Journals of Gerontology: Medical Sciences
cite as: *J Gerontol A Biol Sci Med Sci*, 2021, Vol. XX, No. XX, 1–9
https://doi.org/10.1093/gerona/glab179
Advance Access publication June 21, 2021

Research Article

Fitness vs Fatness as Determinants of Survival in Noninstitutionalized Older Adults: The EXERNET Multicenter Study

David Navarrete-Villanueva, MSc,[1] Alba Gómez-Cabello, PhD,[1,2] Alejandro Gómez-Bruton, PhD,[1,3] Eva Gesteiro, PhD,[4] Irene Rodríguez-Gómez, PhD,[5,] Jorge Pérez-Gómez, PhD,[6] José Gerardo Villa-Vicente, MD, PhD,[7] Luis Espino-Toron, MD,[8] Narcís Gusi, PhD,[9] Marcela González-Gross, PhD,[3,5,7,] Ignacio Ara, PhD,[3,8,9] Germán Vicente-Rodríguez, PhD,[1,3] and José A. Casajús, MD, PhD[1,10,*]

[1]GENUD (Growth, Exercise, NUtrition and Development) Research Group, Instituto Agroalimentario de Aragón-IA2-(CITA-Unizar), Centro de Investigación Biomédica en Red de Fisiopatología de la Obesidad y Nutrición (CIBERObn), University of Zaragoza, Spain. [2]Centro Universitario de la Defensa, Zaragoza, Spain. [3]Faculty of Health and Sport Sciences (FCSD), University of Zaragoza, Huesca, Spain. [4]ImFine Research Group, Department of Health and Human Performance, Universidad Politécnica de Madrid, Centro de Investigación Biomédica en Red de Fisiopatología de la Obesidad y Nutrición, (CIBEROBN), Spain. [5]GENUD Toledo Research Group, Universidad de Castilla-La Mancha, CIBER of Frailty and Healthy Aging (CIBERFES), Spain. [6]HEME Research Group, University of Extremadura, Cáceres, Spain. [7]Institute of Biomedicine (IBIOMED), University of León, Spain. [8]Unit of Sport Medicine, Cabildo of Gran Canaria, Spain. [9]Physical Activity and Quality of Life Research Group (AFYCAV), Faculty of Sport Sciences, University of Extremadura, Cáceres, Spain. [10]Faculty of Medicine, University of Zaragoza, Huesca, Spain.

*Address correspondence to: José A. Casajús, MD, PhD, GENUD (Growth, Exercise, NUtrition and Development) Research Group, University of Zaragoza, 50009 Zaragoza, Spain. E-mail: joseant@unizar.es

Received: September 26, 2020; Editorial Decision Date: June 14, 2021

Decision Editor: Jay Magaziner, PhD, MSHyg

Abstract

Background: Physical fitness and body composition are important health indicators; nevertheless, their combined pattern interrelationships and their association with mortality are poorly investigated.
Methods: This longitudinal study is part of the Spanish EXERNET-Elder project. Person-months of follow-up were calculated from the interview date, performed between June 2008 and November 2009, until the date of death or censoring on March 2018 (whichever came first). In order to be included, participants had to fulfill the following criteria: (a) be older than 65 years, (b) live independently at home, (c) not suffer dementia and/or cancer, and (d) have a body mass index above 18.5. Body fat and weight were assessed by a bioelectrical impedance analyzer. Fitness was measured with the Senior Fitness and the one-leg static balance tests. The Spanish Death Index was consulted for the death's identification. Cluster analysis was performed to identify Fat–Fit patterns and traditional cut-points and percentiles to create the Fat–Fit groups. Cox proportional hazards regression models were used to calculate the hazard ratios (HRs) of death in clustered Fat–Fit patterns and in traditional Fat–Fit groups.
Results: A total of 2299 older adults (76.8% of women) were included with a baseline mean age of 71.9 ± 5.2 years. A total of 196 deaths (8.7% of the sample) were identified during the 8 years of follow-up. Four clustered Fat–Fit patterns (Low fat–Fit, Medium fat–Fit, High fat–Unfit, and Low fat–Unfit) and 9 traditional Fat–Fit groups emerged. Using the Low fat–Fit pattern as the reference, significantly increased mortality was noted in High fat–Unfit (HR: 1.68, CI: 1.06–2.66) and Low fat–Unfit (HR: 2.01, CI: 1.28–3.16) groups. All the traditional Fit groups showed lower mortality risk when compared to the reference group (obese–unfit group).
Conclusion: Physical fitness is a determinant factor in terms of survival in community-dwelling older adults, independently of adiposity levels.

Keywords: Clustering, Fatness, Older populations, Physical fitness, Survival

Aging is associated with a gradual accumulation of a wide variety of molecular and cellular damage (1,2). Over time, this damage leads to a gradual decrease in physiological reserves and a general decline in the capacity of the individual, resulting in greater susceptibility to complications, pathologies, chronic diseases, and death (3). There are multiple sensitive and specific indicators that can measure this physiological reserve decline and can be classified as indicators of successful aging (4).

Physical fitness and body composition are important indicators of current and future health (4) and both suffer important changes during the aging process. While there is a gradual decline of most physical fitness components (5), there is an increase and redistribution of fat mass (6). Moreover, fitness and fatness are so tightly connected that it is difficult to understand one without the other (7).

Numerous studies have shown that some individual objective tests of physical fitness, such as gait speed, endurance, and muscular strength, are predictors of premature mortality in community-dwelling populations, suggesting that physical fitness might be considered as a mortality risk indicator (8,9). Nevertheless, data regarding associations between adiposity measures and survival in older adults are largely equivocal (10).

In this regard, 2 decades ago, Gruberg et al. (11) coined the term obesity paradox to describe their unexpected finding that overweight and obese patients undergoing percutaneous coronary interventions had lower mortality rates than normal-weight patients. Since then, this inverse association between obesity and mortality has been observed in cardiovascular disease (CVD) patients (12) and in several older adult groups without CVD (13,14).

The causes of the obesity paradox have been the subject of intense debate within the scientific community. Its existence has both scientific proponents and opponents (10,15). Researchers who support this phenomenon emphasize the biological advantages of excess fat stores during periods of illness. Body fat may decrease oxidative stress and inflammation and improve the secretion of aminoacids, adipokines, and cytokines. Moreover, obese people may tolerate weight loss better than nonobese individuals due to their higher metabolic reserves (better resistance to cachexia) (16). Opponents refer to this phenomenon as the "Body Mass Index (BMI) paradox" and suggest that this measure has several limitations. People with similar BMI may have distinct body compositions because BMI cannot distinguish among fat mass, lean mass, and adiposity distribution. Thereby, high BMI individuals may be physically fit with a low mortality risk compared with people with low BMI but high adiposity and low levels of muscle mass (10). Due to the body composition changes that occur during aging, it seems necessary to include measures of fat mass in addition to BMI when evaluating older adults in order to ascertain if the obesity paradox has a positive relationship with mortality risk and other health issues.

In relation to mortality, one possible explanation for the discrepancies found between studies is that fitness may act as either a confounder or a modifier of the relationship between adiposity markers and all-cause mortality. Although this concept is popularly conceptualized as the "fat but fit" theory, there is still little evidence explaining the idea of "better to be fat and fit than low weight and unfit" (12,17).

Therefore, there are a limited number of studies that reported the association of adiposity markers with all-cause mortality taking into account measures of physical fitness (17). Moreover, studies that examine physical fitness usually only assess a single dimension (eg, cardiorespiratory fitness) (18) or rely on a single assessment (eg, walking speed) (19). To the best of our knowledge, there are no studies addressing this relationship using cluster analysis among older adults and including both physical fitness tests and adiposity measures.

For this reason, the first aim of this study was to identify the clustering patterns of physical fitness and body fat indicators (fat–fit patterns) in a sample of noninstitutionalized Spanish older adults. The second aim was to ascertain whether the identified clustered patterns and traditional fatness and fitness groups were associated with mortality in this population.

Materials and Methods

Study Design and Participants

This longitudinal study is part of the EXERNET-Elder project, a multicenter study carried out in 6 Spanish regions. The global project is aimed to develop physical fitness and body composition reference values in a representative sample of community-dwelling older adults and to determine their association with several health outcomes (20).

The participants were selected by means of a multistep sampling, taking into account, first the locations (6 different regions of Spain: Aragón, Castilla la Mancha, Castilla León, Madrid, Extremadura, and the Canary Islands) that ensure diversity sample, then 3 different cities in each region (the capital of the region and 2 other cities, one with 10 000–40 000 inhabitants and another with 40 000–100 000 inhabitants); second, a random assignment of civic and sports centers. And finally, the recruitment of participants was carried out through bulletin boards at the civic and sports centers, personal communication, and advertisements in local newspapers (20). The final sample was made up of people who meet the entry criteria and were willing to participate in the study. Participant recruitment was completed when the appropriate number was reached for each geographic site.

In order to be included, participants had to fulfill the following criteria: (a) be older than 65 years, (b) live independently in their homes, (c) not suffer dementia and/or cancer, and (d) have a BMI above 18.5. The information was collected with personal interviews using a structured questionnaire, followed by a physical examination to measure anthropometric and physical fitness. Data collection took place from June 2008 to November 2009. Person-months of follow-up were calculated from the date of the interview until the date of death or censoring on March 31, 2018, whichever came first. In this study, a sample of 2299 older adults was analyzed.

The study protocol was approved by the Clinical Research Ethics Committee of Aragón (18/2008) and it adhered to the Helsinki Declaration of 1964 (revision of Edinburgh 2000 and further amendments). Written informed consent was obtained from each participant before partaking in the study.

Measurements

Physical fitness and body composition

Anthropometric and physical fitness measures were evaluated by trained researchers according to standardized protocols. A detailed manual of operations was designed, and a workshop training session was carried out in Toledo (Spain) in June 2008, in order to standardize and harmonize the assessment of the anthropometric and physical fitness tests (21).

Height was measured using a portable stadiometer (Seca, Hamburg, Germany) with 2.10 m maximum capacity and a 0.001 m error margin. Participants stood barefoot with their scapula, buttocks, and heels resting against a wall, the neck was held in a natural nonstretched position, the heels were touching each other with the toe tips spread to form a 45° angle, and the head was held straight with the inferior orbital border in the same horizontal plane as the external auditory tube (Frankfort's plane) (22). Body weight and body fat percentage (% body fat) were obtained by a portable bioelectrical impedance analyzer Tanita BC 418-MA (Tanita Corp., Tokyo, Japan) with a 200 kg maximum capacity and a ±100 g error margin. This device measures whole-body composition using a high-frequency current (50 kHz, 500 µA). The 8 electrodes are positioned so that the electric current is supplied from the electrodes on the tips of the toes of both feet and the fingertips of both hands, and voltage is measured on the heels of both feet and the thenar side of both hands. Individuals removed shoes, socks, and heavy clothes prior to weighing. Before examinations participants received the following recommendations: (a) no alcohol intake 12 hours prior to the measurement, (b) no vigorous exercise 12 hours prior to the measurement, (c) no food and drink intake 3 hours prior to the measurement, and (d) urination immediately before the measurement took place.

The physical fitness assessment included the senior fitness test battery developed by Rikli and Jones (23) with the following components: lower and upper body strength by the chair stand test and arm curl test, respectively, agility/dynamic balance by the 8-foot up-and-go test, and cardiorespiratory fitness by the 6-minute walk test. Finally, the static balance test (Flamingo test) was performed to assess one-leg static balance (24). All the tests were performed twice, except for the chair stand test and the 6-minute walk test, which were performed once.

Demographic characteristics

Data for all participants were registered through an interview using a sociodemographic questionnaire that included one validated question about walking hours and another about sedentary behaviors (25). Each of them could be registered under a value of daily practice time (h): (a) <1, (b) 1–2, (c) 2–3, (d) 3–4, (e) 4–5, and (f) >5 hours. Organized physical activity (OPA) was also registered through the following question: "Are you currently engaged in organized physical activity?" The question covered any OPA understood as a collective guided and supervised activity that was delivered by an instructor. Regarding smoking habits, the study participants were classified as smokers and nonsmokers according to their responses to the question "Do you currently smoke?" (no/yes). Polypharmacy was defined by the concomitant use of 5 or more medications consumed within the 30 days prior to the interview (26). Regarding the level of studies, the participants had to answer the following question: "what studies do you have?" According to their answer, we established 2 categories: "no studies, but I can read and/or write" and "primary, secondary or university studies." Finally, the alcohol consumption was recorded asking the participant: "Do you usually drink alcoholic drinks?" (no/yes).

Survival data

The Spanish National Death Index was consulted for the identification of all-cause deaths in the EXERNET cohort during the 8 years of the mean follow-up period.

Statistical Analyses

All statistical analyses were performed using the Statistical Package for the Social Sciences version 20 and data were plotted using ggplot2 package in the R (version 3.6.1). Statistical significance was set at level $p < .05$ in all tests.

Sample characteristics are presented with means ± standard deviations (*SD*) or frequencies.

Clustered fat–fit patterns

Cluster analysis was performed to identify physical fitness and body composition patterns. These variables included in the clusters were transformed into sex and age-specific *z*-scores. In order to guarantee a proportional distribution between groups and following the methodology of previous studies (20,27), age was divided into different categories: 65–69, 70–74, and 75 or more years. Outliers (> or <3 *SD*s) were removed before cluster analysis.

In accordance with clustering methods reported in previous studies (28,29), 2 types of cluster analyses were carried out: hierarchical clustering and k-means clustering. First, a hierarchical cluster analysis was performed using Ward's method based on the Euclidean distances. In order to reduce the sensitivity of Ward's method to outliers, individual outliers and multivariate outliers (those with high Mahalanobis values distance) were investigated. The number of clusters was determined by analyzing dendrograms, which suggested a solution of 4 cluster groups.

Finally an iterative nonhierarchical cluster k-means clustering procedure was applied in which initial cluster centers based on Ward's hierarchical method with 4 possible solutions. This strategy minimizes the within-cluster variance and maximizes the between-cluster distance; therefore, the resulting clusters are as homogeneous as possible. Analyses of variance with post hoc Bonferroni tests were used to classify and name the 4 cluster groups.

Traditional fat–fit groups

A second classification was made to identify physical fitness and body composition groups using traditional fatness and fitness classifications.

The results for the 5 physical fitness tests were ranked, using percentile values by sex and age in Spanish older population published by Pedrero-Chamizo et al. (30), as very poor (<P20), poor (between P20 and P40), average (between P40 and P60), above average (between P60 and P80), and excellent (>P80) and transform on a 5-point scale with a maximum score of 25. Scores for the 5 tests were summed and participants were assigned to one of the 3 fitness levels: unfit (<10), medium fit (10–17), and fit (>17) (31). The thresholds of fatness were established at BMIs of 25 kg/m^2 (overweight) and 30 kg/m^2 (obesity) (32). Values of body fat ≥25% and ≥38%, men and women, respectively, were considered as overfat, and values of body fat ≥31% and ≥43%, in men and women of this age group, respectively, were considered as overfat/obesity (33).

The fitness classification can be inspected in full in Supplementary Material.

Survival statistics.—Cox proportional hazards regression models were used to calculate the hazard ratios (HRs) of death in each cluster group. This analysis was adjusted by smoking habits, sedentary behaviors, walking hours, OPA, polypharmacy, level of studies, and alcohol consumption. Adjusted Kaplan–Meier curves were used to illustrate event-free survival of Fat–Fit patterns and Fit-Fat groups. The log-rank test was used to compare survival among different groups. Deaths within the first 3 years were excluded to minimize bias from reverse causation. Proportional hazards assumptions of both models were tested with a correlation of follow-up time and cumulative martingale residuals (Schoenfeld residuals) from the adjusted Cox model.

Results

Participant's Characteristics, Body Composition, and Physical Fitness

Descriptive characteristics, body composition, and physical fitness values of the sample by clustered Fat–Fit pattern group are presented in Table 1. A total of 2299 older adults were included in the study with a baseline mean age of 71.9 ± 5.2 years (from 65 to 91). A total of 196 deaths (8.7% of the sample) were identified during the 8 years of follow-up.

Fat–Fit Patterns by Clustering Analysis

The 4 body composition and physical fitness clusters (Fat–Fit patterns) are presented in Figure 1. Cluster 1 was labeled as Low fat–Fit, as it was characterized by high levels of fitness, especially for the balance test, and the lowest levels of BMI and % body fat. Cluster 2 was labeled as Medium fat–Fit, due to the presence of the highest values for the strength variables, high levels of dynamic balance and cardiorespiratory fitness, and also the presence of medium values for both body composition variables. Cluster 3 was labeled as High fat–Unfit as it showed the lowest values for physical fitness and the highest values for BMI and % body fat. Finally, Cluster 4 was labeled as Low fat–Unfit, because it presented low values for the physical fitness variables and also low values for both, BMI and % body fat, in comparison with the other groups. Statistical differences among groups are described in Table 1.

Interestingly, as Figure 1 shows, it is noteworthy that the static balance component has its own entity, as it significantly differentiates from other physical fitness components among the 4 Fat–Fit patterns. In both the fit and unfit patterns, the groups with more adiposity have significantly less balance. Specifically, the average difference was 30.8 seconds in the static balance test between the 2 fit patterns. On the other hand, it seems that BMI and % body fat act in a similar way within the 4 patterns, as the same results emerged with both variables.

Associations of the Clustered Fat–Fit Patterns With All-Cause Mortality

Figure 2A shows the adjusted estimated HR and 95% CIs from the Cox regression analyses adjusted by smoking habit, sitting hours per day, walking hours per day, OPA, polypharmacy, level of studies, and alcohol consumption for Fat–Fit patterns and all-cause mortality. Figure 2B illustrates survival characteristics according to the different Fat–Fit patterns. Older adults with a Low fat–Unfit pattern had a significant higher risk of mortality (HR: 2.36, CI: 1.30–4.28, $p < .01$) when compared to the Low fat–fit group.

Similarly, older adults who belonged to the High fat–Unfit (HR: 2.09, CI: 1.13–3.83, $p < .05$) and Medium fat–Fit (HR: 1.89, CI: 1.03–3.47, $p < .05$) patterns also had a significant higher risk of mortality when compared to the Low fat–Fit.

Globally, as presented in Figure 2, there was a significant trend toward better survival in the patterns that are characterized by high physical fitness values, taking into account body fat and BMI parameters.

Fat–Fit Groups by Traditional Cut-Points

Nine groups emerged when mixing the 3 BMI groups (Lean, Overweight, and Obese) or the 3 fatness groups (Lean, Overfat, and Overfat/Obese) using traditional cut-points and the 3 fitness groups (Fit, Medium fit, and Unfit) using fitness percentiles. The 9 body composition and physical fitness groups (Fat–Fit groups) are presented in Supplementary Figures 4 and 5. Also, the descriptive analysis by traditional Fat–Fit groups can be inspected in full in Supplementary. Tables 2–7.

Due to the methodology used, all the "Fit groups" have high values of all the components of physical fitness; in the same way, the groups named as "Medium Fit" have medium values and the "Unfit" groups have low values in all physical fitness tests. Closer inspection of the Supplementary Material shows statistical differences between the Obese groups (Obese–Fit, Obese–Medium Fit, Obese–Unfit) and the Overfat/Obese groups (Overfat/Obese–Fit, Overfat/Obese–Medium Fit, Overfat/Obese–Unfit), where, even though all the groups are above the cutoff points, there are significant differences between them, with the Unfit groups (Obese–Unfit and Overfat/Obese–Unfit) having more BMI or % fat than the other groups.

Associations of Traditional Fat–Fit Groups With All-Cause Mortality

Figure 3 provides the survival probability and the adjusted HRs with 95% confidence intervals from the Cox regression analyses. All the Fit groups showed lower mortality risk when compared to the reference group (obese–unfit group). Additionally, the medium-fit overweight group also showed a lower mortality risk when compared to the reference group. The same results were obtained independently of the used body composition method to classify participants (BMI or body fat percentage).

Finally, the Overweight–fit or Overfat–fit groups and the Lean–fit groups did not statistically differ if we compared with the Obese–fit or Overfat/Obese–fit group, even if in Figure 3 it seems that the group Obese–fit or Overfat/Obese–fit had greater survival.

Discussion

This study sets out with the aim of creating clusters using fitness and fatness measures from a sample of Spanish community-dwelling older adults. Four Fat–Fit patterns emerged in this study: Low fat–Fit, Medium fat–Fit, High fat–Unfit, and Low fat–Unfit. To the author's knowledge, this is the first study aiming to identify clusters that include both fitness and fatness variables in older adults.

According to these results, 2 aspects can be highlighted.

First, the own entity of balance test as it significantly differentiates from other physical fitness components among the 4 Fat–Fit patterns. This finding broadly supports the hypothesis of other studies in this area linking poor balance with obesity (34). Hue et al. (35) suggested that obese individuals have reduced sensory functions in the lower limbs because of the high pressure exerted on them by the high body weight. Similarly, Menegoni et al. (36) found obese adults to have a higher mean center of pressure speeds compared to their normal-weight counterparts. This finding is of great relevance due to poor balance being associated with a higher risk of falls and fracture risks in older adults (37,38). Therefore, the idea of having high levels of fat should be taken with caution.

Second, the High fat–Unfit pattern is characterized by reporting the lowest cardiorespiratory fitness values. These results corroborate the findings of previous studies that found that adiposity, not glycemic control or disease type, is the strongest predictor of low cardiorespiratory fitness in those with metabolic diseases (39) and without them (40). Taking into account that low cardiorespiratory

Table 1. Summary of Descriptive Characteristics by Baseline Fat–Fit Patterns

	Total	Low Fat–Fit Pattern	Medium Fat–Fit Pattern	High Fat–Unfit Pattern	Low Fat–Unfit Pattern	*p* Overall
	N = 2299	*N* = 550	*N* = 578	*N* = 597	*N* = 574	
Age (years)	71.9 ± 5.2	71.2 ± 5.1	72.5 ± 5.4	71.8 ± 5.1	72.0 ± 5.2	.001
Sex (% female)	1767 (76.8%)	412 (75.0%)	452 (78.2%)	457 (76.5%)	444 (77.4%)	.6
OPA	1908 (85.9%)	479 (89.7%)	504 (91.1%)	484 (84.3%)	441 (78.7%)	<.001
Walking hours per day (h)						.003
<1	746 (34.0%)	140 (26.4%)	170 (31.3%)	222 (39.6%)	214 (38.2%)	
1–2	1116 (50.9%)	291 (54.9%)	282 (51.9%)	267 (47.6%)	276 (49.3%)	
2–3	260 (11.9%)	77 (14.5%)	70 (12.9%)	57 (10.2%)	56 (10.0%)	
3–4	42 (1.9%)	14 (2.6%)	11 (2%)	10 (1.8%)	7 (1.2%)	
4–5	16 (0.7%)	4 (0.7%)	6 (1.1%)	3 (0.5%)	3 (0.5%)	
>5	14 (0.6%)	4 (0.7%)	4 (0.7%)	2 (0.4%)	4 (0.7%)	
Sitting hours per day (h)						.004
<1	75 (3.53%)	20 (3.86%)	14 (2.70%)	22 (4.00%)	19 (3.51%)	
1–2	266 (12.5%)	71 (13.7%)	52 (10.0%)	65 (11.8%)	78 (14.4%)	
2–3	602 (28.3%)	173 (33.4%)	129 (24.9%)	143 (26.0%)	157 (29.0%)	
3–4	540 (25.4%)	118 (22.8%)	133 (25.7%)	140 (25.5%)	149 (27.5%)	
4–5	330 (15.5%)	74 (14.3%)	101 (19.5%)	89 (16.2%)	66 (12.2%)	
>5	314 (14.8%)	62 (12.0%)	89 (17.2%)	91 (16.5%)	72 (13.3%)	
Smoking (% yes)	74 (3.36%)	20 (3.77%)	9 (1.64%)	23 (4.07%)	22 (3.94%)	.081
Primary or superior studies (% yes)	329 (15.2%)	93 (17.7%)	72 (13.4%)	64 (11.6%)	100 (18.4%)	<.1
Alcohol consumption (% yes)	410 (17.8%)	105 (19.1%)	108 (18.7%)	96 (16.1%)	101 (17.6%)	.556
Polymedication (% yes)	334 (19.6%)	54 (12.6%)	79 (16.8%)	111 (27.3%)	90 (22.4%)	<.001
Static balance (s)	26.3 ± 21.0	52.0 ± 12.8*,†,‡	21.2 ± 16.4*,†	13.7 ± 14.3*,‡	20.0 ± 16.3†,‡	<.001
Leg strength (rep)	14.4 ± 3.3	15.6 ± 2.8*,†,‡	16.8 ± 3.0*,†	12.6 ± 2.7‡	12.9 ± 2.5‡	<.001
Arm strength (rep)	16.3 ± 3.6	16.9 ± 2.9*,†,‡	19.3 ± 2.9*,†	14.8 ± 3.2*,‡	14.2 ± 2.8†,‡	<.001
Dynamic balance (s)	5.8 ± 1.4	5.1 ± 0.8*,†	5.3 ± 0.8*,†	6.8 ± 1.7*,‡	6.1 ± 1.2†,‡	<.001
CRF (m)	525 ± 85.6	577 ± 64.3*,†,‡	558 ± 68.2*,†	464 ± 83.6*,‡	504 ± 74.8†,‡	<.001
BMI (kg/m^2)	29.2 ± 4.2	26.6 ± 2.8†,‡	29.3 ± 2.9*,†	33.8 ± 3.5*,‡	26.8 ± 2.6†,‡	<.001
Fat mass (%)	37.2 ± 6.9	33.8 ± 6.1†,‡	37.9 ± 5.9*,†	42.4 ± 5.6*,‡	34.3 ± 6.1†,‡	<.001
Deaths (%)	196 (8.7%)	30 (5.6%)	45 (8.1%)	57 (9.7%)	64 (11.2%)	.007

Notes: OPA = organized physical activity; CRF = cardiorespiratory fitness, 6-minute walk test. Values are presented as mean ± *SD* or percentages.
*Significant difference with the Low fat–Unfit pattern ($p < .05$).
†Significant difference with the High fat–Unfit pattern ($p < .05$).
‡Significant difference with the Medium fat–Fit pattern($p < .05$).

fitness has been established as an independent predictor of morbidity (41–43) and mortality (44,45), finding out which aspects are related to lower levels of cardiorespiratory fitness will allow us to design strategies that will improve it in this population group.

The second aim of this study sought to determine how fitness and fatness interaction groups are associated with mortality. Our results showed that physical fitness is a determinant factor in terms of survival in community-dwelling older adults, even more important than their adiposity level.

Globally, patterns characterized by high levels of physical fitness had a reduced risk for all-cause mortality, while those patterns with low levels of physical fitness had a significant increase in the risk. Specifically, the Low fat–Unfit pattern had the highest mortality risk and was twofold more likely to die (HR: 2.08, 95% CI: 1.18–3.67) in comparison to the Low fat–Fit pattern. Similarly, individuals belonging to the High fat–Unfit pattern were 2.1 times as likely to die as the Low fat–Fit pattern (HR: 2.09, CI: 1.13–3.83, $p < .05$). The Fat–Fit groups using traditional cut-points support these results. Older adults belonging to the Fit or Medium fit (in the overweight or overfat groups and in the obese or overfat/obese groups) have a lower risk of death than the Obese–Unfit group (Figure 3). However, the Unfit groups (Lean–Unfit, Lean–Medium fit, and Overweight–Unfit or Unfit–Overfat) and Medium Fit–Lean groups did not statistically significantly differ from the reference group (Obese–Unfit or Overfat/Obese–Unfit), being these the ones with the highest risk of death. It is also interesting to note that obese participants belonging to the fit and medium fit groups have the lowest risk of mortality compared to the obese unfit.

There is a result between the 2 figures that may seem contradictory. In Figure 2, the Medium fat–Fit pattern had higher mortality than the Low fat–fit one (HR: 1.89, CI: 1.03–3.47, $p < .05$). Therefore, it seems that in these 2 patterns, increasing fat increases mortality. By contrast, in Figure 3, it is observed that the Obese–fit (Figure 3A) and the Overfat/obese–fit (Figure 3B) were the groups with the lowest mortality. However, no significant differences are found in the mortality between the 3 "Fit groups" when doing separate analysis and using the Obese–fit or Overfat/obese–fit group as a reference.

Two possible explanations can be found for these results. First, these results can be explained in part by the differences between "patterns" and "traditional groups." The Medium fat–fit pattern has significantly less balance, not only more fat or BMI, than the Low fat–fit. However, the 3 "Fit groups" with traditional cutoff points

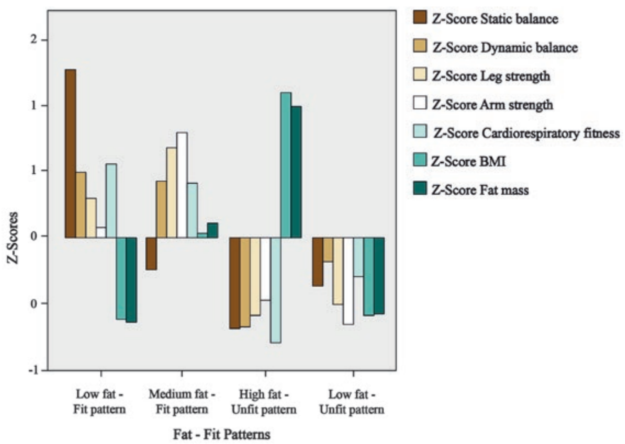

Figure 1. Physical fitness and body fat *z*-scores, adjusted by sex and age. Note: The significant differences found between groups are presented in Table 1.

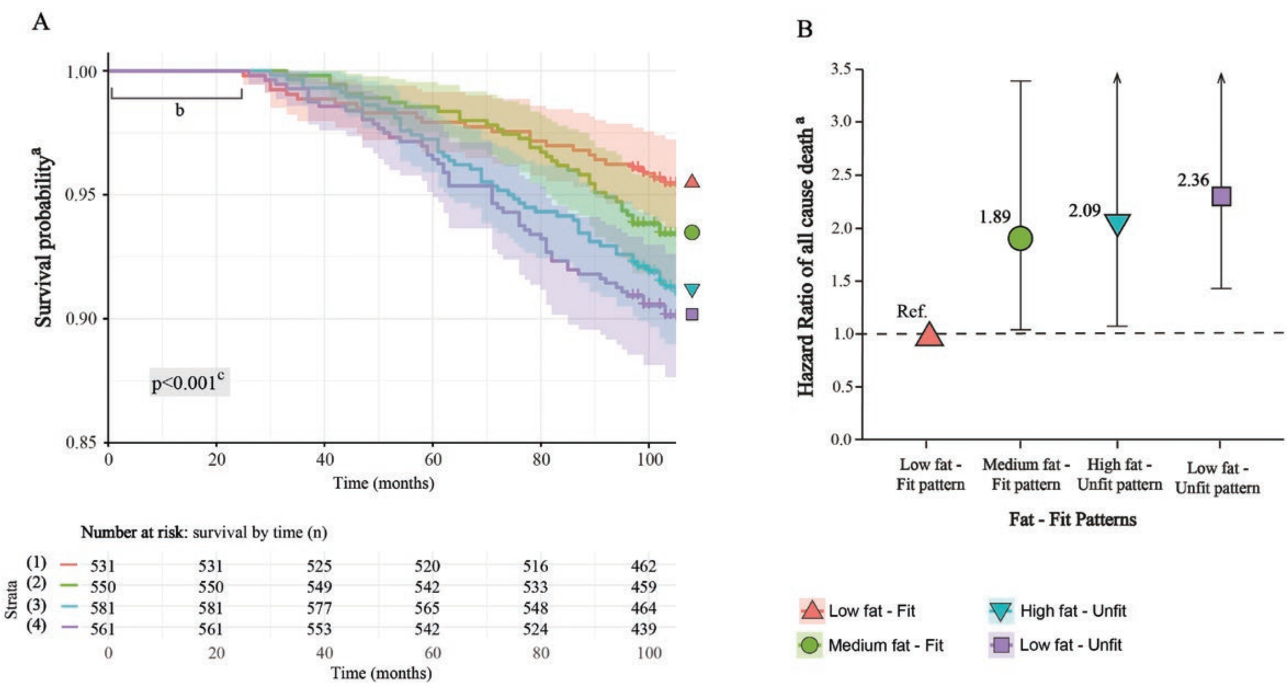

Figure 2. Survival probability and hazard ratios with 95% confidence intervals of all-cause mortality among different Fat–Fit patterns. Note: Bold values denote statistically significant differences ($p < .05$) compared with the reference category (Low fat–Unfit). [a]Adjusted by smoking habits, sedentary behaviors, walking hours, OPA, polypharmacy, level of studies, and alcohol consumption. [b]Deaths within the first 3 years were excluded to minimize bias from reverse causation. [c]*p* value from Log-Rank test.

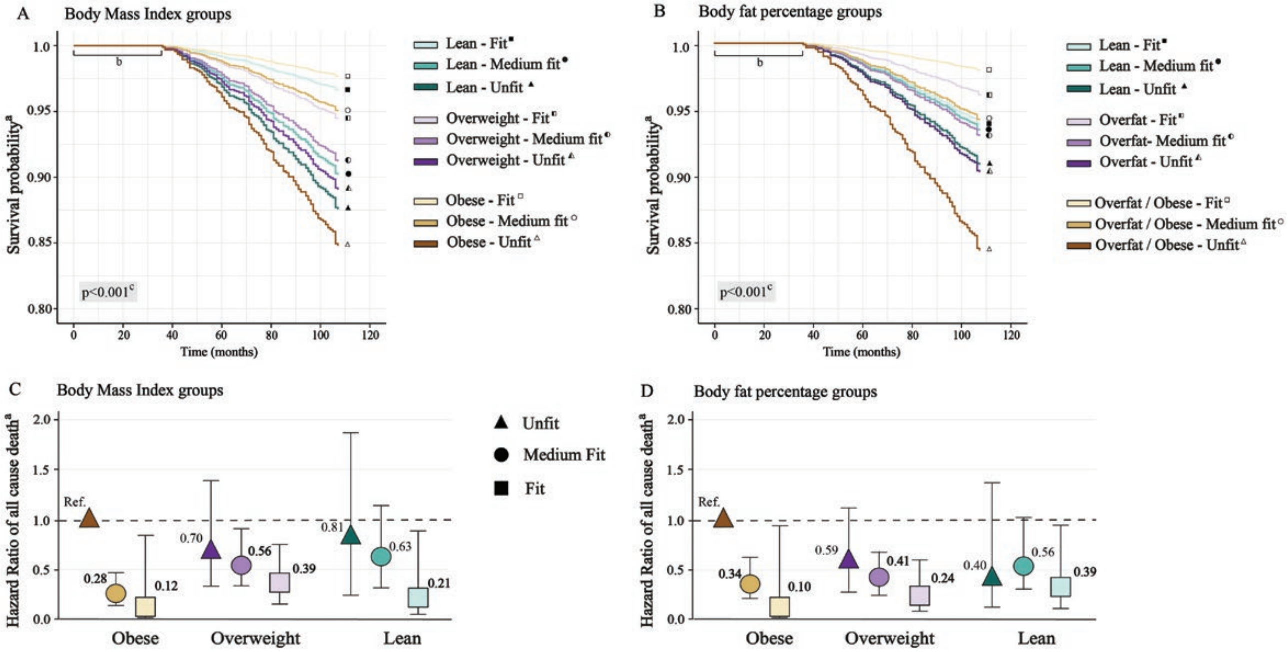

Figure 3. Survival probability and hazard ratios with 95% confidence intervals of all-cause mortality among different fitness and fatness groups. Notes: Body mass index groups (A and C) and body fat groups (B and D). Bold values denote statistically significant differences ($p < .05$) compared with the reference category (Obese–Unfit). [a]Adjusted by smoking habits, sedentary behaviors, walking hours, OPA, polypharmacy, level of studies, and alcohol consumption. [b]Deaths within the first 3 years were excluded to minimize bias from reverse causation. [c]*p* value from Log-Rank test.

have on average the same balance score (Supplementary Material) as the other physical fitness tests, due to the methodology used to create the groups. The methodology of creating patterns using cluster analysis can be interesting at the epidemiological level as we can see how the variables interact; however, the use of traditional cutoff points may limit the interpretation of the results. Second, these results can also be explained by the existing differences in BMI and fat mass. In this regard, although all Obese groups (Obese–fit, Obese–Medium fit, Obese–Unfit) and Overfat/Obese groups (Overfat/Obese–fit, Overfat/Obese–Medium fit, Overfat/Obese–Unfit) exceeded the threshold to be called obese or Overfat/Obese, the Low fit groups have significantly more fat and BMI than the other groups and that could explain this trend.

Taken together, these findings suggest a clear association between low physical fitness and mortality, not finding an obesity paradox in this sample of community-dwelling older adults. These global findings regarding the obesity paradox in older adults are partially in line with some (14,46–52) but not other (19) previous reports examining the relationship between fitness, fatness, and mortality in older adults. Nonetheless, many of these studies have been developed with participants who suffer a specific pathology such as heart failure (46–48), CVDs (49), or prediabetes (52). Nevertheless, previous research developed healthy older adults are in line with our results (14,50,51). Sui et al. (14) found that fit participants had lower death rates than the unfit within each stratum of adiposity, therefore all-cause mortality risk was modulated by cardiorespiratory fitness. Similarly, McAuley et al. (50,51) in their studies with veterans identified that fitness altered the obesity paradox in that overweight and obese men with low fitness were less likely to survive than normal-weight men with high fitness. This finding contrasts with other studies, like the one published by Woo et al. (19). These authors did not identify any interaction between fatness and fitness measures with respect to mortality, concluding that fitness did not account for the obesity paradox. These discrepancies are probably due to the way of measuring physical fitness, because the first 2 measured cardiorespiratory fitness and the third measured walking speed. For that reason, our results shed light on this issue as we use various fitness measurement methods.

Returning to the relationship between obesity and a decrease in mortality. As pointed out in the introduction, some opponents refer to this phenomenon as the “BMI paradox” and suggest that this measure has several limitations. As we can see in both methodologies, body fat percentage and BMI seem to have the same effect. Probably, the possible differences that can occur between different ways of measuring body composition have been alleviated or diminished by the inclusion of the physical fitness components. It is also possible that if other body composition parameters such as body fat percentage measured by DEXA or waist and hip circumferences had been measured, different results would have been found. Finally, the association of obesity with lower mortality among unfit older people and the “fat but fit paradox” could be explained by the biological advantages of excess of fat stores during periods of illness. A greater metabolic reserve of adipose tissue could attenuate the non-purposeful weight loss that can cause frailty and cachexia (12). It should be noted that the 2 patterns with high values for both body composition variables also had higher values of strength. This could have a protective effect in face of mortality. Another explanation could be the relationship between falls and mortality in people older than 65 years of age (53). The fitness protective effect against falls could counteract that of fatness.

Strengths and Limitations

Our study had several strengths. First, fitness and fatness levels were determined by standardized and objective measurements of physical performance and adiposity. Second, the 8-year follow-up was sufficient to accrue enough fatal endpoints to allow for assessing the joint association between risk factors and mortality.

Limitations of the current study include a focus on older adults' volunteers, which imply that the noninstitutionalized with low muscle mass, low muscle strength, and/or poorer health might have been less likely to participate. Moreover, 85.9% of the voluntaries were engaged in OPA, a fact that may have contributed to the study's low mortality rates, so the findings may only be generalizable to a relatively Low fat–Fit population living within the community. Also, the fat measures have some limitations, BMI does not inform about body composition as we have mentioned above, and bioelectrical impedance analysis measurements are limited due to the fact that impedance can vary because of the changes in the quantity and distribution of body water, as well as changes in body temperature. In the same way, any measure of weight or body composition that is "static"—taken at one point in time—is less informative than body weight or composition evaluated over time. Finally, mortality cause, actual diseases, and dietary information were not available to be included in the analysis.

Future Research

In future investigations, it might be possible to use different physical fitness tests that take into account the ground effect of the static balance test and include maximum strength measures such as handgrip strength. On the other hand, further research should be undertaken to investigate the obesity paradox in frail, disable, and prefrail individuals, which could be essential to understand the real validity of physical fitness and body composition as biomarkers of future health. Finally, it could be interesting to investigate the relationship of the results obtained in each individual physical fitness test of physical fitness and fatness with mortality and find specific cutoff points by age and sex for each component.

Conclusions

Taken together, these findings support the role of physical fitness as a crucial biomarker related to mortality, independently of adiposity measures. Moreover, the evidence from this study highlights the importance of assessing mortality risk using indexes of both fat and fitness markers. A key policy priority should therefore be the maintenance of older adults' physical fitness as an effective method of preventing premature mortality.

Supplementary Material

Supplementary data are available at *The Journals of Gerontology, Series A: Biological Sciences and Medical Sciences* online.

Funding

This work was supported by the Ministerio de Trabajo y Asuntos Sociales (104/07), Universidad de Zaragoza (UZ 2008-BIO-01), Ministerio de Sanidad, Servicios Sociales e Igualdad (147/2011), Ministerio de Trabajo y Asuntos Sociales Sociales-IMSERSO (104/07), Universidad de Zaragoza (UZ 2008-BIO-01), Centro Universitario de la Defensa de Zaragoza (UZCUD2016-BIO-01), Ministerio de Economía, Industria y Competitividad (DEP2016-78309-R) and cofinanciated by Fondos FEDER (CB16/10/00477). D.N.-V. received a grant from "Gobierno de Aragón" (DGAIIU/1/20) and I.R.-G. received a postdoctoral contract from "Gobierno de Castilla-La Mancha" (2019/9601).

Acknowledgments

The authors are grateful to all the collaborators, nursing homes, health and sports centers, and participants whose cooperation and dedication made this study possible.

Conflict of Interest

None declared.

References

1. López-Otín C, Blasco MA, Partridge L, Serrano M, Kroemer G. The hallmarks of aging. *Cell*. 2013;153:1194–1217. doi:10.1016/j.cell.2013.05.039
2. World Health Organization (WHO). *World Report on Ageing and Health*. WHO Library Cataloguing-in-Publication Data; 2015.
3. Farr JN, Almeida M. The spectrum of fundamental basic science discoveries contributing to organismal aging. *J Bone Miner Res*. 2018;33:1568–1584. doi:10.1002/jbmr.3564
4. Wagner K-H, Cameron-Smith D, Wessner B, Franzke B. Biomarkers of aging: from function to molecular biology. *Nutrients*. 2016;8(6):338. doi:10.3390/nu8060338
5. Milanović Z, Pantelić S, Trajković N, Sporiš G, Kostić R, James N. Age-related decrease in physical activity and functional fitness among elderly men and women. *Clin Interv Aging*. 2013;8:549–556. doi:10.2147/CIA.S44112
6. Gómez-Cabello A, Vicente Rodríguez G, Vila-Maldonado S, Casajús JA, Ara I. Aging and body composition: the sarcopenic obesity in Spain. *Nutr Hosp*. 2012;27:22–30. doi:10.1590/S0212-16112012000100004
7. Ortega FB, Cadenas-Sanchez C, Lee D, Ruiz JR, Blair SN, Sui X. Fitness and fatness as health markers through the lifespan: an overview of current knowledge. *Prog Prev Med*. 2018;3:13. doi:10.1097/pp9.0000000000000013
8. García-Hermoso A, Cavero-Redondo I, Ramírez-Vélez R, et al. Muscular strength as a predictor of all-cause mortality in an apparently healthy population: a systematic review and meta-analysis of data from approximately 2 million men and women. *Arch Phys Med Rehabil*. 2018;99:2100–2113.e5. doi:10.1016/j.apmr.2018.01.008
9. Veronese N, Stubbs B, Fontana L, et al. A comparison of objective physical performance tests and future mortality in the elderly people. *J Gerontol A Biol Sci Med Sci*. 2017;72:362–368. doi:10.1093/gerona/glw139
10. Wang S, Ren J. Obesity paradox in aging: from prevalence to pathophysiology. *Prog Cardiovasc Dis*. 2018;61:182–189. doi:10.1016/j.pcad.2018.07.011
11. Gruberg L, Weissman NJ, Waksman R, et al. The impact of obesity on the short-term and long-term outcomes after percutaneous coronary intervention: the obesity paradox? *J Am Coll Cardiol*. 2002;39:578–584. doi:10.1016/s0735-1097(01)01802-2
12. Elagizi A, Kachur S, Lavie CJ, et al. An overview and update on obesity and the obesity paradox in cardiovascular diseases. *Prog Cardiovasc Dis*. 2018;61:142–150. doi:10.1016/j.pcad.2018.07.003
13. McAuley PA, Blair SN. Obesity paradoxes. *J Sports Sci*. 2011;29:773–782. doi:10.1080/02640414.2011.553965
14. Sui X, LaMonte MJ, Laditka JN, et al. Cardiorespiratory fitness and adiposity as mortality predictors in older adults. *JAMA*. 2007;298:2507–2516. doi:10.1001/jama.298.21.2507
15. Tojek K, Wustrau B, Czerniak B, et al. Body mass index as a biomarker for the evaluation of the "Obesity Paradox" among inpatients. *Clin Nutr*. 2019;38:412–421. doi:10.1016/j.clnu.2017.12.005
16. Banack HR, Kaufman JS. The obesity paradox: understanding the effect of obesity on mortality among individuals with cardiovascular disease. *Prev Med*. 2014;62:96–102. doi:10.1016/j.ypmed.2014.02.003
17. Yerrakalva D, Mullis R, Mant J. The associations of "fatness," "fitness," and physical activity with all-cause mortality in older adults: a systematic review. *Obesity (Silver Spring)*. 2015;23:1944–1956. doi:10.1002/oby.21181

18. McAuley PA, Beavers KM. Contribution of cardiorespiratory fitness to the obesity paradox. *Prog Cardiovasc Dis.* 2014;56:434–440. doi:10.1016/j.pcad.2013.09.006
19. Woo J, Yu R, Yau F. Fitness, fatness and survival in elderly populations. *Age (Dordr).* 2013;35:973–984. doi:10.1007/s11357-012-9398-6
20. Gomez-Cabello A, Pedrero-Chamizo R, Olivares PR, et al. Prevalence of overweight and obesity in non-institutionalized people aged 65 or over from Spain: the elderly EXERNET multi-centre study. *Obes Rev.* 2011;12:583–592. doi:10.1111/j.1467-789X.2011.00878.x
21. Gómez-Cabello A, Vicente-Rodríguez G, Albers U, et al. Harmonization process and reliability assessment of anthropometric measurements in the elderly EXERNET multi-centre study. *PLoS One.* 2012;7:e41752. doi:10.1371/journal.pone.0041752
22. Marfell-Jones MJ, Stewart AD, de Ridder JH. *International Standards for Anthropometric Assessment.* International Society for the Advancement of Kinanthropometry; 2012.
23. Rikli RE, Jones CJ. Development and validation of criterion-referenced clinically relevant fitness standards for maintaining physical independence in later years. *Gerontologist.* 2013;53:255–267. doi:10.1093/geront/gns071
24. Johnson BL, Nelson JK. *Practical Measurements for Evaluation in Physical Education.* 2nd ed. Burgess Publishing Company; 1969.
25. López-Rodríguez C, Laguna M, Gómez-Cabello A, et al. Validation of the self-report EXERNET questionnaire for measuring physical activity and sedentary behavior in elderly. *Arch Gerontol Geriatr.* 2017;69:156–161. doi:10.1016/j.archger.2016.11.004
26. Masnoon N, Shakib S, Kalisch-Ellett L, Caughey GE. What is polypharmacy? A systematic review of definitions. *BMC Geriatr.* 2017;17:230. doi:10.1186/s12877-017-0621-2
27. Gutiérrez-Fisac JL, López E, Banegas JR, Graciani A, Rodríguez-Artalejo F. Prevalence of overweight and obesity in elderly people in Spain. *Obes Res.* 2004;12:710–715. doi:10.1038/oby.2004.83
28. Prokasky A, Rudasill K, Molfese VJ, Putnam S, Gartstein M, Rothbart M. Identifying child temperament types using cluster analysis in three samples. *J Res Pers.* 2017;67:190–201. doi:10.1016/j.jrp.2016.10.008
29. Sanson A, Letcher P, Smart D, Prior M, Toumbourou JW, Oberklaid F. Associations between early childhood temperament clusters and later psychosocial adjustment. 2009;55:26–54. doi:10.1353/mpq.0.0015
30. Pedrero-Chamizo R, Gomez-Cabello A, Delgado S, et al. Physical fitness levels among independent non-institutionalized Spanish elderly: the elderly EXERNET multi-center study. *Arch Gerontol Geriatr.* 2012;55:406–416. doi:10.1016/j.archger.2012.02.004
31. McElroy JA, Gilbert T, Hair EC, Mathews KJ, Redman SD, Williams A. Obese but fit: the relationship of fitness to metabolically healthy but obese status among sexual minority women. *Womens Health Issues.* 2016;26(suppl 1):S81–6. doi:10.1016/j.whi.2015.09.014
32. *Physical Status: The Use and Interpretation of Anthropometry.* Report of a WHO Expert Committee. Vol. 854; 1995.
33. Gallagher D, Heymsfield SB, Heo M, Jebb SA, Murgatroyd PR, Sakamoto Y. Healthy percentage body fat ranges: an approach for developing guidelines based on body mass index. *Am J Clin Nutr.* 2000;72:694–701. doi:10.1093/ajcn/72.3.694
34. Lee JJ, Hong DW, Lee SA, et al. Relationship between obesity and balance in the community-dwelling elderly population: a cross-sectional analysis. *Am J Phys Med Rehabil.* 2020;99:65–70. doi:10.1097/PHM.0000000000001292
35. Hue O, Simoneau M, Marcotte J, et al. Body weight is a strong predictor of postural stability. *Gait Posture.* 2007;26:32–38. doi:10.1016/j.gaitpost.2006.07.005
36. Menegoni F, Galli M, Tacchini E, Vismara L, Cavigioli M, Capodaglio P. Gender-specific effect of obesity on balance. *Obesity (Silver Spring).* 2009;17:1951–1956. doi:10.1038/oby.2009.82
37. Morris R, Harwood RH, Baker R, Sahota O, Armstrong S, Masud T. A comparison of different balance tests in the prediction of falls in older women with vertebral fractures: a cohort study. *Age Ageing.* 2007;36:78–83. doi:10.1093/ageing/afl147
38. Muir SW, Berg K, Chesworth B, Klar N, Speechley M. Balance impairment as a risk factor for falls in community-dwelling older adults who are high functioning: a prospective study. *Phys Ther.* 2010;90:338–347. doi:10.2522/ptj.20090163
39. Shaw A, Houghton D, Hallsworth K, Jakovljevic DG, Trenell MI, Cassidy S. Adiposity predicts low cardiorespiratory fitness in individuals with metabolic diseases. *Diabetes Res Clin Pract.* 2018;146:300–304. doi:10.1016/j.diabres.2018.10.022
40. Sævarsson ES, Magnússon KT, Sveinsson T, Jóhannsson E, Arngrímsson SÁ. The association of cardiorespiratory fitness to health independent of adiposity depends upon its expression. *Ann Hum Biol.* 2016;43:229–234. doi:10.3109/03014460.2015.1042522
41. Rigdon B, Loprinzi PD. The association of cardiorespiratory fitness on memory function: systematic review. *Medicina (Kaunas).* 2019;55:127. doi:10.3390/medicina55050127
42. Vancampfort D, Rosenbaum S, Schuch F, et al. Cardiorespiratory fitness in severe mental illness: a systematic review and meta-analysis. *Sports Med.* 2017;47:343–352. doi:10.1007/s40279-016-0574-1
43. Mekari S, Dupuy O, Martins R, et al. The effects of cardiorespiratory fitness on executive function and prefrontal oxygenation in older adults. *Geroscience.* 2019;41:681–690. doi:10.1007/s11357-019-00128-5
44. de Lannoy L, Sui X, Lavie CJ, Blair SN, Ross R. Change in submaximal cardiorespiratory fitness and all-cause mortality. *Mayo Clin Proc.* 2018;93:184–190. doi:10.1016/j.mayocp.2017.11.020
45. Imboden MT, Harber MP, Whaley MH, Finch WH, Bishop DL, Kaminsky LA. Cardiorespiratory fitness and mortality in healthy men and women. *J Am Coll Cardiol.* 2018;72:2283–2292. doi:10.1016/j.jacc.2018.08.2166
46. McAuley PA, Keteyian SJ, Brawner CA, et al. Exercise capacity and the obesity paradox in heart failure: the FIT (Henry Ford Exercise Testing) Project. *Mayo Clin Proc.* 2018;93:701–708. doi:10.1016/j.mayocp.2018.01.026
47. Clark AL, Fonarow GC, Horwich TB. Impact of cardiorespiratory fitness on the obesity paradox in patients with systolic heart failure. *Am J Cardiol.* 2015;115:209–213. doi:10.1016/j.amjcard.2014.10.023
48. Lavie CJ, Cahalin LP, Chase P, et al. Impact of cardiorespiratory fitness on the obesity paradox in patients with heart failure. *Mayo Clin Proc.* 2013;88:251–258. doi:10.1016/j.mayocp.2012.11.020
49. Nakamura T, Kamiya K, Matsunaga A, et al. Impact of gait speed on the obesity paradox in older patients with cardiovascular disease. *Am J Med.* 2019;132:1458–1465.e1. doi:10.1016/j.amjmed.2019.06.047
50. McAuley P, Pittsley J, Myers J, Abella J, Froelicher VF. Fitness and fatness as mortality predictors in healthy older men: the veterans exercise testing study. *J Gerontol A Biol Sci Med Sci.* 2009;64:695–699. doi:10.1093/gerona/gln039
51. McAuley PA, Kokkinos PF, Oliveira RB, Emerson BT, Myers JN. Obesity paradox and cardiorespiratory fitness in 12,417 male veterans aged 40 to 70 years. *Mayo Clin Proc.* 2010;85:115–121. doi:10.4065/mcp.2009.0562
52. McAuley PA, Artero EG, Sui X, Lavie CJ, Almeida MJ, Blair SN. Fitness, fatness, and survival in adults with prediabetes. *Diabetes Care.* 2014;37:529–536. doi:10.2337/dc13-1347
53. Haagsma JA, Olij BF, Majdan M, et al. Falls in older aged adults in 22 European countries: incidence, mortality and burden of disease from 1990 to 2017. *Inj Prev J Int Soc Child Adolesc Inj Prev.* 2020;26(suppl 1):i67–i74. doi:10.1136/injuryprev-2019-043347