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How important is current physical fitness for future quality of life? Results from an 8-year longitudinal study on older adults

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ABSTRACT

Introduction: A vast amount of research has focused on the effects of physical fitness (PF) on mortality, with little research evaluating the effects of PF on future expected health related quality of life (HRQoL).
Aim: To evaluate how current PF influences future HRQoL measured in a prospective 8-year study in older adults.
Methods: A total of 617 (157 males) older adults (>65y) participated in the study. PF was assessed with the EXERNET battery in 2008–2009 (baseline) and 2016–2017 (follow-up). HRQoL was assessed using the EQ-5D-3L questionnaire in both evaluations. PF tertiles were developed from baseline PF variables: FIT (highest PF values), REGULAR and UNFIT (lowest PF values) taking into account age and sex. Follow-up HRQoL values were compared to sex and age-specific expected values. Logistic regressions were performed to test differences between PF tertiles regarding future expected quality of life. Linear regressions were developed to test whether baseline PF could predict future HRQoL scores.
Results: The FIT group showed higher probabilities of an improved HRQoL when compared to the UNFIT group. All PF variables seemed to be important at some point of the study except upper extremities flexibility. Aerobic endurance was the variable that showed to be significant for most of the HRQoL predictions.
Conclusion: PF influences future HRQoL in older adults who accordingly should try to remain fit to maintain an increased age-adjusted HRQoL.

1. Introduction

According to the 2019 revision of the World Population Prospects (United Nations and Department of Economic and Social Affairs, 2019) developed by the United Nations "*By 2050, one in six people in the world will be over age 65 (16%), up from one in eleven in 2019 (9%)*". These percentages will be higher in developed countries with an estimated 19% for Switzerland or 20% for Spain. Nonetheless, this increase in age expectancy does not necessarily entail an improved quality of life and researchers should differentiate between overall life expectancy and healthy life expectancy. Due to social, technical and sanitary progress, the second one has not increased as much as the first one (Crimmins, 2015; Salomon et al., 2012), being in many cases chronic medications and medical treatments the reason for a longer life expectancy.

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In order to bring these two concepts as close as possible, older adults should focus on a successful aging (SA). The term SA has been used for the past five decades and was defined as high physical, psychological, and social functioning in old age without major diseases (Rowe and Kahn, 1997). Although there is still no consensus on the meaning of SA, experts agree that it has to cover three components: avoiding disease and disability, maintaining high cognitive and physical function, and engagement with life (Martineau and Plard, 2018). Some authors consider seven key elements to achieve a SA: life satisfaction, longevity, freedom from disability, mastery/growth, active engagement with life, high/independent functioning, and positive adaptation (Phelan and Larson, 2002). Nowadays, experts use several terms of this concept (healthy aging, active aging, productive aging, functional aging, aging well, etc.) as synonyms or with small nuances (Urtamo et al., 2019). Nevertheless, what seems clear is that all these concepts involve multidimensional domains such as physical, functional, social, and psychological and all are directly related to a better Health Related Quality of Life (HRQoL).

HRQoL is an individual's or a group's perceived physical, mental and social health over time ("Health-Related Quality of Life (HRQOL) | CDC", 2020). One of the most worldwide recognized and used HRQoL questionnaire was developed by EuroQol Research Foundation named EQ-5D-3L gathering data from 5 major HRQOL dimensions, three associated with physical capacity (mobility, self-care and usual activities) and two associated with mental health (pain/discomfort and anxiety/depression). The EQ-5D-3L provides normative data for different countries that can be used to compare health profiles of specific populations with the general population, helping to identify the comparative burden of diseases (Szende et al., 2014).

Different cross-sectional studies have shown a relationship between different fitness tests and the EQ-5D-3L results. Gouveia et al. (2017) found higher EQ-5D-3L scores in the three physical domains in older adults with improved physical fitness (PF) while higher scores in the two other domains were more related to social events, such as not living alone. Older adults tend to associate lower PF levels to increased problems and lower HRQoL (Olivares et al., 2011). In the same line, Wanderley et al. (2011) found that physically active older adults were more likely to report improved HRQoL. Aging leads to HRQoL decreased scores (Wong et al., 2019) and skeletal muscle anabolic disfunctions, which result in muscle mass and strength reductions, factors directly associated with mortality rates in older adults (Bae et al., 2019). Therefore, maintaining strong and healthy muscles may improve health, independence, and functionality (McLeod et al., 2016).

In this line, a recent systematic review (Medrano-Ureña et al., 2020) evaluating PF, exercise self-efficacy and quality of life in adulthood, found that most of the performed research included participants with some type of pathology, as from the 37 included studies only five were developed including participants without a disease. From the five studies only three included HRQoL measures and were either cross-sectional (Gregg and Bedard, 2016) or intervention (Damush et al., 2006; Ligibel et al., 2012) studies. Therefore there is a clear need of new longitudinal observational studies evaluating the effect of current PF and changes in PF on future HRQoL, as these type of studies are scarce and evaluate short periods in time (generally below 4 years (López-Torres et al., 2019)) or only evaluate the association between PF and cognitive function (Barnes et al., 2003).

With the development of the aforementioned longitudinal studies, researchers would be able to explore the association between PF and future HRQoL changes. More importantly, if a large sample was measured researchers could evaluate the determinants of future HRQoL. Therefore, the aims of the present study were: 1) to evaluate the association between PF and changes in PF and future expected HRQoL scores in non-institutionalized elderly adults followed during 8 years, and 2) to predict the effect of PF and changes in PF on individual dimensions of the HRQoL.

2. Methods

2.1. Ethics committee

The study was performed according to the principles of the Helsinki Declaration and national and European legislation related to data protection. Written informed consent was obtained from all the included participants. The protocol was approved by the Clinical Research Ethics Committee of Aragón (18/2008) for the baseline and by the Hospital Universitario Fundación de Alcorcón (16/50) for the follow up.

2.2. Quality of life: EQ-5D-3L

The Spanish version of the EQ-5D-3L was used to measure HRQoL (Badia et al., 1999). The EQ-5D is a standardized HRQoL questionnaire used worldwide with available normative data (Szende et al., 2014). This questionnaire includes five dimensions: mobility, self-care, usual activities, pain/discomfort and anxiety/depression. For each dimension, participants can choose between three options: no problems, some problems and severe problems. A unique health state is produced as a result of combining one level from each of the five dimensions and then calculating a final EQ-5D-3L index. A total of 243 possible health states are defined in this way. To determine an overall health index, the Utility index was calculated using the Spanish time trade-off (TTO) tariffs (Badia et al., 1999). This classifies participants from 0 (death) to 1 (fully functional quality of life), providing an overall numerical estimate of the HRQoL of participants.

The questionnaire also includes a visual analog scale (VAS). Participants have to tick on a vertical scale that ranges from a 0 "Worst imaginable health state" to 100 "best imaginable health state", what they think their current health is.

2.3. Fitness assessment

PF was assessed with the EXERNET battery which includes tests adapted from the Senior Fitness Test battery and the Eurofit Testing Battery (Pedrero-Chamizo et al., 2012; Rikli, 2000). The performed tests were:

- Anthropometry: body weight (kg), height (cm) and body mass index (BMI).
- One leg balance test: to evaluate static balance. Seconds a person can balance successfully on a single leg.
- 30-Second chair stand test: to evaluate lower extremities strength. Number of full stands from a seated position that a person can perform in 30 s.
- Arm curl test: to evaluate upper extremities strength. Number of biceps curls that can be completed in 30 s holding a hand weight of 2.5 kg for women and 4 kg for men.
- Chair Sit-and-Reach Test: to evaluate lower extremities flexibility. Number of centimeters (plus or minus) between the extended fingers and the tip of the toe when a person is sitting with the leg extended and his/her hands try to reach the toes without bending his/her leg.
- Back Scratch Test: to evaluate upper extremities flexibility. Number of centimeters (plus or minus) between one hand reaching over the shoulder and the other hand up the middle of the back.
- 8-Foot Up-and-Go Test: to evaluate agility. Seconds required to get up from a seated position, walk 2.45 m, turn and return to a seated position.
- Brisk Walking Test: to evaluate walking speed in 30 m. Seconds require to walk 30 m at maximal speed (without running).
- 6-Minute Walk Test: to assess aerobic endurance. Meters covered during six minutes walking.

2.4. EXERNET questionnaire

Participants completed the validated EXERNET questionnaire (López-Rodríguez et al., 2017) which included questions regarding demographic characteristics, medication, socioeconomic and civil status. From these we classified individuals as polymedicated if they ingested five or more medicines on a daily basis or non polymedicated if the ingested four or less (Masnoon et al., 2017).

2.5. Participants, categorization and study design

The study was carried out in the framework of the longitudinal elderly EXERNET study (Exernet Elder 3.0); a multi-center study performed between 2008 and 2009 (baseline) and 2016 and 2017 (follow-up). In order to be included in the study, participants had to be over 65 years and non-institutionalized in the first evaluation. In 2008, a representative sample of Spanish seniors was evaluated in 6 different regions across Spain. From an initial total sample of 3136 participants, 3093 had complete HRQoL data and 2987 performed the fitness assessment. One center could not perform the follow up (400 participants) and there were 236 deaths between 2008 and 2016, leaving a total of 2351 possible participants for the present study. Nonetheless, due to several reasons (did not answer the phone, became dependent and could not attend the follow-up, change of residence or city or was not willing to undertake the evaluation), and to the fact that data were missing for some participants a final sample of 617 (157 males) was included in the present study.

Two different classifications were performed. Firstly, participants were classified into tertiles according to initial fitness and taking into account their age group (<70y, 70–74.9y, 75–79.9y, 80–84.9y and ≥85y) and sex. The first tertile was called FIT (highest fitness values), the second REGULAR and the third UNFIT (lowest fitness values). Secondly, participants were classified according to their follow-up quality of life into two groups: BELOW or ABOVE expected quality of life. In order to develop both groups expected Utility and VAS cut-off values were extracted from a European and National survey respectively (Szende et al., 2014) and were:

Utility index cut-off values (European values): Younger males (65–75y): 0.936; older males (≥75y): 0.862/Younger females (65–75y): 0.857; older females (≥75y): 0.729.

VAS cut-off values (Spanish values): Younger males (65–75y): 73.1; older males (≥75y): 66.7/Younger females (65–75y): 65.8; older females (≥75y): 59.4.

Participants who had a HRQoL value equal or above the expected for their sex and age group in the follow-up were classified in the ABOVE group, while participants who showed a HRQoL value below the expected were classified in the BELOW group. Demographic and anthropometric characteristics of both groups are displayed in Table 1.

2.6. Statistical analyses

Descriptive characteristics were summarized as frequencies, means and standard deviations. To compare descriptive continuous variables independent *t*-tests were used while for comparing socio-demographic characteristics chi-square tests were used.

Blockwise enter method multiple linear regressions were developed to test whether baseline fitness (independent variable: one regression for each fitness variable) could predict future VAS scores (continuous scores from 0 to 100). The first block included initial fitness adjusted by initial age, BMI, marital status and VAS score. The second block included change in fitness (difference between follow-up and initial fitness). Additionally, a stepwise multiple regression model was developed

Table 1
Descriptive characteristics of the sample.

	Whole sample		Expected quality of life (VAS scores)				Expected quality of life (Utility scores)			
	Baseline	Follow-up	Baseline		Follow-up		Baseline		Follow-up	
	n: 617		BELOW n: 175	ABOVE n: 442	BELOW	ABOVE	BELOW n: 274	ABOVE n: 343	BELOW	ABOVE
Age (y)	70.6 ± 4.4	78.1 ± 4.6	70.2 ± 4.4	70.7 ± 4.4	77.8 ± 4.7	78.2 ± 4.6	70.3 ± 4.8	70.8 ± 4.1	77.7 ± 5	78.4 ± 4.2
Height (cm)	155.9 ± 8.1	154.8 ± 8.7	156.0 ± 7.8	155.9 ± 8.2	154.6 ± 9.7	154.9 ± 8.3	155.6 ± 7.7	156.2 ± 8.3	154.3 ± 9	155.3 ± 8.5
Weight (kg)	70.1 ± 10.9	69.1 ± 11.3	72.2 ± 11.5	69.2 ± 10.5*	71.1 ± 11.5	68.3 ± 11.2*	71.9 ± 10.7	68.6 ± 10.8*	70.6 ± 11.2	67.9 ± 11.3*
BMI (kg/m2)	29.5 ± 4.1	28.2 ± 3.8	29.6 ± 4.0	28.5 ± 3.7*	29.5 ± 4.1	28.5 ± 3.9*	29.7 ± 4	28.1 ± 3.5*	29.5 ± 4.1	28.2 ± 3.8*
Sex (male/female)	157/460	157/460	47/128	85/258	47/128	85/258	72/202	85/157	72/202	85/157
Marital status (a/b/c/d)[$]	28/430/11/146	29/365/10/212	4/127/3/41	24/303/8/105	5/116/2/52	24/249/8/160	10/186/7/70	18/244/4/76	11/161/6/95	18/204/4/117
TTO score	0.81 ± 0.18	0.80 ± 0.18	0.75 ± 0.20	0.83 ± 0.17*	0.73 ± 0.20	0.83 ± 0.17*	0.75 ± 0.18	0.86 ± 0.16*	0.65 ± 0.14	0.93 ± 0.11*
VAS score	75.9 ± 17.3	71.6 ± 16.1	69.1 ± 18.2	78.6 ± 16.1*	52.1 ± 9.2	79.3 ± 10.9*	72.0 ± 18.1	79.1 ± 15.9*	66.4 ± 16.2	75.8 ± 14.9*
Balance (s)	32.7 ± 21.7	20.6 ± 18.8	29.7 ± 20.7	33.9 ± 21.9*	18.4 ± 16.9	21.5 ± 19.4	29.3 ± 21.2	35.5 ± 21.6*	18.2 ± 17.9	22.5 ± 19.3*
LEG strength (Rep.)	14.9 ± 3.1	13.6 ± 3.7	14.3 ± 3.0	15.1 ± 3.1*	12.4 ± 3.3	14.1 ± 3.7*	14.6 ± 3	15.1 ± 3.1*	12.8 ± 3.8	14.3 ± 3.4*
ARM strength (Rep.)	17.3 ± 3.3	15.9 ± 3.6	16.9 ± 3.4	17.5 ± 3.3	14.9 ± 3.5	16.2 ± 3.6*	17.1 ± 3.3	17.5 ± 3.3	15.4 ± 3.7	16.3 ± 3.6*
LEG flex. (cm)	−2.0 ± 10.0	−7.0 ± 10.9	−3.4 ± 9.9	−1.4 ± 10.0	−9.8 ± 12.0	−5.9 ± 10.2*	−2.8 ± 9.8	−1.3 ± 10.1	−8.2 ± 11.4	−6.0 ± 10.4*
ARM flex. (cm)	−8.9 ± 9.7	−12.4 ± 9.8	−10.3 ± 10.3	−8.3 ± 9.4*	−14.5 ± 10.1	−11.6 ± 9.5*	−10.2 ± 10.4	−7.8 ± 8.9*	−13.9 ± 10.7	−11.1 ± 8.8*
Agility (s)	5.4 ± 1.0	6.3 ± 1.9	5.6 ± 1.0	5.3 ± 1.0*	6.9 ± 2.4	6.1 ± 1.5*	5.6 ± 1.2	5.2 ± 0.9*	6.8 ± 2.4	5.9 ± 1.2*
Speed (s)	16.4 ± 2.9	19.1 ± 5.1	16.9 ± 3.1	16.2 ± 2.7*	20.6 ± 6.6	18.6 ± 4.3*	16.9 ± 3.1	16 ± 2.5*	20.6 ± 6.5	18.0 ± 3.3*
Endurance (m)	553.3 ± 76.6	478.1 ± 97.2	534.2 ± 82.3	560.8 ± 72.9*	449.8 ± 112.8	489.3 ± 87.9*	535.7 ± 78.8	567.3 ± 71.9*	453.7 ± 106.5	497.6 ± 84.2*

Whole sample 617 from which 157 males and 460 females.
For marital status a = single, b = married, c = divorced, d = widowed (data for 2 participants were missing).
ARM: Upper extremities, BMI: Body mass index, cm: Centimeters, flex: Flexibility, kg: kilograms, LEG: Lower extremities, m: meters, Rep: Repetitions, s: seconds, TTO: Time trade-off, VAS: Visual analog scale.
* Significant differences between ABOVE and BELOW groups ($p < .05$).
$ For the follow-up two participants did not report their marital status.

including all the fitness variables to determine which one was the most important for future VAS scores including initial age, BMI, marital status, VAS score and polymedication.

The EQ-5D Utility scores have several characteristics that should be considered before the statistical analyses are developed, such as:

- A large amount of the population has exactly the same score due to the ceiling effect of the EQ-5D-3L questionnaire: 1 (perfect health), out of 243 possible different possible scores (in our baseline values 36% of our sample had a score of 1).
- The previous produces a non-normally and skewed to the left distribution
- Although it seems like a continuous variable with possible answers from 0 to 1, the formula used to calculate it (Shaw et al., 2005) cannot produce values between 0.8603 and 1, a gap that represents nearly 15% of the entire range of the EQ-5D index.

Taking into account these important issues, we classified participants into two groups according to follow-up HRQoL: ABOVE and BELOW expected HRQoL as previously explained. Logistic regressions were performed to calculate odds ratios (OR) and 95% confidence intervals (CI). Two different models were developed; Model 1 (baseline fitness adjusted by baseline age, BMI, marital status, sex and HRQoL score), Model 2 (Model 1 + change in fitness (absolute differences)) to predict expected HRQoL (ABOVE or BELOW) for both Utility and VAS scores. Change in fitness was calculated as follow-up absolute values minus baseline values (e.g. an older adult that performed 20 repetitions in the leg strength test in the baseline and 12 repetitions in the follow-up would obtain an absolute score of −8).

Additionally, participants were classified in to tertiles as previously explained. Logistic regressions were performed to calculate OR and CI of expected HRQoL (ABOVE or BELOW) according to fitness group (UNFIT, REGULAR OR FIT), with the UNFIT group as the reference group. Two models were developed; Model 1 (fitness group adjusted by initial age, marital status, BMI and Utility scores), Model 2 (Model 1 + change in fitness).

Finally, each independent dimension of the EQ-5D-3L was analyzed independently through a binary logistic regression where the follow-up dimension was the dependent variable (both mild and severe problems were collapsed into one variable coded as "2" that was compared to the no-problem "1" variable). Therefore, an odd ratio above 1 would indicate a higher probability of suffering a problem, while an odd ratio below 1 would indicate a lower probability of suffering a problem. The fitness tertiles were the dependent variables which were adjusted by initial age, marital status, BMI, sex and initial status of the analyzed dimension in model 1 and by all the previous and change in fitness in model 2 (absolute change). For these models the second dimension (self-care), showed extremely high confidence intervals due to the asymmetric distribution of the variable and the high number of included independent variables. Thus, a backward likelihood ratio method was used.

The Statistical Package for Social Science (version 24.0) was used for statistical analysis (IBM SPSS, Inc., Chicago, Illinois, USA). All probability values of $p < .05$ were considered statistically significant.

3. Results

3.1. Descriptive characteristics of the sample

Descriptive characteristics of the sample are presented in Table 1. No differences were found between the ABOVE and BELOW groups for age and height. Nonetheless, the ABOVE group (independently of the HRQoL scale: VAS scores or Utility scores), showed a lower weight and BMI. The ABOVE group also showed better baseline and follow up values for most fitness variables (Table 1).

3.2. Future VAS scores

The linear regressions showed that baseline leg strength, walking speed and aerobic endurance significantly predicted future VAS scores after adjusting for initial VAS, age, marital status, BMI and sex (all $p <$ .05; Table 2), explaining around 12% of the variability of future VAS scores. When taking change in fitness into account all the PF variables and their change (except arm flexibility and balance) significantly predicted follow-up VAS score (all $p < .05$; Table 2), although only explaining between 12.2 and 14.6% of the variability of future VAS score.

A full model was designed through stepwise linear regression including all the fitness variables in model 1 in order to predict future VAS scores (Table 2). The included variables in the model were initial VAS, walking distance (in the 6 minute test), polymedication and sex. Nonetheless, the model only explained 13% of future VAS score variability.

3.3. Expected quality of life (ABOVE or BELOW expected quality of life)

Results of the effect of initial fitness and changes of fitness values on the expected HRQoL are presented in Table 3.

3.3.1. Utility scores

In Model 1 walking speed (OR: 0.888, CI: 0.813–0.969) and aerobic endurance (OR: 1.005, CI: 1.002–1.008) significantly predicted being in the ABOVE HRQoL group (both $p < .05$; Table 3).

For Model 2 two interpretations can be made: firstly, when controlling for changes in fitness, initial balance (OR: 1.015, CI: 1.002–1.028), agility (OR: 0.723, CI: 0.567–0.922), walking speed (OR: 0.867, CI: 0.790–0.951) and aerobic endurance (OR: 1.007, CI:1.003–1.010) significantly improved the probability of being in the ABOVE HRQoL group. Secondly, when controlling for initial fitness, changes in the following PF variables; leg strength (OR: 1.099, CI: 1.032–1.117), agility (OR: 0.713, CI:0.599–0.848), speed (OR: 0.848, CI:0.787–0.913) and endurance (OR: 1.004, CI:1.002–1.007) all improved the probability of being in the ABOVE HRQoL group (Table 3).

3.3.2. VAS scores

For Model 1, leg strength (OR: 1.086, CI: 1.012–1.166), agility (OR: 0.782, CI: 0.620–0.986), walking speed (OR: 0.896, CI: 0.821–0.977) and aerobic endurance (OR: 1.004, CI: 1.001–1.008) improved the probability of being in the ABOVE QoL group (all $p < .05$; Table 3).

Regarding Model 2, all variables except balance (OR: 1.008, CI: 0.994–1.022), leg flexibility (OR: 1.019, CI:0.996–1.042) and arm flexibility (OR: 1.028, 1.000–1.055) significantly increased the probability of being in the ABOVE QoL group (Table 3). The same results were found for change in fitness, as when taking into account initial fitness, all the changes in fitness significantly increased the probabilities of being in the ABOVE HRQoL group (except for change in balance).

3.4. Quality of life according to fitness tertiles

3.4.1. Expected Utility scores (ABOVE or BELOW)

For expected TTO scores the only difference among tertiles was found for agility and walking speed with the FIT showing higher probabilities of being ABOVE TTO expected values when compared to the UNFIT group (Fig. 1).

3.4.2. Expected VAS scores (ABOVE or BELOW)

Participants classified as REGULAR for leg strength presented higher probabilities of being ABOVE EXPECTED VAS scores when compared to the UNFIT group (model 2: OR: 1.81, CI: 1.70–3.05). For arm strength, the FIT group showed higher probabilities of being in the ABOVE EXPECTED group (model 2: OR: 2.88, CI: 1.16–7.15) when compared with the UNFIT group. Differences among tertiles were also found for aerobic

Table 2
Prediction of visual analog scale (VAS) follow-up scores from baseline and change from baseline fitness values.

	Model 1			Model 2			
				Initial fitness	Change in fitness		
Independent variables	Unstand. Beta	Change in r square	Total r square	Unstand. Beta	Unstand. Beta	Change in r square	Total r square
Balance (s)	0.044	0.003	0.120	0.077	0.052	0.002	0.122
LEG strength (Rep.)	0.453*	0.007	0.123	0.843*	0.798*	0.023*	0.146
ARM strength (Rep.)	0.304	0.004	0.112	0.642*	0.648*	0.015*	0.129
LEG flexibility (cm)	0.028	0.001	0.125	0.080	0.162*	0.007*	0.132
ARM flexibility (cm)	0.007	0.001	0.119	0.046	0.117	0.002	0.121
Agility (s)	−1.391	0.005	0.121	−1.653*	−1.579*	0.020*	0.141
Speed (s)	−0.710*	0.010*	0.126	−0.727*	−0.488*	0.012*	0.138
Endurance (m)	0.028*	0.012*	0.128	0.041*	0.027*	0.015*	0.143
Full model[a]							
= 55.05 + 0.203 Initial VAS + 0.025 * Endurance (m) − 4.76 * polymedication (1 no, 2 yes) − 3.956 * sex (1male, 2female)							R square 0.127

Model 1: Initial fitness variable adjusted by initial VAS score, age, marital status, polymedication, sex and body mass index (BMI).
Model 2: Model 1 + change in fitness scores.
ARM: Upper extremities, BMI: Body mass index, cm: Centimeters, flex: Flexibility, kg: kilograms, LEG: Lower extremities, m: meters, Rep: Repetitions, s: seconds, VAS: Visual analog scale.
* Independent variables that significantly predicted VAS scores
[a] Full model was performed through a stepwise linear model that included all the variables in model 1 and only selected the significant ones. As an example, a women with an initial VAS of 80 who completed 500 m in the 6 minute tests and was not polymedicating would have an estimated future VAS of 71.1.

Table 3
Prediction of fitness and change of fitness on quality-of-life group (ABOVE or BELOW expected).

	Utility scores						VAS scores					
Variables	Model 1		Model 2				Model 1		Model 2			
			Initial fitness		Change in fitness				Initial fitness		Change in fitness	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Balance (s)	1.008	0.998–1.019	1.015*	1.002–1.028	1.011	0.999–1.024	1.005	0.994–1.016	1.008	0.994–1.022	1.006	0.992–1.020
LEG strength (Rep.)	0.996	0.934–1.061	1.043	0.972–1.120	1.099*	1.032–1.170	1.086*	1.012–1.166	1.136*	1.050–1.228	1.099*	1.026–1.177
ARM strength (Rep.)	1.006	0.950–1.066	1.039	0.972–1.111	1.062	0.998–1.131	1.040	0.977–1.107	1.092*	1.016–1.174	1.099*	1.028–1.175
LEG flexibility (cm)	1.005	0.986–1.025	1.013	0.992–1.034	1.023	1.000–1.048	1.004	0.983–1.026	1.019	0.996–1.042	1.045*	1.019–1.071
ARM flexibility (cm)	1.012	0.989–1.035	1.018	0.993–1.044	1.018	0.989–1.048	1.015	0.991–1.040	1.028	1.000–1.055	1.035*	1.004–1.067
Agility (s)	0.793	0.626–1.004	0.723*	0.567–0.922	0.713*	0.599–0.848	0.782*	0.620–0.986	0.743*	0.584–0.945	0.799*	0.684–0.933
Speed (s)	0.888*	0.813–0.969	0.867*	0.790–0.951	0.848*	0.787–0.913	0.896*	0.821–0.977	0.891*	0.816–0.974	0.921*	0.864–0.982
Endurance (m)	1.005*	1.002–1.008	1.007*	1.003–1.010	1.004*	1.002–1.007	1.004*	1.001–1.008	1.006*	1.003–1.010	1.004*	1.002–1.007

OR = Odd ratio, 95%CI = 95% Confidence interval.
Model 1: Effect of initial fitness adjusted by initial age, marital status, body mass index, sex, polymedication and initial Utility or VAS score.
Model 2: Model 2 + change in fitness.
ARM: Upper extremities, BMI: Body mass index, cm: Centimeters, flex: Flexibility, kg: kilograms, LEG: Lower extremities, m: meters, Rep: Repetitions, s: seconds, VAS: Visual analog scale.
* Significant OR ($p < .05$).

endurance as the REGULAR (model 2: OR: 2.12, CI: 1.10–4.07) and FIT groups (model 1: OR: 2.70, CI: 1.25–5.81/model 2: OR: 3.96, CI: 1.75–8.98) both presented higher probabilities of being in the ABOVE group when compared to the UNFIT group (Fig. 2).

3.5. Individual EQ-5D-3L dimensions

Results for the analysis of the future individual five dimensions of the EQ-5D-3L in relation to initial fitness tertiles are presented in Fig. 3.

Results are presented with the UNFIT as the reference. Mobility was the dimension that was most affected by initial fitness, as being in the REGULAR and FIT groups of either balance, walking speed or aerobic endurance significantly reduced the probabilities of presenting a mobility problem 8 years later. Additionally, agility and leg and arm strength also reduced the probability of presenting a mobility problem but only in the FIT group. Self-care was a dimension that was also highly influenced by initial fitness, as those initially classified in the REGULAR or FIT groups of agility or walking speed showed significantly reduced probabilities of presenting self-care related problems 8 years later. Additionally, those classified as FIT for leg strength and aerobic endurance also showed lower probabilities of having a self-care problem in the future. Participants classified as FIT for leg strength values also showed lower probabilities of having problems in performing usual activities, the same was found for those classified as REGULAR for leg flexibility and a tendency was found for those classified as FIT for leg flexibility. Participants classified as FIT for the leg strength variable showed a significant reduced probability of suffering future anxiety or depression. No differences were found among fitness groups for future pain.

4. Discussion

The present study has shown that PF is determinant to HRQoL later in life in older adults. Different results were found for future expected VAS and Utility scores. Nonetheless, the FIT group always showed higher probabilities of an improved HRQoL when compared to the

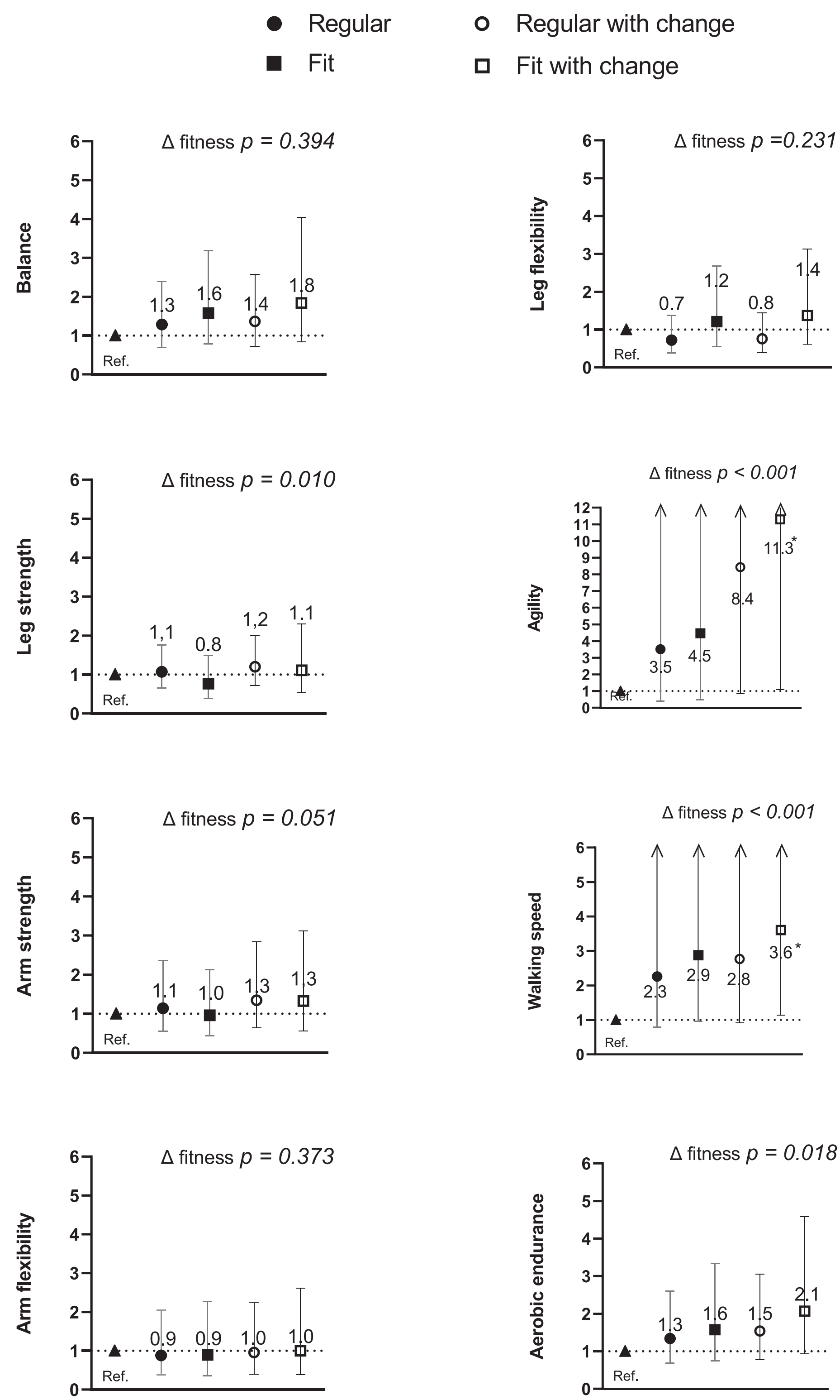

Fig. 1. Odds ratio (OR) and 95% confidence intervals for follow-up expected time trade-off scores (ABOVE or BELOW) according to baseline fitness tertiles. Black figures represent adjusted OR (by initial: age, marital status, sex, body mass index, polymedication and Utility score). White figures are adjusted by all the previous variables and change of the fitness variable from baseline to follow-up. The UNFIT group represented as a black triangle is the reference group.

UNFIT group. All of the PF variables seemed to be important at some point of the study except upper extremities flexibility that did not predict future expected HRQoL in any of the performed analyses. Aerobic endurance was the variable that showed to be significant for most of the predictions suggesting that this PF variable is critical for future HRQoL.

The positive findings regarding aerobic endurance (the 6-minute walk test has been shown to be useful for predicting cardiorespiratory fitness (CRF) in older adults (Sperandio et al., 2015)) are in line with previous studies which found that CRF improvements developed through aerobic training interventions (Awick et al., 2015; Shohani et al., 2019) also improved HRQoL in older adults and with cross-sectional studies finding that higher levels of CRF were associated

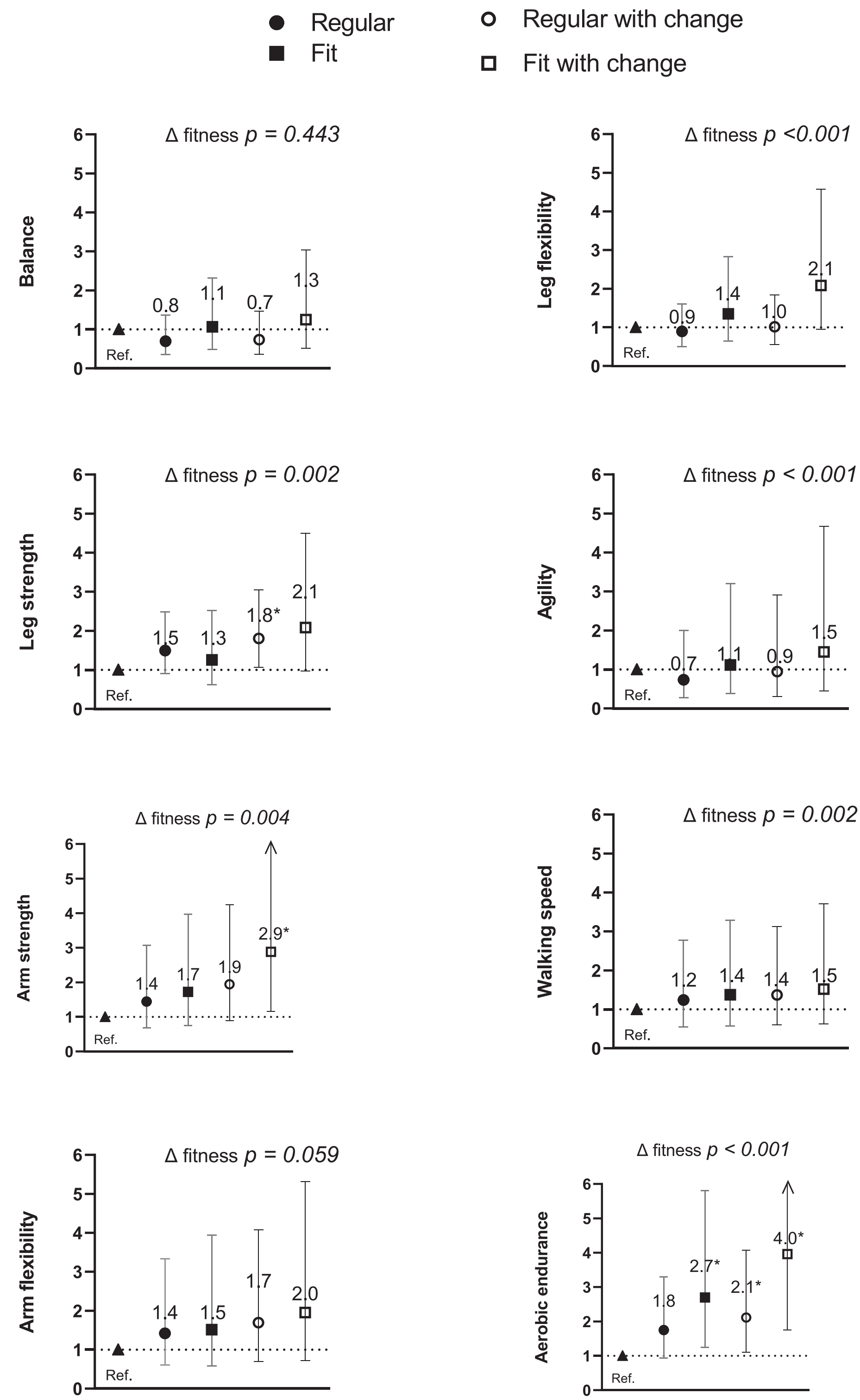

Fig. 2. Odds ratio (OR) and 95% confidence intervals for follow-up expected visual analog scale (VAS) scores (ABOVE or BELOW) according to baseline fitness tertiles. Black figures represent adjusted OR (by initial: age, marital status, sex, body mass index and VAS score). White figures are adjusted by all the previous variables and change of the fitness variable from baseline to follow-up. The UNFIT group represented as a black triangle is the reference group.

with higher levels of HRQoL in adults (Sloan et al., 2009). We think that the longitudinal findings of the present study are of critical importance as a vast amount of literature exists regarding the positive effect of PF (Navarrete-Villanueva et al., 2020) and more specifically CRF (Barry et al., 2014; Sui et al., 2007) on reducing mortality risk. Nonetheless, as mentioned in the introduction it is important to extend years of life and also give more quality of life to those years. To the best of our knowledge very few studies have longitudinally focused on the later, with Barnes et al. (Barnes et al., 2003) performing a 6 year longitudinal study but only evaluating cognitive function finding that baseline CRF was positively associated with preservation of cognitive function. Thus, combining our findings with previous studies it seems like an adequate CRF will extend life years, maintain cognitive function and maintain HRQoL.

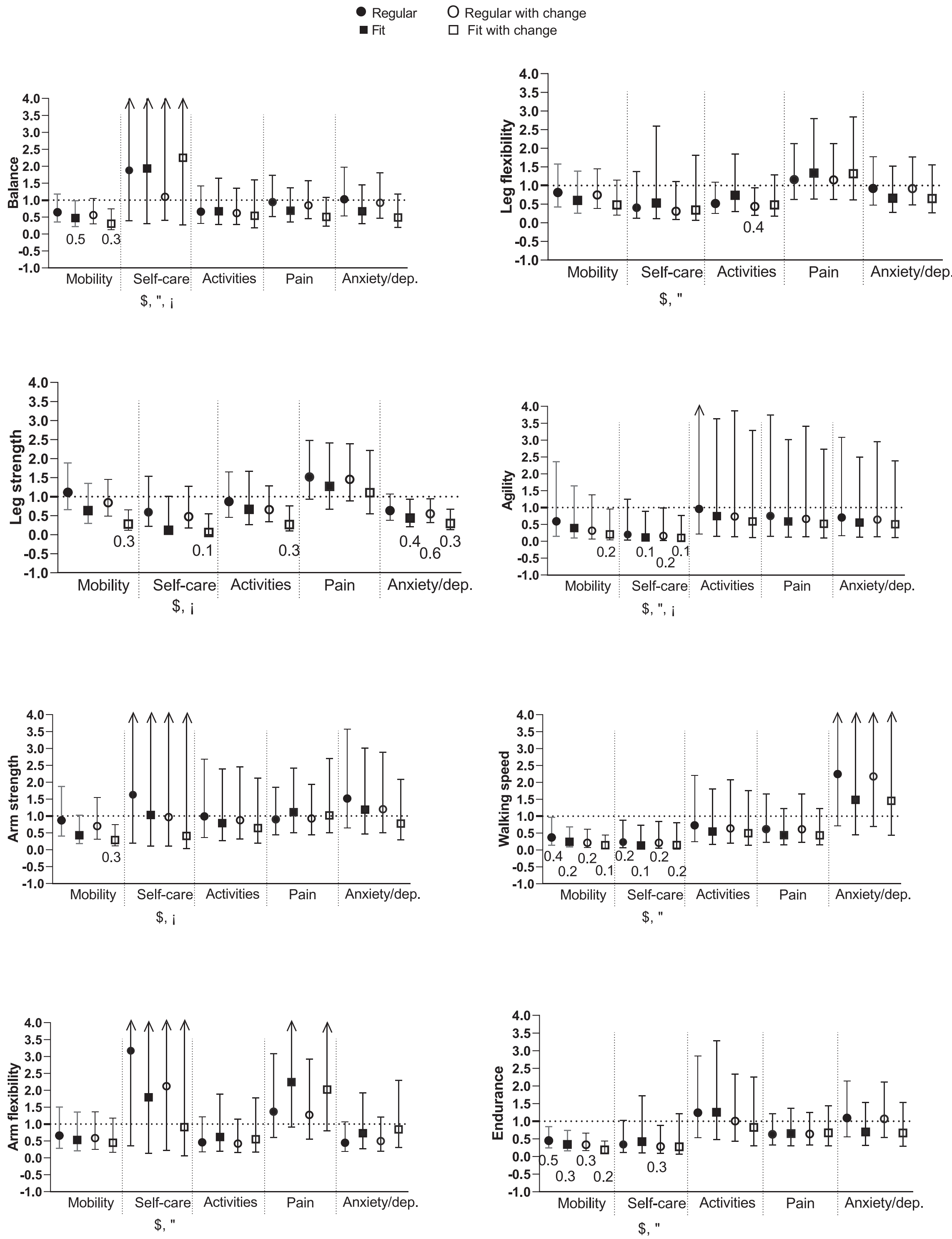

Fig. 3. Odds ratio (OR) and 95% confidence intervals for future EQ-5D-3L dimension scores in relation to initial fitness tertiles. Black figures represent adjusted OR (by initial: age, marital status, sex, body mass index and Utility score). White figures are adjusted by all the previous variables and change of the fitness variable from baseline to follow-up. Significant OR are presented with the OR value. For the self-care dimension a backward likelihood ratio method was used and only included some covariables which are: $: initial age, ": initial BMI, ¡:initial polymedication.

It is obvious that not only current PF will be important to future HRQoL but also the evolution of PF during aging. As shown in our results, all the changes in PF (except for change in arm flexibility) from baseline to follow-up were significant predictors of future HRQoL. Therefore, an older adult who initially presented normal levels of PF could end up having an impaired HRQoL while an older adult who initially presented low levels of PF could end up having a great HRQoL. Nonetheless, this should not undermine the importance of initial PF as we found that even after adjusting by change in PF some of the PF variables significantly predicted future expected HRQoL. Thus, although change in PF will be important, initial PF will also be critical.

Regarding the variables associated with muscle strength, it seems like their impact on HRQoL was lower but still important. A recent systematic review and meta-analysis evaluating the effect of resistance training on HRQoL in older adults concluded that resistance training was important to improve quality of life (Hart and Buck, 2019). When analyzing individual dimensions in the aforementioned review, authors found that resistance training improved physical function, body pain, mental health, vitality and general health. This is partially in line with our findings, as participants classified as REGULAR or FIT for strength variables (leg strength and arm strength) showed a reduced probability of presenting future mobility, self-care and usual activities problems. The studies included in the aforementioned review mainly used the SF-36 questionnaire and therefore we cannot compare mental health (because different variables are examined with the SF-36 such as emotional role functioning, vitality or mental component score). The main difference found between the studies included in the review and our study was found for pain values, as Hart and Buck (2019) suggested that resistance training had a large effect on reducing body pain while we did not find any significant results for pain outcomes. These differences might be due to the differences between the EQ-5D-3L and the SF-36 questionnaires and to the different design of the studies, as the review included randomized controlled trials, which show a short-term effect (effect of an intervention that lasts from 8 to 24 weeks in most studies included in the review) while we evaluated an 8-year period (416 weeks) without an intervention.

It is also important to notice that muscle strength will determine both walking speed and agility, as if a person shows low levels of muscle strength he or she will not be able to walk quickly or perform the agility circuit in a short time. According to our findings, both agility and walking speed predicted future VAS scores, and expected HRQoL independently of the used method (VAS or Utility scores). Additionally, both influenced the mobility and self-care dimensions. Thus, in addition to aerobic endurance, muscle strength will also be critical to future HRQoL.

It is worth mentioning that when analyzing individual dimensions most of the PF variables showed an influence on mobility, self-care and development of usual activity with only leg strength showing a positive influence on anxiety and depression and no variables showing an influence on pain. This could be due to the fact that pain and depression might be associated with psychological factors (e.g., experienced pain management in aged people could reduce or keep the pain-related problem perception) while mobility, self-care and development are physical factors. Nonetheless, in light of previous studies (Hart and Buck, 2019) we think that these results should be interpreted with caution, as an improvement or maintenance in PF could entail an improvement in psychological associated variables, which are better measured with the SF-36 questionnaire than with the EQ-5D-3L used in the present study.

Regarding the differences between the VAS and Utility scores, these could be due to several reasons. Firstly, the VAS is a global perception of health and the Utility score is a composed score of 5 selected dimensions of a health-related quality of life, so both are complementary. In more detail, the EQ-5D-3L Utility could be assessed based on VAS values regression or time-trade-off techniques based on social valuation (we used this as stated in the methodology). Secondly, some of these 5 selected dimensions are specifically related to the expected daily living activities (e.g., walking, self-care, usual activities) that could be individually different according to gender, age or culture (e.g., domestic duties depending on culture, living with partner or alone). Moreover, for the Utility scores calculation there was no sex- and age-specific values for Spain, and we therefore used the European values while for VAS there was sex- and age-specific values for Spain (Szende et al., 2014). Secondly, the VAS is a global scale through which respondents report their general perceived health status with a grade ranging from 0 (worst possible health status) to 100 (best possible health status) while the Utility scores are a result of five different questions with three options for each question (no problems, light/mild problems or severe problems). Lastly, due to the fact that there are only three levels (possible answers) by dimension, most participants select the option “no problem” to answer the question. As a result, there is normally a ceiling effect with most participants showing a Utility score of 1, an effect that is not found when analyzing the VAS scores. Partly due to this limitation in ceiling and sensitiveness to change a new version including five levels by dimension was developed (Van Hout et al., 2012) by the EuroQol group in 2009, but as this study started in 2008, our group decided to maintain the initial 3 L version.

From the present findings it is clear that older adults should try to beM fit. In order to do so they should perform physical activity on a regular basis reaching a minimum of 300 min of weekly aerobic moderate physical activity or 150 of vigorous-intensity aerobic physical activity as recommended by the world health organization (WHO Guidelines on physical activity and sedentary behaviour, 2020). As part of their weekly physical activity they should perform multicomponent physical activity which should include balance and strength training to enhance functional capacity and prevent falls, as this type of training has been found to reduce falls by 24% (programs including balance and functional exercises) and 28% (the previous plus resistance exercises) (Sherrington et al., 2020). In fact, in a previous study with the present sample we found that those adults who stayed involved in organized physical activity maintained PF when compared to those who stopped their involvement in organized physical activity who decreased their PF (Gomez-Bruton et al., 2020). Moreover, we recently performed a multicomponent exercise program in a small sub-sample of the present study including frail and pre-frail older adults finding improvements in body composition in the training group while the control group showed an impairment in body composition variables during the 6 month follow-up period (Moradell et al., 2020b). We also found that the performed multicomponent training slowed down bone impairment associated with aging in frail and pre-frail older adults (Moradell et al., 2020a). This is of critical importance as maintaining adequate bone mass and body composition levels will reduce the risk of fracture, hospitalization and death (Balogun et al., 2019).

Although the present study presents several strengths such as a large sample size, the measurement of PF variables and a long follow-up, it is not exempt of limitations. Firstly, we did not perform yearly assessments to evaluate the evolution during the 8 years. It is probable that older adults went through several stages during aging and during those 8 years, and different results might have emerged if we had also analyzed PF and HRQoL on a yearly basis. Secondly, as previously mentioned, the EQ-5D-3L has shown a ceiling effect and does not register cognitive variables that could have been interesting in the present sample. Thirdly, part of the sample was recruited from fitness centers or organized physical activity classes and was therefore mostly composed by active older adults, which could bias our results.

5. Conclusion

Older adults who want to maintain a high quality of life should try to stay fit, specially focusing on aerobic endurance and muscle strength. Today’s PF can determine future HRQoL as older adults who showed high PF levels and maintained them during the eight-year follow-up presented the highest HRQoL scores.

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