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Physical activity attenuates the impact of poor physical, mental, and social health on total and cardiovascular mortality in older adults: a population-based prospective cohort study

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Abstract

Purpose To examine the separate and joint associations of physical activity and levels of physical, mental, and social health with long-term all-cause and cardiovascular disease (CVD) mortality in older adults.

Methods A cohort of 4008 individuals representative of the non-institutionalized population of Spain aged 60 years and older was analyzed. Information on physical activity was self-reported. Physical and mental health were assessed with the SF-36 questionnaire, and social health with a 4-item score on network structure and social engagement. Participants were categorized as being in a good, intermediate, or poor health according to tertiles of the score in each health dimension. Analyses were performed with Cox regression and adjusted for main confounders, including levels in the other two health dimensions.

Results Over a median follow-up of 14 years, a total of 1811 deaths occurred, 674 due to CVD. Hazard ratios (95% confidence interval) for all-cause mortality were 1.35 (1.18–1.55), 1.18 (1.02–1.36), and 1.37 (1.18–1.58) for poor vs. good physical, mental, and social health, respectively (all p trend < 0.001). Being physically active was associated with a 28% (15–39%), 31% (19–42%), and 19% (5–31%) lower all-cause mortality in participants with poor physical, mental, and social health, respectively. In each health dimension, physically active individuals with poor health showed a similar or lower all-cause mortality than those who had intermediate or good health but were physically inactive. Results for CVD mortality were similar to those for all-cause death.

Conclusions Physical activity might attenuate the excess all-cause and CVD mortality associated with poor physical, mental, and social health.

Keywords Aging · Older adults · Mortality · Physical activity · Health

Introduction

Aging is a process characterized by progressive biological and psychosocial alterations that occur throughout the life course, and which may worsen physical, mental, and social health. Worsening physical health over time has been linked to higher risk of obesity, type 2 diabetes, cardiovascular diseases, some types of cancer, falls, hospitalization, disability, and mortality [1–4]. Mental health includes a state of well-being that allows the individuals to realize their own abilities, to cope with the normal stresses of life, to work productively and fruitfully, and to make a contribution to their community [5]. In older adults, disorders related to poor mental health such as depression and anxiety are highly prevalent [6, 7], and individuals with these disorders are also at high risk of hospitalization, cognitive impairment, and

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mortality [8–10]. The social dimension of health is likely the most understudied dimension, understood as the network of social support maintained by the elderly, their contact structure, and their social relationships with family and friends [11]. The percentage of people living alone or not living in community (i.e., institutionalized) increases with age, and is associated with higher levels of isolation, loneliness, falls, hospitalization, and mortality [11–13].

Physical activity is one of the behaviors with greatest health benefits in older adults; being physically active reduces the risk of many diseases and conditions associated with worse physical, mental, and social health [3, 14–20]. Given that older adults are the segment of population with worse level of health, it is of interest to assess whether physical activity reduces the increased risk of death associated with poor health. Thus, the aim of this study was to examine the separate and joint associations of physical activity and levels of physical, mental, and social health with long-term all-cause and cardiovascular disease (CVD) mortality in older adults. Specifically, we aimed to assess whether physical activity could protect against increased risk of mortality associated with level of physical, mental, and social health.

Methods

Study design and participants

We use data from the UAM (*Universidad Autonoma de Madrid*) cohort, comprising 4008 individuals representative of the non-institutionalized population aged 60 years and older in Spain. The study protocol has been reported elsewhere [21, 22]. Briefly, participants were recruited in 2000/2001 using probabilistic sampling by multistage clusters. The clusters were first stratified according to region of residence and size of municipality. Then, census sections and households were chosen randomly within each cluster, and study participants were selected in gender and age (60–69, 70–79, and ≥ 80 years) strata. Information was collected at the participant's homes by personal interviews and physical examination performed with standardized procedures by trained and certified personnel [21, 22]. The study response rate was 71%.

Written informed consent was obtained from study participants and from an attending family member. This study was approved by the Clinical Research Ethics Committee of *La Paz* University Hospital in Madrid (Spain) [21].

Main study variables

The three health dimensions were assessed using two instruments. The physical and mental dimensions were assessed using the Spanish version of the SF-36 questionnaire, which has shown good validity and reproducibility in the Spanish population [23, 24]. This instrument consists of 36 items that measure eight health sub-dimensions: physical functioning, physical role, body pain, general health, vitality, social functioning, emotional role, and mental health. Information of these eight sub-dimensions was summarized with standardized procedures to obtain two scores indicating the physical and mental dimensions of health [25]. Both dimensions were standardized to a national norm with a mean of 50 and a standard deviation of 10 [23, 24]. The social dimension was evaluated considering network structure and social engagement as sub-dimensions. A global score (range 0–4) was obtained by summing the points obtained on a 4-item instrument, with + 1 point added when participants met any of the following 4 criteria: (a) being married, (b) living with another person, (c) seeing other family members daily or almost daily, and (d) meeting friends daily or almost daily [11, 26]. A higher score in each of the three dimensions represents better health and participants were categorized as being in a good, intermediate, or poor health according to tertiles of the score on each of the three dimensions. However, due to the characteristics of the sample, for social health those who obtained 4 points were considered as a good health; intermediate health with 3 points; and poor health with 2 or fewer points.

Information on physical activity was obtained using a validated single question taken from the Spanish National Health Survey, which is habitually used to monitor the prevalence of physical activity in Spain [27]: "Which of these choices best describes most of your leisure-time activity?" Participants rated their physical activity level as (a) inactive, (b) occasional, (c) several times a month, and (d) several times a week. Because only 2.91% of participants reported engaging in physical activity monthly and weekly, these two categories and the occasional category were merged into a same "physically active" category [27].

Ascertainment of mortality

The outcome variables were all-cause and CVD mortality from study baseline in 2000/2001 to the end of follow-up in 2014. The number, cause, and date of death during the period 2001–2014 were obtained by a computerized search of the Spanish National Death Index of the Ministry of Health and the vital registry of the Spanish National Institute of Statistics. There is evidence of the complete coverage, accuracy, and reliability of vital status information [28]. The underlying cause of death was determined by a nosologist according to the International Classification of Diseases, Tenth Edition, with cardiovascular death corresponding to codes I00-I99. Individual identification data were removed after searching in the National Index, so that the database remained anonymous during the entire study

process according to the Spanish Law on Data Protection 15/1999.

Covariates

Data on age, gender, educational level (no formal studies, primary, secondary, and university education), and some health conditions were obtained. Body height and weight were measured using standardized procedures, and body mass index was calculated as weight in kg divided by height in square meter [21]. Waist circumference was measured using an inelastic belt-type tape at the midpoint between the lowest rib and the iliac crest after breathing out normally. Also, we registered tobacco smoking with the following question: "do you smoke?" The possible answers were: (1) I do not smoke. (2) I do not smoke, but I have smoked. (3) I smoke, but not daily. (4) Yes, I smoke daily. The answers were categorized in never (category 1), former (category 2), and smoker (categories 3 and 4). Alcohol consumption was similarly categorized as never, former, moderate, and heavy drinkers. The threshold between moderate and heavy drinking was ≤ 20 and ≤ 30 g/day in women and men, respectively [29]. Among heavy drinkers also must be included binge-drinking patterns because information was lacking to define this category properly according to current definitions, even though the prevalence of this drinking pattern in Spanish older adults is clearly very low [30]. Cognitive function was assessed with the Mini-Mental State Examination which is valid for use in the Spanish population [31]. Systolic blood pressure was measured six times in the right arm at the level of the heart using standardized methods [32]. Readings were taken at 2-min intervals, with the mean of measurements used in the analysis. Participants were also asked, "Has your doctor ever told you whether you have high (blood) cholesterol?" If the answer was positive, they were considered to have hypercholesterolemia. Finally, information on the following 7 chronic conditions, present for at least 6 months, diagnosed by a physician in the last year and reported by the study participants, was recorded: asthma or chronic bronchitis, coronary heart disease, stroke, depression under drug treatment, diabetes mellitus, cancer at any site, and hip fracture.

Statistical analyses

Of the 4008 study participants, 86 were excluded because of missing data on the study variables. The final analyses were conducted with 3922 individuals (56.38% women). There were no significant differences between the excluded and those who finally participated in the final analyses (for gender 57.39% vs. 56.38%, and age 73.60 vs. 71.82 years). Baseline characteristics of the study participants are presented as mean ± standard deviation or percentages. The Spearman correlation coefficient (rho) was calculated to examine the linear relationship between the three health dimensions.

All-cause and CVD mortality according to categories of physical, mental and social health is summarized using hazard ratios (HRs) and 95% confidence intervals (CI) obtained from Cox regression, which is used to relate several risk factors or exposures, considered simultaneously, to survival time [33]. Good health was used as reference in the analyses. Three models with progressive adjustment for potential confounders were fitted. A basic model or model 1 was adjusted for gender and age, and model 2 was adjusted as in model 1 and for educational attainment, smoking status, alcohol consumption, body mass index, waist circumference, hypercholesterolemia, systolic blood pressure, Mini-Mental State Examination, and chronic diseases. Since the prevalence of hypertension is very high in the old age [32], systolic blood pressure was the variable with better fit for the models, even though the models were also analyzed using the history of hypertension in the participants (systolic blood pressure ≥ 140 mm Hg, diastolic blood pressure ≥ 90 mm Hg, or current drug treatment) and the results did not change. Model 3 was additionally adjusted for the other two health dimensions to examine its independent association. The P for linear trend was calculated by modeling the three dimensions of health tertiles as a continuous variable. Also, to examine the effect of physical activity (inactive vs. active) on all-cause and CVD mortality, we conducted analyses stratified by level of physical, mental, and social health. We checked the potential modifier effect of physical activity on the associations between three health dimensions and mortality by including an interaction term in Cox models. Multicollinearity detection was examined in all analyses, but variance inflation factors were in the normal range since all variables were not strongly related (e.g., the relationship between physical activity and the three health dimensions as continuous variables was $\rho = 0.29$ for physical, $\rho = 0.15$ for mental, and $\rho = 0.16$ for social health). There was also no evidence of multicollinearity when the three dimensions of health were included in the same models.

Finally, to examine whether physical activity attenuates the impact of health status on all-cause and CVD mortality, we assessed the combined association of physical activity and physical, mental, and social health with mortality outcomes by modeling six categories of exposure for each health dimension (active/good health [reference group], active/intermediate health, active/poor health, inactive/good health, inactive/intermediate health, and inactive/poor health), which also allows to identify target groups with the highest increased mortality according to these groups. Analyses were conducted with Cox regression, as described above.

The assumption of proportionality of hazards was assessed both visually and by testing the significance of interaction terms of health status or physical activity with time of follow-up, and no evidence was found of departure from this assumption (all $p > 0.1$). All analyses were weighted to make the results representative of the Spanish population aged ≥ 60 years; each subject was weighed according to their sex, age, region of residence, and size of the municipality to reflect the characteristics in the older population of Spain, and performed with STATA®v.14.1. Statistical significance was set at $p < 0.05$ and all tests were 2-sided.

Results

Baseline characteristics of the study participants are shown in Table 1. The relationship between the physical dimension and the other two dimensions of health was very weak ($\rho = 0.07$, $p < 0.001$ for mental and $\rho = 0.12$, $p < 0.001$ for social). The correlation between the mental and social dimensions was also weak ($\rho = 0.17$, $p < 0.001$).

Over a median follow-up of 14 years, total of 1811 deaths occurred, 674 due to CVD. All-cause and CVD mortality risk according to categories of physical, mental, and social dimensions of health are shown in Table 2. Age- and sex-adjusted HRs (95% CIs) for all-cause mortality in participants with poor vs. good health were 1.47 (1.28–1.68) for physical health, 1.37 (1.20–1.55) for mental health, and 1.41 (1.22–1.62) for social health (all p for trend < 0.001). In fully adjusted analyses, the results did not significantly change (all p for trend < 0.05), so that the corresponding HRs (95% CIs) were 1.35 (1.18–1.55), 1.18 (1.02–1.36), and 1.37 (1.18–1.58). Compared with having a good health, a poor health in the physical and social dimensions, but not in the mental dimension, was also significantly associated with a higher CVD mortality risk (Table 2); in fully adjusted analyses, the HRs (95% CI) were 1.59 (1.26–2.02) for the physical dimension and 1.44 (1.11–1.87) for the social dimension (both p for trend < 0.001).

In fully adjusted analyses, being physically active was associated with a 28% (95% CI 15–39%), 31% (95% CI 19–42%), and 19% (95% CI 5–31%) lower all-cause mortality among participants with poor physical, mental, and social health, respectively (Table 3). The corresponding reductions in CVD mortality were 33% (10–50%), 33% (9–50%), and 45% (26–60%) (Table 3). The main effect of three dimensions of health was not modified by physical activity; for all-cause mortality, p for interactions were 0.429 for physical, 0.082 for mental, and 0.734 for social health; for CVD mortality, p for interactions were 0.423, 0.361, and 0.111 to physical, mental, and social health, respectively.

Table 1 Characteristics of the study participants

n	3922
Women (%)	56.38
Age (years)	71.82 (7.94)
Education level (%)	
No education	51.73
Primary	35.38
Secondary or higher	12.89
Body mass index (kg/m^2)	28.87 (4.49)
Waist circumference (cm)	98.73 (11.97)
Smoking (%)	
Never	65.79
Former	24.10
Currently	10.11
Alcohol drinking (%)	
Never	49.64
Former	11.86
Moderate	28.81
Heavy	9.69
Mini-mental state examination (0–30 score)	25.42 (4.49)
Hypercholesterolemia (%)	24.71
Systolic blood pressure (mm Hg)	143.09 (19.22)
Asthma/chronic bronchitis (%)	14.28
Coronary heart disease (%)	3.34
Stroke (%)	5.98
Depression (%)	10.36
Diabetes mellitus (%)	15.21
Cancer (%)	1.86
Hip fracture (%)	2.65
Physically active (%)	55.58

Values are mean ± SD or percentage. *n* as sample size

All-cause and CVD mortality risks according to physical activity and level of physical, mental, and social health are shown in Fig. 1. Compared with participants who had good health and were physically active, those with poor health and physically inactive had the highest all-cause mortality; HRs (95% CI) were 1.65 (1.39–1.96) for those in poor physical health, 1.67 (1.39–2.00) for poor mental health, and 1.75 (1.45–2.12) for poor social health. Results were similar for CVD mortality. Physically active participants with poor health showed a similar or lower all-cause and CVD mortality than those who had intermediate or good physical, mental, and social health but were physically inactive (Fig. 1).

Discussion

In a representative sample of older adults in Spain, having poor physical, mental, or social health was independently associated with higher long-term risk of death; by contrast,

Table 2 Hazard ratios (95% confidence interval) for all-cause and cardiovascular disease (CVD) mortality according to categories of physical, mental, and social health

	All-cause mortality				CVD mortality			
	Good	Intermediate	Poor	*p* for trend	Good	Intermediate	Poor	*p* for trend
Physical health								
n/deaths	1307/497	1307/574	1308/740		1307/151	1307/210	1308/313	
Model 1	1 (Ref.)	1.07 (0.94–1.23)	**1.47 (1.28–1.68)**	<0.001	1 (Ref.)	1.24 (0.97–1.59)	**1.87 (1.49–2.36)**	<0.001
Model 2	1 (Ref.)	1.05 (0.92–1.21)	**1.33 (1.16–1.53)**	<0.001	1 (Ref.)	1.18 (0.93–1.51)	**1.58 (1.25-2.00)**	<0.001
Model 3	1 (Ref.)	1.07 (0.94–1.23)	**1.35 (1.18–1.55)**	<0.001	1 (Ref.)	1.19 (0.93–1.52)	**1.59 (1.26–2.02)**	<0.001
Mental health								
n/deaths	1307/601	1307/552	1308/659		1307/224	1307/196	1308/255	
Model 1	1 (Ref.)	0.96 (0.84–1.09)	**1.37 (1.20–1.55)**	<0.001	1 (Ref.)	0.89 (0.71–1.12)	**1.33 (1.07–1.65)**	0.014
Model 2	1 (Ref.)	0.95 (0.83–1.08)	**1.23 (1.07–1.41)**	0.004	1 (Ref.)	0.87 (0.70–1.09)	1.14 (0.90–1.43)	0.301
Model 3	1 (Ref.)	0.97 (0.84–1.10)	**1.18 (1.02–1.36)**	0.026	1 (Ref.)	0.90 (0.72–1.13)	1.10 (0.86–1.39)	0.478
Social health								
n/deaths	1400/547	1132/486	1390/777		1400/176	1132/194	1390/304	
Model 1	1 (Ref.)	1.12 (0.97–1.29)	**1.41 (1.22–1.62)**	<0.001	1 (Ref.)	**1.29 (1.01–1.64)**	**1.45 (1.13–1.87)**	0.005
Model 2	1 (Ref.)	1.13 (0.98–1.30)	**1.38 (1.19–1.59)**	<0.001	1 (Ref.)	**1.30 (1.02–1.65)**	**1.43 (1.10–1.84)**	0.008
Model 3	1 (Ref.)	1.13 (0.98–1.31)	**1.37 (1.18–1.58)**	<0.001	1 (Ref.)	**1.32 (1.04–1.67)**	**1.44 (1.11–1.87)**	0.007

Model 1 adjusted for age and gender. Model 2 adjusted as in model 1 and for educational attainment, smoking status, alcohol consumption, body mass index, waist circumference, hypercholesterolemia, systolic blood pressure, Mini-Mental State Examination, and chronic conditions include, asthma/chronic bronchitis, coronary heart disease, stroke, diabetes, depression, cancer, and hip fracture. Model 3 was adjusted as in model 2 and for the other two dimensions of health

Figures in bold indicate $p < 0.05$. *n* as sample size

being physically active was linked to lower mortality in each health dimension, so that, physically active individuals with poor physical, mental, or social health showed a similar, or even lower, mortality than those who had intermediate or good health but were physically inactive. These findings suggest that physical activity might attenuate the excess mortality associated with poor physical, mental, and social health in the aging process.

Several studies in older people with chronic diseases have shown that physical activity is associated with a 20–50% reduction in all-cause mortality [15, 34–39]. In an earlier work using data from 611 diabetic participants from the UAM cohort, we showed that the HR (95% CI) of mortality among physically active compared to physically inactive diabetic adults was 0.59 (0.45–0.78) [15]. Similarly, a study conducted among 481 older adults aged 75–80 years from the Evergreen Project showed that, compared with physically active participants without cardiac disease, physically active patients with cardiac disease had a 31% reduction in all-cause mortality, while physically inactive patients with cardiac disease had almost a threefold risk of all-cause mortality (HR 2.77, 95% CI 1.80–4.26) [39]. A study in a representative sample of 2074 non-institutionalized adult, aged 60 years and older, sought to determine the association between levels of physical activity and mobility difficulties and the risk of mortality. Physical activity and mobility were self-reported measures through questionnaires. The results showed that there was a dose-gradient effect of physical activity on time to death, with high levels associated with a 51% lower risk of mortality, compared with moderate physical activity. Furthermore, in fully adjusted analyses, mobility still remained significantly associated with a 2% reduction in the risk of mortality per each unit increase (HR 0.98, 95% CI 0.97–0.99) [34]. Our results, therefore, extend previous evidence in population with age-associated worse levels of physical health, by showing that older adults who were physically active had lower mortality than those who were physical inactive. Physical activity may be reducing mortality risk among older adults with poor physical health by several mechanisms such as maintaining and improving cardiorespiratory fitness and muscular strength, avoiding abdominal body fat gain, regulating cardiometabolic risk factors (e.g., hypertension, HDL cholesterol, triglycerides, insulin resistance), reducing multimorbidity, and attenuating the development of sarcopenia, frailty, and physical disabilities [4, 40].

To our knowledge, no previous study has assessed the association between physical activity and mortality in people with poor mental health. In a recent study in 5240 men aged 20–86 years and with emotional distress (i.e., depression, anxiety, thoughts of suicide, or receiving psychological or psychiatric counseling), a high cardiorespiratory fitness—a

Table 3 Hazard ratios (95% confidence interval) for all-cause and cardiovascular disease (CVD) mortality according to physical activity stratified by categories of physical, mental, and social health

	All-cause mortality		CVD mortality	
	Inactive	Active	Inactive	Active
Physical health				
Good				
n/deaths	382/152	925/345	382/54	925/98
Model 1	1 (Ref.)	0.85 (0.69–1.04)	1 (Ref.)	0.73 (0.51–1.04)
Model 2	1 (Ref.)	0.88 (0.71–1.08)	1 (Ref.)	0.78 (0.55–1.11)
Model 3	1 (Ref.)	0.88 (0.72–1.09)	1 (Ref.)	0.77 (0.54–1.09)
Intermediate				
n/deaths	626/284	681/290	626/116	681/94
Model 1	1 (Ref.)	**0.69 (0.57–0.85)**	1 (Ref.)	**0.57 (0.40–0.80)**
Model 2	1 (Ref.)	**0.72 (0.59–0.92)**	1 (Ref.)	**0.63 (0.43–0.92)**
Model 3	1 (Ref.)	**0.74 (0.60–0.91)**	1 (Ref.)	**0.65 (0.44–0.94)**
Poor				
n/cases	831/501	477/239	831/218	477/95
Model 1	1 (Ref.)	**0.66 (0.56–0.78)**	1 (Ref.)	**0.62 (0.51–0.93)**
Model 2	1 (Ref.)	**0.69 (0.59–0.82)**	1 (Ref.)	**0.65 (0.49–0.87)**
Model 3	1 (Ref.)	**0.72 (0.61–0.85)**	1 (Ref.)	**0.67 (0.50–0.90)**
Mental Health				
Good				
n/deaths	522/276	785/325	522/121	785/102
Model 1	1 (Ref.)	**0.71 (0.59–0.86)**	1 (Ref.)	**0.54 (0.39–0.76)**
Model 2	1 (Ref.)	**0.75 (0.62–0.92)**	1 (Ref.)	**0.56 (0.38–0.81)**
Model 3	1 (Ref.)	**0.79 (0.64–0.96)**	1 (Ref.)	**0.60 (0.41–0.88)**
Intermediate				
n/deaths	562/249	745/302	562/103	745/92
Model 1	1 (Ref.)	**0.75 (0.62–0.92)**	1 (Ref.)	**0.60 (0.44–0.83)**
Model 2	1 (Ref.)	**0.79 (0.64–0.97)**	1 (Ref.)	**0.71 (0.52–0.97)**
Model 3	1 (Ref.)	0.88 (0.72–1.09)	1 (Ref.)	0.75 (0.55–1.03)
Poor				
n/deaths	755/413	553/246	755/163	553/92
Model 1	1 (Ref.)	**0.64 (0.54–0.76)**	1 (Ref.)	**0.62 (0.46–0.85)**
Model 2	1 (Ref.)	**0.67 (0.56–0.79)**	1 (Ref.)	**0.64 (0.48–0.86)**
Model 3	1 (Ref.)	**0.69 (0.58–0.81)**	1 (Ref.)	**0.67 (0.50–0.91)**
Social health				
Good				
n/deaths	539/225	861/322	539/68	861/109
Model 1	1 (Ref.)	**0.74 (0.60–0.90)**	1 (Ref.)	0.86 (0.62–1.21)
Model 2	1 (Ref.)	**0.74 (0.90–0.91)**	1 (Ref.)	0.90 (0.64–1.27)
Model 3	1 (Ref.)	**0.76 (0.62–0.94)**	1 (Ref.)	0.93 (0.66–1.32)
Intermediate				
n/deaths	511/250	621/237	511/107	621/87
Model 1	1 (Ref.)	**0.64 (0.52–0.78)**	1 (Ref.)	**0.58 (0.42–0.81)**
Model 2	1 (Ref.)	**0.72 (0.58–0.88)**	1 (Ref.)	**0.71 (0.51-1.00)**
Model 3	1 (Ref.)	**0.75 (0.61–0.92)**	1 (Ref.)	0.75 (0.53–1.06)
Poor				
n/deaths	789/463	601/314	789/212	601/92
Model 1	1 (Ref.)	**0.69 (0.59–0.81)**	1 (Ref.)	**0.46 (0.34–0.62)**
Model 2	1 (Ref.)	**0.75 (0.64–0.88)**	1 (Ref.)	**0.51 (0.37–0.69)**
Model 3	1 (Ref.)	**0.81 (0.69–0.95)**	1 (Ref.)	**0.55 (0.40–0.74)**

Models 1, 2, and 3 were adjusted as in Table 2. Figures in bold indicate $p < 0.05$. *n* as sample size

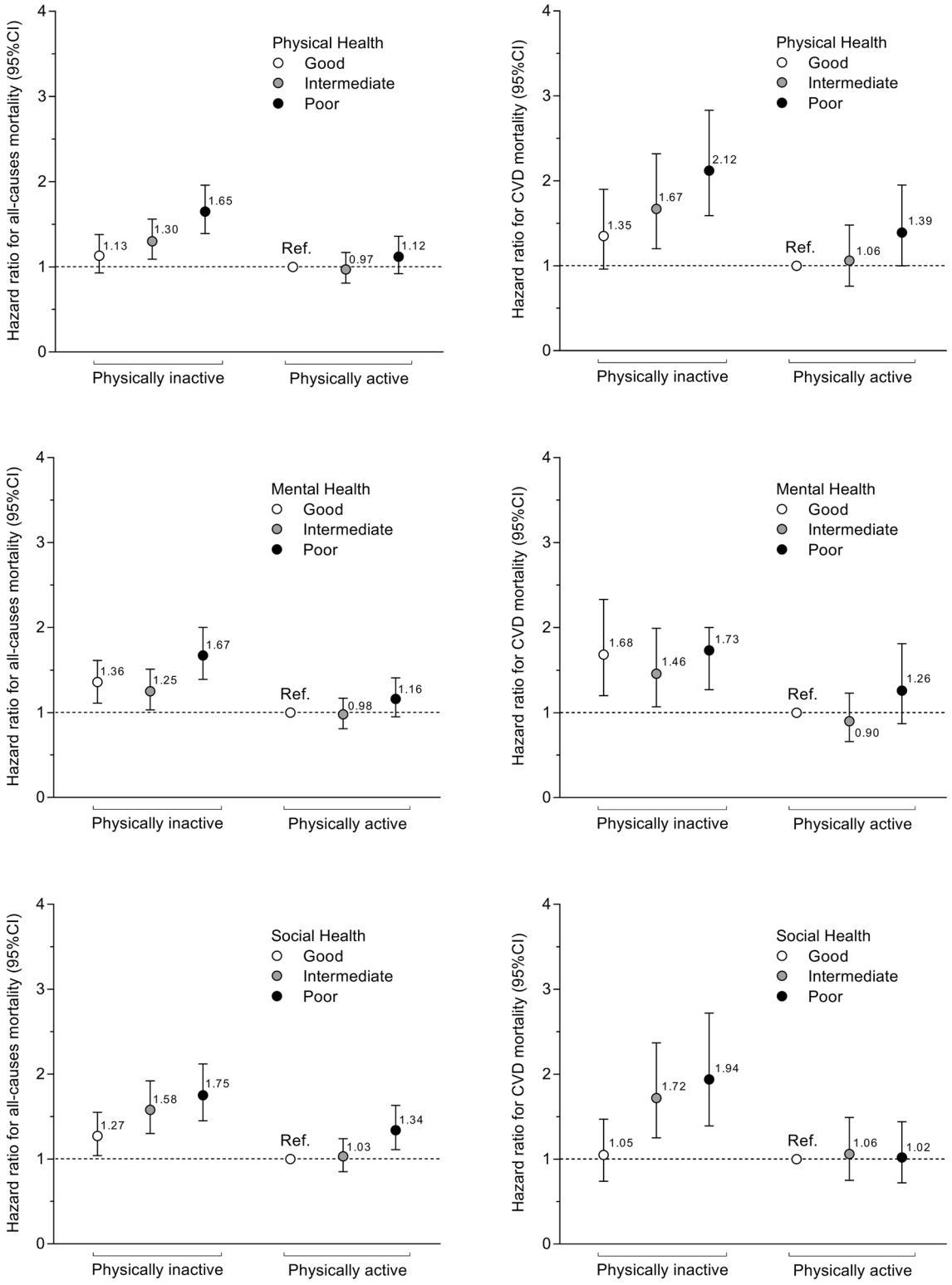

Fig. 1 Hazard ratios and 95% confidence interval (CI) for all-cause and cardiovascular disease (CVD) mortality according to physical activity and level of physical, mental, and social health in older adults ($n = 3920$). Analyses were adjusted as in model 3 in Table 2

proxy for sustained physical activity—was associated with a 53–83% lower risk of all-cause death [41]. On the other hand, a clinical trial of an educational and exercise intervention with 522 patients with coronary artery disease, mortality was approximately 4 times greater in those with high *vs*. low psychosocial stress (i.e., symptoms of depression, anxiety, and hostility) (22% vs. 5%; $p = 0.003$) [42]. However, those who increased physical activity more than 9% through the intervention reduced their risk of all-cause mortality by 19% despite their higher levels of psychosocial stress [42]. Taken together, these results and ours concur in showing that physical activity has beneficial effects on all-cause and CVD mortality in people with poor mental health. It is highly likely that a combination of physiologic and psychological factors may influence the relationship between physical activity and mortality in older adults with poor mental health (e.g., depression, stress, and anxiety), independent of potential improvements in physical and social health [40, 43]. For example, physical activity (i) raises core body temperature, which is responsible for the reduction on feelings of anxiety due to an increase sensation of relaxation and a reduction of muscular tension; (ii) increases release of β-endorphins, which are related to a positive mood and overall sense of well-being; (iii) increases in the availability of brain neurotransmitters (e.g., serotonin, dopamine, and norepinephrine) that are diminished with depression; (iv) serves as a distraction from worries and depressing thoughts; and (v) enhances self-efficacy, which may provide an effective mode which provides the individual with a meaningful mastery experience [43].

No previous study has reported the association between physical activity and all-cause and CVD mortality in people with poor social health. However, some interventional studies have used physical activity to improve general health in institutionalized elderly people [44]. A recent review of almost 40 studies concludes that physical activity may decrease loneliness depending on the quality of relationships during physical activity [45]. Likewise, physical activity can mediate the loneliness–mortality associations [46]; specifically, the results of the Alameda Country Study, a longitudinal study of 6789 individuals aged 21 years and older, showed that physical activity mediated the association between loneliness and mortality for all-cause mortality [46]. Therefore, if physical activity performed by the older adults is done in community, and allows them to relate and interact with their environment, it could improve per se social health.

We expected that the reduction of mortality from physical activity would have been more evident in older adults with better health. However, we found that the strongest associations occurred in those who had worse levels of health. Since people with poor health are usually less physically active than their peers, increasing physical activity could be a main strategy to reduce excess mortality resulting from worsening health. In fact, when older adults cannot do the recommended amounts of physical activity owing to their poor health conditions, public health guidelines recommend that they should be as physically active as their capacities allow [47], because even small increases in physical activity could be beneficial, as found in the present study.

This study had several strengths, including the use of a large and representative sample of older adults, which allows for generalization of results. Also, the study variables were obtained by well-trained staff using standardized procedures. Moreover, follow-up was long and identified a large number of death events. Our study also had some limitations. First, information on the main study variables was obtained at the beginning of the study. Although our analysis assumes that they have some stability over time, some changes are still possible and probably have led to an underestimation of the protective impact of physical activity on mortality. Second, the observational design limits causal inference; however, the strength and dose response of the associations between physical activity and reduced mortality, as well as their consistency across health levels, and the adjustment for many potential confounders lend confidence on study results on a potential cause–effect relationship. Third, physical activity was self-reported and, due to the characteristics of the sample, the answers had to be grouped in two unique categories (e.g., inactive and active participants), which made impossible (i) to explore dose–response associations as well as (ii) to define physical activity levels according to public health recommendations (e.g., 150 min/week of moderate-to-vigorous physical activity). Further evidence is needed using more accurate assessments of physical activity such as accelerometers and heart rate monitors. Also, social health was assessed with an ad hoc questionnaire, although similar measures have been used previously in the literature [11, 26]; for example, in a study conducted with 371 patients, aged 65 and older, admitted to a heart failure-related emergency at 4 Spanish hospital, this questionnaire can identify patients with a higher short-term risk of hospital readmission [11].

In conclusion, engagement in physical activity may attenuate the excess all-cause and CVD mortality associated with poor physical, mental, and social health in older adults. In addition, since a lower mortality associated with physical activity was observed even in those with poor health, it supports the concept of physical activity as a medicine with substantial benefits.

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