



Does fitness attenuate the relationship between changes in sitting time and health-related quality of life over time in community-dwelling older adults? Evidence from the EXERNET multicenter longitudinal study

O. López-Torres^{1,12} · B. del Pozo-Cruz² · B. Maroto-Sánchez¹ · S. Vila-Maldonado^{3,4} · A. Gómez-Cabello^{4,5,6,7,8} · M. Martín-García³ · A. González-Agüero^{6,7,8,9} · N. Gusi^{4,10} · L. Espino^{4,11} · J. A. Casajús^{6,7,8} · M. González-Gross^{1,8} · I. Ara^{3,4} · R. Pedrero-Chamizo¹

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Abstract

Objective To assess the relationship between fitness levels and components, sitting time and health-related quality of life (HRQoL), over time among community-dwelling older adults.

Methods Three different sitting trajectories were calculated: (i) no change; (ii) decrease; and (iii) increase in ST, between baseline and follow-up. Fitness was assessed using the aerobic capacity, upper and lower limb strength, and total fitness. Participants were classified into higher (75th percentile or above) or lower (below 75th percentile) fitness levels, using the fitness tests. HRQoL scores at follow-up were compared to the three different sitting time trajectories within and across both the higher and the lower fitness groups for each of the three fitness indexes.

Results Greater HRQoL scores were observed in those participants that decreased their ST as compared with those increasing their sitting time over time for participants classified in the lower end of their aerobic capacity or total fitness index. No differences were detected in HRQoL scores in people classified in the higher fitness level group for any of the fitness indexes. Participants that increased or did not change their sitting time and who were classified in the higher fitness end of aerobic capacity and total fitness index self-reported higher HRQoL scores when compared with those in the lower fitness end.

Conclusion Increased sitting time over time is associated with poorer HRQoL in older adults. Higher fitness levels could help attenuate the negative impact of sitting over time.

Keywords Physical condition · Sedentary behavior · Well being · Elderly

Introduction

Health-related quality of life (HRQoL) is a multi-dimensional construct that reflects the self-perception of the impact of health status on the quality of life of an individual [1]. Clinicians and public health officials have used HRQoL to measure the effects of chronic diseases, treatment, and disability. In addition, HRQoL has been used to monitor the general health at population level or as a key measurement

in the planning and decision-making processes of health-related policies [2, 3]. With an increasing aging population, and the associated rises of chronic diseases and costs, improving HRQoL is a priority [4].

There is now compelling experimental evidence [5, 6], reviews and meta-analyses [7] providing solid arguments that physical activity [8, 9], most likely through physical fitness [10, 11], is a cost-effective health strategy in improving the HRQoL of the older population [12]. Nonetheless, physical activity levels and physical fitness levels are worryingly low among the older population in Spain [13].

On the other hand, sedentary behaviors, a group of waking behaviors characterized by very low energy expenditure that occur while sitting or lying down, in combination with the lack of moderate-to-vigorous physical activity (MVPA),

O. López-Torres and B. del Pozo-Cruz contributed equally to this work.

✉ O. López-Torres
olga.lopez@upm.es

Extended author information available on the last page of the article

have been recently identified as a risk factor for various cardiometabolic [14, 15] and premature mortality outcomes [16] in the older population. The scarce cross-sectional [5] and longitudinal [6] studies present in the literature that have analyzed the relationship between sedentary behavior, physical activity, and HRQoL confirm the harmful effect of sedentary behavior on the HRQoL of the older population. Fitness has been suggested to have a central role in modulating the relationship between sedentary behavior and different cardiometabolic and mortality outcomes. Sardinha et al. [17] in a recent study involving 66 adults with type two diabetes reported that the negative impact of sitting time may be counteracted by cardiorespiratory fitness. Similarly, Ekblom-Bak et al. [18] reported the moderating effect of high cardiorespiratory fitness in the relationship between objectively assessed sitting time and metabolic syndrome in a group of 2243 Swedish adults aged 50 to 65 years. Whether or not fitness level could also mediate the relationship between sitting time and HRQoL remains unknown.

Data from the population-based EXERNET multicenter study [13, 19] were used to assess the relationship between different fitness levels and components, sitting time and HRQoL over time among community-dwelling older adults in Spain. We hypothesized that increased sitting time in the period of the study will negatively affect HRQoL among older adults and that this association will be mediated by fitness.

Methods

Study design and sample

Data from “The EXERNET multicenter study” were used in this study. The protocol of the EXERNET study has been published elsewhere [19]. Briefly, the EXERNET study is composed of a representative sample of community-dwelling elderly Spanish people and has the main aim of characterizing the longitudinal fluctuations in physical fitness and lifestyle habits through aging. The information was collected through personal interviews using standard procedures and validated questionnaires followed by a physical examination to measure anthropometric and body composition characteristics and physical fitness. Data collection for the baseline assessment started in June 2008 and lasted 15 months. The participants were then contacted again in November 2011 to do a follow-up assessment, and all the follow-up assessment occurred over a 19-month period. An average time of 44.4 months elapsed from baseline to follow-up. The study was approved by the Research Ethics Committees of Aragón (Spain) (18/2008) and performed according to the principles established with the revised Declaration of Helsinki (1964) as revised in 2000 in Edinburgh. Written informed consent

was obtained from each participant before partaking in the study. For the purpose of this study, only data from a subsample of 1164 elderly Spanish people that provided a valid baseline and follow-up assessment were used.

Study variables

Health-related quality of life (HRQoL)

The EuroQol questionnaire (EQ-5D-3L) was used to assess the HRQoL of the participants of the study [20]. The EQ-5D-3L includes five dimensions (mobility, personal care, usual activities, pain/discomfort, and anxiety/depression), each of which has three levels: (1) no problems; (2) some problems; or (3) extreme problems/unable to. The juxtaposition of the levels for these five dimensions correlates to a five-digit number, which reflects 243 possible health status values. These health status values can be collapsed to a health functional index or a ‘utility,’ using time-trade off values (EuroQol utility; 1 = fully functional quality of life, 0 = death), thereby providing an overall numerical estimate of the HRQoL of the participants.

Sitting time trajectories

A validated single question (“How many hours do you usually spend sitting per day?”) was used to assess the sitting time of participants in the study [21]. The question covered any activity in which the person had to be sitting (i.e., watching television, reading, sewing, etc.) and it referred to the present time. Three different groups were made: (i) 0–2 h/day, (ii) 2–4 h/day, or (iii) > 4 h/day. The categories of sitting were based on previous studies [22] and the distribution of sitting time in our sample. In this study, a change in sitting time was considered when a participant transitioned from one sitting time category to another sitting time category between baseline and follow-up. Three different sitting time trajectories were calculated: (i) no change in sitting time between baseline and follow-up time (i.e., no transition between sitting categories during the study period); (ii) decreased sitting time between baseline and follow-up time (i.e., transitioning from one sitting category to a category defined by lower time spent sitting during the study period); and (iii) increased sitting time between baseline and follow-up (i.e., transitioning from one sitting category to a category defined by higher time spent sitting during the study period).

Physical fitness assessment

The following physical fitness components were assessed: lower and upper body strength by the chair stand test and arm curl test, respectively, and aerobic capacity using the 6-min walking test [23]. All tests were performed once. For

the purpose of the study, the z -scores of each of the three components were calculated and added to create a total fitness index. In addition, upper and lower body strength z -scores were added into a strength index. Therefore, three different fitness indexes were used in this study: (i) aerobic capacity; (ii) strength index; and (iii) total fitness index. Two different categories were created for each of the assessed fitness indexes: higher fitness, including those participants classified in the 75th percentile or above in the given test or index; and lower fitness, including participants classified below the 75th percentile in the given test or index.

Covariates

Baseline sociodemographics (i.e., income, education status, and marital status), body mass index (BMI), and body fat were used as covariates in the analyses performed in this study. In order to calculate BMI, weight was measured without heavy clothing or shoes with an electronic scale (TANITA BC-418, Tokyo, Japan) to the nearest 0.1 kg. Height was measured in barefoot positioning the subjects' head in the Frankfort plane with a portable stadiometer with 2.10 m maximum capacity and a 0.001-m error margin (SECA, Hamburg, Germany). Body mass index was then calculated as body weight in kilograms divided by height squared in meters. Body fat was measured by bioimpedance technique (TANITA BC-418, Tokyo, Japan).

Statistical analysis

Data are presented as mean values and 95% confidence intervals (CI) for continuous variables or as percentages for categorical variables. Kolmogorov–Smirnov tests and visualization of normal plots revealed all variables were normally distributed. Univariate Generalize linear model (GLM) was used to test the overall influence of the three different sitting trajectories (fixed factor) assessed on the HRQoL at follow-up time point (dependent variable) for the participants of the study. Covariates included in the model were BMI, body fat percentage, HRQoL score at baseline, and sociodemographic characteristics of participants. To test for the potential influence that fitness may have on the relationship between sitting time trajectories and HRQoL at follow-up, the same GLM model was run several times, for both the higher and the lower fitness groups for each of the three fitness indexes calculated (i.e., aerobic capacity, strength index, and total fitness index). HRQoL at follow-up was then compared within and across the three different sitting trajectories. An additional ANCOVA was conducted to test whether those who maintained high amounts of sitting differed in HRQoL ratings from those who remained in lower sitting categories over time. All analyses were carried out with the Statistical Package for the Social Sciences

(SPSS, Inc. Chicago, USA) Windows software, version 20.0. Statistical significance was set at $p < 0.05$.

Results

The descriptive data of the participants in the study are shown in Table 1. The majority of participants in the study were female (71.74%), overweight (mean BMI 29.11 ± 4.17), and spent on average between 2 and 4 h/day sitting (55.4%) at baseline. Over the study period, a 31.9% of the sample moved to a higher sitting time category, a 49.8% stayed in the same category, and an 18.3% moved to a lower sitting category.

Figure 1 shows the mean (95% CI) HRQoL scores at follow-up for the three different sitting time trajectories. Greater HRQoL scores were observed in those participants that decreased their sitting time as compared with those increasing [mean difference (95% CI) -0.035 (-0.060 , -0.011), $p = 0.002$] or not changing their sitting time over the study period [mean difference (95% CI) -0.024 (-0.046 , -0.001), $p = 0.038$].

Table 1 Sample characteristics at baseline and follow-up $n = 1164$

	Baseline	Follow-up
Age	71.50 (5.01)	74.26 (4.99)
Gender (male)	264 (22.7%)	264 (22.7%)
Height (cm)	155.64 (8.12)	155.36 (8.09)
Weight (kg)	70.45 (11.09)	70.29 (11.08)
BMI (kg/m ²)	29.12 (4.09)	29.11 (4.17)
Fat mass (%)	37.08 (6.84)	37.05 (6.88)
Educational status (%)		
Primary or lower	83.90	86.90
Secondary or higher	16.01	13.11
Marital status (%)		
Single	4.50	4.30
Married	63.90	62.10
Divorced	3.10	2.70
Widow	28.40	31.00
Income (%)		
< 600€/month	42.14	32.9
600–900€/month	33.90	38.3
> 900€/month	24.00	28.8
Leg strength (reps)	14.49 (3.29)	14.68 (3.87)
Arm strength (reps)	17.12 (4.01)	17.98 (3.93)
Aerobic capacity (meters)	529.65 (86.38)	509.66 (98.16)
Sitting time (%)		
< 2 h/day	16.1	11.9
Between 2 and 4 h/day	54.7	45.1
> 4 h/day	29.2	43.0

All values are mean (SD) unless otherwise stated

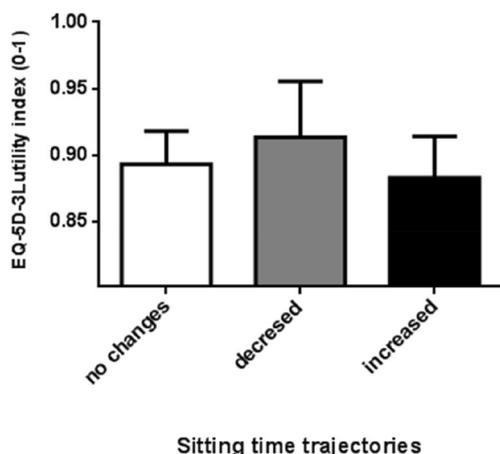


Fig. 1 Relation between the sitting time trajectories and Health related Quality of Life

Figure 2 shows the mean (95% CI) HRQoL scores at follow-up for the three different sitting time trajectories within both the higher and the lower fitness groups for each of the three fitness indexes calculated (i.e., aerobic capacity, strength index, and total fitness index). Greater

HRQoL scores were observed in those participants that decreased their sitting time as compared with those increasing their sitting time over study time [mean difference (95% CI) 0.034 (0.004, 0.064), $p = 0.021$] for participants classified in the lower group of the aerobic capacity index. Similarly, the total fitness index, HRQoL was greater in those participants that decreased their sitting time as compared with those increasing their sitting time over the study period [mean difference (95% CI) -0.032 (0.002, 0.063), $p = 0.032$] for participants classified in the lower group of the total fitness index. No differences were detected in HRQoL scores in the case of people classified as having a higher fitness level (i.e., above P75) for any of the calculated fitness indexes. Participants that increased or did not change their sitting time and that were classified in the higher fitness end of aerobic capacity and total fitness index self-reported higher HRQoL scores when compared with those in the lower fitness index ($p < 0.05$).

Results also indicated that those who maintained high amounts of sitting (i.e., those sitting for more than 4 h/day) had lower HRQoL ratings compared with those remaining in the 0–2 h/day sitting category ($p = 0.038$) and 2–4 h/day category ($p = 0.026$).

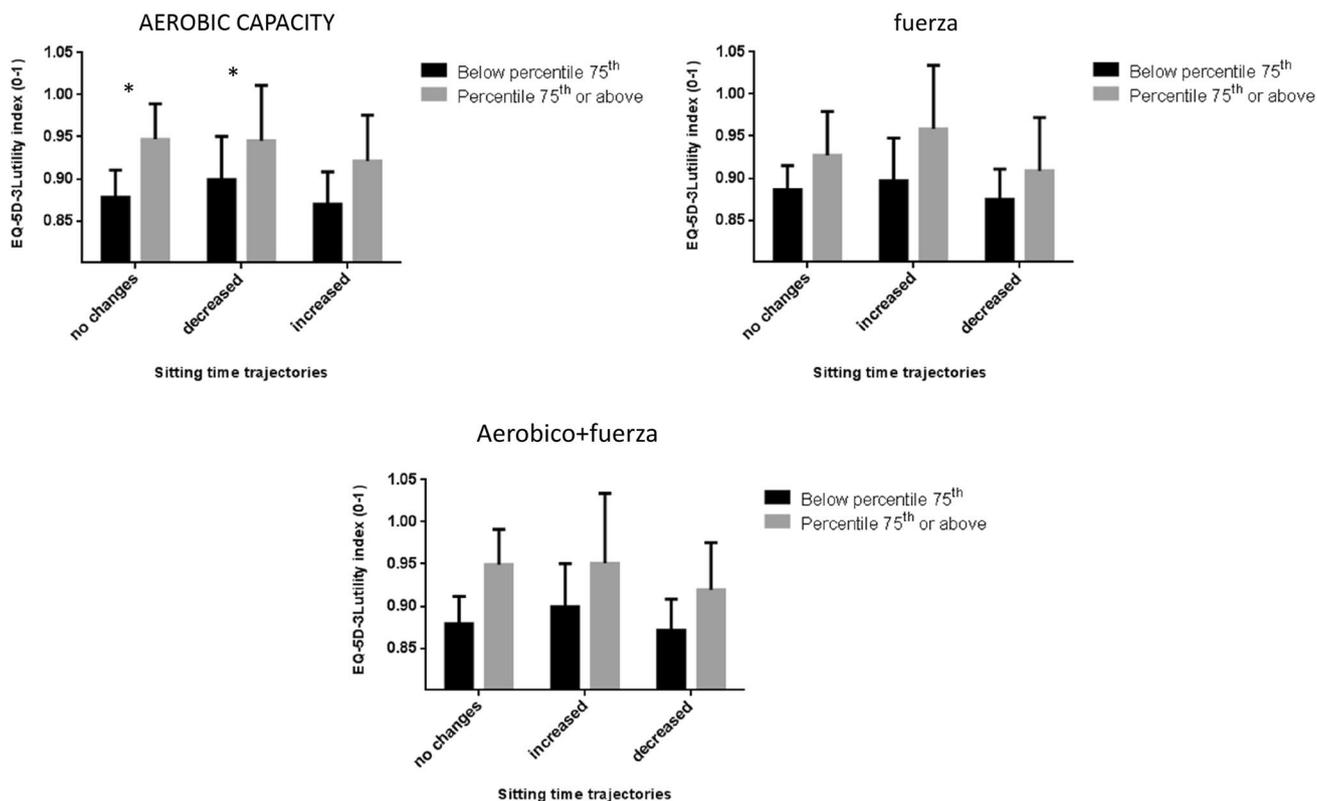


Fig. 2 Relation between the sitting time trajectories and Health related Quality of Life for each physical capacity analyzed among the two fitness levels (percentile 75 or above or below percentile 75)

Discussion

The primary aim of this study was to investigate the impact of changes in sitting time over time on HRQoL in community-dwelling older adults. We also aimed to confirm whether or not different fitness levels of different fitness components (i.e., upper and lower limb strength, cardiorespiratory fitness, or a combination of both) could attenuate the potential negative impact of increasing sitting time over the period of the study. Previous cross-sectional [24] and longitudinal studies [25] have recognized the potential negative role of sitting time on HRQoL in older adults. To our knowledge, this is the first study analyzing the longitudinal relationship between sitting time, fitness, and HRQoL. Our results support the hypothesis tested in the study and suggest that (i) HRQoL decreases with increasing sitting time over time and that (ii) fitness could moderate the negative impact of increasing sitting time on HRQoL in older adults.

As expected, the estimated longitudinal relationships tested in our study show that increasing sitting time over the period of the study led to poorer HRQoL as compared with the other two trajectories analyzed (i.e., decreasing or unchanged sitting time) in our sample of community-dwelling older adults. Also, the results showed that maintaining high amounts of sitting time over time led to poorer HRQoL. In contrast, participants that maintained low sitting time over time also reported the highest HRQoL. Whereas cross-sectional studies have yielded inconsistent results regarding the relationship between HRQoL and self-reporting sitting time [26, 27], the scarce longitudinal evidence available is in agreement with our results. Balboa-Castillo et al. [25] concluded that less baseline leisure sitting time was associated with poorer HRQoL after 6 years of follow-up in 1097 older adults. Interestingly, Omorou et al. [28] confirmed the cumulative and bidirectional inverse relationship between screen time and total sitting time with HRQoL, a sample of 2093 French adults. The mechanisms underlying the (inverse) relationship between sitting time and HRQoL are currently unknown. It is plausible that the mental [24], physical [28], and metabolic inflexibility consequences of a sedentary lifestyle may mediate the here-found associations between sitting time and poor HRQoL. Importantly, other dimensions of sitting such as accumulating patterns or the context in which sitting occurs may also have an influence on HRQoL [16, 25].

As a novelty, in the current study, we tested the hypothesis of whether or not higher fitness levels may attenuate the observed inverse relationship between sitting time and HRQoL. Regardless of the fitness component and independent of the trajectory analyzed, those with higher

fitness levels (i.e., participants sitting in or above the 75th percentile) depicted higher HRQoL scores as compared with those with lower fitness levels (i.e., those participants sitting below the 75th percentile of the particular fitness component).

Previous studies have reported on the protective effect of cardiorespiratory fitness against sitting time for various cardiometabolic markers including type 2 diabetes mellitus, cardiovascular diseases (CVD), notably excess adiposity and disordered lipid and glucose metabolism [29] or metabolic syndrome in adults [30]. Given that a close relationship exists between disease status, fitness, and self-perceived health status, it could be plausible that the protective effect of fitness may also mediate the relationship between sitting time and HRQoL in older adults. In addition, there is evidence that moderate physical activity may also counteract the negative impact of sitting time on HRQoL [25, 28]. Loprinzi [31] suggested in a recent cross-sectional study involving 5536 adults and older adults in the US that even people displaying large amounts of sedentary behaviors, being able to engage in strenuous physical activity may attenuate the negative effects of sitting time on HRQoL. The latter could be understood in the context of fitness. MVPA is strongly associated with fitness [32] and having a good fitness level allows a person to engage in more social activities [27], participate in daily activities, feel generally less anxious or depressed [33], feel less pain [34], or exist with a lesser level of discomfort, which positively influences the EuroQol 5 dimension scores, and so the resulting global HRQoL score. Nonetheless, participating in physical activities may provide unique benefits such as opportunities for social interactions, pain reduction, or relaxation, among others that may independently contribute to improvements in HRQoL.

Because of the multifactorial nature of HRQoL [1], the relationship between the different fitness components and HRQoL could be different and so it could be the relationship between sitting time and HRQoL when mediated by the different fitness components and levels. Therefore, the relationship between the three sitting time trajectories and HRQoL was tested against the level (i.e., lower or higher) of three different components, namely aerobic capacity, body strength (a combination of upper and lower limb strength), and a combination of both aerobic capacity and body strength. In our sample, those participants that did not change or increase their sitting time and that classified in the or above 75th percentile of aerobic capacity showed statistically significant better HRQoL than their peers sitting below the 75th percentile. Similar patterns of HRQoL responses were observed when the effects of the three sitting trajectories were analyzed against the level of the combination of aerobic capacity and body strength. However, strength alone did not significantly influence the relationship between

HRQoL and cumulative sitting time. Altogether, these results may suggest that maintaining or increasing sitting time over time may lead to poorer HRQoL when the fitness level is low. In addition, the negative effects of cumulative sitting tend to disappear if the fitness level is high.

The responsiveness of EQ-5D has been previously assessed in a number of contexts [35, 36]. This literature suggests that even small changes in EQ-5D index can be considered important. Soer et al. [35] demonstrated that a 0.03 difference in EQ-5D index could detect meaningful improvements after treatment in a sample of adults and older adults with chronic low back pain. Also, a study by Goldsmith et al. [36] found that 1-min increase in treadmill exercise time was associated with a 0.019 increase in EQ-5D index among a group of cardiac patients. The same authors also reported that a 10-unit increase in scales of the Seattle Angina Questionnaire, scales used to assess the functional status of people with coronary artery disease, was associated with increases between 0.04 and 0.07 in EQ-5D index. In the context of our study, the small differences detected in EQ-5D index could lead to meaningful outcomes. Future studies are warranted to elucidate the meaning of these differences for a variety of outcomes known to be relevant for older adults.

The strengths of this study include both its longitudinal design, the objective measurement of different components of fitness using a valid battery of field tests [23] and the relatively large sample size. However, this study has several limitations that need to be acknowledged in order to understand the observations made in this study. First, the self-reported nature of the sitting time assessment may limit the validity of the results. In a recent population-based study, Kim et al. [37] have suggested that cross-sectional associations exist between objectively measured sedentary behavior and health-related quality of life in US adults. In addition, the nature of the type of sedentary behavior could potentially moderate the health-related quality of life perception of this population group. The fact that 70.8% of the sample was characterized as sitting less than 4 h/day could simply reflect an artefact of the instrument used in this study to assess the time participants spent sitting in a typical day. Thus, results from the original validation study of the instrument show a tendency to underestimate self-reported time spent sitting compared to accelerometer-derived time spent sitting, particularly among women [21]. The thresholds used in this study to categorize sitting time per day were not able to discriminate beyond > 4 h per day. This could bias the results of this study because some people may sit for even longer periods (i.e., > 8 h per day) [22]. However, the probability of participants self-reporting longer periods of sitting time in this study was low (i.e., only 29% reported to sit for 4 h or more per day). Future studies with a bigger sample size could consider using a more granulated categorization of

sitting time. Furthermore, our sitting time question could not capture other important dimensions known to be relevant for health such as breaks in sedentary time [38] or the type of sedentary behavior [39]. Future studies should investigate the longitudinal relationships between different types of objectively assessed sedentary behavior (including patterns of accumulation of sitting time and the context in which sedentary behaviors occur) and HRQoL in older adults. Also, the gap between baseline assessment and follow-up differed across participants in the study, which may also bias the results (i.e., the shortest gap between baseline and follow-up assessment was 37 months while the longest gap was 52). Finally, 63% ($n=1972$) of participants were not available for the follow-up assessment and therefore were not included in our analysis; thus, one might argue that the observed associations could differ from those in people excluded from our analysis. In the present study, participants who were included were less likely to self-report more health problems and have better fitness at baseline than those that did not return to the follow-up assessment, which could limit the generalizability of the results to those with similar characteristics of those included in the analysis. However, they did not differ in any other demographic variable. Despite the acknowledged limitations, the results of this study may pose some insights into what could be the potential mechanisms underlying the complex relationship between cumulative sitting time, fitness levels, and HRQoL in older adults.

Conclusions

In summary, increasing sitting time or maintaining thereof high levels of sitting time over the period of study is associated with poorer health-related quality of life in older adults. Higher fitness levels could help attenuate the negative impact of sitting over time among the studied population. Overall, our results support the accumulating evidence of the benefits of reducing sitting and increasing fitness levels to promote health among the older adult population. Future studies should confirm these results using objective measurements of sitting time.

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Affiliations

O. López-Torres^{1,12} · B. del Pozo-Cruz² · B. Maroto-Sánchez¹ · S. Vila-Maldonado^{3,4} · A. Gómez-Cabello^{4,5,6,7,8} · M. Martín-García³ · A. González-Agüero^{6,7,8,9} · N. Gusi^{4,10} · L. Espino^{4,11} · J. A. Casajús^{6,7,8} · M. González-Gross^{1,8} · I. Ara^{3,4} · R. Pedrero-Chamizo¹

¹ ImFINE Research Group, Department of Health and Human Performance, Universidad Politécnica de Madrid, Madrid, Spain

² Motivation and Behaviour Program, Institute for Positive Psychology and Education, Australian Catholic University, Sydney, Australia

³ GENU D Toledo Research Group, Universidad de Castilla-La Mancha, Toledo, Spain

⁴ CIBER of Frailty and Healthy Aging (CIBERFES), Madrid, Spain

⁵ Centro Universitario de la Defensa, Zaragoza, Spain

⁶ GENU D (Growth, Exercise, Nutrition and Development) Research Group, Universidad de Zaragoza, Zaragoza, Spain

⁷ Instituto Agroalimentario de Aragón (IA2), Zaragoza, Spain

⁸ CIBEROBN, Biomedical Research Networking Center for Physiopathology of Obesity and Nutrition, Carlos III Health Institute, Madrid, Spain

⁹ Faculty of Health and Sport Science (FCSD), Department of Physiatry and Nursing, Universidad de Zaragoza, Huesca, Spain

¹⁰ Universidad de Extremadura, Cáceres, Spain

¹¹ Unidad de Medicina del Deporte, Cabildo de Gran Canaria, Gran Canarias, Spain

¹² Department of Health and Human Performance, Facultad de Ciencias de la Actividad Física y del Deporte-INEF, c/Martín Fierro 7, 28040 Madrid, Spain