symptoms, 1 = depressive symptoms, *Living Alone (0/1)* 0 = living with others, 1 = living alone

***$p < 0.001$

variables and body strength, aerobic endurance, and physical activity in both physical ($0.28 < r < 0.51$, $ps < 0.001$) and mental ($0.20 < r < 0.37$, $ps < 0.001$) components.

Examining the correlates of HRQoL

Simultaneously considering all variables in the multiple regression model, BMI ($\beta = -0.15$, $p = 0.001$), body strength ($\beta = 0.21$, $p < 0.001$), aerobic endurance ($\beta = 0.29$, $p < 0.001$), physical activity ($\beta = 0.11$, $p = 0.007$), depressive symptoms ($\beta = -0.19$, $p < 0.001$), falls ($\beta = -0.19$, $p < 0.001$), and living alone ($\beta = -0.16$, $p < 0.001$) were all significantly related to HRQoL-SF-36 total score.

We further investigated whether these relation patterns were universal or whether they differed between the physical and the mental component of HRQoL. Thereby, considering physical vs. mental component of HRQoL as moderator in the multiple regression model, we found a significant interaction of HRQoL component with aerobic endurance ($\beta = 0.09$, $p = 0.026$) and also with living status ($\beta = -0.08$, $p = 0.037$). We did not find any other significant two-way interactions of the predictors with HRQoL component ($ps > 0.060$). To investigate the differential HRQoL patterns in more detail, we inspected the relations of the predictors with HRQoL in multiple regressions separately for the physical and the mental component of HRQoL. There was a significant effect of all variables on the physical component of HRQoL, with aerobic endurance being the strongest predictor ($\beta = 0.32$, $p < 0.001$) and living alone being the weakest (but significant) predictor ($\beta = -0.09$, $p = 0.035$). In contrast, regarding the mental component of HRQoL, aerobic endurance showed a smaller relation ($\beta = 0.19$, $p < 0.001$) and living alone emerged to be the strongest predictor ($\beta = -0.20$, $p < 0.001$). Together with the previously reported interaction effects, this suggests that the positive relation to aerobic endurance was significantly higher for physical (compared to mental) HRQoL, while the negative relation to living alone was significantly stronger for mental (compared to physical) HRQoL.

Finally, we investigated whether relationships differed between young-old and old–old adults. Thereby, considering age group as moderator in the multiple regression, we found a significant interaction of physical activity with age group ($\beta = 0.09$, $p = 0.030$), indicating that the effect of physical activity on HRQoL significantly differed between young-old and old–old adults. There were no other significant two-way interactions of the predictors with age group, nor any significant three-way interactions of the predictors, HRQoL component, and age group ($ps > 0.225$). To investigate the differential age patterns in more detail, we inspected the relations of the predictors with HRQoL-SF-36 in multiple regressions separately for young-old and old–old adults. In young-old adults, all variables were significantly related to HRQoL- SF-36 total score ($-0.11 < \beta < 0.26$, $ps < 0.047$), except for physical activity ($\beta = 0.03$, $p = 0.529$). In contrast, in the old–old group, physical activity ($\beta = 0.20$, $p < 0.001$) and all other variables ($-0.13 < \beta < 0.30$, $ps < 0.030$) were significantly related to HRQoL-SF-36 total score. Together with the previously reported interaction effect, this suggests that the positive relation of HRQoL to physical activity was significantly higher in old–old compared to young-old adults.

Discussion

The relationship between HRQoL and its potential predictors, considering physical and mental HRQoL components and age group differences, has been scarcely studied in previous research. In this study, lower scores in the physical and mental components of HRQoL and SF-36 total score were found in old–old, when compared to young-old people. These results are in line with those presented by Zaninotto et al. [18], who described age-specific trajectories of quality of life.

Consistent with previous research on the topic, we found that BMI, body strength, aerobic endurance, physical activity, depressive symptoms, falls and living alone were significant predictors of HRQoL in older adults from the Autonomous Region of Madeira. Notably, when we investigated whether these relationships differed between HRQoL components and age groups, interesting results emerged, which are discussed in the following.

Starting with the physical factors, in this study BMI was negatively associated with the SF-36 total score and with both physical and mental components of HRQoL.

This findings contrast with those of a recent study in Italian older adults. Giuli et al. [13] have found that BMI was negatively associated with the physical component of SF-36, while no significant association was seen for the mental component. However, our results are consistent with those reported by Ozcan et al. [16], who used SF-12 to measure HRQoL in a cross-sectional study of 52 men and 64 women aged 65–90 years old. These authors found that as BMI increased, physical health component, mental health and general health perceptions decreased. Further supporting this idea, longitudinal data from the UK have also shown that non-obese older women reported higher HRQoL, when compared with obese [15]. Overall, together with these studies, our findings reinforce the idea that strategies to prevent high BMI in older adults can be relevant when aiming to maintain or improve older adults' physical and mental HRQoL.

In our study, upper body strength and aerobic endurance were positively and significantly correlated with the physical and mental HRQoL components, as well as, with the SF total score. In a more detailed approach, we found that the significant association between upper body strength and aerobic endurance with HRQoL remained strong when being controlled for age.

Furthermore, the effect of aerobic endurance on HRQoL differed between the physical and mental component and subsequent analyses revealed that it represented the strongest positive predictor of the physical component of HRQoL. Other studies have failed to identify such clear relationships. For example, Wanderley et al. [26] found that individuals with higher upper body strength and aerobic endurance were more likely to score higher on specific sub-dimensions of HRQoL components: role physical, vitality and mental health. However, they did not find significant associations between upper body strength nor aerobic endurance with body pain, general health, role emotional, and social function dimensions. Similar results were seen by Sayer et al. [38] in 2987 community-dwelling men and women (59–73 years old). These authors observed a positive association between upper body strength and HRQoL in general health and physical function sub-dimensions only. These findings again suggest that multidimensional interventions to promote HRQoL at the community level should target aerobic endurance.

This study has also revealed a positive association between physical activity and SF-36 total score and both the physical and mental component. Considering the available literature about this issue, high levels of physical activity have been associated in general with better self-reported HRQoL [25–28, 39, 40]. Dale et al. [15], in a longitudinal study in the UK, concluded that physical activity was the strongest lifestyle predictor for HRQoL. In a more specific view, the study developed by Wanderley et al. [26] found that physical activity was positively associated with self-reported physical function, role physical, and vitality. In this research, we found a significant interaction of physical activity and age group, indicating an age moderation effect. Subsequent analyses indicated that the positive effect of physical activity on HRQoL was significantly larger in old–old, when compared to young-old adults. Importantly, this suggests that increasing physical activity may lead to improvements in HRQoL, particularly in old–old people, a group for which rather secondary goals, such as adjusting (i.e., reducing) personal life goals and standards, had been suggested over the primary goal of staying active. This results suggest that possibly the opposite may be required.

Following up on our results, a conceptually and practically interesting question is whether older adults with cardiac conditions would be able to participate in the same levels of physical activity compared to those without issues. With respect to our data, additional control analyses showed that the observed relations were not moderated by the number of CVD risk factors or the number of medications taken. This may suggest that physical activity seems to play a crucial role for quality of life even in a broader study population in terms of health risks. Thus, staying active may be fundamental for everybody in old age. Following up on that latter issue, future longitudinal and intervention research might investigate whether certain chronic conditions change the type of community interventions to promote quality of life in older adults.

In this study, self-reported depressive symptoms were negatively associated with the SF-36 total score and both the physical and the mental component. This is in line with the results of several studies, developed in different contexts [13, 17, 20, 41]. Since a better understanding about the relationships between HRQoL and psycho-social variables is still necessary, we argue that these relations should be further studied from a mixed-methods approach.

Regarding falls, in this study these were negatively associated with the SF-36 total score and with both the physical and the mental component. These findings confirm several other studies. For example, in a large cross-sectional study in Germany, Thiem et al. [20] reported a negative association between falls and HRQoL, controlling for a large number of covariates and potential confounders, including fear of falling and depressive mood. Similarly, longitudinal data collected by Stenhagen et al. [21] concluded that falls suggest a long-term reduction in the physical component of HRQoL in the older population. Again, the results of this study advocate the importance of fall-prevention interventions at the community level for enhancing HRQoL.

Finally, this study has shown that living alone was negatively associated with the SF-36 total score and both the physical and mental component. In addition, the effect of living alone on HRQoL differed between the physical and

mental component, and subsequent analyses revealed that it was the strongest negative predictor of the mental component of HRQoL. In line with our data, other studies in older adults from Iran [42] and UK [18, 19] have found a better perception of HRQoL in older adults living with others, when compared to those living alone. Our results reinforce the view that living alone may be a risk factor for lower HRQoL in older adults, especially regarding its mental component. Again, it seems that preventive strategies to avoid living alone at the community level can contribute to better HRQoL perceptions.

Concerning the latter notions, we acknowledge that the cross-sectional design of this study limits conclusions regarding the direction of the relationships between the identified predictor variables and HRQoL. However, in this study, high relevance was given to potentially modifiable factors of HRQoL so that this findings may be considered in the design of future research, specially focused on community-based interventions to enhance older adults' HRQoL.

The main strengths of this study are the large representative sample of young-old and old–old men and women from the Autonomous Region of Madeira and the large amount of data collected on variables associated with HRQoL in old age.

In conclusion, this study showed that there were significant differences in HRQoL between young-old and old–old adults from the Autonomous Region of Madeira. BMI, body strength, aerobic endurance, physical activity, depressive symptoms, falls and living alone were significant predictors of HRQoL in this population.

Significant interactions between HRQoL component and aerobic endurance and living alone were found. A positive relation between aerobic endurance was significantly higher for the physical HRQoL component and a negative relation to living alone was significantly stronger for the mental HRQoL component. Finally, a significant interaction between age cohort and physical activity was found. A positive effect of physical activity on HRQoL was significantly larger in old–old adults.

Nowadays, great importance is given to research on the effect of specific community-based interventions towards older adults. However, it has been suggested that the development of interventions should be based on the results of large scale correlational studies, such as this one. A deep understanding of the relationships between HRQoL and its determinants is important to define a targeted intervention, with higher possibility of efficacy. This study specifically suggests that interventions for improving older adults' HRQoL demand a multidimensional approach, in which the prevention of obesity, social isolation, depressive symptoms, and falls, as well as, the promotion of functional fitness and physical activity play a key role. Yet, further longitudinal research is still needed to enhance and confirm the available knowledge on the topic and prospectively predict HRQoL in old age.

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Compliance with ethical standards

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Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures were in accordance with the ethical standards of an institutional research committee and with the 1964 Helsinki declaration and its later amendments.

Informed consent Informed consent was obtained from all individual participants included in the study.

References

1. Spirduso, W.W., Francis, K.L., & MacRae, P.G. (2005). *Physical dimensions of aging. Second* Edition. Champaign IL, Human Kinetics, Inc.
2. Kerschner, H., & Pegues, J. M. (1998). Productive aging: a quality of life agenda. *Journal of the American Dietetic Association, 98*(12), 1445–1448.
3. Rejeski, W. J., & Mihalko, S. L. (2001). Physical activity and quality of life in older adults. *The journals of gerontology. Series A, Biological sciences and medical sciences, 56*(2), 23–35.
4. Stewart, A. L., & King, A. C. (1991). Evaluating the efficacy of physical activity for influencing quality-of-life outcomes in older adults. *Annals of behavioral medicine, 13*(3), 108–116.
5. Ware, J. E., & Jr, Sherbourne, C.D (1992). The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. *Medical care, 30*(6), 473–483.
6. Hart, P. D., Kang, M., Weatherby, N. L., Lee, Y. S., & Brinthaupt, T. M. (2015). Systematic Review of Health-Related Quality of Life Assessments in Physical Activity Research. *World Journal of Preventive Medicine, 3*(2), 28–39. doi:10.12691/jpm-3-2-3.
7. Ribeiro, J.P. (2005). *O importante é a saúde: estudo de adaptação de uma técnica de técnica de avaliação do estado de saúde SF-36*. Lisboa, Merck Sharp & Dolme.
8. Dhana, K., Berghout, M. A., Peeters, A., Ikram, M. A., Tiemeier, H., Hofman, et al. (2016). Obesity in older adults and life expectancy with and without cardiovascular disease. *International Journal of Obesity, 40*(10), 1535–1540. doi:10.1038/ijo.2016.94.

9. Janssen, I. (2007). Morbidity and mortality risk associated with an overweight BMI in older men and women. *Obesity, 15*(7), 1827–1840.
10. Wolin, K. Y., Carson, K., & Colditz, G. A. (2010). Obesity and cancer. *The Oncologist, 15*(6), 556–565. doi:10.1634/theoncologist.2009-0285.
11. Anandacoomarasamy, A., Caterson, I., Sambrook, P., Fransen, M., & March, L. (2008). The impact of obesity on the musculoskeletal system. *International Journal of Obesity, 32*(2), 211–222.
12. Thompson, D., Edelsberg, J., Colditz, G. A., Bird, A. P., & Oster, G. (1999). Lifetime health and economic consequences of obesity. *Archives of Internal Medicine, 159*(18), 2177–2183.
13. Giuli, C., Papa, R., Bevilacqua, R., Felici, E., Gagliardi, C., Marcellini, F., et al. (2014). Correlates of perceived health related quality of life in obese, overweight and normal weight older adults: an observational study. *BioMed Central Public Health, 15*(14), 35. doi:10.1186/1471-2458-14-35.
14. Goins, R. T., Spencer, S. M., & Krummel, D. A. (2003). Effect of obesity on health-related quality of life among Appalachian elderly. *Southern Medical Journal, 96*(6), 552–557.
15. Dale, C. E., Bowling, A., Adamson, J., Kuper, H., Amuzu, A., Ebrahim, S., et al. (2013). Predictors of patterns of change in healthrelated quality of life in older women over 7 years: evidence from a prospective cohort study. *Age and Ageing, 42*(3), 312–318. doi:10.1093/ageing/aft029.
16. Ozcan, A., Donat, H., Gelecek, N., Ozdirenc, M., & Karadibak, D. (2005). The relationship between risk factors for falling and the quality of life in older adults. *BioMed Central Public Health, 26*(5), 90.
17. Sivertsen, H., Bjørkløf, G. H., Engedal, K., Selbæk, G., & Helvik, A. S. (2015). Depression and Quality of Life in Older Persons: A Review. *Dementia and Geriatric Cognitive Disorders, 40*(5–6), 311–339. doi:10.1159/000437299.
18. Zaninotto, P., Falaschetti, E., & Sacker, A. (2009). Age trajectories of quality of life among older adults: results from the English Longitudinal Study of Ageing. *Quality of Life Research: an International Journal of Quality of Life Aspects of Treatment, Care and Rehabilitation, 18*(10), 1301–1309.
19. Hawton, A., Green, C., Dickens, A. P., Richards, S. H., Taylor, R. S., Edwards, R., et al. (2011). The impact of social isolation on the health status and health-related quality of life of older people. *Quality of Life Research: an International Journal of Quality of Life Aspects of Treatment, Care and Rehabilitation, 20*(1), 57–67. doi:10.1007/s11136-010-9717-2.
20. Thiem, U., Klaaßen-Mielke, R., Trampisch, U., Moschny, A., Pientka, L., & Hinrichs, T. (2014). Falls and EQ-5D rated quality of life in community-dwelling seniors with concurrent chronic diseases: a cross-sectional study. *Health and Quality of Life Outcomes, 8*(12), 2. doi:10.1186/1477-7525-12-2.
21. Stenhagen, M., Ekström, H., Nordell, E., & Elmståhl, S. (2014). Accidental falls, health-related quality of life and life satisfaction: a prospective study of the general elderly population. *Archives of Gerontology and Geriatrics, 58*(1), 95–100. doi:10.1016/j.archger.2013.07.006.
22. Pate, R. R., O'Neill, J. R., & Lobelo, F. (2008). The evolving definition of "sedentary". *Exercise and Sport Sciences Reviews, 36*(4), 173–178. doi:10.1097/JES.0b013e3181877d1a.
23. Emerson, R. W., Satcher, D., & Carmona, R. H. (2015). Physical Activity and special Populations. In R. K. Dishman, G. W. Heath & I. Lee (Eds.), *Physical Activity Epidemiology* (pp. 219–240). Champaign, IL: Human Kinetics.
24. Meneguci, J., Sasaki, J. E., Santos, A., Scatena, L. M., & Damião, R. (2015). Sitting time and quality of life in older adults: A population-based study. *Journal of Physical Activity and Health, 12*(11), 1513–1519. doi:10.1123/jpah.2014-0233.
25. Rosenkranz, R. R., Duncan, M. J., Rosenkranz, S. K., & Kolt, G. S. (2013). Active lifestyles related to excellent self-rated health and quality of life: cross sectionalfindings from 194,545 participants in The 45 and Up Study. *BioMed Central Public Health, 13*(13), 1071. doi:10.1186/1471-2458-13-1071.
26. Wanderley, F. A., Silva, G., Marques, E., Oliveira, J., Mota, J., & Carvalho, J. (2011). Associations between objectively assessed physical activity levels and fitness and self-reported health-related quality of life in community-dwelling older adults. *Quality of Life Research: an International Journal of Quality of Life Aspects of Treatment, Care and Rehabilitation, 20*(9), 1371–1378. doi:10.1007/s11136-011-9875-x.
27. Haider, S., Luger, E., Kapan, A., Titz, S., Lackinge, C., Schindle, K. E., et al. (2016). Associations between daily physical activity, handgrip strength, muscle mass, physical performance and quality of life in prefrail and frail community-dwelling older adults. *Quality of Life Research: an International Journal of Quality of Life Aspects of Treatment, Care and Rehabilitation*. doi:10.1007/s11136-016-1349-8.
28. Stewart, K. J., Turner, K. L., Bacher, A. C., DeRegis, J. R., Sung, J., Tayback, M., et al. (2003). Are fitness, activity, and fatness associated with health-related quality of life and mood in older persons? *Journal of Cardiopulmonary Rehabilitation, 23*(2), 115–121.
29. Olivares, P. R., Gusi, N., Prieto, J., & Hernandez-Mocholi, M. A. (2011). Fitness and health-related quality of life dimensions in community-dwelling middle aged and older adults. *Health and Quality of Life Outcomes, 22*(9), 117. doi:10.1186/1477-7525-9-117.
30. Takata, Y., Ansai, T., Soh, I., Awano, S., Yoshitake, Y., Kimura, Y., et al. (2010). Quality of life and physical fitness in an 85-year-old population. *Archives of Gerontology and Geriatrics, 50*(3), 272–276. doi:10.1016/j.archger.2009.04.005.
31. Lin, C. C., Li, C. I., Chang, C. K., Liu, C. S., Lin, C. H., Meng, N. H., et al. (2011). Reduced health-related quality of life in elders with frailty: a cross sectional study of community-dwelling elders in Taiwan. *Public Library of Science one, 6*(7), e21841. doi:10.1371/journal.pone.0021841.
32. Rikli, R. E., & Jones, C. J. (2001). *Senior fitness test manual. Development and validation of a functional fitness test for community-residing older adults*. Champaign, IL: Human Kinetics.
33. Instituto Nacional de Estatística (2014). *Estatísticas Demográficas 2013*. Lisboa, Instituto Nacional de Estatística, I.P. Eds.
34. Instituto Nacional de Estatística: Census 2001. (2002). *Resultados Definitivos*. Lisboa, Instituto Nacional de Estatística, I.P. Eds.
35. American College of Sports Medicine (2006). *ACSM's guidelines for exercise testing and prescription* (7th edn.). Philadelphia: Lippincott Williams & Wilkins.
36. Baecke, J., Burema, J., & Frijters, J. (1982). A short questionnaire for the measurement of habitual physical activity in epidemiological studies. *The American Journal of Clinical Nutrition, 36*(5), 936–942.
37. R Core Team (2014). *R: A language and environment for statistical computing*. Vienna, Austria R Foundation for Statistical Computing.
38. Sayer, A. A., Syddall, H. E., Martin, H. J., Dennison, E. M., Roberts, H. C., & Cooper, C. (2006). Is grip strength associated with health-related quality of life? Findings from the Hertfordshire cohort study. *Age and ageing, 35*(4), 409–415.
39. Kelley, G. A., Kelley, K. S., Hootman, J. M., & Jones, D. L. (2009). Exercise and health-related quality of life in older community-dwelling adults: a meta-analysis of randomized controlled trials. *Journal of Applied Gerontology: the Official Journal of the Southern Gerontological Society, 28*, 369–394.

40. Balboa-Castillo, T., León-Muñoz, L. M., Graciani, A., Rodríguez-Artalejo, F., & Guallar-Castillón, P. (2011). Longitudinal association of physical activity and sedentary behavior during leisure time with health-related quality of life in community-dwelling older adults. *Health and Quality of Life Outcomes, 27*, 9–47. doi:10.1186/1477-7525-9-47.
41. Antunes, H. K., Stella, S. G., Santos, R. F., Bueno, O. F., & de Mello, M. T. (2005). Depression, anxiety and quality of life scores in seniors after an endurance exercise program. *Brazilian Journal of Psychiatry, 27*(4), 266–271.
42. Tajvar, M., Arab, M., & Montazeri, A. (2008). Determinants of health-related quality of life in elderly in Tehran, Iran. *BioMed Central Public Health, 22*(8), 323. doi:10.1186/1471-2458-8-323.