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Cross-sectional and prospective relationship between physical activity and chronic diseases in European older adults

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Abstract
Objectives This study examined the relationship between physical activity (PA) and chronic diseases in European older adults, using a prospective analysis with data from 2011 and 2013.
Methods Participants were 37,524 older adults (16,204 men) who responded to the fourth (in 2011) and fifth (in 2013) wave of SHARE project, from 13 European countries. Participants' answers to interview questions about the presence of chronic conditions and PA. The cross-sectional and prospective association between PA and the number of chronic diseases was assessed using general linear models.
Results Among men and women, moderate or vigorous physical activity (MVPA) in 2011 was associated with fewer reported chronic diseases in 2011 and 2013. In prospective analysis, MVPA in 2011 was inversely associated with the number of chronic diseases in 2013 in the unadjusted model. In the adjusted model MVPA more than once a week remained as a significant predictor of fewer chronic diseases.
Conclusions PA should be prescribed to older adults in order to prevent and reduce the number of chronic diseases, and, when possible, vigorous intensity PA should be recommended.

Keywords Older people vigorous physical activity · Exercise · Public health · SHARE

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Introduction

Chronic diseases, including heart diseases, hypertension, obesity, diabetes, respiratory diseases and cancer or malignant tumours, are the leading causes of death and disability worldwide (WHO 2014). While the annual number of deaths by infectious disease is projected to decline, the prevalence of chronic diseases is accelerating globally, spreading across every region and infusing all socioeconomic classes, and it is projected to increase to 52 million by 2030 (Mathers and Loncar 2006).

The risk factors for chronic diseases are mainly caused by an unhealthy and sedentary lifestyle (Lee et al. 2012). Thus, a worldwide increase in interest in health-enhancing physical activity has been observed (European Union 2008; USDHHS 2008; WHO 2010). Physical activity can reduce chronic diseases and the risk of disease progression (Bryan and Katzmarzyk 2011; Huai et al. 2013; Lee and

Paffenbarger 2001), while improving the functional capacity and quality of life of those suffering from chronic diseases (Kujala et al. 2015). Moreover, physical activity reduces premature mortality and morbidity associated with chronic diseases (Ekelund et al. 2015). Hence, the World Health Organization considers physical activity to be a key determinant to control and prevent chronic diseases (WHO 2014).

Although physical activity is of importance in preventing and reducing chronic diseases (Bryan and Katzmarzyk 2011; Huai et al. 2013; Lee and Paffenbarger 2001), there is evidence that vigorous intensity has a protective and preventive effect against chronic diseases among adults (Lee et al. 2003). However, older adults are less likely to engage in vigorous physical activity (Ayabe et al. 2009; Takagi et al. 2015). Therefore, it is important to further collect evidence, and understand the relationship between chronic diseases and physical activity at different levels of intensity among older adults. This study aimed to examine the relationship between physical activity (moderate and vigorous), and the number of chronic diseases in European older adults, using a prospective analysis with data from 2011 and 2013.

Methods

Participants and procedures

The present study used data from the fourth and fifth wave of the Survey of Health, Aging, and Retirement in Europe (SHARE) study. SHARE is a cross-national panel database of information on a wide range of variables spanning from health behaviour and psychological health to socioeconomic status and social and family networks. The sample in SHARE represents a non-institutionalized population. The fourth wave data was collected in 2011 and the fifth wave in 2013; it included individuals aged 50 and over. The SHARE study is fully described elsewhere (Börsch-Supan et al. 2013; Börsch-Supan and Jürges 2005).

From 58,489 participants who responded to the fourth wave in 2011, the 37,524 (64.2%) who also responded to the fifth wave were included in the present study analysis. This study sample included 16,204 men (43.2%), 21,320 women (56.8%), from 13 European countries (Austria, Belgium, Czech Republic, Denmark, Estonia, France, Germany, Italy, Netherlands, Slovenia, Spain, Sweden and Switzerland). The participants were between the ages of 50 and 102 years (66.2 ± 9.7) in 2011, and were between the ages of 52 and 104 years (68.2 ± 9.7) in 2013. The study protocol was approved by the Ethics Committee of the University of Mannheim, and by the Ethics Council of the Max-Planck-Society for the Advancement of Science.

Measures

Number of chronic diseases

Number of chronic diseases resulting from participants' answers to questions about the presence of the following conditions: heart attack or other heart problems; stroke or cerebral vascular disease, diabetes, chronic lung disease, asthma, arthritis or rheumatism, osteoporosis, cancer or malignant tumour, stomach, duodenal, or peptic ulcer, Parkinson's disease, cataract, hip or femoral fracture, and other conditions. The total number of chronic diseases was summed to produce a single score, as performed previously (Lindwall et al. 2011).

Physical activity

Physical activity was measured as "frequency of moderate physical activity" (e.g., gardening, cleaning the car, going for a walk) and "frequency of vigorous physical activity" (e.g., sports, heavy housework, a job involving physical labour). The response alternatives both for moderate and vigorous activity were: (1) more than once a week, (2) once a week, (3) up to three times a month, and (4) hardly ever or never. The last two response options were grouped into one category called less than once a week.

Covariates

Age, marital status, education level, living place, country, self-rated health, and number of chronic diseases measured at baseline were used as covariates. Age and number of chronic diseases at baseline were used as a continuous covariate. Marital status was classified into the following: married (including in a registered partnership) or not married (including widowed, divorced, separated, or never married). Education was categorized according to the International Standard Classification of Education Degrees (UNESCO 1997) and divided into three levels: low educational level (ISCED code 0 to code 2), middle educational level (ISCED codes 3 and 4), and high educational level (ISCED codes 5 and 6). To determine the living place, participants were asked to report whether they lived in a big city, a suburb or the outskirts of a big city, a large town, a small town, or in rural area or village. Self-rated health was assessed with a single-item question about the perception of health in general. The response options were on a 5-point scale: excellent, very good, good, fair, and poor. For data analysis the scale was reversed, and high values thus represent better health perception.

Data analysis

Descriptive statistics (means, standard deviation, and percentage) were used to characterize the sample. The comparison between men and women according to participants' characteristics was tested by Chi square test and independent sample t test. Bivariate cross-sectional and prospective relationships between moderate and vigorous physical activity and the number of chronic diseases in 2011 and 2013 were tested by ANOVA. The cross-sectional and prospective association between moderate and vigorous physical activity with the number of chronic diseases was assessed using general linear models. Three different models were performed: Model 1 was the crude (unadjusted) analysis between physical activity and the number of chronic diseases. Model 2 was adjusted for age, marital status, educational level, living place and country. Model 3 was adjusted for model 2 and self-rated health. For prospective analysis, a fourth model was added. This fourth model was adjusted for model 3 and additionally for the number of chronic diseases in 2011. To capture changes in physical activity, participants' physical activity results trajectories were examined. For that, physical activity participation in 2011 and 2013 was recoded into inactive (less than once a week) and active (if the answers were once a week or more than once a week) and then stratified into four groups as follows: (1) inactive in 2011 and in 2013 (inactive–inactive), active in 2011 and inactive in 2013 (active-inactive), inactive in 2011 and active in 2013 (inactive-active), and active in both 2011 and 2013 (active–active). The association between the trajectory analysis of physical activity with the number of chronic diseases was also assessed using the four models of general linear models, the same as for prospective analysis. Data analysis was performed using SPSS 22. For all tests statistical significance was set at $p < 0.05$.

Results

Descriptive data of the participants' characteristics in the study in waves 4 and 5 are provided in Table 1. Men and women were significantly different in almost all variables analysed. The average number of chronic diseases remained relatively stable in both waves, but more participants reported moderate or vigorous activity more than once a week at wave 5, as compared to wave 4, for both men and women.

Table 2 presents the bivariate analysis of the cross-sectional and prospective relationship between physical activity and the number of chronic diseases. Among men, moderate or vigorous physical activity in 2011 was associated with fewer reported chronic diseases in 2011 [moderate: $F(2, 16{,}140) = 135{,}843$, $p < 0.001$; vigorous: $F(2, 16{,}140) = 414{,}750$, $p < 0.001$] and in 2013 [moderate: $F(2, 16{,}140) = 137{,}934$, $p < 0.001$; vigorous: $F(2, 16{,}140) = 383{,}915$, $p < 0.001$]. For the women, physical activity in 2011 was also related with a reduced number of chronic diseases in 2011 [moderate: $F(2, 21{,}191) = 243{,}550$, $p < 0.001$; vigorous: $F(2, 21{,}151) = 546{,}141$, $p < 0.001$] and in 2013 [moderate: $F(2, 21{,}191) = 246{,}586$, $p < 0.001$; vigorous: $F(2, 21{,}151) = 551{,}952$, $p < 0.001$].

Cross-sectional parameters' estimates of chronic diseases according to physical activity intensity and frequency are shown in Table 3. Physical activity at moderate or vigorous intensity was negatively associated with the number of chronic diseases, for both men and women. This relationship between physical activity (moderate or vigorous) and number of chronic diseases was materially unchanged following adjustments for age, marital status, educational level, living place and country, and also when further adjusted for health perception.

In prospective analysis, moderate or vigorous physical activity in 2011 was inversely associated with the number of chronic diseases in 2013 in the unadjusted model (Table 4). Following adjustment for age, marital status, educational level, living place and country (model 2), and further self-rated health (model 3), the relationship was attenuated although statistically significant. In the final model we further adjusted model 3 for the number of chronic diseases in 2011, to examine whether the associations were independent of baseline number of chronic diseases. In this model (model 4) moderate (men: $\beta = -0.12$, 95% CI: -0.20 to -0.04, $p < 0.01$; women: $\beta = -0.22$, 95% CI: -0.28 to -0.15, $p < 0.001$) or vigorous (men: $\beta = -0.09$, 95% CI: -0.14 to -0.04, $p < 0.001$; women: $\beta = -0.14$, 95% CI: -0.19 to -0.09, $p < 0.001$) physical activity more than once a week remained as a significant predictor of fewer chronic diseases.

The association between the trajectory of physical activity and the number of chronic diseases is presented in Table 5. In the unadjusted model, being active or having been active in the past was negatively related with the number of chronic diseases as compared to those who were inactive in both cases, among men and women. Nonetheless, after adjustments for age, marital status, educational level, living place, country, self-rated health and the number of chronic diseases in 2011, only vigorous physical activity was significantly related with a fewer number of chronic diseases (men inactive-active: $\beta = -0.12$, 95% CI: -0.20 to -0.05, $p < 0.01$; men active–active: $\beta = -0.16$, 95% CI: -0.23 to -0.08, $p < 0.001$; women inactive–active: $\beta = -0.10$, 95% CI: -0.16 to -0.04, $p < 0.01$;

Table 1 Participants' characteristics—Survey of Health, Aging, and Retirement in Europe (SHARE), 2011–2013, Europe

	2011 (% or $M \pm$ SD)		p	2013 (% or $M \pm$ SD)		p
	Men (n = 16,204)	Women (n = 21,320)		Men (n = 16,204)	Women (n = 21,320)	
Education			<0.001[a]			<0.001[a]
Low	62.7	58.9		43.2	35.8	
Middle	25.2	27.4		37.1	40.6	
High	12.1	13.8		19.6	23.6	
Age	66.0 ± 9.4	66.3 ± 9.9	0.036[b]	68.1 ± 9.4	68.3 ± 10.0	0.032[b]
Marital status			<0.001[a]			<0.001[a]
Not married	20.0	21.3		37.2	39.7	
Married	80.0	78.7		62.8	60.3	
Living place			<0.001[a]			<0.001[a]
Big city	12.5	12.3		14.6	14.1	
Suburbs of a big city	10.9	12.4		10.2	10.8	
Large town	15.3	14.8		17.1	16.3	
Small town	25.0	24.9		25.1	25.1	
Rural area	36.4	35.7		32.9	33.7	
Chronic diseases (number)	1.6 ± 1.5	1.8 ± 1.6	<0.001[b]	1.6 ± 1.5	1.8 ± 1.6	<0.001[b]
Self-rated health	2.9 ± 1.1	2.8 ± 1.1	<0.001[b]	2.8 ± 1.1	2.7 ± 1.1	<0.001[b]
Moderate PA			<0.001[a]			<0.001[a]
Less than once a week	8.7	9.9		2.6	1.9	
Once a week	8.1	8.6		2.1	1.3	
More than once a week	83.2	81.5		95.3	96.8	
Vigorous PA			<0.001[a]			<0.001[a]
Less than once a week	45.4	55.2		17.1	20.3	
Once a week	14.0	.2		12.7	13.0	
More than once a week	40.6	30.6		70.2	66.7	

M media, *SD* standard deviation, *PA* physical activity

[a] Tested by Chi square

[b] Tested by *t* test

Table 2 Cross-sectional and prospective relationship between physical activity and number of chronic diseases—Survey of Health, Aging, and Retirement in Europe (SHARE), 2011–2013, Europe

	Men Number of chronic diseases ($M \pm$ SD)				Women Number of chronic diseases ($M \pm$ SD)			
	2011	p	2013	p	2011	p	2013	p
Moderate PA in 2011		<0.001		<0.001		<0.001		<0.001
Less than once a week	2.2 ± 1.8		2.2 ± 1.8		2.5 ± 1.8		2.6 ± 1.9	
Once a week	1.6 ± 1.5		1.7 ± 1.5		1.8 ± 1.5		1.9 ± 1.6	
More than once a week	1.6 ± 1.4		1.6 ± 1.4		1.7 ± 1.5		1.7 ± 1.5	
Vigorous PA in 2011		<0.001		<0.001		<0.001		<0.001
Less than once a week	2.0 ± 1.6		2.0 ± 1.6		2.1 ± 1.6		2.2 ± 1.7	
Once a week	1.4 ± 1.3		1.5 ± 1.4		1.4 ± 1.3		1.5 ± 1.4	
More than once a week	1.3 ± 1.3		1.3 ± 1.3		1.4 ± 1.4		1.4 ± 1.4	

Tested by ANOVA

PA physical activity

Table 3 Cross-sectional parameters estimates of chronic diseases according to physical activity intensity levels and frequency—Survey of Health, Aging, and Retirement in Europe (SHARE), 2011–2013, Europe

	Parameters estimates of predicting the number of chronic diseases in 2011		
	Model 1 β (95% CI)	Model 2 β (95% CI)	Model 3 β (95% CI)
Men			
MPA in 2011			
Less than once a week	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
Once a week	−0.58 (−0.69, −0.47)***	−0.42 (−0.55, −0.28)***	−0.10 (−0.22, 0.02)
More than once a week	−0.67 (−0.75, −0.59)***	−0.46 (−0.56, −0.36)***	−0.15 (−0.24, −0.06)**
VPA in 2011			
Less than once a week	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
Once a week	−0.53 (−0.60, −0.47)***	−0.39 (−0.48, −0.31)***	−0.16 (−0.24, −0.08)***
More than once a week	−0.68 (−0.73, −0.64)***	−0.54 (−0.60, −0.48)***	−0.22 (−0.28, −0.16)***
Women			
MPA in 2011			
Less than once a week	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
Once a week	−0.68 (−0.77, −0.58)***	−0.47 (−0.58, −0.36)***	−0.22 (−0.32, −0.12)***
More than once a week	−0.78 (−0.85, −0.71)***	−0.52 (−0.61, −0.44)***	−0.24 (−0.32, −0.17)***
VPA in 2011			
Less than once a week	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
Once a week	−0.64 (−0.70, −0.58)***	−0.46 (−0.52, −0.41)***	−0.14 (−0.19, −0.09)***
More than once a week	−0.72 (−0.76, −0.67)***	−0.49 (−0.56, −0.42)***	−0.22 (−0.29, −0.16)***

MPA, sedentary time, FMI, TFM, and BFM did not have normally distributed residuals and were therefore log-transformed for analyses

Model 1: unadjusted analyses

Model 2: analyses were adjusted for age, marital status, educational level, living place and country

Model 3: analyses were adjusted for age, marital status, educational level, living place, country and self-rated health

MPA moderate physical activity, *VPA* vigorous physical activity, *CI* confidence interval

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

women active–active: $\beta = -0.18$, 95% CI: −0.25 to −0.12, $p < 0.001$).

Discussion

The present study examined the cross-sectional and prospective relationship between physical activity, and chronic diseases, across a 2-year period. It utilized a large representative sample of 37,524 older adults from 13 European countries included in the SHARE study. Results showed that the number of chronic diseases is higher among those who were less physically active (less than once a week). Engaging in moderate or vigorous physical activity more than once a week is negatively related with the number of chronic diseases.

This study's results provide additional support for the well-documented inverse relationship between physical activity and chronic diseases (Bryan and Katzmarzyk 2011; Huai et al. 2013; Lee and Paffenbarger 2001). On one hand, engaging in moderate physical activity more than once a week is related with reducing the number of chronic diseases. This strengthens previous findings that engaging in moderate physical activity is not only very important for the primary prevention of chronic diseases (Kruk 2007), but it also reduces cardiovascular risk (Della Valle et al. 2008). On the other hand, when analysing patterns of physical activity from 2011 and 2013 and its relationship with the number of chronic diseases, the intensity of physical activity was revealed as an important factor. In the last adjusted model, only participation in vigorous physical activity in 2013 (inactive-active; active–active) was negatively related with the number of chronic diseases in 2013, regardless of physical activity participation in 2011. Likewise, previous study findings proposed that only vigorous physical activity was inversely related to reductions in coronary heart disease risk for men (Sesso et al. 2000). These results suggest that engaging in vigorous physical activity should be adopted as a tool to reduce the number of chronic diseases, even for those who are inactive. Moreover, the association between the trajectory of physical activity and the number of chronic diseases shows that the physical activity practice at present is the most important. Thus, if those who are inactive decide to engage in physical

Table 4 Prospective parameters estimates of chronic diseases according to physical activity intensity levels and frequency—Survey of Health, Aging, and Retirement in Europe (SHARE), 2011–2013, Europe

	Parameters estimates of predicting the number of chronic diseases in 2013			
	Model 1 β (95% CI)	Model 2 β (95% CI)	Model 3 β (95% CI)	Model 4 β (95% CI)
Men				
MPA in 2011				
Less than once a week	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
Once a week	−0.55 (−0.66, −0.44)***	−0.42 (−0.56, −0.29)***	−0.20 (−0.29, −0.10)***	−0.09 −0.20, 0.02)
More than once a week	−0.68 (−0.66, −0.44)***	−0.48 (−0.58, −0.38)***	−0.14 (−0.26, −0.02)*	−0.12 (−0.20, −0.04)**
VPA in 2011				
Less than once a week	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
Once a week	−0.48 (−0.55, −0.41)***	−0.34 (−0.42, −0.26)***	−0.13 (−0.21, −0.05)**	−0.05 (−0.12, 0.02)
More than once a week	−0.68 (−0.72, −0.62)***	−0.49 (−0.55, −0.43)***	−0.20 (−0.26, −0.14)***	−0.09 (−0.14, −0.04)***
Women				
MPA in 2011				
Less than once a week	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
Once a week	−0.61 (−0.51, −0.72)***	−0.42 (−0.53, −0.30)***	−0.19 (−0.29, −0.08)***	−0.08 (−0.17, 0.01)
More than once a week	−0.81 (−0.88, −0.73)***	−0.59 (−0.68, −0.51)***	−0.34 (−0.41, −0.26)***	−0.22 (−0.28, −0.15)***
VPA in 2011				
Less than once a week	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
Once a week	−0.61 (−0.67, −0.55)***	−0.46 (−0.53, −0.38)***	−0.21 (−0.28, −0.14)***	−0.10 (−0.16, −0.04)**
More than once a week	−0.76 (−0.80, −0.71)***	−0.50 (−0.56, −0.44)***	−0.21 (−0.26, −0.15)***	−0.14 (−0.19, −0.09)***

MPA, sedentary time, FMI, TFM, and BFM did not have normally distributed residuals and were therefore log-transformed for analyses

Model 1: unadjusted analyses

Model 2: analyses were adjusted for age, marital status, educational level, living place and country

Model 3: analyses were adjusted for age, marital status, educational level, living place, country and self-rated health

Model 3: analyses were adjusted for age, marital status, educational level, living place, country, self-rated health and the number of chronic diseases in 2011

MPA moderate physical activity, *VPA* vigorous physical activity, *CI* confidence interval

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

activity, they will collect its benefits regardless of the past behaviours.

There is strong evidence that participation in physical activity should be used as a strategy in the prevention and treatment of many chronic diseases (Adami et al. 2010), and this study's results suggest the same. Furthermore, recent studies suggest that proper levels of physical activity can reduce the risk of progression of chronic diseases, such as hypertension and type 2 diabetes mellitus (Huai et al. 2013; Lambert and Bull 2014) and improve the functional capacity and quality of life of that portion of the population with chronic disease (Kujala et al. 2015). Thus, physical activity should be prescribed to older adults in order to prevent and reduce the number of chronic diseases, and, when possible, vigorous intensity physical activity should be recommended.

Despite the benefits of physical activity, its levels among people with chronic diseases are low (Evenson et al. 2014; Lin et al. 2010). Due to a preponderance of health problems, community-dwelling older adults with chronic diseases hardly achieved the recommended levels of physical activity (Lin et al. 2010). Therefore, the implementation of programs that promote continuous participation in moderate physical activity may be considered as a strategy to reduce the number of chronic diseases in the older population.

Some limitations should be considered in light of these results. First, the measurement of physical activity may be susceptible to bias as it was self-reported. Self-reported physical activity may be overestimated because of social desirability (Sallis and Saelens 2000). Nonetheless, social desirability only accounts for a small variance in self-reported physical activity (Motl et al. 2005). Furthermore, self-reports about physical activity are considered a reliable method for epidemiologic studies (Craig et al. 2003). Second, the measure of physical activity used in SHARE, where the highest possible response option for the most active people was more than once a week, might create a ceiling effect that does not allow for the discernment of different levels of active people. For instance, those who

Table 5 Association between the trajectory of physical activity and the number of chronic diseases—Survey of Health, Aging, and Retirement in Europe (SHARE), 2011–2013, Europe

	Parameters estimates of predicting the number of chronic diseases in 2013			
	Model 1 β (95% CI)	Model 2 β (95% CI)	Model 3 β (95% CI)	Model 4 β (95% CI)
Men				
MPA in 2011				
Inactive–inactive	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
Active–inactive	−0.85 (−1.22, −0.48)***	−0.36 (−1.10, 0.37)	−0.45 (−1.11, 0.21)	−0.12 (−0.69, 0.45)
Inactive–active	−0.80 (−1.14, −0.45)***	−0.39 (−1.08, 0.31)	−0.15 (−0.78, 0.47)	−0.08 (−0.62, 0.46)
Active–active	−1.44 (−1.77, −1,10)***	−0.86 (−1.54, −0.17)*	−0.35 (−0.96, 0.27)	−0.17 (−0.70, 0.37)
VPA in 2011				
Inactive–inactive	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
Active–inactive	−0.68 (0−81, −0.56)***	−0.46 (−0.61, −0.31)***	−0.26 (−0.40, −0.12)***	−0.05 (−0.17, 0.07)
Inactive–active	−0.67 (−0.74, −0.58)***	−0.53 (−0.62, −0.44)***	−0.19 (−0.28, −0.11)***	−0.12 (−0.20, −0.05)**
Active–active	−1.14 (−1.21, −1.07)***	−0.89 (−0.98, −0.80)***	−0.35 (−0.43, −0.26)***	−0.16 (−0.23, −0.08)***
Women				
MPA in 2011				
Inactive–inactive	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
Active–inactive	−0.50 (−0.88, −0.12)***	−0.38 (−0.84, 0.09)	−0.62 (−1.04, 0.20)	−0.36 (−0.72, 0.01)
Inactive–active	−0.68 (−1.02, −0.33)***	−0.32 (−0.73, 0.09)	−0.15 (−0.52, 0.22)	−0.19 (−0.52, 0.13)
Active–active	−1.45 (−1.79, 1,12)***	−0.90 (−1.31, −0.49)***	−0.45 (−0.82, −0.08)*	−0.35 (−0.67, 0.00)
VPA in 2011				
Inactive–inactive	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
Active–inactive	−0.80 (−0.92, −0.68)***	−0.55 (−0.69, −0.42)***	−0.36 (−0.44, −0.29)***	−0.14 (−0.25, 0.03)
Inactive–active	−0.85 (−0.91, −0.79)***	−0.56 (−0.63, −0.48)***	−0.18 (−0.25, −0.12)***	−0.10 (−0.16, −0.04)**
Active–active	−1.36 (−1.42, −1.30)***	−0.94 (−1.01, −0.86)***	−0.37 (−0.50, −0.24)***	−0.18 (−0.25, −0.12)***

MPA, sedentary time, FMI, TFM, and BFM did not have normally distributed residuals and were therefore log-transformed for analyses

Model 1: unadjusted analyses

Model 2: analyses were adjusted for age, marital status, educational level, living place and country

Model 3: analyses were adjusted for age, marital status, educational level, living place, country and self-rated health

Model 3: analyses were adjusted for age, marital status, educational level, living place, country, self-rated health and the number of chronic diseases in 2011

MPA moderate physical activity, *VPA* vigorous physical activity, *CI* confidence interval

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

were active two times a week were in the same group as those who were active five or more times a week. The current investigation also had its strengths. The SHARE study provides a large and representative sample size of several European countries. Considering the sample size and the heterogeneity of the participants in terms of age, culture, and other sociodemographic variables, the generality of these results should be considered a strength. Prospective analysis allows for the examination of the relationship between physical activity patterns and the number of chronic diseases.

Compliance with ethical standards

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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

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