UNIVERSIDADE DE LISBOA

FACULDADE DE MOTRICIDADE HUMANA

CROSS-SECTIONAL AND PROSPECTIVE RELATIONSHIP BETWEEN PHYSICAL

ACTIVITY AND DEPRESSION IN EUROPEAN OLDER ADULTS

Dissertação elaborada com vista à obtenção do Grau de Mestre em Exercício e Saúde

Orientador: Professor Doutor Adilson Passos da Costa Marques

Júri: Doutora Analiza Mónica Lopes de Almeida Silva

Doutor Adilson Passos da Costa Marques

Doutora Ana Sofia Pedrosa Gomes dos Santos

Doutora Diana Frasquilho Guerreiro

Joana Magalhães Bordado

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Index

Abstract

Objectives: The present study aims to analyse the cross-sectional and prospective relationship between regular practice of moderate and vigorous physical activity (PA) and depression symptoms using data from 2011 and 2013.

Methodology: This study analysed 38135 European older adults, from 13 European countries across a two-year follow-up. Data was collected in the fourth (in 2011) and fifth (in 2013) wave, from the Survey of Health, Ageing and Retirement in Europe (SHARE). For the present analysis were only considered participants who responded to the EURO-D 12-item scale of symptoms of depression, and with reported PA. Participants were inquired about the presence or absence of twelve symptom domains of depression and asked to report their frequency of moderate PA and vigorous PA. General linear models were conducted to access the cross-sectional and prospective associations.

Results: For both men and women, practising moderate or vigorous PA in 2011 was associated with a lower score of depression in 2011 and 2013. From the prospective analysis, moderate and vigorous PA in 2011 was inversely associated with the score of depression. This association remains significant in the fully adjusted model.

Conclusions: Moderate and vigorous PA practised once, or more than once a week is negatively related to the score of depression, both in men and women. The present study brings further support to the notion that PA is negatively associated with depression symptoms.

Keywords: Depression; physical activity; older people; mental health; SHARE

Introduction

The health benefits of physical activity (PA) are well recognised and documented (WHO, 2010). There is strong evidence that regular PA is associated with reducing the risk of all-cause mortality and several chronic medical conditions, such as cardiovascular diseases, type 2 diabetes, all-cancer mortality, hypertension (Warburton & Bredin, 2017).

Nowadays life expectancy of survival into old age has increased, being considered one of humanity's greatest achievements (Prince et al., 2015). With that, there's a rising necessity in improving older people's health to allow a more active contribution to society (Bowling, 2007). However, this change in population ageing is also strongly linked with the worldwide epidemic of chronic diseases., Population ageing is a major driver for increased strongly age-dependent disorders, such as dementia, stroke, diabetes (Prince et al., 2015). Regular practice of PA confers effective functional independence, reduced risk of functional limitations and disability (Paterson & Warburton, 2010), and also related to successful ageing and social inclusion (Fougner, Bergland, Lund, & Debesay, 2019).

Mental health is often left out the concept of public health, being mostly considered the prevention of physical illness. However, there's increasing evidence suggesting mental health as a relevant component of prevention and health promotion (Chapman & Perry, 2008). One of the most significant contributors to the global burden of disease is depression (WHO, 2008). Being the cause of the largest amount of non-fatal burden, it represents a major public health concern, affecting patients and society in all communities across the world (Ustun, Ayuso-Mateos, Chatterji, Mathers, & Murray, 2004).

Depression is a mental disorder characterized by symptoms of persistent sad or irritable mood accompanied by physical and cognitive changes that affect an individual's life (Marcus, Yasamy, Van Ommeren, Chisholm, & Saxena, 2012). With episodes longer than two weeks depression symptoms include, the loss of interest and/or pleasure in previously

enjoyed activities, feeling tired, changes in mood, sleep and appetite, as well as concentration difficulties. Long-lasting and moderate or severe severity depression symptoms can become a serious health concern (Smit, Cuijpers, Duivis, & Petrea, 2013). To note that these characteristics differ from the usual mood swings or going through a grieving process (APA, 2013).

Magnitude

Typically associated with depressive disorders is an increase in morbidity, mortality and greater functional psychosocial impairment, making its high prevalence a significant public health problem (Cassano & Fava, 2002). It is estimated that more than 300 million inhabitants of the world population (4.4%) suffer from depression, having a higher prevalence in women (5.1%) than in men (3.6%) (WHO, 2017). Between 2005 and 2015, there was an increase of 18.4% in people with depression, mainly due to the increase in life expectancy, with the main increase in the age groups which is more prevalent (Vos et al., 2016). Within these general prevalence estimates, at least one-third of the symptomatic cases become cases of moderate to severe severity (Ferrari et al., 2013).

On average, a depressive episode lasts for six months and in 20% of cases lasts longer than two years. In 60-70% of people, episodes become recurrent, some cases live about 20% of their lives with depressive moods (Vos et al., 2004). By 2020, depression, followed by heart disease, is projected to be the second-largest contributor to the Global Weight of Disease (GBD), measured by the sum of Years of Life Lost due to premature mortality (YLLs) and Years Lived with Disability (YLDs) , in order to obtain Adjusted Life Years for Disability (DALY) (Chapman & Perry, 2008). It is, however, considered globally, as the non-fatal disease most contributory to the loss of health, and in 2015 depressive disorders were responsible for the cumulative loss of more than 50 million years of life with the disability (WHO, 2017). In 2008 it was already considered as the disease that contributes most to the

incapacity of the productive activity of women, both in high, medium and low-income countries (WHO, 2008).

The age group 55-74 is the one with the highest prevalence rates of depression, and it is in the elderly, over 60 years of age, that a greater dysfunction occurs in daily living, removing them from their important social contributions such as family members and volunteers. Because it is a disease with concomitant symptoms of other age-related disorders, it is often neglected and underdiagnosed in primary health care. In European health systems, only a minority receives adequate treatment for depression (Smit et al., 2013).

Older people, with depressive symptoms, have less functionality when compared to those with other chronic diseases (Murray & Lopez, 1996). Untreated or poorly treated depressions, in the elderly, are associated with serious health consequences, including increased mortality (Crabb & Hunsley, 2006). Depression in later life also increases the perception of poor health, with an excessive recurrence to health care services (Smit et al., 2013).

Depression and physical activity

The relationship between depression and physical activity (PA) appears to be bidirectional. People with depression are less physically active and more sedentary (Schuch et al., 2017). At the same time, low levels of PA increase the risk of developing depression (Mammen & Faulkner, 2013).

The protective effects of PA are in increasing evidence, and higher levels of PA are consistently associated with a lower probability of developing depression (Schuch et al., 2018). These results remain, even when adjusted for gender, women with low levels of PA are significantly at greater risk of developing depression than women with high levels of PA (Mikkelsen et al., 2010). Regarding the effect of PA on depression, literature shows beneficial effects in depressive symptoms similar to those of antidepressant treatments, suggesting as a

possible means of therapy for acute or chronic depression (Dinas, Koutedakis, & Flouris, 2011; Kvam, Kleppe, Nordhus, & Hovland, 2016). Even when results are adjusted to account for possible publication biases, PA continues to have a significant effect on the treatment of depression (Schuch et al., 2016a). Other studies confirm that exercise has a positive effect on reducing depression, demonstrating that PA results even in lower levels of depression and that the level of depression decreases as PA time increases (Cicek, Atan, Kamuk, & İmamoğlu, 2015).

In a meta-analytic comparison of PA and self-reported sedentary behaviour, among individuals with and without depression, it was observed that individuals with depression are 50% less likely to comply, with the recommendations of 150 min/week of PA, than individuals without depression. When objective means of measurement are used, the proportion of people with depression, who fail to meet recommendations, increases to 88% (Schuch et al., 2017). In addition, there's strong evidence on the positive effect of PA on both prevention and treatment, most individuals with depression show an interest in PA, yet they refer depressive symptoms as significant barriers (Busch et al., 2016).

PA intensity tends to decrease with age, in both men and women, therefore, it occurs an age-related intensity decrease. When compared with older people who maintained or increased practice intensity, this activity decrease is associated with an increased risk of depressive symptoms (Lampinen, Heikkinen, & Ruoppila, 2000).

In non-institutionalized elders, there is a high-risk profile for potential depression symptoms. Low levels of functional performance combined with low levels of PA practice increase the risk of depression (Holmquist, Mattsson, Schele, Nordstrom, & Nordstrom, 2017). PA is considered an alternative to antidepressant medications in the treatment of depression in the elderly (Blumenthal et al., 1999). Its beneficial effects are increased,

suggesting an underestimation of the clinical effect of exercise on previous meta-analyses (Schuch et al., 2016b).

Despite the various studies about exercise and/or PA and depression, the sample size is considered small and from one country region or area only. Most of them also don't control variables for different PA intensity levels. It is of our interest to analyse the effect of PA in depression's symptoms, using a wide sample of European older adults. SHARE study enables to analyse a larger sample size, with several countries and cultures, and simultaneously, to observe intensity levels of PA practice in order to prevent nationality bias and allow more heterogeneous sample study. Therefore, this study aims to analyse the cross-sectional and prospective relationship between regular practice of moderate and vigorous PA and the score of depression in European older adults, using data from 2011 and 2013.

Methods

The present study analysed data from the Survey of Health, Ageing and Retirement in Europe (SHARE) from wave 4 and 5, performed in 2011 and 2013, respectively. SHARE is a multidisciplinary and cross-national survey designed to answer the upcoming and growing challenges we face due to the rapid population ageing. Since 2000 SHARE has been conducting data collection every two years, it is a database of microdata on health, socio-economic status and social and family networks of about 140.000 individuals aged 50 or older, from across 27 European countries and Israel. Out of the 20 countries participating in SHARE at the time of collection, waves 4 and 5 were conducted by the 13 following countries: Austria, Germany, Sweden, Netherlands, Spain, Italy, France, Denmark, Switzerland, Belgium, Czech Republic, Slovenia, and Estonia (Calvo-Perxas, Vilalta-Franch, Turro-Garriga, Lopez-Pousa, & Garre-Olmo, 2016).

The Ethics Council of the Max-Planck Society for the Advancement of Science reviewed waves 4 and 5 of the SHARE project, attested all the research projects and procedures to assure confidentiality, data privacy and given information to the participants to follow international ethical standards. The survey interview has averagely 90 minutes duration conducted by trained interviewers at the participant's household. Its questions cover a wide range of topics such as health, economics, and social variables. SHARE's data is available to the research community free of charge (www.share-project.org) (Calvo-Perxas et al., 2016).

From wave 4 the total sample consisted of 42522 participants and 47855 participants in wave 5. For the present study only respondents of the 12 items of the depression scale and with reported PA, in both waves, were considered eligible (n=38135). The SHARE sample represents the non-institutionalized population and its database presents a wide range of

variables from social networks, socioeconomic status to health, behaviour and psychological health.

Measurements

Covariates

Measured at the baseline age, marital status, education level, living place, country, self-rated health and number of chronic diseases were used as covariates, however, age and number of chronic diseases were used as continuous covariates. Education was collected according to the International Standard Classification of Education-97 (ISCED- 97) codes (UNESCO, 1997) and then categorized in three groups: (i) low education level, including participants with no education or ISCED-97 codes 1 and 2; (ii) middle educational level, which included participants with ISCED-97 codes 3 and 4; (iii) high education level, which included participants with ISCED-97 codes 5 and 6. Marital status was coded in 2 groups: married, which included a registered partnership or living together; and not married, which included single, separated, divorced and widower. 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, to determine the Living Place (Calvo-Perxas et al., 2016; Marques, Peralta, Martins, de Matos, & Brownson, 2017). To assess self-related health was used a single-item question about responders' general health perception in a 5-point scale response options (excellent, very good, good, fair and poor). For data analysis, the scale was inverted so that, higher values represent better health perception.

Number of chronic diseases

As performed previously by Lindwall, Larsman, and Hagger (2011), to produce a single score, the number of chronic diseases was summed. To determine the number of chronic medical diseases the participants were asked about the presence or absence from 14 named listed diseases, self-reported diagnosed by a doctor. They could also include other

unnamed medical condition diagnosed by a doctor (Gallagher, Savva, Kenny, & Lawlor, 2013)

Physical activity

Participants were asked to report their frequency of moderate PA such as brisk walking, gardening or household activities, and frequency of vigorous PA, including activities like hiking, sports, carrying heavy loads. To measure its frequency, for both moderate and vigorous activities, the responses were categorized into: (1) more than once a week, (2) once a week, (3) up to three times a month, and (4) hardly ever or never. The responses (3) up to three times a month and (4) hardly ever or never were grouped into a category named "less than once a week" (Lindwall et al., 2011; Marques et al., 2017).

Depression

Depression was assessed through the EURO-D 12-item scale, developed and validated to compare cross-nationally symptoms of depression in Europe (Prince et al., 1999). The scale inquires the presence or absence of the 12 symptom domains of depression: depressed mood, pessimism, suicidality, guilt, sleep, interest, irritability, appetite, fatigue, concentration, enjoyment and tearfulness. In each of the domains, it is scored one if present and zero if absent, being the total score, from 0 to 12, the sum of all the domains. The score's validation was demonstrated in each of the EURODEP study sites and according to the author, the optimal cut-off point is a score of 4 or more points for clinically significant depression (Gallagher et al., 2013; Prince et al., 1999).

Data analysis

To characterize the sample, descriptive statistics (means, standard deviation, and percentage) were used. To compare men and women, according to their characteristics, the Chi-square and the independent sample t-test were used. To analyse the bivariate cross-sectional and prospective relationships between, moderate and vigorous PA and the score of

depression, in 2011 and 2013, ANOVA tests were performed. The cross-sectional and prospective association between moderate and vigorous PA with the score of depression was assessed using general linear models. Different models were performed for the cross-sectional analysis: Model 1 was the unadjusted analysis between PA and the depression score. Model 2 was adjusted for age, marital status, educational level, living place and country. Model 3 was further adjusted for self-rated health. To observe the prospective analysis of PA with the depression score a fourth model was created. This model was adjusted for variables from model 3, adding further adjustments for the number of chronic diseases in 2011. Data analysis was performed using SPSS 25. Statistical significance was set at $p<0.05$.

Results

The participants' sociodemographic characteristics are shown in Table 1. In all the analysed variables men and women were significantly different. The scores of the EURO depression scale remained similar although there was a significant change in PA participation, from wave 4 to wave 5. Concerning moderate PA, more than 95% of the participants were active for more than once a week. There was also a significant change in the participation of vigorous PA, having a swift from 31% of women doing more than once a week to 67% and men from 40.8% to 70.2%.

Table 1. Participants' characteristics.

	2011 (% or M±SD)			2013 (% or M±SD)		
	Men (n=16269)	Women (n=21866)	p	Men (n=16269)	Women (n=21866)	p
Education			<0.001			<0.001
Low	58.6	62.0		35.7	42.8	
Middle	27.5	25.7		40.7	37.4	
High	13.9	12.3		23.7	19.8	
Age	65.9±9.5	65.7±10.4	<0.001	67.9±9.5	67.7±10.4	<0.001
Marital status			<0.001			<0.001
Not married	20.1	36.5		21.3	38.9	
Married	79.9	63.5		78.7	61.1	
Living place			<0.001			<0.001
Big city	12.5	14.5		12.3	14.0	
Suburbs of a big city	10.9	10.2		12.4	10.7	
Large town	15.3	17.1		14.8	16.3	
Small town	25.0	25.2		24.9	25.2	
Rural area	36.4	33.0		35.7	33.8	
EURO depression scale (score)	2.0±2.0	2.8±2.3	<0.001	2.0±2.0	2.8±2.3	<0.001
Self-rated health	2.9±1.1	2.8±1.1	<0.001	2.8±1.1	2.8±1.1	<0.001
Number of chronic diseases	1.6±1.5	1.8±1.6	<0.001	1.6±1.5	1.8±1.6	<0.001
Moderate PA			<0.001			<0.001
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			<0.001
Less than once a week	45.3	54.9		17.1	20.1	
Once a week	14.0	14.2		12.7	13.0	
More than once a week	40.8	30.9		70.2	66.9	

Abbreviation: M, media; SD, standard deviation; PA, physical activity.
[a] Tested by Chi Square.
[b] Tested by t test.

Table 2 presents the bivariate analysis of the cross-sectional and prospective relationship between PA and the EURO depression score. Regarding men in 2011, there is a relationship between moderate or vigorous physical activity with a lower score of depression (moderate: $F_{(2, 16100)}=155.473$, $p<0.001$; vigorous: $F_{(2, 16171)}=240.661$, $p<0.001$). In 2013, even though once a week moderate PA didn't relate with lower scores than less than once a week, this relation is shown in vigorous PA (moderate: $F_{(2, 16266)}=157.480$, $p<0.001$; vigorous: $F_{(2, 16266)}=514.113$, $p<0.001$). For women in 2011, practicing more PA was associated with lower depression score (moderate: $F_{(2, 21154)}=153.155$, $p<0.001$; vigorous: $F_{(2, 21692)}=307.882$, $p<0.001$). The same was observed in 2013 for moderate and vigorous PA (moderate: $F_{(2, 21863)}=132.497$, $p<0.001$; vigorous: $F_{(2, 21863)}=763.337$, $p<0.001$).

Table 2. Cross-sectional and prospective relationship between physical activity and the score of depression.

	Men Score of Depression (M±SD)				Women Score of Depression (M±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	2.8±2.4		3.1±2.8		3.6±2.5		4.2±2.8	
Once a week	2.0±1.9		3.4±2.7		2.8±2.3		4.2±2.9	
More than once a week	1.9±1.9		1.9±2.0		2.7±2.3		2.7±2.3	
Vigorous PA in 2011		<0.001		<0.001		<0.001		<0.001
Less than once a week	2.3±2.1		3.1±2.6		3.2±2.4		3.9±2.7	
Once a week	1.7±1.8		2.0±2.0		2.4±2.0		2.9±2.3	
More than once a week	1.6±1.7		1.7±1.8		2.4±2.1		2.4±2.1	

Abbreviation: PA, physical activity.
Tested by ANOVA.

Table 3 shows the cross-sectional parameters estimates of depression score according to PA intensity and frequency. For both genders, moderate and vigorous PA were negatively associated with the score of depression. For men, practising moderate PA once a week (β=-0.31, 95% CI: -0.48, -0.14, $p<0.001$) and more than once a week (β=-0.37, 95% CI: -0.50, -0.24, $p<0.001$) were negatively associated with the score of depression. For vigorous PA similar results were observed (once a week – β=-0.23, 95% CI: -0.34, -0.13, $p<0.001$; more than once a week – β=-0.28, 95% CI: -0.35, -0.20, $p<0.001$). Regarding women, practising

moderate PA once a week (β=-0.27, 95% CI: -0.43, -0.11, p<0.001) and more than once a

week (β=-0.26, 95% CI: -0.37, -0.14, p<0.001) was also associated with lower score of

depression; Similarly this results were also observed for vigorous PA practising (once a week

– β=-0.36, 95% CI: -0.47, -0.26, p<0.001; more than once a week – β=-0.21, 95% CI: -0.29, -

0.13, p<0.001).

Table 3. Cross-sectional parameters estimates of depression score according to
physical activity intensity levels and frequency.

	Parameters estimates of predicting the score of depression in 2011		
	Model 1	Model 2	Model 3
Men	β (95% CI)	β (95% CI)	β (95% CI)
MPA in 2011			
Less than once a week	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
Once a week	-0.83 (-0.98, -0.69)*	-0.66 (-0.84, -0.48)*	-0.31 (-0.48, -0.14)*
More than once a week	-0.96 (-1.06, -0.85)*	-0.72 (-0.85, -0.59)*	-0.37 (-0.50, -0.24)*
VPA in 2011			
Less than once a week	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
Once a week	-0.59 (-0.68, -0.50)*	-0.49 (-0.60, -0.38)*	-0.23 (-0.34, -0.13)*
More than once a week	-0.69 (-0.75, -0.63)*	-0.64 (-0.72, -0.56)*	-0.28 (-0.35, -0.20)*
Women			
MPA in 2011			
Less than once a week	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
Once a week	-0.84 (-0.99, -0.70)*	-0.62 (-0.79, -0.45)*	-0.27 (-0.43, -0.11)*
More than once a week	-0.93 (-1.03, -0.83)*	-0.65 (-0.78, -0.53)*	-0.26 (-0.37, -0.14)*
VPA in 2011			
Less than once a week	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
Once a week	-0.78 (-0.88, -0.69)*	-0.73 (-0.85, -0.62)*	-0.36 (-0.47, -0.26)*
More than once a week	-0.77 (-0.84, -0.70)*	-0.65 (-0.74, -0.56)*	-0.21 (-0.29, -0.13)*

Abbreviation: MPA, moderate physical activity; VPA, vigorous physical activity; CI, confidence
interval
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.
* *p*<0.001.

Table 4 shows the prospective analysis of parameters estimates predicting the score of

depression. This prospective analysis indicates that moderate PA and vigorous PA practice,

once or more than once a week, are negatively associated with the score of depression. Even

when the model is fully adjusted (model 4), this relationship remains significant. Regarding

men, moderate PA practice (once a week – β=-0.36, 95% CI: -0.54, -0.18, p<0.001; more than

once a week – β=-0.36, 95% CI: -0.50, -0.23, p<0.001) and vigorous PA practice (once a

week – β=-0.23, 95% CI: -0.35, -0.12, p<0.001; more than once a week – β=-0.21, 95% CI: -0.29, -0.13, p<0.001) show a significant reduction on depression score. This relationship is also observed for women, practicing moderate PA (once a week – β=-0.13, 95% CI: -0.24, -0.02, p<0.001; more than once a week – β=-0.21, 95% CI: -0.30, -0.13, p<0.001) and vigorous PA (once a week – β=-0.19, 95% CI: -0.29, -0.08, p<0.05); more than once a week – β=-0.20, 95% CI: -0.29, -0.12, p<0.001) significantly reduces depression score.

Table 4. Prospective parameters estimates of Depression Score to physical activity intensity levels and frequency.

	Parameters estimates of predicting the score of depression in 2013			
	Model 1	Model 2	Model 3	Model 4
Men	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)
MPA in 2011				
Less than once a week	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
Once a week	-0.79 (-0.94, -0.64)***	-0.70 (-0.89, -0.52)***	-0.38 (-0.56, -0.20)***	-0.36 -0.54, 0.18)***
More than once a week	-0.88 (-0.99, -0.77)***	-0.71 (-0.85, -0.57)***	-0.39 (-0.53, -0.26)***	-0.36 (-0.50, -0.23)***
VPA in 2011				
Less than once a week	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
Once a week	-0.63 (-0.72, -0.53)***	-0.50 (-0.62, -0.38)***	-0.26 (-0.37, -0.15)***	-0.23 (-0.35, 0.12)***
More than once a week	-0.70 (-0.76, -0.63)***	-0.58 (-0.66, -0.49)***	-0.25 (-0.33, -0.16)***	-0.21 (-0.29, -0.13)***
Women				
MPA in 2011				
Less than once a week	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
Once a week	-0.74 (-0.84, -0.64)***	-0.57 (-0.70, -0.44)**	-0.16 (-0.28, -0.05)***	-0.13 (-0.24, 0.02)***
More than once a week	-0.84 (-0.91, -0.77)***	-0.65 (-0.74, -0.55)***	-0.25 (-0.33, -0.16)***	-0.21 (-0.30, -0.13)***
VPA in 2011				
Less than once a week	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
Once a week	-0.66 (-0.75, -0.56)***	-0.46 (-0.58, -0.34)***	-0.22 (-0.33, -0.11)***	-0.19 (-0.29, -0.08)*
More than once a week	-0.79 (-0.86, -0.72)***	-0.58 (-0.67, -0.50)***	-0.23 (-0.31, -0.14)***	-0.20 (-0.29, -0.12)***

Abbreviation: MPA, moderate physical activity; VPA, vigorous physical activity; CI, confidence interval

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

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

Discussion

The present study analysed the cross-sectional and prospective relationship between PA and the depression score in a 2-year period. It was used a large sample including older adults from 13 European countries. The main result was that moderate and vigorous PA is significantly associated with a lower score of depression, among men and women. These results corroborate with current literature (Kvam et al., 2016; Rebar et al., 2015; Schuch et al., 2018; Schuch et al., 2016b), emphasizing the importance of PA and its association with lower depression scores, or depression symptoms.

Exercise effectiveness in depression symptoms is already well documented (De Mello et al., 2013; Kvam et al., 2016; Rebar et al., 2015; Schuch et al., 2018) and considered comparable to antidepressant treatments (Dinas et al., 2011). A review of four meta-analyses concludes that the effects of PA might be comparable to medication and psychotherapy for mild to moderate depression and that it seems to be a valuable complement to traditional clinical approaches for severe depression (Knapen, Vancampfort, Morien, & Marchal, 2015). There is even the potential finding that combining PA with antidepressant medication might help late-life treatment-resistant depressions (Mura & Carta, 2013). Nonetheless, for clinical approaches, more details on the optimal prescription are needed to further support its clinical administration (Strohle, 2009).

The non-clinical research about depression and PA has also been referring the need of long term follow-up studies and exercise characteristics like intensity, frequency, and duration (Helgadottir, Forsell, Hallgren, Moller, & Ekblom, 2017).

PA frequency hasn't been receiving much attention in the current literature. Most studies account the sum of physically active minutes but do not consider frequency and intensity at the same time (Schuch et al., 2018). Acknowledging this gap and following recommendations for future studies (Harris, Cronkite, & Moos, 2006; Sjosten & Kivela,

2006), this study provides differentiation between PA frequencies and intensity. Emphasizing the main result of this study, those less physically active are more likely to have a higher score of depression, adding to the premise that practising moderate or vigorous PA more than once a week is inversely associated with the likelihood of depression symptoms.

Mikkelsen et al. (2010) reported that women are significantly at higher risk of depression when practising low levels of PA and that prediction was not observed in men. When men do not achieve the PA recommended levels (≥150 min/week of moderate PA or ≥75 min/week of vigorous PA), have a higher likelihood of having depression (Werneck, Oyeyemi, & Silva, 2018). These results, for women, are less clear, hypothesized that this may be due to the fact that women have more daily PA in other domains, such as household activities (Oliveira, Oancea, Nucci, & Vogeltanz-Holm, 2018). Interestingly our results are observed in both genders. From the present study, it can be concluded that PA is beneficial and has a similar impact, on depression score reduction, for both men and women. Similarly to a cohort study on clinically diagnosed patients, on a 10-year follow-up (Harris et al., 2006) it was observed a strong relationship between physical activity and depression, even when adjusted for sociodemographic and health perception variables. Our results also corroborate Loprinzi (2013) and Park et al. (2015) results, concluding that moderate-to-vigorous PA were inversely associated with depression, even after controlling for potential confounding variables.

The present findings are very promising and robust, due to the large sample size, however, this research does not control for light intensity PA. Loprinzi (2013) refers that severer depression cases may condition these older adults to be more physically active and, with an objective measurement it was found that light PA was inversely associated with depression symptoms in US older adults. Werneck et al. (2018) also refer that, especially in advanced ages, it is necessary to emphasize the importance of "doing something is better than

nothing". Jonsdottir, Rodjer, Hadzibajramovic, Borjesson, and Ahlborg (2010) support these findings, although just in adult employees, stating that it seems that every activity above sedentary behaviour may be beneficial for mental health status. It might be interesting, for future research to better understand PA intensity and frequency, necessary to show positive results in older populations. An interesting article from Helgadottir et al. (2017) shows that light PA practice, such as light-yoga, result in rather small differences between intensity groups. Suggesting that PA, for mild to moderate depression, could be prescribed at patient's desirable intensity (Helgadottir et al., 2017). This analysis provides a promising research area to contradict the lack of ability and desire to engage in more intensive forms of PA as referred by Loprinzi (2013) and ultimately improve older people's adhesion to a more active lifestyle.

Strengths and Limitations

Our study methodology is based on an interview and self-report answers and, therefore is more prone to bias than using objective measurements (Grimm, Swartz, Hart, Miller, & Strath, 2012). PA was assessed by a questionnaire which is subject to bias. It would be more accurate to use objective instruments of measurement, like accelerometers. Adams et al. (2005) reported that there is an over-reporting of PA due to social desirability, resulting in energy expenditure, and activity duration overestimation. Grimm et al. (2012) confirms this tendency to over-report PA level but, despite those findings, they support the notion of using PA questionnaires, namely IPAQ, for large population studies, like our own, as it was designed to (Grimm et al., 2012). Although the validated methodology for depression score measurement (Prince et al., 1999), it is considered that it can be biased, for example, mood fluctuations change the way questions are answered. A person may not have depression and score 4 or more points that day, so it would be considered depressive, even though it may not correspond to the overall picture of the person. The notion of episodic depressive symptoms is confirmed by Park et al. (2015), that overcomes this limitation with collected information on

depression diagnosis which is more viable to collect with smaller sample size. It is also recommended for future studies, with large sample sizes, to extend the follow-up period with regular inter-assessment intervals to reduce potential bias.

Major strengths of this study include using a large sample size, so it can overcome the limitation on using an indirect measurement of PA and Depression. Using a large European sample of older adults is considered important to provide available evidence to policymakers reflect upon the impact on society (Allmark, 2004). Following the recommendations by some authors, like Loprinzi (2013) the design of the study is considered a strength, using a cross-sectional prospective study design allows to better determine the prevalence and identify associations (Mann, 2003).

A unique feature of this study was the comparison between moderate PA and vigorous PA, as all previous studies found aggregate moderate-to-vigorous PA, and to notice that it's enough to practice moderate PA to have significant depression score reduction and that these results are significant for both men and women.

Conclusion

Depression is one of the main contributors to the global burden of disease affecting millions of people in all communities worldwide. Therefore, is considerate a major public health concern. From the present work, it seems clear that PA is negatively related to depression symptoms. PA has shown to have positive effects on the prevention and treatment of depression in older adults.

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