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Relationship between physical activity and chronic diseases among European adults from several countries: A cross sectional and prospective population-based study

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Resumo

Introdución: As enfermidades crónicas son a principal causa de morbilidade e mortalidade no mundo. Para a prevención de enfermidades crónicas recoméndase a práctica da actividade física. O obxectivo deste estudo foi examinar a relación entre a actividade física e as enfermidades crónicas nos adultos europeos. **Métodos xerais:** utilizáronse datos do Survey of Health, Aging, and Retirement in Europe (SHARE), as ondas 4 e 5; e do European Social Survey (ESS), ronda 7. **Resultados principais:** Observouse que a actividade física moderada ou vigorosa era transversal e prospectivamente asociada a un número menor de enfermidades crónicas. O tempo dedicado a asistir á televisión está asociado coa multimorbilidade (≥2 enfermidades crónicas). Todavia, a participación na actividade física pode mitigar ou incluso eliminar esta asociación. A multimorbilidad estaba relacionada negativamente coa autoavaliación da saúde e a satisfacción coa vida, pero a actividade física amortiguou esta relación negativa, contribuíndo a unha mellor auto-percepción da saúde e satisfacción coa vida. **Conclusión:** a actividade física impide as enfermidades crónicas. Por iso, deben considerarse programas para fomentar a participación en actividades físicas para reducir a cantidade de enfermidades crónicas na poboación.

Resumen

Introducción: Las enfermedades crónicas son la principal causa de morbilidad y mortalidad en el mundo. Para la prevención de enfermedades crónicas, se recomienda la práctica de actividad física. Este estudio tuvo como objetivo examinar la relación entre la actividad física y las enfermedades crónicas en adultos europeos. **Métodos generales**: Fueron utilizados datos del estudio del Survey of Health, Aging, and Retirement in Europe (SHARE), onda 4 y 5; y del European Social Survey (ESS), ronda 7. **Resultados principales:** Se observó que la actividad física moderada o vigorosa era transversal y prospectivamente asociada a un menor número de enfermedades crónicas. El tiempo que se pasa viendo la televisión se asocia con la multimorbilidad (≥2 enfermedades crónicas). Todavía, la participación en la actividad física puede atenuar o incluso eliminar esta asociación. La multimorbilidad se relacionó negativamente con la autoevaluación de la salud y la satisfacción con la vida, pero la actividad física amortiguó esta relación negativa, contribuyendo para una mejor autopercepción de la salud y la satisfacción con la vida. **Conclusión:** La actividad física previene las enfermedades crónicas. Por lo tanto, programas para promover la participación en actividades físicas debe considerarse para reducir el número de enfermedades crónicas en la población.

Abstract

Introduction: Chronic diseases are the leading cause of morbidity and mortality worldwide. For prevention of chronic diseases regular practice of physical activity has been recommended. This study aimed to examine the relationship between physical activity and chronic diseases in European adults and older adults. **General methods:** The present thesis used data from the Survey of Health, Aging, and Retirement in Europe (SHARE) study, wave 4 and 5; and from the European Social Survey (ESS) project, round 7. **Main results:** It was observed that moderate or vigorous physical activity was cross-sectionally and prospective associated with fewer chronic diseases. Time spent watching television is associated with multimorbidity (≥2 chronic diseases). However, physical activity participation can attenuate or even eliminate this association. Multimorbidity was negatively related to self-rated health and life satisfaction, however physical activity buffered this negative relationship, contributing to better self-rated health and life satisfaction. **Conclusion:** Physical activity prevent chronic diseases. Therefore, implementation of programs to promote participation in moderate or vigorous physical activity should be considered as a strategy to reduce the number of chronic diseases in the population.

Summary

Introduction

Chronic diseases are the leading cause of morbidity and mortality, and are considered to be at epidemic levels worldwide (WHO, 2015, 2016, 2017). Chronic diseases affects negatively quality of life due to physical and psychological consequences and in 2015 were responsible for 70% of the world's deaths (WHO, 2017).

Chronic diseases were associated with older population, nonetheless, because of the lifestyle changes that have been rapidly occurring in recent years, chronic diseases are now becoming more prominently among young adults and adults (WHO, 2017). Out of the 38 million deaths due to chronic diseases in 2012, more than 40% were premature (WHO, 2014). The risk factors for chronic diseases are mainly caused by an unhealthy and sedentary lifestyle (Lee et al., 2012; Rayner, Wickramasinghe, Williams, McColl, & Mendis, 2017). Thus, a worldwide increase in interest in health enhancing physical activity has been observed. Regular practice of physical activity has been recommended (European Union, 2008; USDHHS, 2008; WHO, 2010) because of its effectiveness for primary and secondary prevention of chronic diseases (Alves et al., 2016).

Physical activity seems to reduce chronic diseases and the risk of disease progression (Bryan & Katzmarzyk, 2011; Ekelund et al., 2016; Huai et al., 2013), while improving the functional capacity and quality of life of those suffering with chronic diseases (Kujala, Kukkonen-Harjula, & Tikkanen, 2015). Moreover, there is evidence that physical activity reduces premature mortality and morbidity associated with chronic diseases (Ekelund et al., 2015; Lear et al., 2017). Even a minimum amount of physical activity has a protective health effect against chronic diseases, and reduces mortality (Ekelund et al., 2015; Lee, Sesso, Oguma, & Paffenbarger, 2003;

O'Donovan, Lee, Hamer, & Stamatakis, 2017; Wen et al., 2011). Hence, the World Health Organization considers physical activity to be a key determinant to control and prevent chronic diseases (WHO, 2014).

Although the importance of physical activity on chronic diseases, a large proportion of the world's population (Sallis et al., 2016), and specifically European adults (Loyen et al., 2017; Marques, Sarmento, Martins, & Saboga Nunes, 2015), are not considered physical active. The prevalence of physical inactivity of adults is, therefore, a major public health issue (Lee et al., 2012; WHO, 2016, 2017). The majority of the studies have analysed the relationship between physical activity and a particular chronic disease, not considering that a person can have several diseases (Banks, Lim, Seubsman, Bain, & Sleigh, 2011; Karjalainen et al., 2015; Swift et al., 2013). The use of a more comprehensive approach that evaluates several diseases is needed. Furthermore, other studies only involved men (Chomistek, Cook, Flint, & Rimm, 2012; Lee et al., 2003), and it would be of importance to study men and women (Tambalis et al., 2016).

Although physical activity is of importance in preventing and reducing chronic diseases (Ekelund et al., 2015; Lee et al., 2003; O'Donovan et al., 2017; Wen et al., 2011) 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, Nishida, & Fujita, 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.

Furthermore, the prevalence of sedentary behaviours has increased (Hansen, Kolle, Dyrstad, Holme, & Anderssen, 2012; Kohl et al., 2012). In several countries most adults spend their awake time in sedentary behaviours (Dumith, Hallal, Reis, & Kohl, 2011), being television viewing time reported as the most prevalent leisure-time sedentary behaviour (Clark et al., 2009; Harvey, Chastin, & Skelton, 2013). Studies have demonstrated that sedentary behaviours, and particularly the time spent watching television, is associated with increased risk for mortality and chronic diseases (Ekelund et al., 2016; Keadle et al., 2015; Pinto Pereira, Ki, & Power, 2012). The deleterious associations of television viewing with mortality and chronic diseases has been investigated independently of physical activity (Wijndaele et al., 2011). Although the negative impact of time watching television has been also observed in active people (Healy et al., 2008), higher levels of physical activity may reduce or even eliminate the risk associated with sedentary behaviours (Ekelund et al., 2016; Rao, Orpana, & Krewski, 2016). For that, studies have addressed the association of television viewing and physical activity with specific chronic diseases (Ekelund et al., 2016; Keadle et al., 2015; Pinto Pereira et al., 2012), but only few studies have investigated this issue with the presence of multimorbidity.

Chronis diseases, but mainly multimorbidity, influences health perception and wellbeing because of its physical and psychological health consequences (WHO, 2016). Self-rated health is a predictor of morbidity and mortality (DeSalvo, Bloser, Reynolds, He, & Muntner, 2006; Mavaddat, Valderas, van der Linde, Khaw, & Kinmonth, 2014b), related to several biomarkers (DeSalvo et al., 2006), and a barometer of physiological states (Jylha, Volpato, & Guralnik, 2006). Life satisfaction and wellbeing has been related to several mental negative health outcomes such as depression and psychiatric problems (Nes et al., 2013), along with somatic disability and mortality (Koivumaa-Honkanen et al., 2004). Thus, research has shown that multimorbidity is negatively associated with both self-rated health (Cimarras-Otal et al., 2014; Mavaddat et al., 2014b; Perruccio, Katz, & Losina, 2012) and life satisfaction (Lukkala et al., 2016).

In opposition to multimorbidity, physical activity has been shown to have a significant and positive association with self-rated health and life satisfaction (Maher, Pincus, Ram, & Conroy, 2015; Sodergren, Sundquist, Johansson, & Sundquist, 2008). It is thus expected that, by having a positive effect on self-rated health and life satisfaction, and by having a protective health effect against chronic diseases, physical activity might moderate the relationship between multimorbidity and self-rated health and life satisfaction.

The above concerns are the guiding principles of this thesis. In order to answer the questions raised, 6 different studies were carried out that compose the thesis. The first one sought to analyse cross-sectional and longitudinally the relationship between the regular practice of physical activity and the number of chronic diseases. The second analysed the relationship between physical activity and the most prevalent chronic diseases, controlling the relation to other potential diseases. The third and fourth attempt to study the intensity of physical activity in the probability of the onset of chronic diseases. The fifth analysed the moderating effect of physical activity on the relationship between multimodality and time spent watching television. Finally, the sixth analysed the effect that physical activity has on the negative relationship between multimorbidity and self-rated health perception and life satisfaction.

Objective of the study

Considering the problems and concerns presented previously, with this thesis we intend to analyse the relationship between physical activity and chronic diseases. From the main objective of research derive more specific ones, that we intend to analyse through a compilation of several articles of investigation.

Therefore, this project aimed to:

1) 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.

2) Evaluate whether reporting physical activity is associated with lower odds of self-reported chronic diseases, individually and mutually adjusted, including heart problems, high blood pressure, breathing problems, allergies, type 2 diabetes, cancer and obesity, among nationally representative samples of adults European countries.

3) Examine the cross-sectional and prospective relationship between physical activity at different levels of intensity (moderate and vigorous), and chronic diseases.

4) Analyse the association of television viewing, physical activity, and chronic diseases; and to understand if physical activity attenuates or eliminates the detrimental association between television viewing and chronic diseases.

5) Examine the relationship between multimorbidity, self-rated health, and life satisfaction, and to analyse the moderate effect of physical activity on the relationship between multimorbidity, self-rated health, and life satisfaction

General methods

Data source

The present thesis used data from the Survey of Health, Aging, and Retirement in Europe (SHARE) study, wave four and fifth; and from the European Social Survey (ESS) project, round 7.

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 & Jürges, 2005).

The European Social Survey is an academically driven cross-national survey that has been conducted every two years across 20 European countries and Israel. The survey measures the attitudes, beliefs and behaviour of European people. The European Social Survey uses a multi-stage probability cluster sampling designed to provide national representative samples among several European countries. According to national options, participants are sampled by means of postal code address files, population registers, social security register data, or telephone books. In the sampling procedure statistical precision was kept the same for all countries. In each country the information was collected using a questionnaire filled-in through an hour-long face-to-face interview that included questions on the use of medicine, immigration, citizenship, socio-demographic and socioeconomic issues, health status, and physical activity. The questionnaire was translated by language experts, into the language of each of the participating countries. Further details about European Social Survey are available elsewhere (Schnaudt, Weinhardt, Fitzgerald, & Liebig, 2014).

Measures

Physical activity. From SHARE data 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. From ESS information on physical activity was assessed with a single item asking, "on how many of the last 7 days did you walk quickly, do sports, or other physical activity for 30 minutes or longer?". Using the reported information on physical activity a new variable was computed to classified participants into three groups: 1) practice of physical activity ≤1 time/week; 2) practice of physical activity 2-4 times/week; and 3) practice of physical activity ≥5 times/week. Although physical activity was assessed with a single item, there is evidence in previous studies where physical activity is not the primary focus and more detailed measures are not feasible, that a single question is an acceptable alternative (Wanner et al., 2014).

Chronic diseases. In both databases, chronic diseases were assessed by asking participants to report whether their doctor told them the presence of the several chronic diseases, such as heart attack or other heart problems, hypertension, stroke or cerebral vascular disease, high blood cholesterol, diabetes, chronic lung disease, cancer, stomach or duodenal ulcer, Parkinson disease, hip fracture/femoral fracture, Alzheimer's disease/dementia.

Television. Participants were asked to report how much time, in total, they spend watching television on an average day. Responses were from no time to more than 3 hours, using intervals of 30 minutes. Responses were recoded to “no time at all”, “less than 1-hour/day”, “2-3 hours/day”, and “more than 3 hours/day”.

Self-rated health. 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.

Life satisfaction. Life satisfaction was assessed with the item, “How satisfied are you with your life as a whole nowadays?” Responses were indicated using a scale ranging from 0 “extremely dissatisfied” to 10 “extremely satisfied.” Studies have shown that life satisfaction is associated to mental health outcomes (Nes et al., 2013), can predict mortality (St John, Mackenzie, & Menec, 2015), and that one single item is a robust measure capable of reliably estimating life-satisfaction (Cheung & Lucas, 2014).

Socio demographic variables. Participants reported their sex, age, educational level, marital status, living place, and household income. Both SHARE and ESS databases provide two variables of education attainment: a recoded variable that focuses on achieved levels of education (primary, lower secondary, upper secondary, post-secondary, and tertiary education), according to the International Standard Classification of Education (UNESCO, 2012), and years of full time education. Respondents were asked to describe whether they live with or without a husband/wife/partner, and the correspondent legal situation. Marital status was classified into the following: married (including in a registered partnership) or not married (including widowed, divorced, separated, or never married). To determine the living place, participants were asked to report whether they lived in a big city, suburbs or outskirts of a big city, town or small city, country village, or home in countryside.

Those who indicated that they lived in a big city, or suburbs, or outskirts of a big city were grouped into a new category named urban areas; those who responded that they lived in country village or home in countryside were grouped into rural areas. Household income was determined based on decile. Using this data, 1st to 3rd decil, 4th to 7th decil, and 8th to 10th were grouped to create three groups: low, middle and high, respectively.

Smoking habits and drinking alcohol. Participants were asked about their smoking behaviors. Response options ranged from "I have never smoked" to "I smoke every day". Because there is no threshold of safety for smoking cigarettes, responses were recoded into current smoker, former smoker, and never smoke. Participants were also asked how often they drink alcohol. Responses were recoded into less than once a month, 2-3 times a month, once a week, several times a week, and every day.

Data analysis

In all articles, descriptive statistics were calculated for all variables (means, standard deviation and percentages) for the entire sample and stratified by sex. The comparison between men and women according to participants' characteristics will be tested by Chi Square test and Independent sample t-test. When observed an interaction effect between sex and other independent variables, the subsequent analysis will be perform stratified by sex. In cases when interaction effect is not observed the analysis will be perform for the entire sample, but adjusted for sex. All data analysis will performed using IBM SPSS Statistics version 24 (SPSS Inc., an IBM Company, Chicago, Illinois, U.S.A.). For all tests statistical significance will be set at $p<0.05$.

For the first article, 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 4 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

In the second article binary logistic regression models were conducted to analyse the effects that the practice of physical activity, in the last 7 days, had on chronic diseases. First, an unadjusted analysis was performed. Then analyses were adjusted for educational level (years of full time education), age, marital status, living place, and household income. Finally, the analyses were adjusted for the same variables and additionally for all other chronic diseases. Using the recoded participants' classification based on physical activity practice, new binary logistic regression models were conducted, using physical activity ≤1 time/week as a reference group.

For the third and fourth article bivariate relationship between moderate or vigorous physical activity and the presence of chronic diseases at baseline was tested by Chi-square test. The cross-sectional and prospective association between moderate or vigorous physical activity and the presence of chronic diseases was assessed using binary logistic regression. For cross-sectional and prospective analysis, two different models were performed. Model 1 was adjusted for age, marital status, educational level, living place, smoking, and country. Model 2 was further adjusted for the presence of all other chronic diseases. In all analysis moderate or vigorous physical activity entered as categorical variable and the presence of chronic disease were tested against the practice of physical activity "less than once a week" (reference category). All analyses were stratified by gender, because an interaction effect between gender and some chronic diseases was observed.

In the fifth article, to analyze the independent association of the time watching television and physical activity with multimorbidity a Chi-square test was used. Binary logistic regression models were conducted to analyze the association of watching television and practice of physical activity with the presence of multimorbidity. First, an unadjusted model was performed, afterwards analyses were adjusted for age, educational level, marital status, living place, country, and household income, smoking status and drinking alcohol. Finally, the analyses were further mutually adjusted for time watching television and physical activity. To analyse the effect of time spent watching television on multimorbidity, according to physical activity levels, new analyses were then performed stratified for physical activity frequency. These analyses were adjusted for age, educational level, marital status, living place, country, household income, smoking status, and drinking alcohol.

In the sixth article the relationship between the presence or absence of chronic diseases and multimorbidity, according self-rated health and life satisfaction, was tested by ANCOVA. Linear regression models were used to estimate the principal effects of multimorbidity, physical activity, and the interaction effect of multimorbidity X physical activity on self-rated health and life satisfaction. Multimorbidity enters the models as a dummy variable, and physical activity as a continuous variable. To calculate the variable that expresses the interaction effect (multimorbidity X physical activity), physical activity was transformed using grand mean centring. The grand mean centring was calculated by taking each value of physical activity (times/week) and subtracting from it the mean of the total sample. Physical activity grand mean centring was then multiplied by multimorbidity to have a variable to test the moderation effect (multimorbidity X physical activity). For ANCOVA and linear regression, the analysis was adjusted for sex, age, education, marital status, household income, occupation, living place, having children, and household members.

Article 1

Cross-sectional and prospective relationship between physical activity and chronic diseases in European older adults – a study based on SHARE data

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Cross-sectional and prospective relationship between physical activity and chronic diseases in European older adults – a study based on SHARE data

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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 37524 older adults (16204 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 condition 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 in 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

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 & 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 & Katzmarzyk, 2011; Huai et al., 2013; Lee & Paffenbarger, 2001), while improving the functional capacity and quality of life of those suffering with 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 & Katzmarzyk, 2011; Huai et al., 2013; Lee & 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 & Jürges, 2005).

From 58489 participants who responded to the fourth wave in 2011, the 37524 (64.2%) who also responded to the fifth wave were included in the present study analysis. This study sample included 16204 men (43.2%), 21320 women (56.8%), from 13 European countries (Austria, Belgium, Czech Republic, Denmark, Estonia, France, Germany, Italy, Netherlands, Slovenia, Spain, Sweden, 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, Larsman, & Hagger, 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 (ISCED 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 4 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, compared to wave 4, for both men and women.

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

	2011 (% or M±SD)			2013 (% or M±SD)		
	Men (n=16204)	Women (n=21320)	*p*	Men (n=16204)	Women (n=21320)	*p*
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	14.2		12.7	13.0	
More than once a week	40.6	30.6		70.2	66.7	

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 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, 16140)=135,843, *p*<0.001; vigorous: F(2, 16140)=414,750, *p*<0.001] and in 2013 [moderate: F(2, 16140)=137,934, *p*<0.001; vigorous: F(2, 16140)=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, 21191)=243,550, *p*<0.001; vigorous: F(2, 21151)=546,141, *p*<0.001] and in 2013 [moderate: F(2, 21191)=246,586, *p*<0.001; vigorous: F(2, 21151)=551,952, *p*<0.001].

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±SD)				Women Number of chronic diseases (M±SD)			
	2011	*p*	2013	*p*	2011	*p*	2013	*p*
Moderate PA in 2011		<0.001		<0.001		<0.001		<0.001
<1/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	
>1/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
<1/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	
>1/week	1.3±1.3		1.3±1.3		1.4±1.4		1.4±1.4	

Abbreviation: PA, physical activity.
Tested by ANOVA.

Cross-sectional parameters estimates of chronic diseases according 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.

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	Model 2	Model 3
Men	β (95% CI)	β (95% CI)	β (95% CI)
MPA in 2011			
<1/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)
>1/week	-0.67 (-0.75, -0.59)***	-0.46 (-0.56, -0.36)***	-0.15 (-0.24, -0.06)**
VPA in 2011			
<1/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)***
>1/week	-0.68 (-0.73, -0.64)***	-0.54 (-0.60, -0.48)***	-0.22 (-0.28, -0.16)***
Women			
MPA in 2011			
<1/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)***
>1/week	-0.78 (-0.85, -0.71)***	-0.52 (-0.61, -0.44)***	-0.24 (-0.32, -0.17)***
VPA in 2011			
<1/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)***
>1/week	-0.72 (-0.76, -0.67)***	-0.49 (-0.56, -0.42)***	-0.22 (-0.29, -0.16)***

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

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: β=-0.12, 95% CI: -0.20 to -0.04, p<0.01; women: β=-0.22, 95% CI: -0.28 to -0.15, p<0.001) or vigorous (men: β=-0.09, 95% CI: -0.14 to -0.04,

p<0.001; women: β=-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.

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	Model 2	Model 3	Model 4
Men	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)
MPA in 2011				
<1/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)
>1/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				
<1/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)
>1/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				
<1/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)
>1/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				
<1/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)**
>1/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)***

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 3: 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.

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 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: β=-0.12, 95% CI: -0.20 to -0.05, $p<0.01$; men active-active: β=-0.16, 95% CI: -0.23 to -0.08, $p<0.001$; women inactive-active: β=-0.10, 95% CI: -0.16 to -0.04, $p<0.01$; women active-active: β=-0.18, 95% CI: -0.25 to -0.12, $p<0.001$).

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			
Men	Model 1. β (95% CI)	Model 2. β (95% CI)	Model 3. β (95% CI)	Model 4. β (95% CI)
MPA 2011				
I-I	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
A-I	-0.85 (-1.22, -0.48)***	-0.36 (-1.10, 0.37)	-0.45 (-1.11, 0.21)	-0.12 (-0.69, 0.45)
I-I	-0.80 (-1.14, -0.45)***	-0.39 (-1.08, 0.31)	-0.15 (-0.78, 0.47)	-0.08 (-0.62, 0.46)
A-A	-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 2011				
I-I	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
A-I	-0.68 (0-81, -0.56)***	-0.46 (-0.61, -0.31)***	-0.26 (-0.40, -0.12)***	-0.05 (-0.17, 0.07)
I-I	-0.67 (-0.74, -0.58)***	-0.53 (-0.62, -0.44)***	-0.19 (-0.28, -0.11)***	-0.12 (-0.20, -0.05)**
A-A	-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 2011				
I-I	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
A-I	-0.50 (-0.88, -0.12)***	-0.38 (-0.84, 0.09)	-0.62 (-1.04, 0.20)	-0.36 (-0.72, 0.01)
I-I	-0.68 (-1.02, -0.33)***	-0.32 (-0.73, 0.09)	-0.15 (-0.52, 0.22)	-0.19 (-0.52, 0.13)
A-A	-1.45 (-1.79, -1,12)***	-0.90 (-1.31, -.49)***	-0.45 (-0.82, -0.08)*	-0.35 (-0.67, 0.00)
VPA 2011				
I-I	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
A-I	-0.80 (-0.92, -0.68)***	-0.55 (-0.69, -0.42)***	-0.36 (-0.44, -0.29)***	-0.14 (-0.25, 0.03)
I-I	-0.85 (-0.91, -0.79)***	-0.56 (-0.63, -0.48)***	-0.18 (-0.25, -0.12)***	-0.10 (-0.16, -0.04)**
A-A	-1.36 (-1.42, -1.30)***	-0.94 (-1.01, -0.86)***	-0.37 (-0.50, -0.24)***	-0.18 (-0.25, -0.12)***

Abbreviation: I-I, inactive-inactive; A-I, active-inactive; I-A, inactive-active; A-A, active-active; 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 2: 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.
*$p<0.05$, **$p<0.01$, ***$p<0.001$.

Discussion

The present study examined the cross-sectional and prospective relationship between physical activity, and chronic diseases, across a two-year period. It utilized a large representative sample of 37524 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 & Katzmarzyk, 2011; Huai et al., 2013; Lee & 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, Grimaldi, & Farinaro, 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, Paffenbarger, & Lee, 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 in the present is the most important. Thus, if those who are inactive decide to engage in physical 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, Negro, Lala, & Martelletti, 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 & 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, Butler, & Rosamond, 2014; Lin, Yeh, Chen, & Huang, 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 & Saelens, 2000). Nonetheless, social desirability only accounts for a small variance in self-reported physical activity (Motl, McAuley, & DiStefano, 2005). Furthermore, self-reported is 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 were active two times a week were in the same group as those who were active 5 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 socio-demographic 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.

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

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Conflicts of interests: None to declare.

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Article 2

The association between physical activity and chronic diseases in European adults

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The association between physical activity and chronic diseases in European adults

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Abstract

Chronic diseases are the leading cause of morbidity and mortality and are considered to be at epidemic levels worldwide. This is a cross-sectional multi-country study based on data from the European Social Survey round 7, 2014, comprising 30826 participants (14813 men) with mean age 50.4±18.0. Physical activity and chronic diseases were self-reported. Men and women who practiced physical activity more often had lower odds of having heart problems, breathing problems, type 2 diabetes, and obesity. Engaged in physical activity 2-4 times/week and ≥5 times/week decrease the odds of having heart problems, high blood pressure, breathing problems, type 2 diabetes, and obesity, compared with men and women who engaged in physical activity 1 or less times per week. For the women, the practice of physical activity ≥5 times/week was significantly and negatively associated with having cancer, when compared with women who engaged in physical activity 1 or less times per week. Physical activity is associated with a lower risk of chronic diseases, in particular: heart problems, high blood pressure, breathing problems, allergies, type 2 diabetes, and obesity. Furthermore, even small amounts of weekly physical activity seem to decrease the risk of chronic diseases.

Keywords: Chronic disease; quantitative study; lifestyle

Introduction

Chronic diseases are the leading cause of morbidity and mortality and are considered to be at epidemic levels worldwide (WHO, 2015). Chronic diseases negatively affect quality of life because of their physical and psychological consequences. In 2012, chronic diseases were responsible for 68% of the world's deaths (GBD Risk Factors Collaborators et al., 2015; WHO, 2014).

Until recently, chronic diseases were associated with the older population. Nonetheless, because of lifestyle changes that have been rapidly occurring in recent years, chronic diseases are now becoming more prominent among young adults and adults (WHO, 2014, 2015). Out of the 38 million deaths due to chronic diseases in 2012, more than 40% were premature (WHO, 2014).

One relevant change in lifestyle is physical inactivity, which is an important contributor to the development of chronic diseases (Lee et al., 2012). A lack of physical activity contributes to 3.2 million deaths and 69.3 million disability-adjusted life years (DALYs) each year, due to the development of chronic diseases (WHO, 2014). Those who are insufficiently physically active have a higher risk of mortality compared with those who are regularly physically active (Hardman & Stensel, 2009). Even a minimum amount of physical activity has a protective health effect against chronic diseases, and tends to reduce mortality (Wen et al., 2011). There is evidence that physical activity is associated with several health benefits, including a lower risk of: cardiovascular diseases (Barengo et al., 2004), hypertension (Huai et al., 2013), type 2 diabetes (Hu et al., 2004), cancer (Anzuini, Battistella, & Izzotti, 2011) and obesity (Banks et al., 2011). Thus, physical activity has been recommended (WHO, 2010) because of its effectiveness for primary and secondary prevention of chronic diseases (Alves et al., 2016; Swift et al., 2013).

Although the health benefits of physical activity, with respect to chronic diseases, are well established, a large proportion of the world's population (Sallis et al., 2016), and specifically European adults (Marques et al., 2015), is not considered physically active. The prevalence of physical inactivity of adults is, therefore, a major public health issue (Lee et al., 2012). Many studies have analysed the relationship between physical activity and each individual chronic disease, not considering that a person can have several diseases (Banks et al., 2011; Karjalainen et al., 2015; Kyu et al., 2016; Swift et al., 2013). The use of a more comprehensive approach that evaluates several diseases is needed. Therefore, the purpose of this study was to analyse the relationship between self- reported physical activity and self-reported chronic diseases, individually and mutually adjusted, including heart problems, high blood pressure, breathing problems, allergies, type 2 diabetes, cancer and obesity, among nationally representative samples of adults from 18 European countries. Involving representative samples from several countries and collecting data with the same instrument is important because internationally comparable data is needed to inform public health policies.

Methods

Study design and participants

The present study is a cross-sectional multi-country study based on data from the European Social Survey round 7, 2014, comprising 20 European countries (Austria, Belgium, Switzerland, Czech Republic, Germany, Denmark, Estonia, Spain, Finland, France, Hungary, Ireland, Lithuania, Netherlands, Norway, Poland, Portugal, Sweden, Slovenia, United Kingdom) and Israel. The European Social Survey is an academically driven cross-national survey that has been conducted every two years across Europe since 2001. The survey measures the attitudes, beliefs and behaviour of European people. The European Social Survey uses a multi-stage probability cluster sampling designed to provide national representative samples among several European countries. According to national options, participants are sampled by means of postal code address files, population registers, social security register data, or telephone books. In the sampling procedure, statistical precision was kept the same for all countries. In each country the information was collected using a questionnaire filled-in through an hour-long face-to-face interview that included questions on the use of medicine, immigration, citizenship, socio-demographic and socioeconomic issues, health status, and physical activity. The questionnaire was translated by language experts, into the language of each of the participating countries. Further details about European Social Survey are available elsewhere (Schnaudt et al., 2014). The study protocol of the European Social Survey subscribes the Declaration on Professional Ethics of the International Statistical Institute.

Probability sampling from all residents aged 15 years and older was applied in all countries (excluding only the homeless and the institutionalized population), comprising 40185 participants. For the present study participants under the age of 18 were excluded from the analyses (n=1215), because the focus was on the adult population. Participants from Czech Republic and Estonia did not report information on chronic diseases and were therefore excluded (n=3943). Participants from Israel were excluded because they were not European (n=2105). Furthermore, respondents without information in more than two socio-demographic variables were also excluded (n=2096).

Measures

Socio demographic characteristics. Participants reported their sex and age. The European Social Survey data provides two variables of education attainment: a recoded variable that focuses on achieved levels of education (primary, lower secondary, upper secondary, post-secondary, and tertiary education), according to the International Standard Classification of Education (UNESCO, 2012), and years of full time education. Respondents were asked to describe whether they lived with or without a husband/wife/partner, and their correspondent legal status (e.g. married, civil union, illegally recognized). Response options were dichotomized into live with or without a partner. To determine the living place, participants were asked to report whether they lived in a big city, suburbs or outskirts of a big city, town or small city, country village, or home in countryside. Those who indicated that they lived in a big city, or suburbs, or outskirts of a big city were grouped into a new category named urban areas; those who responded that they lived in country village or home in countryside were grouped into rural areas. Household income was determined based on decile. Using this data, 1^{st} to 3^{rd} decile, 4^{th} to 7^{th} decile, and 8^{th} to 10^{th} were grouped to create three groups: low, middle and high, respectively.

Chronic diseases. Chronic diseases were assessed by asking participants to indicate whether they currently had, or have has chronic diseases in the last 12 months (yes/no). For obesity, body mass index (BMI) was calculated from self-reported height and weight (kg/m^2). Body mass index categories were calculated in accordance with the WHO guidelines (WHO, 2000): normal weight (18.5-24.9 kg/m^2), overweight (25-29.9 kg/m^2), and obese (≥30 kg/m^2).

Television watching. Participants were asked to report time they spent watching television on an average weekday. Response options were from “no time at all” to "more than 3 hours", in interval lengths of 30 minutes. The response answers were recoded into three groups: 1) no time at all, 2) ≤3 hours per day, and 3) >3 hours per day.

Physical activity. Information on physical activity was assessed with a single item asking, "on how many of the last 7 days did you walk quickly, do sports, or other physical activity for 30 minutes or longer?". Using the reported information on physical activity, a new variable was computed to classify participants into three groups: 1) practice of physical activity ≤1 time/week; 2) practice of physical activity 2-4 times/week; and 3) practice of physical activity ≥5 times/week.

Data analysis

Descriptive statistics were calculated for all variables (means, standard deviation, and percentages) for the entire sample, and stratified by sex. Mann-Whitney and Chi-square tests were used to compare men and women according to socio-demographic characteristics, the presence of chronic diseases in the last 12 months, and physical activity. Binary logistic regression models were conducted to analyse the effects that the practice of physical activity, in the last 7 days, had on chronic diseases. First, an unadjusted analysis was performed. Then analyses were adjusted for educational level (years of full time education), age, marital status, living place, and household income. Finally, the analyses were adjusted for the same variables and additionally for time spent watching television and all other chronic diseases. Using the recoded participants' classification based on physical activity practice, new binary logistic regression models were conducted, using physical activity ≤1 time/week as a reference group. All analyses were stratified by sex, and statistical analysis was performed using IBM SPSS Statistics 23. The significance level was set at $p<0.05$.

Results

A total sample of 30826 (14813 men, 16013 women) with mean age 50.4±18.0 (50.0±17.9 men, 50.7±18.0 women) participated in the study. Table 1 presents the characteristics of the study population stratified by sex. Overall, the highest prevalence of chronic disease was observed for high blood pressure (19.4%), followed by obesity (15.6%), allergies (12.2%), cancer (11.1%), heart problems (11.0%), breathing problems (8.9%), and type 2 diabetes (5.6%). With the exception of type 2 diabetes, women had a statistically higher prevalence of all chronic diseases than men. Also, men were more physically active ($p<0.001$) than women.

Table 1. Participants' characteristics for total sample and stratified by sex.

	Total (n=30826)	Men (n=14813)	Women (n=16013)	*p*
	% or M±SD	% or M±SD	% or M±SD	
Education				<0.001
Primary	10.5	9.9	11.1	
Lower secondary	16.4	16.2	16.7	
Upper secondary	35.2	36.9	33.6	
Post-secondary	14.3	14.6	14.0	
Tertiary education	23.6	22.4	24.6	
Age	50.4±18.0	50.0±17.9	50.7±18.0	0.001
Marital status				<0.001
Live with partner	61.2	64.0	58.7	
Live without partner	38.8	36.0	41.3	
Living place				0.022
Urban area	62.4	61.7	63.0	
Rural area	37.6	38.3	37.0	
Household income				<0.001
Low (1st to 3rd decile)	30.5	26.4	34.3	
Middle (4th to 7th decile)	42.1	46.6	40.7	
High (8th to 10th decile)	27.4	30.0	25.0	
Chronic diseases (last 12 month)				
Heart problems	11.0	10.5	11.5	0.019
High blood pressure	19.4	19.0	19.8	0.095
Breathing problems	8.9	8.3	9.5	<0.001
Allergies	12.2	10.4	13.9	<0.001
Diabetes	5.6	5.9	5.2	0.005
Cancer	11.5	9.8	13.0	<0.001
Obesity	15.5	15.8	15.3	0.491
Chronic diseases (number)	0.8±1.1	0.8±1.0	0.9±1.1	<0.001
Time spending watching television				<0.001
No time at all	4.3	4.5	4.1	
≤ 3 hours/day	77.6	78.1	77.2	
> 3 hours/day	18.1	17.4	18.7	
Physical activity (times/week)	3.2±2.6	3.3±2.6	3.1±2.6	<0.001
Physical activity				<0.001
≤1 time/week	33.7	32.1	35.1	
2-4 times/week	32.9	33.0	32.8	
≥5 times/week	33.4	34.8	32.1	

Abbreviation: M, media; SD, standard deviation
Differences between men and women were tested by Chi Square and Mann-Whitney tests.

The results of the unadjusted and adjusted association between physical activity in the last 7 days and having chronic diseases are presented in table 2. In the unadjusted model, men and women who practiced physical activity more often had lower odds of having heart problems, high blood pressure, breathing problems, type 2 diabetes, cancer, and obesity than those who were less physically active. After the fully adjusted model for educational level, age, marital status, living place, household income, time spent watching television and for all other chronic diseases, the practice of physical activity remained negatively associated with heart problems, breathing problems, and obesity. For just women, physical activity was significantly and positively related with allergies, and type 2 diabetes, even when the model was fully adjusted.

Table 2. Relationship between physical activity in the last 7 days and having chronic diseases.

	Physical activity in the last 7 days (times/week)		
	Model 1	Model 2	Model 3
Men	OR (95% CI)	OR (95% CI)	OR (95% CI)
Heart problems[1]	0.91 (0.89-0.93)***	0.93 (0.91-0.95)***	0.96 (0.93-0.98)***
High blood pressure[1]	0.95 (0.93-0.96)***	0.96 (0.94-0.98)***	0.99 (0.97-1.01)
Breathing problems[1]	0.91 (0.89-0.94)***	0.93 (0.91-0.95)***	0.94 (0.92-0.97)***
Allergies[1]	0.99 (0.97-1.02)	0.98 (0.96-1.00)	0.99 (0.97-1.01)
Diabetes[1]	0.93 (0.90-0.95)***	0.95 (0.92-0.98)***	0.98 (0.95-1.01)
Cancer[1]	0.97 (0.94-0.99)**	0.98 (0.96-1.00)	0.99 (0.96-1.01)
Obesity[1]	0.90 (0.88-0.92)***	0.91 (0.89-0.93)***	0.92 (0.90-0.94)***
Women			
Heart problems[1]	0.92 (0.90-0.94)***	0.95 (0.93-0.97)***	0.96 (0.94-0.98)**
High blood pressure[1]	0.95 (0.93-0.96)***	0.98 (0.96-0.99)*	1.01 (0.99-1.03)
Breathing problems[1]	0.95 (0.93-0.97)***	0.96 (0.94-0.98)**	0.97 (0.95-0.99)**
Allergies[1]	1.03 (1.01-1.05)**	1.02 (1.02-1.04)**	1.03 (1.01-1.05)***
Diabetes[1]	0.85 (0.83-0.88)***	0.90 (0.87-0.93)***	0.93 (0.90-0.96)***
Cancer[1]	0.97 (0.95-0.99)***	0.99 (0.97-1.01)	1.00 (0.98-1.02)
Obesity[1]	0.90 (0.88-0.91)***	0.91 (0.90-0.93)***	0.93 (0.91-0.95)***

[1] The reference category was not having the disease.
Model 1: Unadjusted analyses. Model 2: Analyses were adjusted for educational level, age, marital status, living place, country, and household income. Model 3: Analyses were adjusted for educational level, age, marital status, living place, country, household income, sedentary time watching television, and for all others chronic diseases.
$p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 3 presents the results of the relationship between the frequency of weekly physical activity practice and having chronic diseases. For both sexes, in the unadjusted and adjusted analyses for educational level, age, marital status, living place, and household income, to be engaged in physical activity 2 to 4 times per week and 5 or more times per week decreased the odds of having heart problems, high blood pressure, breathing problems, type 2 diabetes, cancer, and obesity, when compared with those who engaged in physical activity 1 or less times per week. When the analyses were further adjusted for time spent watching television and all other chronic diseases, to be engaged in physical activity 2 to 4 times per week and 5 or more times per week persisted in decreasing the odds of having heart problems, breathing problems, type 2 diabetes, and obesity, compared with men and women who engaged in physical activity 1 or less times per week. Conversely, in all different models, the more active women had higher odds of having allergies when compared with those who were less active.

Table 3. Relationship between physical activity and having chronic diseases.

	Model 1. OR (95% CI)			
	Men		Women	
Chronic diseases	2-4 times/week	≥ 5 times/week	2-4 times/week	≥ 5 times/week
Heart problems[1]	0.57 (0.50-0.65)***	0.56 (0.49-0.64)***	0.61 (0.54-0.69)***	0.47 (0.42-0.54)***
High blood pressure[1]	0.69 (0.62-0.76)***	0.68 (0.61-0.75)***	0.70 (0.63-0.77)***	0.57 (0.52-0.64)***
Breathing problems[1]	0.56 (0.48-0.65)***	0.51 (0.44-0.60)***	0.74 (0.65-0.84)***	0.63 (0.55-0.73)***
Allergies[1]	0.96 (0.83-1.10)	1.13 (0.99-1.29)	1.18 (1.05-1.33)**	1.20 (1.07-1.35)**
Diabetes[1]	0.62 (0.52-0.73)***	0.48 (0.40-0.58)***	0.41 (0.34-0.49)***	0.43 (0.34-0.51)***
Cancer[1]	0.77 (0.67-0.89)***	0.73 (0.63-0.84)***	0.79 (0.70-0.89)***	0.70 (0.62-0.79)***
Obesity[1]	0.54 (0.48-0.60)***	0.58 (0.51-0.65)***	0.52 (0.47-0.58)***	0.56 (0.50-0.62)***
	Model 2. OR (95% CI)			
Chronic diseases	Men		Women	
Heart problems[1]	0.61 (0.53-00.70)***	0.67 (0.59-0.77)***	0.69 (0.61-0.78)***	0.59 (0.52-0.68)***
High blood pressure[1]	0.71 (0.64-0.79)***	0.77 (0.70-0.86)***	0.81 (0.73-0.90)***	0.74 (0.67-0.83)***
Breathing problems[1]	0.58 (0.50-0.67)***	0.56 (0.48-0.65)***	0.76 (0.67-0.89)***	0.69 (0.60-0.79)***
Allergies[1]	0.91 (0.80-1.04)	1.03 (0.89-1.18)	1.13 (1.00-1.03)*	1.11 (1.00-1.25)*
Diabetes[1]	0.66 (0.56-0.78)***	0.57 (0.47-0.68)***	0.48 (0.40-0.58)***	0.58 (0.45-0.70)***
Cancer[1]	0.81 (0.70-0.93)**	0.82 (0.70-0.94)*	0.86 (0.76-0.97)*	0.82 (0.72-0.92)***
Obesity[1]	0.56 (0.50-0.63)***	0.63 (0.56-0.70)***	0.57 (0.50-0.63)***	0.65 (0.58-0.73)***
	Model. OR (95% CI)			
Chronic diseases	Men		Women	
Heart problems[1]	0.74 (0.64-0.86)***	0.81 (0.70-0.94)**	0.80 (0.70-0.91)**	0.68 (0.59-0.79)***
High blood pressure[1]	0.88 (0.78-1.00)	0.94 (0.84-1.05)	1.05 (0.94-1.17)	0.94 (0.84-1.06)
Breathing problems[1]	0.66 (0.57-0.77)***	0.61 (0.52-0.72)***	0.81 (0.70-0.93)**	0.73 (0.63-0.85)***
Allergies[1]	0.94 (0.82-1.11)	1.07 (0.93-1.23)	1.19 (1.05-1.34)**	1.19 (1.05-1.35)**
Diabetes[1]	0.85 (0.71-0.99)*	0.68 (0.56-0.83)***	0.60 (0.49-0.73)***	0.73 (0.60-0.89)**
Cancer[1]	0.89 (0.77-1.03)	0.89 (0.77-1.03)	0.95 (0.84-1.08)	0.90 (0.79-1.02)
Obesity[1]	0.61 (0.54-0.69)***	0.68 (0.61-0.77)***	0.63 (0.56-0.71)***	0.73 (0.65-0.83)***

[1] The reference category was not having the disease.

Model 1: Unadjusted analyses. Model 2: Analyses were adjusted for educational level, age, marital status, living place country and household income. Model 3: Analyses were adjusted for educational level, age, marital status, living place, country, household income, sedentary time watching television, and for all others chronic diseases. *p*<0.05, ** *p*<0.01, *** *p*<0.001

The relationship between physical activity participation and the three chronic diseases (heart problems, breathing problems and obesity) significantly related in both men and women, in model 3 table 2, are presented in figure 1. In almost all countries, those who reported not having chronic diseases, practiced physical activity significantly more times per week. For the relationship between physical activity participation and heart problems, the absence of significant differences was observed in Portugal, Slovenia, Switzerland, Germany and Finland (figure 1a). For the relationship between physical activity participation and breathing problems there were no differences in Portugal, Belgium, Slovenia, the Netherlands, and Switzerland (figure 1b). Finally, for the relationship between physical activity participation and obesity, the absence of differences was only observed in Denmark and Switzerland (figure 1c).

Figure 1a. Relationship between physical activity participation and heart problems.

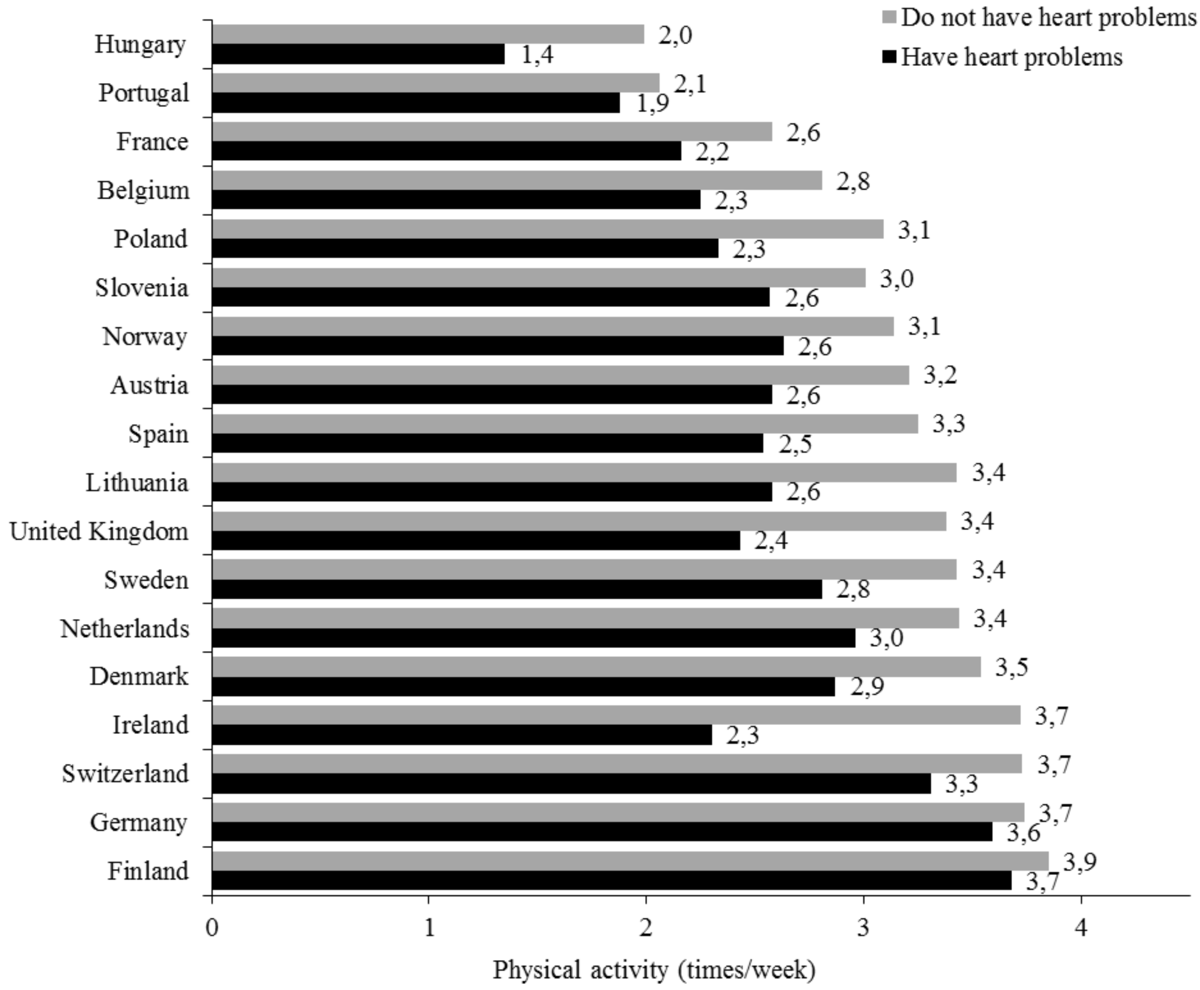


Figure 1b. Relationship between physical activity participation and breathing problems.

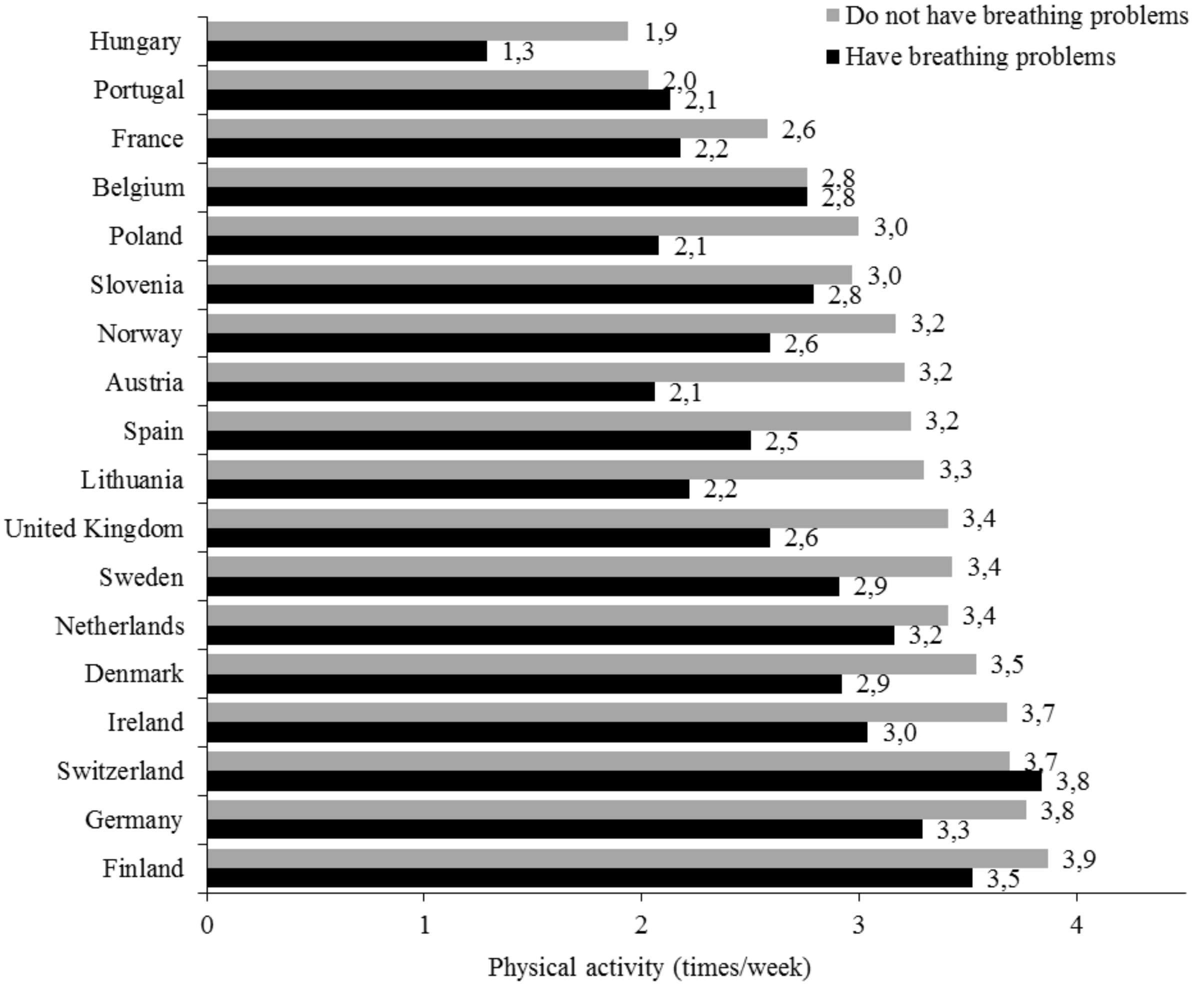
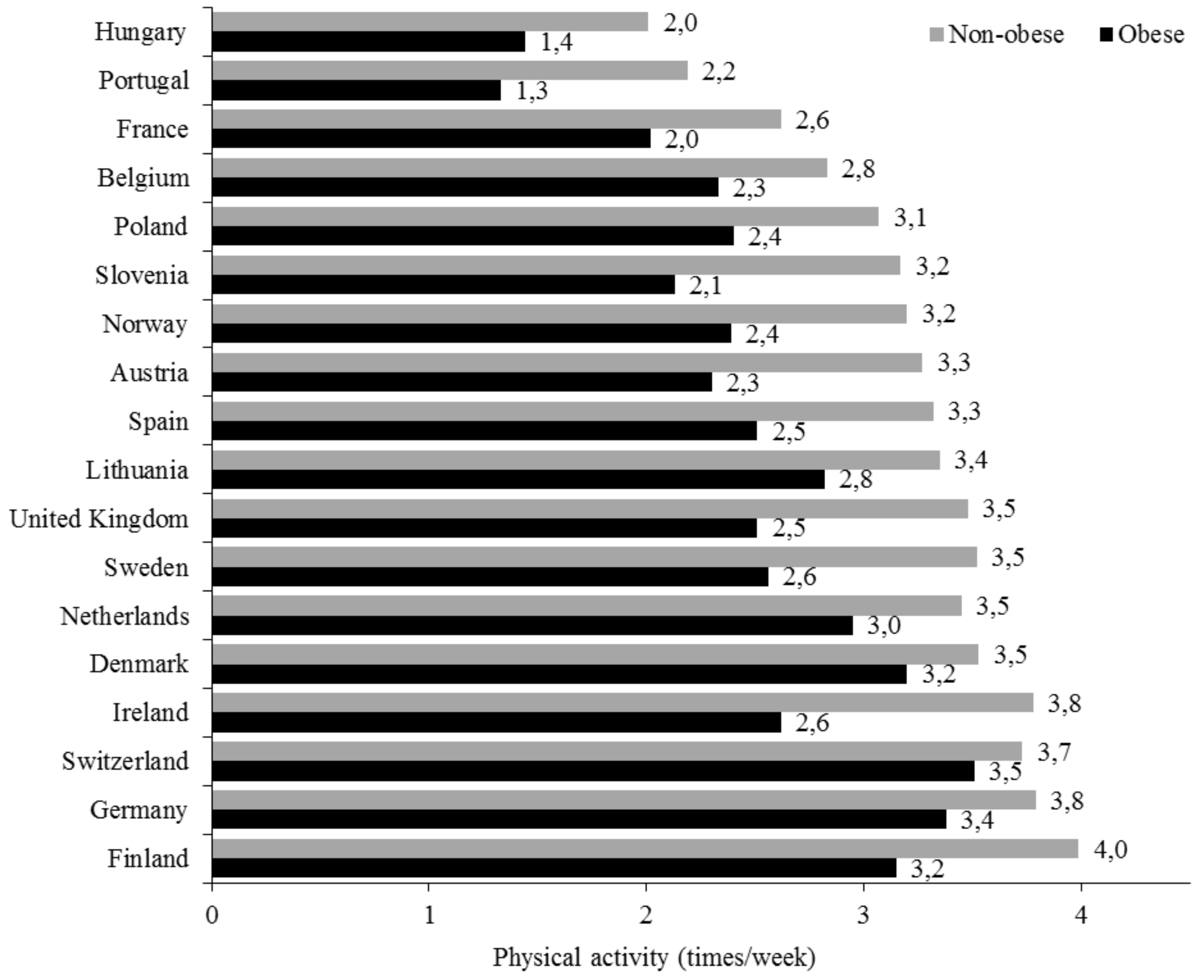


Figure 1c. Relationship between physical activity participation and obesity.



Discussion

The aim of this study was to analyse the association between physical activity and chronic diseases, including heart problems, high blood pressure, breathing problems, allergies, type 2 diabetes, cancer, and obesity in European adults. The main results highlight that physical activity was inversely related with having heart problems, breathing problems, type 2 diabetes, and obesity among men and women, supporting the idea that physical activity is a healthy behaviour.

The observed relationship between physical activity and chronic diseases is in line with previous studies, showing lower physical activity levels in people with more chronic diseases (Kaptein & Badley, 2012; Loef, de Hollander, Boot, & Proper, 2016; Marques, Peralta, Martins, de Matos, & Brownson, 2016c). Furthermore, the study results also endorse the fact that even a few episodes of physical activity per week have a positive impact on health, and may contribute to reduce mortality (O'Donovan et al., 2017). This is an important message for public health because adulthood might be a demanding time, with various commitments leading to physical inactivity. Adults have to make trade-offs between necessary (work) activities and physical activity, which could be considered as a discretionary activity.

The negative and significant relationship between heart problems and physical activity has been observed over the course of several decades by epidemiologic studies, mainly designed to determine factors related to cardiovascular diseases and coronary heart diseases (Lee et al., 2003; Paffenbarger & Hyde, 1988). Since heart diseases include several diseases, that can be related to type 2 diabetes or obesity (Murtagh et al., 2015), and also to a cluster of other diseases (Fuchs, Moreira, Camey, Moreira, & Fuchs, 2008), the observed negative relationship with physical activity (after the adjustments for all other chronic diseases) reinforces the role of physical activity engagement to reduce the clinical manifestation of heart problems. Similarly, there is a relationship between high blood pressure, type 2 diabetes, and obesity (Ahmad et al., 2016; Matsuo, Sairenchi, Suzuki, Tanaka, & Muto, 2011; Patel et al., 2016). Physical activity was independently, and after adjustments for each other, negatively associated with these chronic diseases. These results strengthen the importance of an active lifestyle as a protective factor against these diseases, which have the highest prevalence and incidence in middle and higher income countries (WHO, 2014, 2015). Physical activity should be promoted (WHO, 2010), in order to reverse the increasing prevalence of inactivity and its effects on public health (Lee et al., 2012).

Results showed that physical activity decreases the odds of having breathing problems, even when physical activity was practised more often. In fact, the literature has shown that even light physical activity 3 or more times per week is prospectively associated with less risk ratio of asthma and wheezing, while vigorous physical activity is not associated with any asthma outcomes (Russell et al., 2016). These specific results, and the general present study results, emphasize the idea that increased physical activity does not augment breathing problems or compromise asthma control. On the contrary, it is associated with its improvements (Mancuso et al., 2013).

The result of the relationship between physical activity and cancer seems to point to a negative association. Nevertheless, when the analysis was adjusted for other variables and chronic diseases, the association was no longer significant. Although there is evidence that physical activity is associated with cancer prevention in several organs, strong biases, such as body mass index, sex, and age, make it difficult to assess the effect of physical activity to reduce the risk (Anzuini et al., 2011). Furthermore, participants were asked to report whether they had cancer or not, but the type of cancer was not specified. This information would be rather important because there is convincing evidence for a beneficial effect of physical activity on the risk of colon, breast and endometrial cancers, but the evidence is weaker or insufficient for all other types of cancers (Friedenreich, Neilson, & Lynch, 2010). The positive effect of physical activity on cancer is of major importance for Europeans because it is estimated that between 9% and 19% of cancer cases could be attributed to a lack of sufficient physical activity (Friedenreich et al., 2010).

Although the results present similarities between men and women, there are some differences. For instance, physical activity in the last 7 days was positively related to allergies and negatively related to type 2 diabetes in women but not in men, when the model was fully adjusted. Perhaps the differences are due to the diversities in biology, lifestyle, environment, and socioeconomic status, because these factors impact differences between men and women in predisposition, and development of some chronic diseases. Furthermore, sex hormones have an impact on energy metabolism, which can explain the differences observed between men and women in the relationship between physical activity and some chronic diseases (Kautzky-Willer, Harreiter, & Pacini, 2016; Leynaert et al., 2012).

In the interpretation of this study's results, several limitations should be noted. First, the cross-sectional design implies that no causal inferences can be made. Thus, the current study cannot answer the question whether the presence of chronic diseases leads to lower physical activity levels, or vice versa. Second, physical activity and television-viewing time were self-reported rather than objectively measured, which could be subject to bias in terms of over- and underestimation (Marques, Martins, Ramos, Yazigi, & Carreiro da Costa, 2014; Otten, Littenberg, & Harvey-Berino, 2010). Moreover, physical activity was measured using a single item. However, there is evidence that assessed physical activity with a single question is an acceptable alternative in epidemiologic studies (Wanner et al., 2014). Third, while chronic diseases were also self-reported, studies have suggested that self-report of chronic diseases is fairly to largely accurate for most chronic diseases (Haapanen, Miilunpalo, Pasanen, Oja, & Vuori, 1997; Hansen et al., 2014).

A major strength of this study was the European Social Survey database that includes a large and representative sample size of various European countries, as well as several socio-demographic characteristics of the study sample. Furthermore, due to the large sample, there was an adequate statistical power.

Conclusion

In conclusion, this study broadens the scope of research in physical activity and chronic diseases by using a large population-based European survey. Physical activity is associated with a lower risk of cardiovascular diseases, in particular: heart problems, high blood pressure, breathing problems, allergies, type 2 diabetes, and obesity.

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Article 3

Associations between vigorous physical activity and chronic diseases in older adults: a cross-sectional and prospective study in 13 European countries

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Associations between vigorous physical activity and chronic diseases in older adults: a cross-sectional and prospective study in 13 European countries

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Abstract

Background: This study aimed to assess cross-sectional and prospective relationships between vigorous physical activity (VPA) and the risk of major chronic diseases among European older adults. **Methods:** Participants were 37524 older adults who responded to the fourth (in 2011) and fifth (in 2013) wave of the SHARE project, from 13 European countries. Participants answered interview questions about the presence of chronic conditions and VPA. The cross-sectional and prospective association between PA and the number of chronic diseases was assessed using logistic regression models. **Results:** Among men and women, the prevalence of chronic diseases was significantly lower among those who reported VPA once a week or more than once a week. For men, VPA once a week was prospectively related with lower odds of heart attack, chronic lung disease, Parkinson’s disease, and Alzheimer’s disease. VPA more than once a week was prospectively related with lower odds of having all chronic diseases. Women who engaged in VPA once a week presented lower odds of having chronic diseases, except for hypertension, high blood cholesterol, and cancer. For VPA more than once a week, cancer was the only disease not associated with physical activity. **Conclusion:** VPA is associated with reduced risk of chronic diseases in men and women. Even the practice of VPA once a week seems to be sufficient to reduce risks of chronic diseases.

Keywords: physical activity, Europe, exercise, disease, health

Introduction

The prevalence of chronic diseases has been growing around the world, mainly among older adults, including: heart diseases, hypertension, diabetes, cancer, obesity, and respiratory diseases (WHO, 2014) As a result, chronic diseases are now the leading cause of morbidity and mortality worldwide (WHO, 2015). The main factor identified as being, in part, responsible for the increasing prevalence of chronic diseases is the prevalence of physical inactivity (Lee et al., 2012).

Physical activity can reduce chronic diseases and the risk of disease progression (Huai et al., 2013; Lee & Paffenbarger, 2001). Thus, regular practice of physical activity has been recommended (WHO, 2010) because of its effectiveness for primary and secondary prevention of chronic diseases (Alves et al., 2016). Even a minimum amount of physical activity has a protective health effect against chronic diseases, and it reduces mortality (Ekelund et al., 2015; Lee et al., 2003; O'Donovan et al., 2017; Wen et al., 2011).

Adults and older adults are recommended to practice at least 150 minutes per week of moderate to vigorous-intensity physical activity or 75 minutes per week of vigorous-intensity physical activity (VPA), furthermore older adults with poor mobility are suggested to perform physical activity to enhance balance and prevent falls on three or more days per week (WHO, 2010). There is evidence that VPA is associated with a greater decrease in the risk of incidence of major chronic diseases than moderate-intensity physical activity (Chomistek et al., 2012; Lee et al., 2003). As older adults are less likely to engage in VPA, which might be detrimental to their health and quality of life (European Commission, 2014; Takagi et al., 2015), it is important to better understand the cross-sectional and prospective relationship between VPA and the major chronic diseases among this population.

Several studies have analysed the relationship between physical activity and a particular chronic disease, not considering that a person can have several diseases (Banks et al., 2011; Karjalainen et al., 2015; Swift et al., 2013). The use of a more comprehensive approach that evaluates several diseases is needed. Furthermore, a study published recently using data from the Survey of Health, Aging, and Retirement in Europe (SHARE) observed that VPA was cross-sectionally and prospectively associated with fewer reported chronic diseases (Marques, Peralta, Martins, de Matos, & Brownson, 2017a). This study provided general results and did not analyse the relationship between physical activity and particular chronic disease, adjusted for others diseases. Therefore, the purpose of the present study was to assess the cross-sectional and prospective relationship between self-reported VPA and the risk of major chronic diseases among European older adults.

Methods

Participants and procedures

The present study was based on the fourth and fifth wave of the Survey of Health, Aging, and Retirement in Europe (SHARE). SHARE is an interdisciplinary and cross-national survey on aging that is run every two years and collects extensive information of individuals aged 50 and over in several European countries. It is fully described elsewhere (Börsch-Supan et al., 2013; Börsch-Supan & Jürges, 2005). The fourth wave data was collected in 2011 and the fifth wave in 2013; each included individuals aged 50 and over. From 58489 participants who responded to the fourth wave in 2011, the 37417 (64%) who also responded to the fifth wave were included in the present study. The sample includes 16157 men and 21260 women from 13 countries from Scandinavia to the Mediterranean (Austria, Belgium, Czech Republic, Denmark, Estonia, France, Germany, Italy, Netherlands, Slovenia, Spain, Sweden and Switzerland). Participants were between the ages of 50 and 102 years (66.2±9.7) in 2011, and between the ages of 52 and 104 years (68.2±9.7) in 2013.

Data were collected face to face by trained interviewers using a computer-assisted personal interviewing program, supplemented by a self-completed paper-and-pencil questionnaire. Comparable questionnaires were applied in each country. Translation guidelines were applied and pilots were performed to enhance comparability. 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

Physical activity. Participants were asked to report their VPA practice frequency (e.g., sports, heavy housework, a job involving physical labour). The response options 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”.

Chronic diseases. Participants were asked to report whether their doctor has told them of the presence of the following conditions: heart attack or other heart problems, hypertension, high blood cholesterol, diabetes, chronic lung disease, cancer, stomach or duodenal ulcer, Parkinson’s disease, hip fracture/femoral fracture, Alzheimer’s disease/dementia.

Socio-demographic variables. The following elements were self-reported: age, marital status, education level, and place of residence. Marital status was classified into: married (e.g. married, civil union, illegally recognized) or not married (e.g. widowed, divorced, or never married). Education was categorized according to the

International Standard Classification of Education Degrees (UNESCO, 2006) 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). 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 a rural area.

Statistical analysis

Descriptive statistics were calculated for all variables (means, standard deviation, and percentages) for the entire sample, and stratified by gender. The men and women comparison at baseline (in 2011), according to participants' characteristics, was tested by Chi Square test and Independent sample t-test. Bivariate relationship between VPA and the presence of chronic diseases at baseline was tested by Chi-square test. The presence of chronic diseases in 2011 and VPA in 2011 entered in the cross-sectional analyses, while the presence of chronic diseases in 2013 and VPA in 2011 entered in the prospective analyses. The cross-sectional and prospective association between VPA and the presence of chronic diseases was assessed using binary logistic regression. For cross-sectional and prospective analysis, two different models were performed. Model 1 was adjusted for age, marital status, educational level, place of residence, smoking, and country. Model 2 was further adjusted for the presence of all other chronic diseases. In all analysis VPA entered as categorical variable and the presence of chronic disease were tested against the practice of physical activity "less than once a week" (reference category). All analyses were stratified by gender, because an interaction effect between gender and some chronic diseases was observed. Data analysis was performed using IBM SPSS Statistics version 24 (SPSS Inc., an IBM Company, Chicago, Illinois, U.S.A.). The significance level was set at $p<0.05$.

Results

Table 1 presents the participants' characteristics at baseline. Most participants had a lower level of education (61.1%), were married (70.2%), and lived in a small town or rural areas (59.4%). The most prevalent chronic diseases were hypertension (39.2%), high blood cholesterol (23.3%), heart attack (13.2%) and diabetes (11.9%). More than half of participants reported no VPA (51%), 14.1% did once a week and 34.9% more than once a week.

Table 1. Participants' characteristics at baseline (2011)

	(% or M±SD)			
	Total (n=37417)	Men (n=16157)	Women (n=21260)	*p*
Education				<0.001[a]
Low	61.1	59.0	62.8	
Middle	26.1	27.3	25.2	
High	12.8	13.7	12.0	
Age	66.2±9.7	66.1±9.4	66.3±9.9	0.035[b]
Marital status				<0.001[a]
Not married	29.8	20.0	37.0	
Married	70.2	80.0	62.8	
Living place				<0.001[a]
Big city	13.7	12.5	14.6	
Suburbs of a big city	10.5	10.9	10.2	
Large town	16.4	15.3	17.1	
Small town	25.1	24.9	25.2	
Rural area	34.3	36.3	32.9	
Doctor said you had				
Heart attack	13.2	15.4	11.5	<0.001[a]
Hypertension	39.2	37.9	40.2	<0.001[a]
High cholesterol	23.3	22.4	24.1	<0.001[a]
Diabetes	11.9	13.1	11.0	<0.001[a]
Chronic lung disease	6.5	6.9	6.2	0.005[a]
Cancer	5.1	4.9	5.2	0.158[a]
Stomach ulcer	5.6	5.8	5.4	0.123[a]
Parkinson's disease	0.6	0.8	0.5	0.002[a]
Hip/femoral fracture	2.2	2.0	2.4	0.007[a]
Alzheimer's disease	1.1	1.0	1.1	0.140[a]
Vigorous PA				<0.001[a]
Less than once a week	51.0	45.4	55.2	
Once a week	14.1	14.0	14.2	
More than once a week	34.9	40.6	30.5	

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

The results of bivariate analysis between VPA and chronic diseases are presented in table 2. Among men and women, the prevalence of chronic diseases (heart attack, hypertension, high blood cholesterol, diabetes, chronic lung disease, cancer, stomach or duodenal ulcer, Parkinson's disease, hip fracture/femoral fracture, Alzheimer's disease) in 2011 and 2013 were significantly lower (p<0.001) among those who reported the practice of VPA once a week or more than once a week.

Table 2. Relationship between vigorous physical activity and chronic diseases, by gender and year (2011 and 2013).

	Men (%)							
	2011				2013			
Doctor said you had (yes)	Less than once a week	Once a week	More than once a week	*p*	Less than once a week	Once a week	More than once a week	*p*
Heart attack	20.9	11.1	10.7	<0.001	18.5	11.1	10.1	<0.001
Hypertension	42.3	38.5	32.9	<0.001	43.5	40.2	35.2	<0.001
High cholesterol	25.2	22.5	19.1	<0.001	22.2	21.7	19.0	<0.001
Diabetes	16.8	12.2	9.2	<0.001	17.8	14.0	10.5	<0.001
Chronic lung disease	9.7	5.5	4.4	<0.001	9.2	5.8	4.4	<0.001
Cancer	6.3	4.5	3.5	<0.001	6.1	4.3	3.4	<0.001
Stomach ulcer	6.9	4.7	4.8	<0.001	4.2	2.7	2.5	<0.001
Parkinson's disease	1.3	0.3	0.3	<0.001	1.7	0.4	0.5	<0.001
Hip/femoral fracture	2.8	1.2	1.3	<0.001	1.9	1.0	0.8	<0.001
Alzheimer's disease	1.7	0.3	0.3	<0.001	2.9	0.4	0.7	<0.001
	Women (%)							
	2011				2013			
Doctor said you had (yes)	Less than once a week	Once a week	More than once a week	*p*	Less than once a week	Once a week	More than once a week	*p*
Heart attack	15.1	7.7	6.7	<0.001	13.5	6.9	5.7	<0.001
Hypertension	45.3	37.7	32.2	<0.001	46.8	39.2	34.5	<0.001
High cholesterol	27.1	20.8	20.3	<0.001	26.6	21.5	20.3	<0.001
Diabetes	14.0	8.2	6.8	<0.001	15.1	9.1	7.8	<0.001
Chronic lung disease	7.6	4.5	4.6	<0.001	7.3	4.6	4.1	<0.001
Cancer	6.0	4.0	4.5	<0.001	4.8	3.3	3.4	<0.001
Stomach ulcer	6.1	4.1	4.7	<0.001	4.5	2.7	3.0	<0.001
Parkinson's disease	0.8	0.1	0.1	<0.001	1.1	0.3	0.3	<0.001
Hip/femoral fracture	3.2	1.2	1.2	<0.001	2.8	0.8	0.9	<0.001
Alzheimer's disease	1.6	0.4	0.3	<0.001	2.7	0.7	0.5	<0.001

Abbreviation: MPA, moderate physical activity; VPA, vigorous physical activity
Tested by Chi Square.

Table 3 presents the results of the cross-sectional relationship between VPA and chronic diseases. For men, in the adjusted model for socio-demographic variables and smoking habits, engaging in VPA more than once a week was significantly associated with lower odds of having chronic diseases. When the model was further adjusted for the presence of other chronic diseases simultaneously, VPA more than once a week remained associated with lower odds of having chronic diseases when compared to those who reported VPA less than once a week. For women, the results were similar to men. However, in the adjusted model for socio-demographic variables and smoking habits, the relationship between VPA more than once a week and chronic diseases was not significantly related with cancer when compared to those who engaged in VPA less than once a week. In the further adjusted model for the presence of other chronic diseases, engaging in VPA more than once a week was not significantly associated with cancer, stomach or duodenal ulcer, and Parkinson's disease when compared with less active women.

Table 3. Cross-sectional parameters estimates the association of vigorous physical activity and chronic diseases.

	Men			
	Model 1. OR (95% CI)		Model 2. OR (95% CI)	
Doctor said you had (in 2011):	Once a week	More than once a week	Once a week	More than once a week
Heart attack	0.62 (0.52-0.74)***	0.55 (0.48-0.62)***	0.65 (0.54-0.78)***	0.61 (0.54-0.70)***
Hypertension	0.94 (0.83-1.06)	0.74 (0.67-0.81)***	0.99 (0.87-1.13)***	0.82 (0.75-0.91)***
High cholesterol	0.90 (0.78-1.03)	0.71 (0.64-0.79)***	0.99 (0.85-1.14)	0.84 (0.75-0.94)*
Diabetes	0.79 (0.66-0.94)**	0.58 (0.51-0.66)***	0.83 (0.69-0.99)*	0.65 (0.57-0.74)***
Chronic lung disease	0.61 (0.48-0.79)***	0.49 (0.40-0.59)***	0.66 (0.51-0.84)**	0.53 (0.44-0.64)***
Cancer	0.90 (0.68-1.18)	0.72 (0.58-0.89)*	0.77 (0.72-1.27)	0.79 (0.64-0.98)*
Stomach ulcer	0.55 (0.41-0.73)***	0.56 (0.47-0.69)***	0.58 (0.34-0.79)***	0.63 (0.51-0.76)***
Parkinson's disease	0.35 (0.14-0.88)*	0.34 (0.18-0.64)**	0.38 (0.15-0.96)*	0.36 (0.19-0.67)**
Hip/femoral fracture	0.49 (0.29-0.80)**	0.47 (0.34-0.67)***	0.52 (0.31-0.86)*	0.51 (0.36-0.72)***
Alzheimer's disease	0.23 (0.07-0.74)*	0.39 (0.21-0.72)**	0.26 (0.08-0.84)*	0.47 (0.25-0.88)*

	Women			
	Model 1. OR (95% CI)		Model 2. OR (95% CI)	
Doctor said you had (in 2011):	Once a week	More than once a week	Once a week	More than once a week
Heart attack	0.54 (0.46-0.65)***	0.57 (0.50-0.66)***	0.61 (0.51-0.73)***	0.66 (0.57-0.75)***
Hypertension	0.81 (0.73-0.90)***	0.68 (0.63-0.74)***	0.90 (0.81-1.00)***	0.76 (0.70-0.83)***
High cholesterol	0.79 (0.70-0.89)***	0.75 (0.68-0.82)***	0.87 (0.77-0.99)*	0.86 (0.78-0.94)*
Diabetes	0.65 (0.55-0.77)***	0.53 (0.47-0.61)***	0.73 (0.61-0.86)***	0.61 (0.53-0.70)***
Chronic lung disease	0.60 (0.48-0.75)***	0.69 (0.59-0.81)***	0.67 (0.54-0.84)**	0.76 (0.65-0.90)**
Cancer	0.71 (0.56-1.00)	0.85 (0.72-1.01)	0.75 (0.59-1.00)	0.89 (0.75-1.06)
Stomach ulcer	0.67 (0.53-0.85)**	0.77 (0.65-0.92)**	0.77 (0.61-0.98)*	0.87 (0.74-1.04)
Parkinson's disease	0.08 (0.12-0.61)*	0.44 (0.22-0.88)*	0.10 (0.01-0.71)*	0.51 (0.26-1.03)
Hip/femoral fracture	0.50 (0.33-0.75)**	0.60 (0.45-0.81)**	0.53 (0.35-0.80)**	0.63 (0.47-0.85)**
Alzheimer's disease	0.27 (0.11-0.68)**	0.25 (0.12-0.52)**	0.28 (0.11-0.69)**	0.25 (0.12-0.51)***

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

[1] Physical activity "less than once a week" was the reference category.

Model 1: Analyses were adjusted for age, marital status, educational level, living place, smoking, and country.

Model 2: Analyses were adjusted for age, marital status, educational level, living place, smoking, country, and the presence of others chronic diseases.

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

Results of the prospective relationship between VPA and chronic diseases are presented in the table 4. In both models, compared with men who engaged in VPA less than once a week, those doing VPA more than once a week presented prospectively lower odds of having chronic diseases. For men, VPA seems to have a greater effect on Parkinson's disease (OR: 0.36, 95% CI: 0.19-0.67, *p*<0.01) and Alzheimer's disease (OR: 0.47, 95% CI: 0.25-0.88, *p*<0.01). Practicing VPA once a week, compared to those who do less than once a week, was prospectively related with lower odds of heart attack (OR: 0.73, 95% CI: 0.61-0.88), chronic lung disease (OR: 0.70, 95% CI: 0.55-0.90), Parkinson's disease (OR: 0.38, 95% CI: 0.17-0.84), and Alzheimer's disease (OR: 0.16, 95% CI: 0.05-0.51). In the model adjusted for socio-demographic variables and smoking habits, women who practice VPA at least once a week were prospectively less likely to have chronic diseases, except for cancer, when compared to those who do less VPA. In the fully adjusted model, women who engaged in VPA once a week, compared to those who do VPA less than once a week, presented lower odds of having chronic diseases, except for hypertension, high blood cholesterol, and cancer. As for VPA more than once a week, cancer was the only disease not associated with physical activity.

Table 4. Prospective parameters estimates the association of vigorous physical activity and chronic diseases.

	Men			
	Model 1. OR (95% CI)		Model 2. OR (95% CI)	
Doctor said you had (in 2013):	Once a week	More than once a week	Once a week	More than once a week
Heart attack	0.69 (0.58-0.83)***	0.62 (0.54-0.70)***	0.73 (0.61-0.88)**	0.69 (0.60-0.79)***
Hypertension	0.92 (0.81-1.04)	0.76 (0.69-0.83)***	0.97 (0.86-1.11)	0.84 (0.77-0.93)***
High cholesterol	0.85 (0.74-0.98)*	0.72 (0.65-0.80)***	0.90 (0.78-1.05)	0.83 (0.75-0.93)**
Diabetes	0.88 (0.74-0.104)	0.62 (0.54-0.70)***	0.94 (0.79-1.12)	0.69 (0.61-0.79)***
Chronic lung disease	0.66 (0.52-0.85)**	0.53 (0.44-0.64)***	0.70 (0.55-0.90)**	0.58 (0.48-0.70)***
Cancer	0.86 (0.65-1.15)	0.67 (0.54-0.84)***	0.93 (0.70-1.23)	0.75 (0.60-0.93)**
Stomach ulcer	0.63 (0.44-0.90)*	0.50 (0.38-0.65)***	0.70 (0.49-1.01)	0.59 (0.45-0.77)***
Parkinson's disease	0.36 (0.17-0.79)*	0.36 (0.21-0.60)***	0.38 (0.17-0.84)*	0.36 (0.21-0.61)***
Hip/femoral fracture	0.69 (0.40-1.18)	0.60 (0.40-0.89)*	0.72 (0.42-1.23)	0.65 (0.44-0.97)*
Alzheimer's disease	0.15 (0.05-0.46)**	0.53 (0.34-0.83)**	0.16 (0.05-0.51)**	0.61 (0.39-0.95)*

	Women			
	Model 1. OR (95% CI)		Model 2. OR (95% CI)	
Doctor said you had (in 2013):	Once a week	More than once a week	Once a week	More than once a week
Heart attack	0.58 (0.48-0.70)***	0.57 (0.48-0.64)***	0.64 (0.53-0.77)***	0.63 (0.55-0.73)***
Hypertension	0.84 (0.76-0.93)**	0.72 (0.67-0.78)***	0.92 (0.83-1.03)	0.80 (0.74-0.87)***
High cholesterol	0.83 (0.74-0.94)**	0.78 (0.71-0.85)***	0.92 (0.82-1.04)	0.90 (0.82-0.99)*
Diabetes	0.64 (0.55-0.76)***	0.55 (0.48-0.62)***	0.71 (0.60-0.84)***	0.62 (0.54-0.71)***
Chronic lung disease	0.69 (0.55-0.86)**	0.61 (0.51-0.72)***	0.75 (0.60-0.94)*	0.66 (0.56-0.79)***
Cancer	0.72 (0.55-0.93)*	0.85 (0.70-0.1.03)	0.77 (0.59-1.01)	0.91 (0.75-1.11)
Stomach ulcer	0.57 (0.42-0.76)***	0.70 (0.57-0.85)***	0.64 (0.48-0.86)**	0.79 (0.65-0.97)*
Parkinson's disease	0.20 (0.06-0.64)**	0.53 (0.30-0.94)*	0.21 (0.07-0.67)**	0.54 (0.31-0.97)*
Hip/femoral fracture	0.41 (0.25-0.67)***	0.52 (0.37-0.73)***	0.45 (0.28-0.74)**	0.56 (0.40-0.80)**
Alzheimer's disease	0.48 (0.28-0.83)**	0.43 (0.27-0.69)***	0.51 (0.29-0.89)*	0.45 (0.28-0.72)**

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

[1] Physical activity "less than once a week" was the reference category.

Model 1: Analyses were adjusted for age, marital status, educational level, living place, smoking, and country. Model 2: Analyses were adjusted for age, marital status, educational level, living place, smoking, country, and the presence of others chronic diseases in 2011.

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

Discussion

The purpose of this study was to investigate the cross-sectional and prospective associations between self-reported VPA and the risk of major chronic diseases in European older adults. It was found that VPA was associated with a reduced risk of chronic diseases. One of the most relevant findings was that even one session of VPA per week was cross-sectionally and prospectively associated with lower odds of having chronic diseases such as heart attack, chronic lung disease, Parkinson's disease, and Alzheimer's disease among both men and women. Practicing VPA more than once per week further increased the number of chronic diseases that were negatively associated with VPA.

These results provide additional support for the documented inverse relationship between physical activity and cardiovascular, metabolic and mental chronic diseases (Huai et al., 2013; Lee & Paffenbarger, 2000; Lee et al., 2003; O'Donovan et al., 2017). The results also support that older people benefit from engaging in VPA, as observed previously (Lee & Paffenbarger, 2000; Marques et al., 2016c; Molmen-Hansen et al., 2012), regardless of adherence to prevailing physical activity guidelines.

The fact that the practice of VPA once a week was cross-sectionally and prospectively associated with lower odds of having some chronic diseases among men and women (e.g. heart attack, chronic lung disease, Parkinson’s disease and Alzheimer’s disease) reinforces the evidence that even a single weekly bout of exercise of high intensity may reduce the risk of chronic disease or cardiovascular death (Moholdt, Wisloff, Nilsen, & Slordahl, 2008; Souto Barreto, Cesari, Andrieu, Vellas, & Rolland, 2017; Wisloff et al., 2006). This fact is a message of hope for those who are unable to fulfil the recommendation for regular practice of physical activity, as being physically active, even below the recommended levels, still carries beneficial health effects. Moreover, if those who are physically inactive resolve to participate in VPA, at least once a week, they will collect its health benefits, regardless of their past sedentary behaviour (Marques et al., 2016c).

Although the analysis was stratified by gender, it was interesting to observe that cross-sectionally and prospectively VPA had the same effect on heart attack, chronic lung disease, Parkinson’s disease, and Alzheimer’s disease among men and women. On the other hand, VPA once a week was cross-sectionally related to hypertension and high blood cholesterol in women, but not in men. This suggests that the gender has a moderating effect in some chronic diseases (Keller & Howlett, 2016; Tambalis et al., 2016).

In spite of the benefits of physical activity, its levels among older people are low (European Commission, 2014). Due to a multitude of health problems, older adults hardly achieved the recommended levels of physical activity. Therefore, the implementation of programs that promote participation in MPA, but mainly VPA, may be considered as a strategy to reduce the number of chronic diseases in the older population. Furthermore, as even the practice of VPA once a week seems to have health benefits, it could be of interest for future studies to investigate the minimum amount of VPA for reduced odds of having chronic diseases.

The present study has some limitations. The main limitation is the lack, or the shortage, of information on physical activity type, duration, and frequency, which limits a more precise calculation of physical activity volume. Chronic diseases and physical activity were self-reported which is susceptible to bias, and the measurement of VPA includes only frequency, but not duration making it impossible to evaluate adherence to the guidelines. However, self-reported physical activity is considered a reliable method for epidemiologic studies (Craig et al., 2003), and is still the backbone of surveillance studies (Pedisic & Bauman, 2015). The follow-up was shorter than that of previous prospective studies (Lee & Paffenbarger, 2000; Lee et al., 2003; Souto Barreto et al., 2017).

The current investigation also had its strengths. A major strength of this study was the SHARE database that includes a large and representative sample size of various European countries, as well as several socio-demographic characteristics of the study sample. Another strength, considering the sample size and the heterogeneity of the participants, is the generality of these results. Furthermore, due to the large sample, there was an adequate statistical power. Prospective analysis allows for the examination of the cause and effect relationship between VPA and chronic diseases.

Conclusion

In conclusion, results from this large and statistically powerful study suggest that VPA is associated with a reduced risk of chronic diseases in men and women. Even the practice of VPA once a week seems to be sufficient to reduce the risk of chronic diseases.

Conflict of interest

The authors declare that there are no conflicts of interest.

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Key-points

There is evidence that vigorous-intensity physical activity is associated with a greater decrease in the risk of incidence of major chronic diseases than moderate-intensity physical activity.

Vigorous physical activity per week is associated with lower odds of having chronic diseases such as heart attack, chronic lung disease, Parkinson’s disease, and Alzheimer’s disease among both men and women.

Even the practice of vigorous physical activity once a week seems to be sufficient to reduce the risk of chronic diseases, regardless of adherence to prevailing physical activity guidelines.

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Article 4

Cross-sectional and prospective relationship between low to moderate-intensity physical activity and chronic diseases in older adults from 13 European countries

Article accepted for publication

Marques, A., Peralta, M., Martins, J., Rúbio, E., González Valeiro, M. (2017). Cross-sectional and prospective relationship between low to moderate-intensity physical activity and chronic diseases in older adults from 13 European countries. *Journal of Aging and Physical Activity*.

Abstract

Aim: Assess the relationship between low-to-moderate-intensity physical activity (LMPA) in 2011 and chronic diseases in 2011 and 2013 among European older adults. **Methods:** Participants (16157 men, 21260 women) from 13 European countries were interviewed about the presence of chronic conditions and LMPA. The association between LMPA and number of chronic diseases was assessed using logistic regression models. **Results:** Most of the older adults participated in LMPA more than once a week (81.9%), 8.4% participated once a week and 9.3% did not participated. The prevalence of chronic diseases was significantly lower among those who reported engaging in LMPA. LMPA in 2011 was related with lower odds of having several chronic diseases in 2013. **Conclusion:** Engaging in LMPA is associated with reduced risk for chronic diseases in European older men and women. Even the practice of LMPA once a week seems to be enough to diminish the risk of having chronic diseases.

Keywords: non-communicable diseases; physical activity; exercise; Europe

Introduction

Chronic diseases, such as heart attack, hypertension, diabetes, chronic lung disease, cancer, stomach or duodenal ulcer, and Alzheimer's disease, are the major cause of mortality and disability worldwide (WHO, 2015). Chronic diseases have a negative effect on quality of life because of the physical and psychological consequences (WHO, 2005). Due to the aging of the population (specifically in western countries), it is expected that the prevalence of chronic diseases will increase considerably in future years (Joly et al., 2013). The foremost factor identified as being, in part, responsible for the increasing prevalence of chronic diseases is physical inactivity (Lee et al., 2012). Physical activity can reduce chronic diseases and the risk of disease progression (Huai et al., 2013). As a result, practice of physical activity has been recommended to promote health (European Commission, 2008; WHO, 2010) and to prevent chronic diseases (Alves et al., 2016).

Although there is evidence that vigorous intensity physical activity (VPA) is associated with a larger decreased risk of the incidence of chronic diseases than low-to-moderate-intensity physical activity (LMPA) (Chomistek et al., 2012; Lee et al., 2003), studies have been showing that even a minimum amount of physical activity has a protective effect on health, preventing chronic diseases and mortality (Ekelund et al., 2015; O'Donovan et al., 2017; Wen et al., 2011). Older adults are less likely to engage in VPA because of their physical condition. They usually engage in less intense activities (Jansen et al., 2015). Thus, it is important to better understand the relationship between LMPA and chronic diseases among this population.

Most studies that have analysed the relationship between physical activity and chronic diseases do not consider the co-occurrence of chronic diseases on an individual (Banks et al., 2011; Karjalainen et al., 2015; Swift et al., 2013), are cross-sectional, and mainly focused on a population from one country. What is needed is the use of a more comprehensive approach that evaluates several chronic diseases as well as the relationship of chronic diseases and LMPA in populations from different countries. Therefore, the purpose of the present study was to assess the relationship between self-reported LMPA frequency in 2011 and chronic diseases in 2011 and 2013 among a wide sample of European older men and women.

Methods

Participants and procedures

This study was based on the fourth and fifth wave of the Survey of Health, Aging, and Retirement in Europe (SHARE). The SHARE is a biennial interdisciplinary and cross-national survey on aging that collects extensive information on individuals aged 50 and over in several European countries. This survey is fully described elsewhere (Börsch-Supan et al., 2013; Börsch-Supan & Jürges, 2005). Data from the fourth and fifth waves were collected in 2011 and 2013 respectively. Fifty eight thousand four hundred and eighty nine people participated in the fourth wave in 2011. From those, the 37417 (64%) who also responded to the fifth wave in 2013 were included in the present study. The final sample included 16157 (43.2%) men and 21260 (56.8%) women from 13 countries: Austria, Belgium, Czech Republic, Denmark, Estonia, France, Germany, Italy, Netherlands, Slovenia, Spain, Sweden, and Switzerland. Participants' age range was between 50 and 102 years (66.2±9.7) in 2011, and between 52 and 104 years (68.2±9.7) in 2013.

Data were collected through face-to-face interviews done by trained interviewers using a computer-assisted personal interviewing program, and supplemented by a self-completed paper-and-pencil questionnaire. Comparable questionnaires were applied in each country. Translation guidelines were applied, and pilots were performed to enhance comparability. 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

Physical activity. Participants were asked, "How often do you engage in activities that require a low or moderate level of energy such as gardening, cleaning the car, or going for a walk?" and also to report ''frequency of vigorous physical activity'' (e.g., sports, heavy housework, a job involving physical labour). Response options were: (1) more than once a week, (2) once a week, (3) up to three times a month, and (4) hardly ever or never. For the present study, the last two response options were grouped into one category named "less than once a week". Self-reported physical activity may be overestimated because of social desirability (Sallis & Saelens, 2000). Nonetheless, social desirability only accounts for a small variance in self-reported physical activity (Motl et al., 2005). There is evidence that assessed physical activity with a single question is an acceptable alternative in epidemiologic studies (Wanner et al., 2014).

Chronic diseases. The presence or absence of chronic disease was reported by the participants themselves, based on information provided to them by a doctor. Participants were asked to indicate whether they currently have, or had, chronic diseases in the last 12 months. Self-report chronic diseases is fairly to largely accurate for most chronic diseases, mainly when reported based on doctor information (Haapanen et al., 1997; Hansen et al., 2014). The following diseases were considered: heart attack or other heart problems, hypertension, high blood cholesterol, diabetes, chronic lung disease, cancer, stomach or duodenal ulcer, Parkinson's disease, hip fracture/femoral fracture, and Alzheimer's disease/dementia.

Socio-demographic variables. The following variables were self-reported: age, marital status, education level, and living place. Marital status was dichotomized into: 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, 2006), and grouped into three levels: low educational level (ISCED code 0 to code 2), medium educational level (ISCED codes 3 and 4), and high educational level (ISCED codes 5 and 6). ISCED is a framework for organizing information on education and is divided in seven code levels consisting of: pre-primary education (code 0), primary education (code 1), lower secondary education (code 2), upper secondary education (code 3), post-secondary non-tertiary education (code 4), first stage of tertiary education (code 5) and second stage of tertiary education (code 6), e.g. doctoral education. Living place categories were living in: a big city, a suburb or the outskirts of a big city, a large town, a small town, or in a rural area.

Statistical analysis

All variables' descriptive statistics (means, standard deviation, and percentages) at baseline (fourth wave in 2011) were calculated for the entire sample, and for men and women separately. Differences between men and women at baseline for the participants' characteristics were tested by the Chi Square test and the Independent sample t-test. The bivariate relationship between LMPA frequency and the presence of chronic diseases at baseline was tested by the Chi-square test. The association between LMPA frequency and the presence of chronic diseases was assessed using binary logistic regression. Two different models were performed for these analyses. Model 1 was adjusted for age, marital status, educational level, living place, smoking, and country. Model 2 was further adjusted for the presence of all other chronic diseases. Model 3 was adjusted for model 2 and further adjusted for vigorous physical activity. Odds ratio and confidence interval for the presence of chronic disease was tested against practicing LMPA “less than once a week” (reference category). An interaction effect was observed between sex and some chronic diseases, so all analyses were stratified by sex. Data analysis was performed using IBM SPSS Statistics version 24 (SPSS Inc., an IBM Company, Chicago, Illinois, U.S.A.). The significance level was set at $p<0.05$.

Results

Participants’ characteristics at baseline are presented in table 1. Most participants had a low level of education (61.1%), were married (70.2%), and lived in a small town or rural area (59.4%). Overall, hypertension (39.2%), high blood cholesterol (23.3%), heart attack (13.2%) and diabetes (11.9%) were the most prevalent chronic diseases. Although significant, sex differences in the prevalence of several chronic diseases (heart attack, hypertension, high blood cholesterol, diabetes, chronic lung disease, Parkinson’s disease, hip fracture/femoral fracture and Alzheimer's disease/dementia) were small. The large majority of the participants (81.9%) reported having participated more than once a week in MPA. Once again, although significant, sex differences in LMPA frequency were small.

Table 1. Participants' characteristics at baseline (2011).

	(% or M±SD)			
	Total (n=37417)	Men (n=16157)	Women (n=21260)	*p*
Education				<0.001
Low	61.1	59.0	62.8	
Medium	26.1	27.3	25.2	
High	12.8	13.7	12.0	
Age	66.2±9.7	66.1±9.4	66.3±9.9	0.035
Marital status				<0.001
Not married	29.8	20.0	37.0	
Married	70.2	80.0	62.8	
Living place				<0.001
Big city	13.7	12.5	14.6	
Suburbs of a big city	10.5	10.9	10.2	
Large town	16.4	15.3	17.1	
Small town	25.1	24.9	25.2	
Rural area	34.3	36.3	32.9	
Doctor reported you had				
Heart attack	13.2	15.4	11.5	<0.001
Hypertension	39.2	37.9	40.2	<0.001
High cholesterol	23.3	22.4	24.1	<0.001
Diabetes	11.9	13.1	11.0	<0.001
Chronic lung disease	6.5	6.9	6.2	0.005
Cancer	5.1	4.9	5.2	0.158
Stomach or ulcer	5.6	5.8	5.4	0.123
Parkinson's disease	0.6	0.8	0.5	0.002
Hip/femoral fracture	2.2	2.0	2.4	0.007
Alzheimer's disease	1.1	1.0	1.1	0.140
LMPA frequency				<0.001
Less than once a week	9.3	8.6	9.8	
Once a week	8.4	8.1	8.5	
More than once a week	81.9	82.1	83.2	

Abbreviation: M, mean; SD, standard deviation; LMPA, low to moderate intensity physical activity.
[a] Tested by Chi Square.
[b] Tested by t test.

Table 2 presents the results of bivariate analysis between LMPA frequency in 2011 and chronic diseases in 2011 and 2013. For men, with one exception for high blood cholesterol, the prevalence of all chronic diseases in 2011 and 2013 was significantly lower (p<0.001) among those who reported practicing LMPA once a week or more than once a week. For women, similar results were observed. However, the difference lies in the high blood cholesterol prevalence in 2013, which was significantly lower (p=0.001) among women who reported practicing LMPA once a week or more than once a week.

Table 2. Relationship between low to moderate intensity physical activity in 2011, and prevalence of chronic diseases in 2011 and 2013.

	Men (%)							
	2011				2013			
Doctor reported you had (yes)	Less than once a week	Once a week	More than once a week	*p*	Less than once a week	Once a week	More than once a week	*p*
Heart attack	24.5	17.3	14.3	<0.001	20.6	14.1	13.4	<0.001
Hypertension	45.1	38.8	37.1	<0.001	45.9	40.9	38.9	<0.001
High cholesterol	23.2	23.6	22.1	0.340	24.0	22.2	21.9	0.217
Diabetes	19.4	12.8	12.5	<0.001	20.2	15.4	13.6	<0.001
Chronic lung disease	10.0	6.4	6.7	<0.001	10.4	7.0	6.4	<0.001
Cancer	7.6	5.6	4.6	<0.001	7.5	4.7	4.5	<0.001
Stomach ulcer	5.8	6.3	5.4	<0.001	7.2	4.6	2.8	<0.001
Parkinson’s disease	2.2	0.7	0.7	<0.001	3.0	1.1	0.8	<0.001
Hip femoral fracture	4.3	1.5	1.8	<0.001	3.0	1.1	1.2	<0.001
Alzheimer's disease	2.5	0.9	0.8	<0.001	4.4	1.2	1.5	<0.001
	Women (%)							
	2011				2013			
Doctor reported you had (yes)	Less than once a week	Once a week	More than once a week	*p*	Less than once a week	Once a week	More than once a week	*p*
Heart attack	20.8	12.5	10.2	<0.001	18.2	10.5	9.2	<0.001
Hypertension	51.1	44.1	38.5	<0.001	52.7	45.8	40.3	<0.001
High cholesterol	26.0	24.7	23.8	0.078	26.3	26.3	23.4	0.001
Diabetes	17.8	11.4	10.1	<0.001	19.1	13.5	11.0	<0.001
Chronic lung disease	10.5	5.8	5.7	<0.001	10.3	5.6	5.4	<0.001
Cancer	7.7	5.3	5.0	<0.001	5.7	4.5	3.9	<0.001
Stomach ulcer	9.1	6.2	4.9	<0.001	7.1	5.6	3.2	<0.001
Parkinson’s disease	1.7	0.5	0.4	<0.001	2.4	0.6	0.6	<0.001
Hip femoral fracture	5.6	2.6	1.9	<0.001	4.6	1.8	1.6	<0.001
Alzheimer's disease	2.9	0.7	0.9	<0.001	3.7	1.1	1.6	<0.001

Tested by Chi Square.

The results of the relationship between LMPA frequency in 2011 and chronic diseases in 2011 are shown in table 3. In model 1, men who engaged in LMPA more than once a week had lower odds of having chronic diseases (except for high blood cholesterol and chronic lung disease) than those who practiced LMPA less than once a week. When the model was further adjusted for the presence of other chronic diseases (model 2), engaging in LMPA more than once a week remained associated only with lower odds of having heart attack, diabetes, cancer, Parkinson’s disease, and hip fracture/femoral fracture. For women, in all models, engaging in LMPA more than once a week was significantly associated with lower odds of having several chronic diseases (with the exception of high blood cholesterol and Parkinson’s disease).

However, in model 2, women who practiced LMPA more than once a week also had higher odds of having high blood cholesterol than women who engaged in LMPA less than once a week (OR: 1.16, CI: 1.02-1.32, $p<0.05$). For model 2, practicing LMPA once a week was related to lower odds of having diabetes (OR: 0.72, CI: 0.54-0.95, $p<0.05$), Parkinson's disease (OR: 0.25, CI: 0.07-0.86, $p<0.05$), and hip fracture/femoral fracture (OR: 0.42, CI: 0.21-0.86, $p<0.05$) in men, and diabetes (OR: 0.72, CI: 0.58-0.90, $p<0.01$), chronic lung disease (OR: 0.63, CI: 0.47-0.84, $p<0.01$), and cancer (OR: 0.73, CI: 0.54-1.00, $p<0.05$) in women. In model 3, further adjusted for vigorous physical activity, men who practiced LMPA once a week still present lower odds of having fracture/femoral fracture (OR=0.71, 95% CI:0.53-0.96, $p<0.05$), and women presented less likelihood of having diabetes (OR: 0.76, CI: 0.61-0.94, $p<0.05$), and chronic lung disease (OR: 0.64, CI: 0.48-0.86, $p<0.01$).

Table 3. Parameters estimates for the association of low to moderate intensity physical activity in 2011 and chronic diseases in 2011.

	Men					
Doctor reported you had (in 2011):	Model 1. OR (95% CI)		Model 2. OR (95% CI)		Model 3. OR (95% CI)	
	Once a week	More than once a week	Once a week	More than once a week	Once a week	More than once a week
Heart attack	0.79 (0.62-1.02)	0.66 (0.55-0.79)***	0.85 (0.66-1.09)	0.70 (0.59-0.85)***	0.91 (0.70-1.18)	0.84 (0.69-1.00)
Hypertension	0.84 (0.69-1.02)	0.82 (0.71-0.95)**	0.85 (0.70-1.05)	0.86 (0.74-1.01)	0.88 (0.72-1.08)	0.93 (0.0.80-1.09)
High blood cholesterol	1.05 (0.84-1.32)	0.92 (0.77-1.08)	1.21 (0.95-1.53)	1.06 (0.88-1.26)	1.25 (0.99-1.58)	1.13 (0.94-1.36)
Diabetes	0.69 (0.53-0.91)**	0.71 (0.59-0.86)***	0.72 (0.54-0.95)*	0.76 (0.63-0.93)**	0.89 (0.73-1.09)	0.77 (0.58-1.00)
Chronic lung disease	0.64 (0.44-0.94)*	0.79 (0.61-1.02)	0.69 (0.47-1.02)	0.86 (0.67-1.11)	0.77 (0.53-1.13)	1.09 (1.84-1.42)
Cancer	0.73 (0.49-1.10)	0.63 (0.48-0.84)**	0.77 (0.51-1.15)	0.67 (0.50-0.89)**	0.79 (0.52-1.19)	0.71 (0.53-0.96)*
Stomach or duodenal ulcer	0.72 (0.50-1.05)	0.70 (0.54-0.91)**	0.79 (0.54-1.15)	0.78 (0.60-1.02)	0.85 (0.58-1.24)	0.94 (0.71-1.24)
Parkinson’s disease	0.22 (0.06-0.78)*	0.42 (0.23-0.74)**	0.25 (0.07-0.86)*	0.43 (0.24-0.78)**	0.58 (0.32-1.05)	0.28 (0.08-0.96)*
Hip fracture/femoral fracture	0.39 (0.19-0.78)**	0.57 (0.38-0.84)**	0.42 (0.21-0.86)*	0.61 (0.41-0.92)*	0.47 (0.23-0.94)*	0.76 (0.50-1.15)
Alzheimer's disease/dementia	0.47 (0.16-1.33)	0.47 (0.25-0.88)*	0.54 (0.19-1.53)	0.53 (0.28-1.00)	0.59 (0.21-1.70)	0.66 (0.34-1.28)

	Women					
Doctor reported you had (in 2011):	Model 1. OR (95% CI)		Model 2. OR (95% CI)		Model 3. OR (95% CI)	
	Once a week	More than once a week	Once a week	More than once a week	Once a week	More than once a week
Heart attack	0.75 (0.61-0.92)**	0.66 (0.57-0.76)***	0.82 (0.66-1.02)	0.74 (0.64-0.86)***	0.85 (0.69-1.05)	0.82 (0.71-0.95)**
Hypertension	0.84 (0.72-0.99)*	0.74 (0.66-0.83)***	0.91 (0.77-1.07)	0.80 (0.71-0.90)***	0.36 (0.79-1.09)	0.86 (0.76-0.97)*
High blood cholesterol	0.99 (0.84-1.18)	0.98 (0.87-1.11)	1.12 (0.93-1.34)	1.16 (1.02-1.32)*	1.14 (1.06-1.38)	1.21 (1.06-1.38)**
Diabetes	0.68 (0.55-0.85)**	0.61 (0.53-0.71)***	0.72 (0.58-0.90)**	0.67 (0.58-0.78)***	0.76 (0.61-0.94)*	0.75 (0.64-0.87)***
Chronic lung disease	0.57 (0.43-0.77)***	0.65 (0.54-0.79)***	0.63 (0.47-0.84)**	0.74 (0.61-0.89)**	0.64 (0.48-0.86)**	0.79 (0.65-0.96)*
Cancer	0.69 (0.51-0.94)*	0.70 (0.56-0.86)**	0.73 (0.54-1.00)*	0.75 (0.61-0.92)**	0.74 (0.54-1.01)	0.77(0.62-0.95)*
Stomach or duodenal ulcer	0.71 (0.53-0.94)*	0.64 (0.52-0.78)***	0.78 (0.59-1.05)	0.72 (0.59-0.89)**	0.79 (0.59-1.06)	0.74 (0.60-0.91)**
Parkinson’s disease	0.63 (0.24-1.63)	0.59 (0.32-1.06)	0.72 (0.28-1.87)	0.69 (0.38-1.25)	0.76 (0.29-1.97)	0.80 (0.44-1.47)
Hip fracture/femoral fracture	0.82 (0.56-1.20)	0.47 (0.36-0.61)***	0.86 (0.58-1.27)	0.49 (0.38-0.64)***	0.89 (0.60-1.31)	0.53 (0.41-0.70)***
Alzheimer's disease/dementia	0.54 (0.27-1.10)	0.47 (0.31-0.70)***	0.55 (0.27-1.12)	0.47 (0.31-0.71)***	0.60 (0.29-1.21)	0.56 (0.37-0.85)**

Abbreviation: OR, odds ration; CI, confidence interval. [1] Physical activity “less than once a week” was the reference category.
Model 1: Analyses were adjusted for age, marital status, educational level, living place, smoking, and country. Model 2: Analyses were adjusted for age, marital status, educational level, living place, smoking, country, and the presence of others chronic diseases. Model 3: Analyses were adjusted for age, marital status, educational level, living place, smoking, country, vigorous physical activity and the presence of others chronic diseases. *p<0.05, **p<0.01, ***p<0.001.

Table 4 shows the results of the relationship between LMPA frequency in 2011 and chronic disease presence in 2013. For model 2, men who engaged in LMPA more than once a week in 2011 had lower odds of having diabetes (OR=0.80, 95% CI: 0.66-0.97, p<0.05), chronic lung disease (OR=0.68, 95% CI: 0.53-0.86, p<0.001), cancer (OR=0.67, 95% CI: 0.50-0.89, p<0.01), stomach or duodenal ulcer (OR=0.49, 95% CI: 0.36-0.68, p<0.001), Parkinson’s disease (OR=0.39, 95% CI: 0.24-0.65, p<0.001), hip fracture/femoral fracture (OR=0.50, 95% CI: 0.31-0.79, p<0.01), and Alzheimer's disease/dementia (OR=0.44, 95% CI: 0.28-0.71, p<0.05) in 2013. Women who engaged in LMPA more than once a week in 2011 had lower odds of having heart attack OR=0.82 (95% IC: 0.70-0.95, p<0.05), hypertension OR=0.84 (95% IC: 0.75-0.95, p<0.01), diabetes OR=0.67 (95% IC: 0.58-0.78, p<0.001), chronic lung disease OR=0.62 (95% IC: 0.51-0.75, p<0.001), stomach or duodenal ulcer OR=0.57 (95% IC: 0.45-0.71, p<0.001), Parkinson’s disease OR=0.49 (95% IC: 0.30-0.80, p<0.01), and hip fracture/femoral fracture OR=0.53 (95% IC: 0.39-0.71, p<0.001) in 2013. In the full adjusted model (model 3), LMPA more than once a week remained related with lower odds of having cancer (OR=0.73, 95% CI:0.54-0.98, p<0.05), stomach or duodenal ulcer (OR=0.57, 95% CI:0.41-0.80, p<0.01), Parkinson’s disease (OR=0.53, 95% CI:0.32-0.89, p<0.05), hip fracture/femoral fracture (OR=0.56, 95% CI:0.35-0.89, p<0.05), Alzheimer's disease (OR=0.51, 95% CI:0.31-0.83, p<0.01) in men. Among women, those who engaged in LMPA more than once a week decreased the odds of having hypertension (OR=0.89, 95% CI:0.79-1.00, p<0.05), diabetes (OR=0.74, 95% CI:0.64-0.87, p<0.001), chronic lung disease (OR=0.67, 95% CI:0.55-0.82, p<0.001), stomach or duodenal ulcer (OR=0.59, 95% CI:0.47-0.75, p<0.001), Parkinson’s disease (OR=0.54, 95% CI:0.33-0.88, p<0.05), and hip fracture/femoral fracture (OR=0.58, 95% CI:0.43-0.78, p<0.001). Model 3 results further show that even practicing LMPA once a week in 2011 were related with lower odds of having Parkinson's disease (OR=0.32, 95% CI:0.12-0.86, $p<0.05$), hip fracture/femoral fracture (OR=0.45, 95% CI:0.21-0.98, $p<0.05$) in men and chronic lung disease (OR=0.61, 95% CI:0.46-0.82, $p<0.01$) in women.

Table 4. Parameters estimates for the association of low-to-moderate intensity physical activity in 2011 and chronic diseases in 2013.

	Men					
	Model 1. OR (95% CI)		Model 2. OR (95% CI)		Model 3. OR (95% CI)	
Doctor reported you had (in 2013):	Once a week	More than once a week	Once a week	More than once a week	Once a week	More than once a week
Heart attack	0.81 (0.62-1.06)	0.81 (0.67-0.98)*	0.90 (0.68-1.18)	0.90 (0.74-1.10)	0.96 (0.73-1.26)	1.04 (0.85-1.28)
Hypertension	0.87 (0.72-1.06)	0.83 (0.72-0.96)*	0.92 (0.75-1.13)	0.82 (0.75-1.02)	0.94 (0.77-1.16)	0.94 (0.80-1.10)
High blood cholesterol	0.88 (0.70-1.11)	0.92 (0.78-1.10)	0.97 (0.76-1.24)	1.05 (0.87-1.25)	1.01 (0.79-1.29)	1.13 (0.94-1.36)
Diabetes	0.80 (0.62-1.04)	0.75 (0.62-0.90)**	0.86 (0.66-1.12)	0.80 (0.66-0.97)*	0.91 (0.70-1.19)	0.91 (0.75-1.11)
Chronic lung disease	0.62 (0.43-0.88)**	0.61 (0.48-0.78)***	0.67 (0.47-0.96)**	0.68 (0.53-0.86)***	0.73 (0.51-1.05)	0.81 (0.63-1.05)
Cancer	0.60 (0.39-0.92)*	0.60 (0.45-0.80)***	0.66 (0.43-1.01)	0.67 (0.50-0.89)**	0.69 (0.45-1.05)	0.73 (0.54-0.98)*
Stomach or duodenal ulcer	0.62 (0.40-0.96)*	0.43 (0.31-0.58)***	0.72 (0.46-1.12)	0.49 (0.36-0.68)***	0.74 (0.47-1.17)	0.57 (0.41-0.80)**
Parkinson’s disease	0.26 (0.10-0.70)**	0.37 (0.23-0.61)***	0.28 (0.10-0.75)*	0.39 (0.24-0.65)***	0.32 (0.12-0.86)*	0.53 (0.32-0.89)*
Hip fracture/femoral fracture	0.41 (0.19-0.89)*	0.46 (0.30-0.73)**	0.43 (0.20-0.93)*	0.50 (0.31-0.79)**	0.45 (0.21-0.98)*	0.56 (0.35-0.89)*
Alzheimer's disease/dementia	0.39 (0.17-0.87)*	0.39 (0.25-0.62)***	0.44 (0.20-1.01)	0.44 (0.28-0.71)*	0.47 (0.21-1.08)	0.51 (0.31-0.83)**
	Women					
	Model 1. OR (95% CI)		Model 2. OR (95% CI)		Model 3. OR (95% CI)	
Doctor reported you had (in 2013):	Once a week	More than once a week	Once a week	More than once a week	Once a week	More than once a week
Heart attack	0.74 (0.59-0.92)**	0.71 (0.61-0.82)***	0.78 (0.62-0.98)*	0.82 (0.70-0.95)*	0.81 (0.65-1.02)	0.91 (0.78-1.07)
Hypertension	0.91 (0.78-1.06)	0.77 (0.68-0.86)***	0.95 (0.81-1.12)	0.84 (0.75-0.95)**	0.97 (0.83-1.14)	0.89 (0.79-1.00)*
High blood cholesterol	1.04 (0.88-1.23)	0.89 (0.79-1.01)	1.15 (0.96-1.37)	1.05 (0.92-1.20)	1.16 (0.98-1.39	1.08 (0.95-1.24)
Diabetes	0.75 (0.61-0.92)**	0.60 (0.52-0.69)***	0.79 (0.64-0.98)*	0.67 (0.58-0.78)***	0.82 (0.67-1.01)	0.74 (0.64-0.87)***
Chronic lung disease	0.56 (0.42-0.75)***	0.56 (0.46-0.68)***	0.59 (0.44-0.80)**	0.62 (0.51-0.75)***	0.61 (0.46-0.82)**	0.67 (0.55-0.82)***
Cancer	0.83 (0.59-1.18)	0.78 (0.61-1.00)*	0.91 (0.64-1.29)	0.88 (0.69-1.13)	0.92 (0.64-1.31)	0.91 (0.70-1.17)
Stomach or duodenal ulcer	0.79 (0.58-1.07)	0.50 (0.40-0.62)***	0.87 (0.64-1.19)	0.57 (0.45-0.71)***	0.88 (0.69-1.21)	0.59 (0.47-0.75)***
Parkinson’s disease	0.50 (0.23-1.13)	0.46 (0.29-0.75)**	0.55 (0.25-1.23)	0.49 (0.30-0.80)**	0.57 (0.25-1.27)	0.54 (0.33-0.88)*
Hip fracture/femoral fracture	0.65 (0.41-1.02)	0.47 (0.35-0.63)***	0.71 (0.45-1.12)	0.53 (0.39-0.71)***	0.74 (0.47-1.16)	0.58 (0.43-0.78)***
Alzheimer's disease/dementia	0.62 (0.34-1.12)	0.77 (0.55-1.06)	0.66 (0.37-1.20)	0.79 (0.56-1.10)	0.70 (0.39-1.27)	0.90 (0.64-1.26)

Abbreviation: OR, odds ration; CI, confidence interval. [1] Physical activity “less than once a week” was the reference category.
Model 1: Analyses were adjusted for age, marital status, educational level, living place, smoking, and country. Model 2: Analyses were adjusted for age, marital status, educational level, living place, smoking, country, and the presence of others chronic diseases in 2011. Model 3: Analyses were adjusted for age, marital status, educational level, living place, smoking, country, vigorous physical activity and the presence of others chronic diseases in 2011. *p<0.05, **p<0.01, ***p<0.001.

Discussion

This study aimed to analyse the associations between self-reported LMPA frequency in 2011 and chronic diseases in 2011 and 2013 among European older adults. The results highlight that practicing LMPA weekly was inversely related with having some chronic diseases. Among men, engaging in LMPA more than once a week was related with lower odds of having cancer, and Parkinson's disease in 2011; and related with reduced likelihood of having cancer, stomach or duodenal ulcer, Parkinson's disease, hip or femoral fracture, and Alzheimer's disease in 2013. Among women, those who engage in LMPA more than once a week were less likely to have a heart attack, high blood cholesterol, hypertension, diabetes, chronic lung disease, cancer, stomach or duodenal ulcer, hip or femoral fracture, and Alzheimer's disease in 2011; also, the likelihood of having hypertension, diabetes, chronic lung disease, stomach or duodenal ulcer, Parkinson's disease, and hip or femoral fracture was significantly lower in 2013. One of the most relevant findings, among men and women, was that even one session of LMPA per week was associated with lower odds of having some chronic diseases both in 2011 and 2013.

Results from this study are in line with previous studies, showing that the practice of physical activity is related with lower odds of having chronic diseases, such as cardiovascular, metabolic and mental diseases (Huai et al., 2013; Lee & Paffenbarger, 2000; Lee et al., 2003; O'Donovan et al., 2017). Previous studies reported that older people would benefit from engaging in VPA (Lee & Paffenbarger, 2000; Marques et al., 2017a; Molmen-Hansen et al., 2012). Therefore, VPA is usually associated with a larger volume of exercise than LMPA, and offers greater health benefits (Lollgen, Bockenhoff, & Knapp, 2009). Nonetheless, this study's results provide support that older people would also benefit from engaging in LMPA in present and prospectively. This is particularly important because older adults are less likely to engage in VPA because of their physical condition (Jansen et al., 2015).

Achieving the physical activity recommendations, at vigorous or moderate intensity, seems to protect against chronic diseases (Bryan & Katzmarzyk, 2011; USDHHS, 2008). However, even small amounts of physical activity, regardless of adherence to prevailing physical activity guidelines (European Commission, 2008; WHO, 2010), have a positive impact on health (Moholdt et al., 2008; Souto Barreto et al., 2017; Wen et al., 2011) and contribute to reduced mortality (Hupin et al., 2015). Among older men and women, practicing LMPA once a week was related, with lower odds of having some chronic diseases both in 2011 and 2013. This could be a message of hope for inactive people and older adults who do not fulfil the regular physical activity recommendations for health (European Commission, 2008; WHO, 2010). If these people resolve to engage in LMPA, at least once a week, they will still collect some health benefits from it.

Different results for men and women were expected, because an interaction effect between sex and some chronic diseases was observed. For the present study LMPA is negatively cross-sectional and prospectively related with more chronic diseases among women than among men. It seems that LMPA might be more important to prevent chronic diseases in women, while for men the activities require more intensity. This suggests that the sex has a moderating effect on the relationship between LMPA frequency and chronic diseases (Keller & Howlett, 2016; Tambalis et al., 2016). Although there is already some descriptive data available that confirm a sex difference in the incidence and mortality of the most common chronic diseases (Kuri-Morales et al., 2009; Lee & Paffenbarger, 2000), so far there are no studies specifically designed to understand variations in disease mechanisms across both sexes. Future studies are needed to deeply analyse the interaction effect between sex and physical activity on chronic diseases within these specific populations.

The results from this study allow for a public health message. Despite the health benefits of physical activity (Ekelund et al., 2015; Marques, Peralta, Martins, Matos, & Brownson, 2017b; O'Donovan et al., 2017; Wen et al., 2011), the levels of physical activity among older European people are low (European Commission, 2014; Marques et al., 2015). Due to the health problems related with their physical condition, older adults hardly achieve the recommended levels of physical activity. Thus, the implementation of programs that promote participation in LMPA, even only once a week, may be an effective and more realistic strategy to reduce both sedentariness and the number of chronic diseases in the older population. More important, LMPA seems to have a prospectively effect against chronic diseases.

There are some strengths and limitations that should be noted. The main strength of this study was the SHARE database that includes a large and representative sample size of older adults from several European countries, as well as socio-demographic characteristics of the study sample. In view of the large sample and the heterogeneity of the participants, the generality of these results should be viewed as a strength. Additionally, due to the large sample size, there was an adequate statistical power. The principal limitation of the study is the lack of information on physical activity, such as duration and more detail about frequency. This lack of information precludes the calculation of physical activity volume more accurately. Physical activity was self-reported, which is susceptible to bias. Nonetheless, self-reported physical activity is a reliable method for epidemiologic studies (Craig et al., 2003), and is still the mainstay of surveillance studies (Pedisic & Bauman, 2015). Moreover, the follow-up was shorter than that of previous studies (Lee & Paffenbarger, 2000; Lee et al., 2003; Souto Barreto et al., 2017).

Conclusion

In conclusion, this study found that LMPA is associated with reduced risk for chronic diseases in European older men and women. Even the practice of LMPA once a week seems to be enough to diminish the risk of having chronic diseases, regardless of fulfilling the physical activity guidelines.

Competing interests

None of the authors declare competing financial interests.

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Article 5

Regular physical activity eliminates the harmful association of television watching with multimorbidity. A cross-sectional study from the European Social Survey

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Regular physical activity eliminates the harmful association of television watching with multimorbidity. A cross-sectional study from the European Social Survey

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Abstract

The aims of the study were to analyse the association of television viewing, physical activity (PA), and multimorbidity; and to understand if PA attenuates or eliminates the detrimental associations between television viewing and multimorbidity. This is a cross-sectional study based on data from the European Social Survey round 7, 2014. Participants were 32,931 adults (15,784 men), aged 18-114 years old, from 18 European countries. Self-reported information regarding chronic diseases (CD), PA and time watching television was collected through interview. Logistic regression analysis were conducted to analyse the association between watching television and PA with the presence of multimorbidity (≥2 CD). Men and women who watched television had increased odds of having multimorbidity. When considering PA it was observed that, independently of television viewing, compared to engaging in PA for ≤1 day/week, engaging in 2-4 days/week and in ≥5 days/week were inversely associated with multimorbidity. Increased odds of multimorbidity were observed for men spending more than 3 hours/day watching television in the 2-3 days/week and ≤ 1 day/week categories of PA. For women engaged in 30 minutes of physical activity 2-3 days/week, spending >3 hours/day watching television was associated with higher odds for multimorbidity. For adults who practiced physical activity on >= 5days/week watching television was not associated with multimorbidity. Time spent watching television is associated with multimorbidity. However, physical activity participation can attenuate or even eliminate this association.

Keywords: exercise; non-communicable diseases; sedentary behaviour

Introduction

The prevalence of sedentary behaviours has increased (Hansen et al., 2012; Kohl et al., 2012). In high-income countries most adults spend their awake time in sedentary behaviours (Dumith et al., 2011), being television viewing time reported as the most prevalent leisure-time sedentary behaviour (Clark et al., 2009; Harvey et al., 2013). Several studies have demonstrated that sedentary behaviours, and particularly the time spent watching television, is associated with increased risk for mortality and chronic diseases, such as obesity, diabetes, cardiovascular diseases, and some cancers (Ekelund et al., 2016; Keadle et al., 2015; Pinto Pereira et al., 2012).

The deleterious associations of television viewing with mortality and chronic diseases in adults has been investigated to be independent of physical activity (Wijndaele et al., 2011). Interestingly, although the detrimental impact of time watching television has been also observed in active people (Healy et al., 2008), higher levels of physical activity may attenuate or even eliminate the increased risk associated with sedentary behaviours (Ekelund et al., 2016; Rao et al., 2016).

Several studies have addressed the association of television viewing and physical activity with specific chronic diseases (Ekelund et al., 2016; Keadle et al., 2015; Pinto Pereira et al., 2012) but few studies have investigated this issue with the presence of multimorbidity. The World Health Organization defines multimorbidity as the coexistence of two or more chronic conditions (WHO, 2016). The prevalence of multimorbidity is considering high (Barnett et al., 2012; Prazeres & Santiago, 2015; Puth, Weckbecker, Schmid, & Munster, 2017), and evidence suggests that the most patients with chronic health conditions do not have a single diagnosis, but various diagnoses coexist within one person (Violan et al., 2014). Furthermore, multimorbidity becomes increasingly more common with age (Barnett et al., 2012; Prazeres &

Santiago, 2015; Puth et al., 2017), is linked with high disability and mortality (Barnett et al., 2012), increased hospital admissions, use of inpatient and ambulatory health care (Salisbury, Johnson, Purdy, Valderas, & Montgomery, 2011), and reduced functional status (Fortin et al., 2014). Due to the high prevalence of sedentary behaviours (Hansen et al., 2012; Kohl et al., 2012), particularly the time watching television (Clark et al., 2009; Harvey et al., 2013), ageing population, and a high proportion of inactive adults (Loyen et al., 2017; Marques et al., 2015), the prevalence of multimorbidity has been rising (Pefoyo et al., 2015; Prazeres & Santiago, 2015; WHO, 2016). Therefore, the aim of this study was twofold: a) to analyse the association of television viewing, physical activity, and multimorbidity; and b) to understand if physical activity attenuates or eliminates the detrimental association between television viewing and multimorbidity.

Methods

Study design and participants

This is a cross-sectional study based on data from the European Social Survey round 7, 2014, including 20 European countries (Austria, Belgium, Switzerland, Czech Republic, Germany, Denmark, Estonia, Spain, Finland, France, Hungary, Ireland, Israel, Lithuania, Netherlands, Norway, Poland, Portugal, Sweden, Slovenia, United Kingdom) and Israel. The European Social Survey is an academically driven survey that has been conducted every two years across Europe since 2001. The survey measures the attitudes, beliefs, and behaviours of European adults. The European Social Survey uses national representative samples among countries. Participants are sampled by means of postal code address files, population registers, social security register data, or telephone books. In each country, the information was collected using a questionnaire filled-in through an hour-long face-to-face interview that included questions on the use of medicine, immigration, citizenship, socio-demographic and socioeconomic issues, health status, and physical activity. The questionnaire was translated into the language of each of the participating countries by language experts. Further details about European Social Survey are available elsewhere (Schnaudt et al., 2014). The study protocol of the European Social Survey subscribes the Declaration on Professional Ethics of the International Statistical Institute (http://www.europeansocialsurvey.org/about/ethics.html).

Probability sampling from residents aged 15 years and older was applied in all countries (excluding only the homeless and the institutionalized population), comprising 40185 participants. For the present study participants under 18 years old were excluded from the analyses (n=1215), because the focus was on the adult population. Participants from Czech Republic and Estonia did not report information on chronic diseases and were therefore excluded (n=3943). Respondents without information in more than two socio-demographic variables were also excluded (n=2096). These restrictions resulted in a total sample size of 32931 participants (15784 men, 17147 women), aged 18-114 years old.

Measures

Chronic diseases

Chronic diseases (heart or circulation problems, high blood pressure, breathing problems, allergies, diabetes, and cancer) were assessed by asking participants to indicate whether they currently have, or had chronic diseases (yes/no) in the last 12 months. For obesity, body mass index (BMI) was calculated from self-reported height and weight (kg/m^2). body mass index categories were calculated in accordance with the WHO guidelines (WHO, 2000) and dichotomized into non-obese ($<30.0\ kg/m^2$)

and obese (≥30 kg/m^2). Multimorbidity was defined as the co-occurrence of two or more of these conditions.

Physical activity

Information on physical activity was assessed with a single item asking, “On how many of the last 7 days did you walk quickly, do sports, or other physical activity for 30 minutes or longer?”. Using the reported information on physical activity, a new variable was computed to classify participants into three groups: 1) practice of physical activity ≤1 day/week; 2) practice of physical activity 2-4 days/week; and 3) practice of physical activity ≥5 days/week. Although physical activity was assessed with a single item, there is evidence in previous studies that a single question is an acceptable alternative (Wanner et al., 2014). The American College of Sports Medicine highlights that, although health and fitness benefits may occur exercising only once per week, this is not recommended due to an increased risk in musculoskeletal injury and adverse cardiovascular events (ACSM, 2014). Accordingly, in this study, performing 0 and 1 days per week were grouped in the same category.

Time watching television

Participants were asked to report how much time, in total, they spend watching television on an average day. Responses were from no time to more than 3 hours, using intervals of 30 minutes. Based on previous recodification (Keadle et al., 2015), responses were recoded to “no time at all”, “less than 1-hour/day”, “2-3 hours/day”, and “more than 3 hours/day”.

Covariates

Participants reported their sex and age. The European Social Survey data provides two variables of education attainment: a recoded variable that focuses on achieved levels of education (primary, lower secondary, upper secondary, post-secondary, and tertiary education), according to the International Standard Classification of Education (UNESCO, 2012), and years of full-time education. Participants were asked to describe whether they lived with or without a husband/wife/partner, and their correspondent legal status (e.g. married, civil union, illegally recognized). Response options were dichotomized into live with or without a partner. To determine the living place, participants were asked to report whether they lived in a big city, suburbs or outskirts of a big city, town or small city, country village, or home in countryside. Those who indicated that they lived in a big city, or suburbs, or outskirts of a big city were grouped into a new category named urban areas; those who responded that they lived in country village or home in countryside were grouped into rural areas. Household income was determined based on decile. Using this data, 1^{st} to 3^{rd}, 4^{th} to 7^{th}, and 8^{th} to 10^{th} decile were grouped to create three groups: low, middle and high, respectively.

Participants were asked about their smoking behaviors. Response options ranged from "I have never smoked" to "I smoke every day". Because there is no threshold of safety for smoking cigarettes, responses were recoded into current smoker, former smoker, and never smoke. Participants were also asked how often they drink alcohol. Responses were recoded into less than once a month, 2-3 times a month, once a week, several times a week, and every day.

These socio-demographic variables were selected as covariates because they are determinant factors of physical activity and sedentary behaviours (Marques, Martins, Peralta, Catunda, & Nunes, 2016a). Age, education, socioeconomic status (Barnett et al., 2012; Prazeres & Santiago, 2015; Puth et al., 2017), employment status and family structured (Agborsangaya, Lau, Lahtinen, Cooke, & Johnson, 2012; Chung et al., 2015) are also related with multimorbidity. Smoking cigarettes was also selected due to its associations to the development of several chronic diseases and mortality (Dhalwani et al., 2017; Loef & Walach, 2012).

Statistical analysis

Descriptive statistics were calculated (means, standard deviation, and percentages) for the entire sample, and stratified by sex. Chi-square and Student t-test were used to compare men and women according to socio-demographic characteristics, the presence of chronic diseases in the last 12 months, multimorbidity, time spent watching television, and physical activity. To analyze the independent association of the time watching television and physical activity with multimorbidity a Chi-square test was used. Binary logistic regression models were conducted to analyze the association of watching television and practice of physical activity with the presence of multimorbidity. First, an unadjusted model was performed, afterwards analyses were adjusted for age, educational level, marital status, living place, country, and household income, smoking status and drinking alcohol. Finally, the analyses were further mutually adjusted for time watching television and physical activity. To analyse the effect of time spent watching television on multimorbidity, according to physical activity levels, new analyses were then performed stratified for physical activity frequency. These analyses were adjusted for age, educational level, marital status, living place, country, household income, smoking status, and drinking alcohol. Linear trends for odds-ratio were further assessed. All analyses were stratified by sex, because an interaction effect between sex and time spent watching television on chronic diseases was verified. Statistical analysis was performed using IBM SPSS Statistics v.24.0. The significance level was set at $p<0.05$.

Results

In table 1 are presented the descriptive characteristics of the participants. Considering both males and females, 21.6% of the participants had multimorbidity. Considering the time watching television, the category with fewer participants was “no time at all” (5%), while in the other extreme 32.9% of the participants spent 1-2 hours in this behaviour. Regarding physical activity, the proportion of participants was overall equally distributed by the three categories.

Table 1. Participants' characteristics for total sample and stratified by sex in 2014.

	Total (n=32931)	Men (n=15784)	Women (n=17147)
	% or M±SD	% or M±SD	% or M±SD
Education			
Low	25.6	20.3	30.6
Middle	51.3	57.2	45.8
High	23.1	22.5	23.7
Age	50.2±18.1	49.9±18.0	50.6±18.0
Marital status			
Live with partner	61.5	64.4	58.9
Live without partner	38.5	35.6	41.1
Living place			
Urban area	63.6	63.0	64.2
Rural area	36.4	37.0	35.8
Household income			
Low (1st to 3rd decile)	30.5	26.5	34.3
Middle (4th to 7th decile)	42.4	43.8	41.0
High (8th to 10th decile)	27.1	29.7	24.6
Cigarette smoking			
Current	24.0	27.9	20.5
Former	33.1	38.2	28.3
Never	42.9	33.9	51.2
Drinking alcohol			
Less than once a month	44.7	32.4	56.0
2-3- times/month	12.8	12.8	12.7
Once a week	18.5	21.2	16.0
Several times/week	16.6	22.4	11.3
Every day	7.5	11.2	4.0
Chronic diseases (last 12 month)			
Without chronic diseases	52.8	55.2	50.6
High blood pressure	19.1	18.7	19.4
Obesity	15.6	15.7	15.4
Allergies	11.8	10.1	13.3
Cancer	11.4	9.9	12.8
Heart or circulation problems	10.8	10.4	11.2
Breathing problems	8.7	8.1	9.3
Diabetes	5.8	6.2	5.5
Multimorbidity			
No	78.4	79.7	77.2
Yes	21.6	20.3	22.7
Time watching TV (hours/day)			
No time at all	5.0	5.2	4.8
< 1 hour	20.7	21.5	20.0
1-2 hours	31.3	31.4	31.2
2-3 hours	24.9	24.2	25.3
> 3 hours	18.1	17.4	18.7
Physical activity(times/week)			
≤1 time	34.7	33.1	36.3
2-4 times	32.8	33.3	32.6
≥5 times	32.4	33.9	31.1

Abbreviation: M, media; SD, standard deviation

Table 2 represents the prevalence of multimorbidity (≥2 chronic diseases) by television watching and physical activity categories, stratified by sex. Chi-square analysis demonstrated that, for both men and women, there were differences in the distribution of multimorbidity for television watching and physical activity categories.

Table 2. Prevalence of multimorbidity stratified by sex and physical activity and time watching television categories in 2014.

	Chronic diseases		
Men (n=15784)	≤ 1 chronic disease	Multimorbidity	*p*
Time watching TV (hours/day)			<0.001
No time at all	5.8	2.9	
< 1 hour	23.2	14.5	
1-2 hours	32.4	27.4	
2-3 hours	23.5	28.3	
> 3 hours	15.0	26.9	
Physical activity			<0.001
≤1 time/week	30.3	43.8	
2-4 times/week	34.7	26.5	
≥5 times/week	34.9	29.7	
Women (n=17147)			
Time watching TV (hours/day)			<0.001
No time at all	5.4	2.6	
< 1 hour	21.8	13.8	
1-2 hours	32.9	25.3	
2-3 hours	24.1	29.3	
> 3 hours	15.7	28.9	
Physical activity			<0.001
≤1 time/week	33.3	46.4	
2-4 times/week	34.4	26.4	
≥5 times/week	32.3	27.1	

Tested by Chi-square test.

Table 3 depicts the results for multiple logistic regression analysis. Unadjusted analysis demonstrated that, when comparing to no time watching television, participants that watched television had increased odds of having multimorbidity. When accounting for other social-demographic confounders, men spending more than 3 hours/day watching television had 1.6 (95% CI: 1.3-2.1) higher odds of multimorbidity than those who did not watch television. In women, results were similar to those of the unadjusted model. After additionally accounting for physical activity it was observed that men spending 2-3 hours/day (OR=1.3, 95% CI: 1.01-1.69) and >3 hours/day watching television had increased odds for multimorbidity. Also, independently of physical activity, increased odds for multimorbidity were observed for women reporting <1 hour/day (OR=1.33, 95% CI:1.03-1.71), 1-2 hours/day (OR=1.30, 1.02-1.66); 2-3 hours/day (OR=1.55, 1.21-1.99), and >3 hours/day (OR=1.81, 1.41; 2.32) watching television, compared to those that did not spend any time in this sedentary behaviour.

When considering physical activity it was observed that, independently of television watching, compared to engaging in physical activity for ≤1 day/week, engaging in 2-4 days/week (men: OR=0.69, 95% CI: 0.61-0.76; women: OR=0.77, 95% CI: 0.70-0.86) and in ≥5 days/week (men: OR=0.65, 95% CI: 0.58-0.72; women: OR=0.74, 95% CI: 0.67-0.82) were significantly and inversely associated with multimorbidity.

Table 3. Relationship between multimorbidity, and time spend watching television and physical activity in 2014.

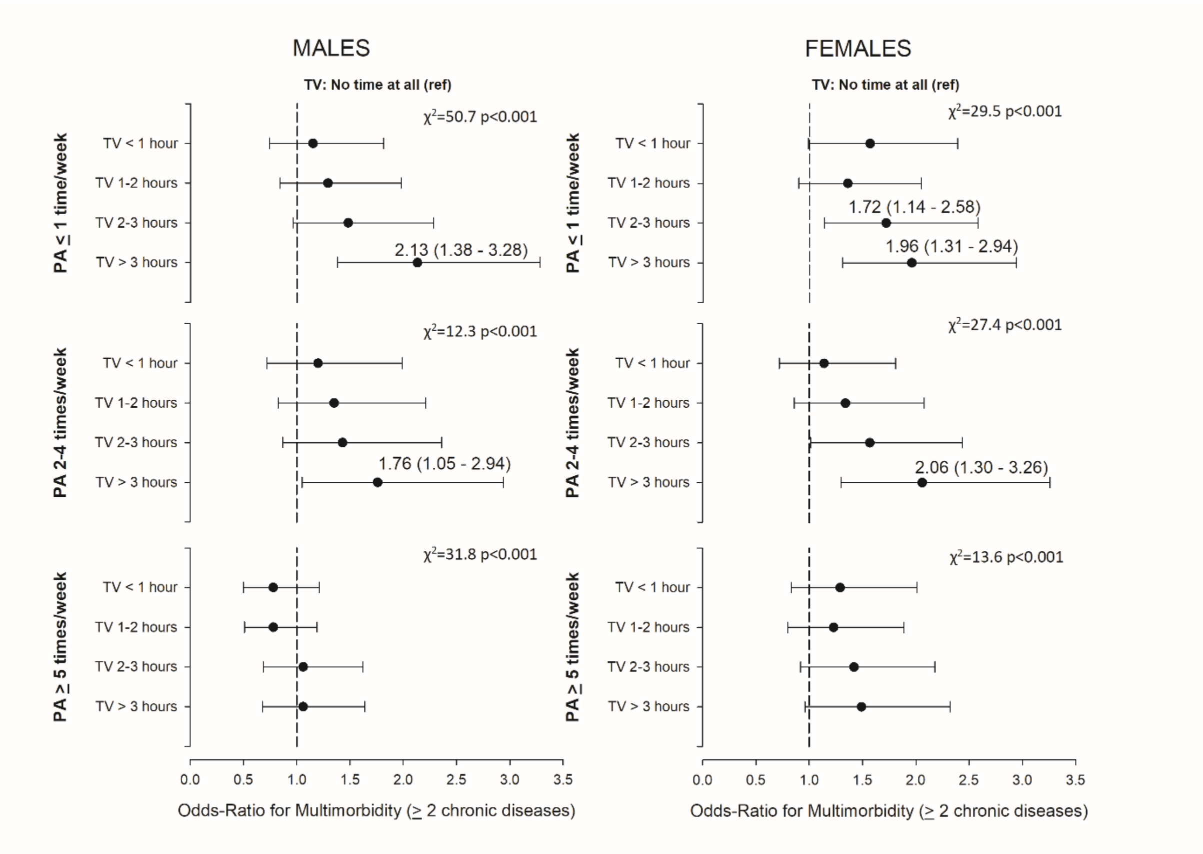
	Multimorbidity (≥ 2 chronic diseases)[1]		
	Model 1	Model 2	Model 3
Men	OR (95% CI)	OR (95% CI)	OR (95% CI)
Time watching TV (hours/day)			
No time at all	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
< 1 hour	1.25 (0.99-1.58)	1.01 (0.77-1.31)	1.02 (0.78-1.33)
1-2 hours	1.70 (1.35-2.13)	1.08 (0.84-1.40)	1.10 (0.85-1.42)
2-3 hours	2.42 (1.92-3.04)	1.28 (0.99-1.66)	1.30 (1.01-1.69)
> 3 hours	3.58 (2.84-4.51)	1.62 (1.25-2.11)	1.60 (1.23-2.09)
Physical activity			
≤1 time/week	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
2-4 times/week	0.53 (0.48-0.58)	0.68 (0.61-0.76)	0.69 (0.61-0.76)
≥5 times/week	0.59 (0.54-0.65)	0.64 (0.57-0.71)	0.65 (0.58-0.72)
	Model 1	Model 2	Model 3
Women	OR (95% CI)	OR (95% CI)	OR (95% CI)
Time watching TV (hours/day)			
No time at all	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
< 1 hour	1.29 (1.03-1.62)	1.32 (1.03-1.71)	1.33 (1.03-1.71)
1-2 hours	1.56 (1.26-1.94)	1.29 (1.01-1.65)	1.30 (1.02-1.66)
2-3 hours	2.48 (1.99-3.08)	1.55 (1.21-1.98)	1.55 (1.21-1.99)
> 3 hours	3.74 (3.00-4.66)	1.85 (1.44-2.37)	1.81 (1.41-2.32)
Physical activity			
≤1 time/week	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
2-4 times/week	0.55 (0.50-0.60)	0.76 (0.69-0.84)	0.77 (0.70-0.86)
≥5 times/week	0.60 (0.55-0.66)	0.72 (0.66-0.80)	0.74 (0.67-0.82)

[1] The reference category was not having multimorbidity.
Model 1: Unadjusted analyses.
Model 2: Analyses were adjusted for age, educational level, marital status, living place, country, and household income, smoking cigarettes smoking and drinking alcohol.
Model 3: Analyses were adjusted for age, educational level, marital status, living place, country, household income, smoking cigarettes smoking, drinking alcohol, and mutually adjusted for time spent watching TV and physical activity.

The associations of television watching with multimorbidity, stratified by sex and physical activity categories are illustrated in Figure 1. For participants engaging in 30 minutes of physical activity at least 5 days/week, time spent watching television and multimorbidity were not associated. Increased odds of multimorbidity were observed for men spending more than 3 hours/day watching television among those who reported engaging in physical activity 2-3 days/week (OR=1.76, 95% CI: 1.05-2.94) and ≤ 1 day/week (OR=2.13, 95% CI: 1.38-3.28). For women engaged in 30 minutes of physical activity 2-3 days/week spending >3 hours/day watching television was associated with higher odds for multimorbidity (OR=2.1, 95% CI: 1.3-3.3).

However, when analysing women that reported participating in physical activity ≤1 day/week, those watching television 2-3 hours/day and >3 hours/day had higher odds for multimorbidity, 1.7 (95% CI: 1.1-2.6) and 2.0 (95% CI: 1.3-3.0) respectively.

Figure 1. Relationship between multimorbidity, and time spend watching television stratified by sex and physical activity categories in 2014.



Abbreviations: PA, physical activity; TV, television
Analyses were adjusted for age, educational level, marital status, living place, country, household income, smoking status, drinking alcohol. χ^2 square was used to analyse linear-by-linear association between odds-ratio.

Discussion

This study provides data from over thirty thousand European adults and examines the association between television viewing and physical activity with multimorbidity. The main findings from the current investigation envision that television viewing was positively associated with multimorbidity, while physical activity was negatively related to multimorbidity. Interestingly, our results suggest that for participants who more frequently engage in physical activity, the harmful association between television viewing and multimorbidity is attenuated or even eliminated.

In the current investigation it was observed that the prevalence of multimorbidity was higher among those participants spending more time watching television and also for those performing less frequently physical activity. Additionally, the physical activity was related to lower odds, while time spent watching television was related to increased odds for multimorbidity, for both men and women, though in men this was only verified for those watching two or more hours of television. The risk for multiple chronic diseases has been previously investigated to be higher for those spending more time watching television (Keadle et al., 2015; Pinto Pereira et al., 2012) and lower for adults engaging in more physical activity (Cassidy, Chau, Catt, Bauman, & Trenell, 2016; Jakes et al., 2003). The results from our study further strengthen the negative role of sedentary behaviour in health, particularly watching television.

Previous investigations have observed that sedentary behaviour is deleteriously related to some chronic diseases (Keadle et al., 2015; Pinto Pereira et al., 2012). The findings from the current investigation extend these observations in a large sample of European adults and further verified that in participants engaging more frequently in physical activity (i.e. ≥5 days/week) these associations were not significant. This finding strengthens the evidence that being physically active (i.e. spending ≥30 min/d of moderate-to-vigorous physical activity for at least 5 days/week) is not only beneficial for not having multiple chronic disease, as it also helps to attenuate or eliminate the negative role of watching television. Ekelund et al. (2016) have also observed that the spending up to 4-hours watching television was not associated to all-cause mortality in more active participants (>35.5 MET-h/week). Although, previous studies have highlighted that higher levels of physical activity may attenuate or even eliminate the increased risk of time spent watching television in other outcomes such as mortality or metabolic syndrome (Ekelund et al., 2016; Rao et al., 2016), the role of physical activity in the relationship between watching television and multimorbidity has been less investigated.

Previous research has reported that, in adults, the association between watching television with mortality and chronic diseases is independent of physical activity (Wijndaele et al., 2011) and the detrimental impact of the time watching television on metabolic risk has been also observed in active people (Healy et al., 2008). Contrary, the findings from the current study suggest otherwise. Dissimilarities in the population studied and in the health outcome that was analysed may be in part responsible for the different conclusions.

Some strengths and limitations of the study should be acknowledged. The main strength of this study was the European Social Survey database, which includes a large and representative sample of adults from several European countries, as well as socio-demographic characteristics and numerous chronic diseases of the study sample. In view of the large sample and the heterogeneity of the participants, the generality of these results should be considered strengths of the study. Moreover, due to the large sample size, there was an adequate statistical power. Also, the use of multimorbidity, instead of specific single chronic diseases, as a health indicator is of importance, mainly because multimorbidity is becoming progressively common (Barnett et al., 2012) and an increasing burden for public health (Pefoyo et al., 2015). On the other hand, the main limitation of the study is the lack of information on physical activity, such as duration and more detail about frequency. This lacking information precludes the calculation of physical activity volume more accurately. Physical activity was self-reported which is susceptible to bias. Nonetheless, self-reported physical activity is a reliable method for epidemiologic studies (Craig et al., 2003), and is still as the mainstay of surveillance studies (Pedisic & Bauman, 2015). Furthermore, the cross-sectional design implies that no causal inferences can be made. However, the results from this study allow to generate hypothesis. It seems that being physically active is not only beneficial for not having multiple chronic disease, as it also helps to attenuate or eliminate the negative role of watching television. This generated hypothesis should stimulate future research using longitudinal design to analyse the cause-effect relationship between multimorbidity, physical activity, and time spending watching television.

Conclusion

The present study found that, independently, the time spent watching television and the frequency of physical activity are associated with multimorbidity. However, when combining these behaviours, physical activity participation attenuates or even eliminates the deleterious effect of watching television on the presence multiple chronic diseases. Future interventions to prevent multimorbidity should focus on increasing physical activity, particularly emphasising on accomplishment of physical activity recommendations. Still, whenever higher levels of physical activity are not achievable, for timing or health reasons, reducing screen time, and particularly the time watching television, may be suggested as an effective prevention strategy.

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Article 6

Physical activity buffers the negative relationship between multimorbidity, self-rated health and life satisfaction

Marques, A., Peralta, M., Rúbio, E., Gómez Chávez, F., & González Valeiro, M. (2018). Physical activity buffers the negative relationship between multimorbidity, self-rated health and life satisfaction. *Journal of Public Health.* DOI: 10.1093/pubmed/fdy012

Physical activity buffers the negative relationship between multimorbidity, self-rated health and life satisfaction

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Abstract

Background: This study aimed to examine the relationship between multimorbidity, self-rated health, and life satisfaction, and to test the moderating effect of physical activity on the relationship between multimorbidity, self-rated health, and life satisfaction. **Methods:** This is a cross-sectional study based on data from the European Social Survey 2014. Participants were 25713 adults (12830 men), aged 18-64 years old, from 18 European countries and Israel. Self-reported information regarding chronic diseases, health perception, life satisfaction, and physical activity was collected through interview. Multimorbidity was defined as the co-occurrence of ≥ 2chronic diseases. Linear regression models were used to estimate the effects of multimorbidity, physical activity, and the interaction effect of multimorbidity X physical activity on self-rated health and life satisfaction. **Results:** Multimorbidity was negatively related to self-rated health (d=0.03) and life satisfaction (d=0.03). Physical activity was positively related to self-rated health and life satisfaction. There was a significant interaction effect between multimorbidity and physical activity with regard to self-rated health ($\beta=0.01$, $p<0.001$) and life satisfaction ($\beta=0.04$, $p<0.001$). **Conclusions:** Physical activity buffered the negative relationship between multimorbidity, self-rated health and life satisfaction; contributing to better self-rated health and life satisfaction.

Keywords: chronic diseases; European; exercise

Introduction

Self-rated health reproduces the subjective experience of health, and it has been shown to be a significant predictor of morbidity and mortality (DeSalvo et al., 2006; Mavaddat et al., 2014b), related to several biomarkers such as blood pressure, blood levels of albumin, white blood cell count, haemoglobin, HDL cholesterol, serum creatinine, and a barometer of physiological states (DeSalvo et al., 2006; Jarczok et al., 2015; Jylha et al., 2006). Life satisfaction can be defined as a general evaluation of an individual's personal life, and has been related to several mental adverse health outcomes such as depression and psychiatric problems (Nes et al., 2013), along with somatic disability and mortality (Koivumaa-Honkanen et al., 2004). The association between self-rated health and life satisfaction with health outcomes enables a conceptual understanding of the health from people's perspective.

Multimorbidity, defined as the co-occurrence of two or more chronic diseases (Valderas, Starfield, Sibbald, Salisbury, & Roland, 2009) is a consequence of the aging of the population; it results from both an increase in the prevalence of chronic diseases (Global Burden of Disease Study, 2015), and the number of diseases from which a patient suffers (Marques et al., 2017b). Multimorbidity influences health perception and subjective wellbeing perhaps because of its physical and psychological consequences (WHO, 2016). Chronic diseases affect people ability to manage their daily functioning, and those people usually experienced a decline on their quality of life (Mukherjee, Ou, Wang, & Erickson, 2011). Thus, the presence of multimorbidity is negatively associated with both self-rated health (Cimarras-Otal et al., 2014; Mavaddat et al., 2014b; Perruccio et al., 2012) and life satisfaction (Lukkala et al., 2016). Most studies relating self-rated health or life satisfaction to chronic diseases focus on specific populations or specific diseases or group of diseases. For example, among middle-aged and older adults, poorer self-rated health is strongly associated with single chronic diseases, particularly cardiovascular diseases, multimorbidity, and poor psychosocial function (Mavaddat et al., 2014b; Perruccio et al., 2012; Wister, Kendig, Mitchell, Fyffe, & Loh, 2016), while life satisfaction is inversely associated with multimorbidity (Lukkala et al., 2016; Wister et al., 2016). Similarly, cardiovascular mortality in the general populations with and without prior cardiovascular disease is associated with poor self-rated health (Mavaddat, Parker, Sanderson, Mant, & Kinmonth, 2014a). Also, increased risk of specific diseases, such as cancer, stroke and type 2 diabetes mellitus are associated with lower life satisfaction (Feller, Teucher, Kaaks, Boeing, & Vigl, 2013).

In opposition to multimorbidity, physical activity has been shown to have a significant and positive association with self-rated health and life satisfaction (Maher et al., 2015; Sodergren et al., 2008). Furthermore, physical activity can reduce chronic diseases and the risk of disease progression (Ekelund et al., 2015; O'Donovan et al., 2017; Wen et al., 2011), and it is inversely associated with multimorbidity (Cimarras-Otal et al., 2014). However, the possibility for physical activity moderating the relationship between multimorbidity and self-rated health and life satisfaction has yet to be explored. It is thus expected that, by having a positive effect on self-rated health and life satisfaction, and by having a protective health effect against chronic diseases, physical activity might moderate the relationship between multimorbidity and self-rated health and life satisfaction. Therefore, the purpose of this study was two-pronged: a) to examine the relationship between multimorbidity, self-rated health, and life satisfaction, and b) to test the moderating effect of physical activity on the relationship between multimorbidity, self-rated health, and life satisfaction.

Methods

Study design and participants

The present study was based on the seventh wave of the European Social Survey, 2014, which included 20 European countries (Austria, Belgium, Switzerland, Czech Republic, Germany, Denmark, Estonia, Spain, Finland, France, Hungary, Ireland, Lithuania, Netherlands, Norway, Poland, Portugal, Sweden, Slovenia, United Kingdom) and Israel. The European Social Survey is a survey that has been conducted every two years to measure the attitudes, beliefs, and behaviours of European adults. The survey uses representative samples among countries. Participants were sampled by: postal code, address files, social security registry data, population registers, and/or telephone books. The information was collected in each country, using a questionnaire filled-in through an hour-long face-to-face interview. The questionnaire was translated, by language experts, into the language spoken in each of the participating countries. Further details about the European Social Survey are available elsewhere (Schnaudt et al., 2014). The study protocol subscribes to the Declaration on Professional Ethics of the International Statistical Institute.

Probability sampling from residents aged 15 years and older was applied (excluding the homeless, and institutionalized people), comprising 40185 participants. For the present study participants under 18 years and above 64 years of age were excluded (n=9851), because the focus was on the adult population. Participants from Czech Republic and Estonia, and others that also did not report information on chronic diseases and were therefore excluded (n=4255). Respondents without information in more than two socio-demographic variables were also excluded (n=366). These restrictions resulted in a sample of 25713 participants (12830 men, 12883 women).

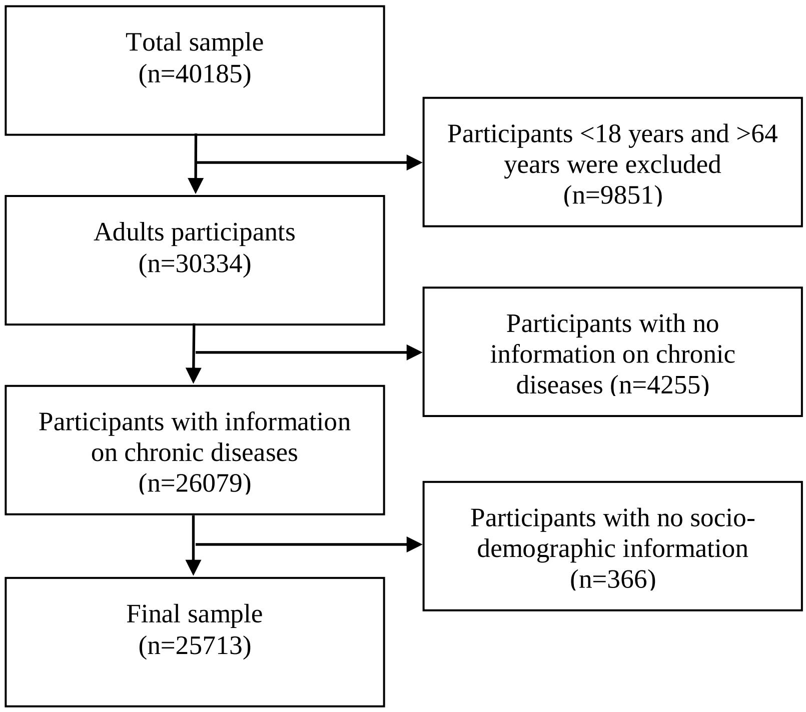

Figure 1. Flow chart diagram of participants.

Measures

Chronic diseases

Most of the chronic diseases (heart or circulation problems, high blood pressure, diabetes, stomach or digestion problems, breathing problems, allergies, headaches, and cancer) were assessed by asking participants to indicate whether they currently have, or had, chronic diseases (yes/no) in the last 12 months. For obesity, body mass index (BMI) was calculated from self-reported height and weight (kg/m^2). Body mass index categories were calculated in accordance with the WHO guidelines (WHO, 2000) and dichotomized into non-obese (<30.0 kg/m^2) and obese (≥30 kg/m^2). Multimorbidity was defined as the co-occurrence of two or more of the nine aforementioned diseases (Valderas et al., 2009).

Physical activity

Physical activity was assessed with a single item asking, “On how many of the last 7 days did you walk quickly, do sports, or other physical activity for 30 minutes or longer?” Although physical activity was assessed with a single item, there is evidence in previous studies that a single question is an acceptable alternative (Wanner et al., 2014); this approach was used previously with European Social Survey data (Marques et al., 2016b; Marques et al., 2015).

Self-rated health

Self-rated health was assessed with a single item question. Participants were asked, “How is your health in general?” The response options were: very bad, bad, fair, good, or very good. This single item question has been widely validated in epidemiological studies (Chandola & Jenkinson, 2000; Marques et al., 2016b; Marques et al., 2015). Previous studies have found a relationship between levels of self-rated health and adverse health outcomes, indicating its validity (Bopp, Braun, Gutzwiller, Faeh, & Swiss National Cohort Study, 2012; DeSalvo et al., 2006).

Life satisfaction

Life satisfaction was assessed with the item, “How satisfied are you with your life as a whole nowadays?” Responses were indicated using a scale ranging from 0 “extremely dissatisfied” to 10 “extremely satisfied.” Studies have shown that life satisfaction is associated to mental health outcomes (Nes et al., 2013), can predict mortality (St John et al., 2015), and that one single item is a robust measure capable of reliably estimating life-satisfaction (Cheung & Lucas, 2014).

Covariates

Participants reported sex, age, and years of full-time education. Respondents were asked to describe whether they live with or without a husband/wife/partner, and the legal situation. Response options were dichotomized into live with, or without, a partner. Household income was determined based on decile. It is a socioeconomic indicator as important as or more important than education and occupation, because is indicative of a standard of living (Daly, Duncan, McDonough, & Williams, 2002). Household income also shows relationship with health status (Bird, Lemstra, Rogers, & Moraros, 2015). Using household income decile information, 1^{st} to 3^{rd} decile, 4^{th} to 7^{th} decile, and 8^{th} to 10^{th} were grouped to create three groups. Participants were asked to report their occupation. To determine the living place, those who indicated that they lived in a big city, the suburbs, or the outskirts of big city were grouped into a new category named urban areas; those who responded that they lived in the country, a village, or a home in countryside were grouped into rural areas. Participants answered if they lived with or without children at home, along with the number of people living regularly as a member of the household.

Data analysis

Descriptive statistics were calculated for the entire sample (means, standard deviation, and percentages). The relationship between the presence or absence of chronic diseases and multimorbidity, according self-rated health and life satisfaction, was tested by ANCOVA. Linear regression models were used to estimate the principal effects of multimorbidity, physical activity, and the interaction effect of multimorbidity X physical activity on self-rated health and life satisfaction. Multimorbidity enters the models as a dummy variable, and physical activity as a continuous variable. To calculate the variable that expresses the interaction effect (multimorbidity X physical activity), physical activity was transformed using grand mean centring. The grand mean centring was calculated by taking each value of physical activity (times/week) and subtracting from it the mean of the total sample.

Physical activity grand mean centring was then multiplied by multimorbidity to have a variable to test the moderation effect (multimorbidity X physical activity). Analyses were not stratified by sex or age because an interaction effect between sex and age on multimorbidity was not verified. For ANCOVA and linear regression, the analysis were adjusted for sex, age, education, marital status, household income, occupation, living place, having children, and household members. Statistical analysis was performed using IBM SPSS Statistics v.24.0. The significance level was set at $p<0.05$.

Results

Table 1 presents the characteristics of the study sample. The most prevalent chronic diseases were: high blood pressure (17.5%), stomach or digestion problems (16.2%) and obesity (15.5%). Almost 30% of the participants had multimorbidity (≥ 2 chronic diseases). From 1 to 5, the mean value for self-rated health was 3.8±0.9, and from 0 to 10, the mean of life satisfaction was 7.2±2.2. Physical activity was practiced, on average, 3.2±2.6 times/week.

Table 1. Participants' characteristics for total sample and stratified by sex in 2014.

	Total (n=25713)
	% or M±SD
Sex	
Male	48.7
Female	51.3
Age	47.4±18.3
Education (years)	12.5±3.9
Marital status	
Live with partner	62.0
Live without partner	38.0
Household income	
Low (1st to 3rd decile)	30.1
Middle (4th to 7th decile)	43.1
High (8th to 10th decile)	26.8
Occupation	
Employed	61.9
Unemployed	6.8
Student	8.7
Retired	22.5
Living place	
Urban area	61.1
Rural area	38.9
Children	
Do not have children	60.8
Have children	39.2
Household members	2.8±1.4
Chronic diseases (last 12 month)	
Heart or circulation problems	9.8
High blood pressure	17.5
Diabetes	4.9
Obesity	15.5
Stomach/digestion problems	16.2
Breathing problems	8.8
Allergies	12.4
Headaches	14.4
Cancer	10.3
Multimorbidity	
No	70.3
Yes	29.7
Self-rated health	3.8±0.9
Life satisfaction	7.2±2.2
Physical activity(times/week)	3.2±2.6

Results of the relationship between the presence or absence of chronic diseases and multimorbidity, according to self-rated health and life satisfaction, are presented in table 2. For each chronic disease, participants who did not report having the disease had significantly better self-rated health than those who reported having the disease.

Similar results were observed for life satisfaction. Those who did not report the presence of the disease had better life satisfaction, with the exception of allergies. Although the effect size was small, multimorbidity was also significantly related to self-rated health and life satisfaction. Those without multimorbidity had better self-rated health (4.08±0.77 vs. 3.40±0.89, F(1)=2399.93, p<0.001) and better life satisfaction (7.37±20.00 vs. 6.86±2.30, F(1)=243.35, p<0.001).

Tables 2. Relationship between, chronic diseases and the presence of multimorbidity and self-rated health of European adults in 2014.

Chronic diseases and multimorbidity	Self-rated health		Life satisfaction	
	Mean±SD	*p*	Mean±SD	*p*
Heart or circulation problems		<0.001		<0.001
No	3.96±0.81		7.28±2.07	
Yes	3.08±0.90		6.62±2.39	
High blood pressure		<0.001		<0.001
No	3.99±0.82		7.29±2.05	
Yes	3.35±0.87		6.89±2.33	
Diabetes		<0.001		<0.001
No	3.92±0.84		7.24±2.09	
Yes	3.09±0.89		6.82±2.38	
Obesity		<0.001		<0.001
No	3.95±0.84		7.28±2.07	
Yes	3.49±0.87		6.90±2.29	
Stomach/digestion problems		<0.001		<0.001
No	3.94±0.84		7.27±2.08	
Yes	3.59±0.91		6.97±2.21	
Breathing problems		<0.001		<0.001
No	3.93±0.84		7.25±2.08	
Yes	3.34±0.96		6.88±2.33	
Allergies		<0.001		0.964
No	3.89±0.86		7.21±2.11	
Yes	3.81±0.87		7.27±2.09	
Headaches		<0.001		<0.001
No	3.92±0.84		7.30±2.05	
Yes	3.64±0.93		6.77±2.37	
Cancer		<0.001		<0.001
No	3.93±0.84		7.25±2.08	
Yes	3.43±0.95		6.93±2.33	
Multimorbidity		<0.001		<0.001
No	4.08±0.77		7.37±2.00	
Yes	3.40±0.89		6.86±2.30	

Tested by ANCOVA.
Abbreviation: SD, standard deviation
Analysis were adjusted for sex, age, education, marital status, household income, occupation, living place, having children, and household members.

Table 3 depicts the results for linear regression analysis. Unadjusted analysis demonstrated that multimorbidity was negatively related to self-rated health and life satisfaction. When accounting for other social-demographic confounders, multimorbidity remained negatively related with self-rated health (β=-0.52, 95% CI: -0.54 to -0.50, $p<0.001$) and life satisfaction (β=-0.43, 95% CI: -0.49 to -0.37, $p<0.001$). In turn, in the unadjusted and adjusted model, physical activity was positively related to self-rated health (β=0.04, 95% CI: 0.04 to 0.05, $p<0.001$) and life satisfaction (β=0.07, 95% CI: 0.05 to 0.08, $p<0.001$). There was a significant interaction effect between multimorbidity and physical activity with regard to self-rated health (β=0.01, 95% CI: 0.01 to 0.02, $p<0.001$) and life satisfaction (β=0.04, 95% CI: 0.02 to 0.06, $p<0.001$), portraying physical activity as a moderator of the relationship between multimorbidity and these variables.

Table 3. Main and interaction effect of multimorbidity and physical activity on self-rated health and life satisfaction of European adults in 2014.

	Self-rated health	
	Model 1 β (95% CI)	Model 2 β (95% CI)
Multimorbidity[a]	-0,60 (-0.68,-0.64)*	-0.52 (-0,54, -0.50)*
Physical activity	0.05 (0.04, 0.05)*	0.04 (0.04, 0.05)*
Multimorbidity * physical activity[b]	0.02 (0.02, 0.03)*	0.01 (0.00, 0.02)*
	Life satisfaction	
	Model 1 β (95% CI)	Model 2 β (95% CI)
Multimorbidity[a]	-0.48 (-0.54, -0.42)*	-0.43 (-0.49, -0.37)*
Physical activity	0.07 (0.06, 0.09)*	0.07 (0.05, 0.08)*
Multimorbidity * physical activity[b]	0.04 (0.02, 0.06)*	0.04 (0.02, 0.06)*

Abbreviation: CI, confidence interval
[a]Multimorbidity enter into the model as a dummy variable.
[b]Physical activity was transformed using grand mean centring. The grand mean centring was achieved by taking each value of physical activity (times/week) and subtracting from it the mean of the total sample.
Model 1: Unadjusted analyses. Model 2: Analyses were adjusted for sex, age, education, marital status, household income, occupation, living place, having children, and household members.
* $p<0.001$

Discussion

Main finding of this study

This study investigated the relationship between multimorbidity, self-rated health, and life satisfaction, as well as the moderating effect of physical activity on the relationship between multimorbidity, self-rated health and life satisfaction. Multimorbidity was negatively related to self-rated health and life satisfaction. On the other hand, physical activity was positively related to self-rated health and life satisfaction, thereby buffering the effect of multimorbidity on self-rated health and life satisfaction. In sum, physical activity moderates the effect of multimorbidity on self-rated health and life satisfaction.

What is already known on this topic

Subjective health expressed, as self-rated health, is associated with single chronic diseases and with multimorbidity. Those with chronic diseases and multimorbidity had lower self-rated health. Results from this study are in line with previous findings in literature (Cimarras-Otal et al., 2014; Mavaddat et al., 2014b; Perruccio et al., 2012). These results corroborate that self-rated health is a proxy of health biomarkers (DeSalvo et al., 2006), and a barometer of physiologic states (Jylha et al., 2006), because it is sensitive to the presence of chronic diseases or multimorbidity. Self-rated health is correlated with socio-demographic factors (Mavaddat et al., 2014b; Perruccio et al., 2012). However, adjusting the analysis of the relationship between multimorbidity and self-rated health, for socio-demographic factors, did not significantly modify the association. This reinforces the strong relationship between the two variables, independently of socio-demographic factors.

Literature shows that chronic diseases and multimorbidity are associated with lower life satisfaction (Hu, Lei, Chao, Hall, & Chung, 2016; Lukkala et al., 2016). This was observed, in the present study, for all particular chronic diseases (except for allergies) and for multimorbidity, confirming that the presence of these diseases, or a cluster of these diseases, has a negative effect on subjective wellbeing. The observed negative relationship supports the fact that life satisfaction depends on the individual's health status (Schuz, Wurm, Warner, & Tesch-Romer, 2009). This finding depicts life satisfaction as an important health outcome used to characterize the population's health and wellbeing (Diener, 1994; Nes et al., 2013).

Regarding the relationship between physical activity, self-rated health, and life satisfaction, this study's results provide evidence that regular physical activity is associated with better self-rated health and life satisfaction among adults. Previous studies have also demonstrated the positive relationship between these variables (Maher et al., 2015; Sodergren et al., 2008). The impact of physical activity on self-rated health and life satisfaction is observed even among people with chronic diseases (Lee, Kim, & Merighi, 2015; Mulroy et al., 2016), and exists across the spectra of both age and socioeconomic status (Maher et al., 2015; Trachte, Geyer, & Sperlich, 2016).

What this study adds

The identification of physical activity as a mediator between multimorbidity, self-rated health, and life satisfaction is of importance because this moderation effect changes the slope of the negative relationship (i.e., physically active people with multimorbidity can have better self-rated health and life satisfaction than their non-active peers). Considering that self-rated health and life satisfaction are directly linked to mortality, health biomarkers, and mental health outcomes (DeSalvo et al., 2006; Mavaddat et al., 2014b; Nes et al., 2013), improving self-rated health and life satisfaction can result in improving general health status. This study's results offer potential targets for future public health interventions. In order to enhance overall physical and mental health status, both of which are strongly linked to self-rated health and life satisfaction, physical activity should be promoted. For those who are not physically active, even a minimum amount of physical activity has a protective health effect against chronic diseases and mortality (Ekelund et al., 2015; O'Donovan et al., 2017; Wen et al., 2011).

Limitations of this study

A number of strengths and limitations should be kept in mind. The main strength of this study was the European Social Survey database, which includes a large and representative sample of adults from several European countries, as well as socio-demographic characteristics and numerous chronic diseases of the study sample. In view of the large sample and the heterogeneity of the participants, the generality of these results should be considered strengths of the study. The use of multimorbidity as a predictor variable is of importance, because multimorbidity is becoming progressively common (Barnett et al., 2012), and is an increasing burden for public health (Pefoyo et al., 2015). On the other hand, there are some limitations that should be acknowledged. The cross-sectional design implies that no causal inferences can be made. The current study cannot answer the question whether multimorbidity changes self-rated health and life satisfaction, or vice versa. Although the large and representative sample of adults contributes to the generalization of the results, when doing so and when designing public health interventions the cultural and socio-demographic differences across European countries should be taken into account. Notwithstanding, all the analyses were adjusted to socio-demographic characteristics. Multimorbidity was based on self-reports, and only nine chronic diseases were considered, albeit the major ones (WHO, 2014). However, studies have suggested that self-reported chronic disease is fairly to largely accurate for most diseases (Hansen et al., 2014). Physical activity was self-reported which could be subject to bias in terms of over- and underestimation (Marques et al., 2014). Nonetheless, self-reported physical activity is a reliable method for epidemiologic studies, and is still the mainstay of surveillance studies (Pedisic & Bauman, 2015). Considering that only nine chronic diseases were used to calculate multimorbidity, perhaps some participants classified as not suffering from multimorbidity could be included in this group if more diseases had been asked for. Nevertheless, the chronic diseases included in the study were the most prevalent ones. Finally, the European Social Survey had no data on whether individuals had mobility limitations or not. Therefore the analyses were not adjusted for mobility limitations.

Conclusion

Multimorbidity was negatively related to self-rated health and life satisfaction. Physical activity buffered these relationships, contributing to better self-rated health and life satisfaction, even among European adults with multimorbidity. These findings offer potential targets for future public health interventions. Promoting physical activity, and thus improving self-rated health and life satisfaction in order to enhance overall physical and mental health status, is suggested to be an important intervention strategy.

Conflict of Interest

The authors declare none conflict of interests.

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General conclusion

This study aimed to analysed the relationship between physical activity and chronic diseases or multimorbidity among European adults from several countries. This study is particularly important because chronic diseases affects negatively quality of life (WHO, 2017), and are the leading cause of morbidity and mortality worldwide (WHO, 2015, 2016, 2017). Therefore, it is important to identity the behaviours that could effectively reduce or prevent chronic diseases. Chronic diseases are mainly caused by an unhealthy and sedentary lifestyle (Lee et al., 2012; Rayner et al., 2017). Thus, the practice of physical activity in a regular basis is recommended (European Union, 2008; USDHHS, 2008; WHO, 2010) for being effective in primary and secondary prevention of chronic diseases (Alves et al., 2016). From the present study, it could be concluded that:

a) among men and women, moderate or vigorous physical activity is cross-sectional and prospectively associated with fewer reported chronic diseases;

b) engaged in physical activity 2-4 times/week and ≥5 times/week decrease the odds of having heart problems, high blood pressure, breathing problems, type 2 diabetes, and obesity, compared with who engaged in physical activity 1 or less times per week;

c) moderate or vigorous physical activity is associated with reduced risk of chronic diseases in men and women, and even the practice of vigorous physical activity once a week seems to be sufficient to reduce risks of chronic diseases, regardless of adherence to prevailing physical activity guidelines;

d) time spend watching television is associated with multimorbidity, but physical activity participation can attenuate or even eliminate this association;

e) physical activity buffered the negative relationship between multimorbidity, self-rated health and life satisfaction; contributing to better self-rated health and life satisfaction.

These study's results support the well-documented opposite relationship between physical activity and chronic diseases (Bryan & Katzmarzyk, 2011; Huai et al., 2013; Lee & Paffenbarger, 2001). In fact, engaging in moderate or vigorous physical activity more than once a week is related with reducing the number of chronic diseases, strengthening earlier findings (Della Valle et al., 2008; Kruk, 2007). Analysing patterns of physical activity and its relationship with the number of chronic diseases prospectively, the intensity of physical activity was revealed as an important factor. Participation in vigorous physical activity is negatively related with the number of chronic diseases. Prior study findings proposed that only physical activity at vigorous intensity was inversely related to reductions in coronary heart disease risk for men (Sesso et al., 2000). It suggests that vigorous physical activity should be adopted to diminish the number of chronic diseases, even for those who are inactive. Furthermore, the association between the trajectory of physical activity and the number of chronic diseases shows that the physical activity practice in the present is the most important. This is of importance for those who are inactive, because if they decide to engage in physical activity, they will collect its benefits notwithstanding of the past behaviours.

From these study it is possible to endorse the fact that even a few episodes of physical activity weekly have impact on health, and could contribute to reduce mortality (Moholdt et al., 2008; O'Donovan et al., 2017; Souto Barreto et al., 2017; Wisloff et al., 2006). From public health view point this is an important message because most adults have several commitments leading to physical inactivity (Loyen et al., 2017; Marques et al., 2015). Adults have to make trade-offs between necessary (work) activities and physical activity, which could be considered as a discretionary activity.

The negative relationship between physical activity and several chronic diseases, such as heart problems, high blood pressure, type 2 diabetes, and obesity reinforces the role of physical activity engagement to reduce the clinical manifestation of heart problems (Ahmad et al., 2016; Lee et al., 2003; Murtagh et al., 2015; Patel et al., 2016). Physical activity was observed to be independently, and after adjustments for several chronic diseases, negatively associated with these chronic diseases. These results strengthen the importance of an active lifestyle as a protective factor against these diseases. Thus, physical activity has been recommended (WHO, 2010), in order to reverse the increasing prevalence of inactivity and its effects on public health (Lee et al., 2012).

Considering the harmful associations of television viewing with mortality and chronic diseases in adults (Keadle et al., 2015; Pinto Pereira et al., 2012; Wijndaele et al., 2011), it would be interesting to verified whether physical activity may attenuate or even eliminate the increased risk associated with sedentary behaviours. From this study it was observed that television viewing was positively associated with multimorbidity, physical activity was negatively related to multimorbidity, but the harmful association between television viewing and multimorbidity is attenuated or even eliminated by engaging in physical activity.

A previous studies have observed that spending up to 4-hours watching television was not associated to all-cause mortality in more active participants (Ekelund et al., 2016). Demonstrating that higher levels of physical activity may attenuate or even eliminate the increased risk of time spent watching television in other outcomes such as mortality or metabolic syndrome (Ekelund et al., 2016; Rao et al., 2016). The findings from the current investigation extend these observations in a large sample of European adults and additional verified that in participants engaging more frequently in physical these associations were not significant. This finding reinforces the evidence that being physically active is not only beneficial for not having multiple chronic disease, as it also helps to attenuate or eliminate the negative role of watching television. However, the role of physical activity in the relationship between watching television and multimorbidity has been less investigated.

For the relationship between multimorbidity, self-rated health, and life satisfaction, physical activity moderates the effect of multimorbidity on self-rated health and life satisfaction. People with multimorbidity had lower self-rated health and life satisfaction (Cimarras-Otal et al., 2014; Lukkala et al., 2016; Mavaddat et al., 2014b); in opposition, physical activity is positively linked to self-rated health and life satisfaction (Maher et al., 2015; Sodergren et al., 2008). Therefore, the observation of physical activity as a mediator between multimorbidity, self-rated health, and life satisfaction is important because this moderation effect changes the slope of the negative relationship (i.e., physically active people with multimorbidity can have better self-rated health and life satisfaction than their non-active peers). Once self-rated health and life satisfaction are related to mortality, health biomarkers, and mental health outcomes (DeSalvo et al., 2006; Mavaddat et al., 2014b; Nes et al., 2013), improving self-rated health and life satisfaction may result in improving health status. Thus, physical activity should be promoted should be promoted to enhance overall physical and mental health status, both of which are strongly linked to self-rated health and life satisfaction

Despite the benefits of physical activity in preventing or reduce chronic diseases (Ekelund et al., 2015; Marques et al., 2017b; O'Donovan et al., 2017; Wen et al., 2011), its levels among people with chronic diseases are low (Evenson et al., 2014; Lin et al., 2010). Therefore, the implementation of programs to promote participation in moderate or vigorous physical activity, even only once a week, should be considered as a strategy to reduce the number of chronic diseases among adult and in the older population.

Strengths and limitation

From these studies some strengths and limitations of the study should be acknowledged and kept in mind. A major strength were the European Social Survey and the Survey of Health, Aging, and Retirement in Europe databases that includes a large and representative sample size of various European countries, as well as several socio-demographic characteristics of the study sample. Another strength, considering the sample size and the heterogeneity of the participants, is the generality of these results. Due to the large sample, there was an adequate statistical power. Prospective analysis allows for the examination of the cause and effect relationship between physical activity and chronic diseases. Furthermore, the use of multimorbidity as a predictor variable is of importance, because multimorbidity is becoming progressively common (Barnett et al., 2012), and is an increasing burden for public health (Pefoyo et al., 2015).

The central limitation is the lack of information on physical activity, such as type, duration, and frequency, which limits a precise calculation of physical activity volume. Physical activity was self-reported which is susceptible to bias. Additionally, physical activity was measured using a single item. However, self-reported physical activity is considered a reliable method for epidemiologic studies (Craig et al., 2003), and there is evidence that assessed physical activity with a single question is an acceptable alternative (Wanner et al., 2014). For the prospective analysis, the follow-up was shorter than that of previous prospective studies (Lee & Paffenbarger, 2000; Lee et al., 2003; Souto Barreto et al., 2017). Chronic diseases were also self-reported, but studies have suggested that self-report of chronic diseases is fairly to largely accurate for most chronic diseases (Haapanen et al., 1997; Hansen et al., 2014).

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Appendixes

Published articles

Article 1

Marques, A., Peralta, M., Martins, J., Matos, M. G., & Browson, R. (2017). Cross-sectional and prospective relationship between physical activity and chronic diseases in European older adults. *International Journal of Public Health, 62(4)*, 495-502. DOI: 10.1007/s00038-016-0919-4

Article 2

Marques, A., Santos, T., Martins, J., Matos, M. G., & González Valeiro, M. (2018). The association between physical activity and chronic diseases in European adults. *European Journal of Sport Science, 18(1)*, 140-149. DOI: 10.1080/17461391.2017.1400109

Article 3

Marques, A., Peralta, M., Sarmento, H., Martins, J., & González Valeiro, M. (2017). Associations between vigorous physical activity and chronic diseases in older adults: a cross-sectional and prospective study in 13 European countries. *European Journal of Public Health.* DOI: 10.1093/eurpub/cky086

Article 4

Marques, A., Peralta, M., Martins, J., Rúbio, E., González Valeiro, M. (2017). Cross-sectional and prospective relationship between low to moderate-intensity physical activity and chronic diseases in older adults from 13 European countries. *Journal of Aging and Physical Activity*. (Accepted for publication)

Article 5

Marques, A., Santos, D., Peralta, M., Sardinha, L., & Gonzalez Valeiro, M. (2018). Regular physical activity eliminates the harmful association of television watching with multimorbidity. A cross-sectional study from the European Social Survey. *Preventive Medicine, 109*, 28-33. DOI: 10.1016/j.ypmed.2018.01.015

Article 6

Marques, A., Peralta, M., Rúbio, E., Gómez Chávez, F., & González Valeiro, M. (2018). Physical activity buffers the negative relationship between multimorbidity, self-rated health and life satisfaction. *Journal of Public Health*. DOI: 10.1093/pubmed/fdy012.

Expanded abstract in Spanish

Expanded abstract in Galego

Article 1

Marques, A., Peralta, M., Martins, J., Matos, M. G., & Browson, R. (2017). Cross-sectional and prospective relationship between physical activity and chronic diseases in European older adults. *International Journal of Public Health, 62(4)*, 495-502. DOI: 10.1007/s00038-016-0919-4

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ORIGINAL ARTICLE

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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Article 2

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ORIGINAL ARTICLE

The association between physical activity and chronic diseases in European adults

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Abstract
Chronic diseases are the leading cause of morbidity and mortality and are considered to be at epidemic levels worldwide. This is a cross-sectional multi-country study based on data from the European Social Survey round 7, 2014, comprising 30,826 participants (14,813 men) with mean age 50.4 ± 18.0. Physical activity and chronic diseases were self-reported. Men and women who practiced physical activity more often had lower odds of having heart problems, breathing problems, type 2 diabetes, and obesity. Engaged in physical activity 2–4 times/week and ≥5 times/week decrease the odds of having heart problems, high blood pressure, breathing problems, type 2 diabetes, and obesity, compared with men and women who engaged in physical activity 1 or less times per week. For the women, the practice of physical activity ≥5 times/week was significantly and negatively associated with having cancer, when compared with women who engaged in physical activity 1 or less times per week. Physical activity is associated with a lower risk of chronic diseases, in particular: heart problems, high blood pressure, breathing problems, allergies, type 2 diabetes, and obesity. Furthermore, even small amounts of weekly physical activity seem to decrease the risk of chronic diseases.

Keywords: *Chronic disease, quantitative study, lifestyle*

Highlights

- Chronic diseases are the leading cause of morbidity and mortality and are considered to be at epidemic levels worldwide.
- Physical activity is associated with a lower risk of chronic diseases, in particular: heart problems, high blood pressure, breathing problems, allergies, type 2 diabetes, and obesity.
- Even small amounts of weekly physical activity seem to decrease the risk of chronic diseases.

Introduction

Chronic diseases are the leading cause of morbidity and mortality and are considered to be at epidemic levels worldwide (WHO, 2015). Chronic diseases negatively affect quality of life because of their physical and psychological consequences. In 2012, chronic diseases were responsible for 68% of the world's deaths (GBD Risk Factors Collaborators *et al.*, 2016; WHO, 2014).

Until recently, chronic diseases were associated with the older population. Nonetheless, because of lifestyle changes that have been rapidly occurring in recent years, chronic diseases are now becoming more prominent among young adults and adults (WHO, 2014, 2015). Out of the 38 million deaths due to chronic diseases in 2012, more than 40% were premature (WHO, 2014).

One relevant change in lifestyle is physical inactivity, which is an important contributor to the development of chronic diseases (Lee et al., 2012). A lack of physical activity contributes to 3.2 million deaths and 69.3 million disability-adjusted life years each year,

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due to the development of chronic diseases (WHO, 2014). Those who are insufficiently physically active have a higher risk of mortality compared with those who are regularly physically active (Hardman & Stensel, 2009). Even a minimum amount of physical activity has a protective health effect against chronic diseases, and tends to reduce mortality (Wen et al., 2011). There is evidence that physical activity is associated with several health benefits, including a lower risk of: cardiovascular diseases (Barengo et al., 2004), hypertension (Huai et al., 2013), type 2 diabetes (Hu et al., 2004), cancer (Anzuini, Battistella, & Izzotti, 2011), and obesity (Banks, Lim, Seubsman, Bain, & Sleigh, 2011). Thus, physical activity has been recommended (WHO, 2010) because of its effectiveness for primary and secondary prevention of chronic diseases (Alves et al., 2016; Swift et al., 2013).

Although the health benefits of physical activity, with respect to chronic diseases, are well established, a large proportion of the world's population (Sallis et al., 2016), and specifically European adults (Marques, Sarmento, Martins, & Saboga Nunes, 2015), is not considered physically active. The prevalence of physical inactivity of adults is, therefore, a major public health issue (Lee et al., 2012). Many studies have analysed the relationship between physical activity and each individual chronic disease, not considering that a person can have several diseases (Banks et al., 2011; Karjalainen et al., 2015; Kyu et al., 2016; Swift et al., 2013). The use of a more comprehensive approach that evaluates several diseases is needed. Therefore, the purpose of this study was to analyse the relationship between self-reported physical activity and self-reported chronic diseases, individually and mutually adjusted, including heart problems, high blood pressure, breathing problems, allergies, type 2 diabetes, cancer and obesity, among nationally representative samples of adults from 18 European countries. Involving representative samples from several countries and collecting data with the same instrument is important because internationally comparable data are needed to inform public health policies.

Methods

Study design and participants

The present study is a cross-sectional multi-country study based on data from the European Social Survey round 7, 2014, comprising 20 European countries (Austria, Belgium, Switzerland, Czech Republic, Germany, Denmark, Estonia, Spain, Finland, France, Hungary, Ireland, Lithuania, Netherlands, Norway, Poland, Portugal, Sweden, Slovenia, United Kingdom) and Israel. The European Social Survey is an academically driven cross-national survey that has been conducted every two years across Europe since 2001. The survey measures the attitudes, beliefs, and behaviour of European people. The European Social Survey uses a multi-stage probability cluster sampling designed to provide national representative samples among several European countries. According to national options, participants are sampled by means of postal code address files, population registers, social security register data, or telephone books. In the sampling procedure, statistical precision was kept the same for all countries. In each country the information was collected using a questionnaire filled-in through an hour-long face-to-face interview that included questions on the use of medicine, immigration, citizenship, socio-demographic and socioeconomic issues, health status, and physical activity. The questionnaire was translated by language experts, into the language of each of the participating countries. Further details about European Social Survey are available elsewhere (Schnaudt, Weinhardt, Fitzgerald, & Liebig, 2014). The study protocol of the European Social Survey subscribes the Declaration on Professional Ethics of the International Statistical Institute (http://www.europeansocialsurvey.org/about/ethics.html).

Probability sampling from all residents aged 15 years and older was applied in all countries (excluding only the homeless and the institutionalized population), comprising 40,185 participants. For the present study participants under the age of 18 were excluded from the analyses ($n = 1215$), because the focus was on the adult population. Participants from Czech Republic and Estonia did not report information on chronic diseases and were therefore excluded ($n = 3943$). Participants from Israel were excluded because they were not European ($n = 2105$). Furthermore, respondents without information in more than two socio-demographic variables were also excluded ($n = 2096$).

Measures

Socio-demographic characteristics. Participants reported their sex and age. The European Social Survey data provide two variables of education attainment: a recoded variable that focuses on achieved levels of education (primary, lower secondary, upper secondary, post-secondary, and tertiary education), according to the International Standard Classification of Education (UNESCO, 2012), and years of full time education. Respondents were asked to describe whether they lived with or without a husband/wife/

partner, and their correspondent legal status (e.g. married, civil union, illegally recognized). Response options were dichotomized into live with or without a partner. To determine the living place, participants were asked to report whether they lived in a big city, suburbs or outskirts of a big city, town or small city, country village, or home in countryside. Those who indicated that they lived in a big city, or suburbs, or outskirts of a big city were grouped into a new category named urban areas; those who responded that they lived in country village or home in countryside were grouped into rural areas. Household income was determined based on decile. Using this data, 1st to 3rd decile, 4th to 7th decile, and 8th to 10th were grouped to create three groups: low, middle, and high, respectively.

Chronic diseases. Chronic diseases were assessed by asking participants to indicate whether they currently had, or have has chronic diseases in the last 12 months (yes/no). For obesity, body mass index (BMI) was calculated from self-reported height and weight (kg/m^2). BMI categories were calculated in accordance with the WHO guidelines (WHO, 2000): normal weight (18.5–24.9 kg/m^2), overweight (25–29.9 kg/m^2), and obese (≥30 kg/m^2).

Television watching: Participants were asked to report time they spent watching television on an average weekday. Response options were from "no time at all" to "more than 3 h", in interval lengths of 30 min. The response answers were recoded into three groups: (1) no time at all, (2) ≤3 h per day, and (3) >3 h per day.

Physical activity. Information on physical activity was assessed with a single item asking, "on how many of the last 7 days did you walk quickly, do sports, or other physical activity for 30 minutes or longer?". Using the reported information on physical activity, a new variable was computed to classify participants into three groups: (1) practice of physical activity ≤1 time/week; (2) practice of physical activity 2–4 times/week; and (3) practice of physical activity ≥5 times/week.

Data analysis

Descriptive statistics were calculated for all variables (means, standard deviation, and percentages) for the entire sample, and stratified by sex. Mann–Whitney and Chi-square tests were used to compare men and women according to socio-demographic characteristics, the presence of chronic diseases in the last 12 months, and physical activity. Binary logistic regression models were conducted to analyse the effects that the practice of physical activity, in the last 7 days, had on chronic diseases. First, an unadjusted analysis was performed. Then analyses were adjusted for educational level (years of full time education), age, marital status, living place, and household income. Finally, the analyses were adjusted for the same variables and additionally for time spent watching television and all other chronic diseases. Using the recoded participants' classification based on physical activity practice, new binary logistic regression models were conducted, using physical activity ≤1 time/week as a reference group. All analyses were stratified by sex, and statistical analysis was performed using IBM SPSS Statistics 23. The significance level was set at $p < .05$.

Results

A total sample of 30,826 (14,813 men, 16,013 women) with mean age 50.4 ± 18.0 (50.0 ± 17.9 men, 50.7 ± 18.0 women) participated in the study. Table I presents the characteristics of the study population stratified by sex. Overall, the highest prevalence of chronic disease was observed for high blood pressure (19.4%), followed by obesity (15.6%), allergies (12.2%), cancer (11.1%), heart problems (11.0%), breathing problems (8.9%), and type 2 diabetes (5.6%). With the exception of type 2 diabetes, women had a statistically higher prevalence of all chronic diseases than men. Also, men were more physically active ($p < .001$) than women.

The results of the unadjusted and adjusted association between physical activity in the last 7 days and having chronic diseases are presented in Table II. In the unadjusted model, men and women who practiced physical activity more often had lower odds of having heart problems, high blood pressure, breathing problems, type 2 diabetes, cancer, and obesity than those who were less physically active. After the fully adjusted model for educational level, age, marital status, living place, household income, time spent watching television and for all other chronic diseases, the practice of physical activity remained negatively associated with heart problems, breathing problems, and obesity. For just women, physical activity was significantly and positively related with allergies, and type 2 diabetes, even when the model was fully adjusted.

Table III presents the results of the relationship between the frequency of weekly physical activity practice and having chronic diseases. For both sexes, in the unadjusted and adjusted analyses for educational level, age, marital status, living place, and household income, to be engaged in physical activity 2–4 times per week and 5 or more times per

Table I. Participants' characteristics for total sample and stratified by sex.

	Total ($n = 30{,}826$) % or M ± SD	Men ($n = 14{,}813$) % or M ± SD	Women ($n = 16{,}013$) % or M ± SD	p
Education				<.001
Primary	10.5	9.9	11.1	
Lower secondary	16.4	16.2	16.7	
Upper secondary	35.2	36.9	33.6	
Post-secondary	14.3	14.6	14.0	
Tertiary education	23.6	22.4	24.6	
Age	50.4 ± 18.0	50.0 ± 17.9	50.7 ± 18.0	.001
Marital status				<.001
Live with partner	61.2	64.0	58.7	
Live without partner	38.8	36.0	41.3	
Living place				.022
Urban area	62.4	61.7	63.0	
Rural area	37.6	38.3	37.0	
Household income				<.001
Low (1st to 3rd decile)	30.5	26.4	34.3	
Middle (4th to 7th decile)	42.1	46.6	40.7	
High (8th to 10th decile)	27.4	30.0	25.0	
Chronic diseases (last 12 month)				
Heart problems	11.0	10.5	11.5	.019
High blood pressure	19.4	19.0	19.8	.095
Breathing problems	8.9	8.3	9.5	<.001
Allergies	12.2	10.4	13.9	<.001
Diabetes	5.6	5.9	5.2	.005
Cancer	11.5	9.8	13.0	<.001
Obesity	15.5	15.8	15.3	.491
Chronic diseases (number)	0.8 ± 1.1	0.8 ± 1.0	0.9 ± 1.1	<.001
Time spending watching television				<.001
No time at all	4.3	4.5	4.1	
≤3 h/day	77.6	78.1	77.2	
>3 h/day	18.1	17.4	18.7	
Physical activity (times/week)	3.2 ± 2.6	3.3 ± 2.6	3.1 ± 2.6	<.001
Physical activity				<.001
≤1 time/week	33.7	32.1	35.1	
2–4 times/week	32.9	33.0	32.8	
≥5 times/week	33.4	34.8	32.1	

Notes: M: media; SD: standard deviation.
Differences between men and women were tested by Chi Square and Mann–Whitney tests.

week decreased the odds of having heart problems, high blood pressure, breathing problems, type 2 diabetes, cancer, and obesity, when compared with those who engaged in physical activity 1 or less times per week. When the analyses were further adjusted for time spent watching television and all other chronic diseases, to be engaged in physical activity 2–4 times per week and 5 or more times per week persisted in decreasing the odds of having heart problems, breathing problems, type 2 diabetes, and obesity, compared with men and women who engaged in physical activity 1 or less times per week. Conversely, in all different models, the more active women had higher odds of having allergies when compared with those who were less active.

The relationship between physical activity participation and the three chronic diseases (heart problems, breathing problems, and obesity) significantly related in both men and women, in model 3 Table II, are presented in Figures 1 –3. In almost all countries, those who reported not having chronic diseases, practiced physical activity significantly more times per week. For the relationship between physical activity participation and heart problems, the absence of significant differences was observed in Portugal, Slovenia, Switzerland, Germany, and Finland (Figure 1). For the relationship between physical activity participation and breathing problems there were no differences in Portugal, Belgium, Slovenia, the Netherlands, and Switzerland (Figure 2). Finally, for the relationship between physical activity participation and obesity, the absence of differences was only observed in Denmark and Switzerland (Figure 3).

Table II. Relationship between physical activity in the last 7 days and having chronic diseases.

	Physical activity in the last 7 days (times/week)		
Men	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)
Heart problems[a]	0.91 (0.89–0.93)***	0.93 (0.91–0.95)***	0.96 (0.93–0.98)***
High blood pressure[a]	0.95 (0.93–0.96)***	0.96 (0.94–0.98)***	0.99 (0.97–1.01)
Breathing problems[a]	0.91 (0.89–0.94)***	0.93 (0.91–0.95)***	0.94 (0.92–0.97)***
Allergies[a]	0.99 (0.97–1.02)	0.98 (0.96–1.00)	0.99 (0.97–1.01)
Diabetes[a]	0.93 (0.90–0.95)***	0.95 (0.92–0.98)***	0.98 (0.95–1.01)
Cancer[a]	0.97 (0.94–0.99)**	0.98 (0.96–1.00)	0.99 (0.96–1.01)
Obesity[a]	0.90 (0.88–0.92)***	0.91 (0.89–0.93)***	0.92 (0.90–0.94)***
Women			
Heart problems[a]	0.92 (0.90–0.94)***	0.95 (0.93–0.97)***	0.96 (0.94–0.98)**
High blood pressure[a]	0.95 (0.93–0.96)***	0.98 (0.96–0.99)*	1.01 (0.99–1.03)
Breathing problems[a]	0.95 (0.93–0.97)***	0.96 (0.94–0.98)**	0.97 (0.95–0.99)**
Allergies[a]	1.03 (1.01–1.05)**	1.02 (1.02–1.04)**	1.03 (1.01–1.05)***
Diabetes[a]	0.85 (0.83–0.88)***	0.90 (0.87–0.93)***	0.93 (0.90–0.96)***
Cancer[a]	0.97 (0.95–0.99)***	0.99 (0.97–1.01)	1.00 (0.98–1.02)
Obesity[a]	0.90 (0.88–0.91)***	0.91 (0.90–0.93)***	0.93 (0.91–0.95)***

[a]The reference category was not having the disease.

Note: Model 1: Unadjusted analyses. Model 2: Analyses were adjusted for educational level, age, marital status, living place, country, and household income. Model 3: Analyses were adjusted for educational level, age, marital status, living place, country, household income, sedentary time watching television, and for all others chronic diseases.

*$p < .05$, **$p < .01$, ***$p < .001$.

Discussion

The aim of this study was to analyse the association between physical activity and chronic diseases, including heart problems, high blood pressure, breathing problems, allergies, type 2 diabetes, cancer, and obesity in European adults. The main results highlight that physical activity was inversely related with having heart problems, breathing problems, type 2 diabetes, and obesity among men and women, supporting the idea that physical activity is a healthy behaviour.

The observed relationship between physical activity and chronic diseases is in line with previous studies, showing lower physical activity levels in people with more chronic diseases (Kaptein & Badley, 2012; Loef, de Hollander, Boot, & Proper, 2016; Marques, Peralta, Martins, de Matos, & Brownson, 2017). Furthermore, the study results also endorse the fact that even a few episodes of physical activity per week have a positive impact on health, and may contribute to reduce mortality (O'Donovan, Lee, Hamer, & Stamatakis, 2017). This is an important message for public health because adulthood might be a demanding time, with various commitments leading to physical inactivity. Adults have to make trade-offs between necessary (work) activities and physical activity, which could be considered as a discretionary activity.

The negative and significant relationship between heart problems and physical activity has been observed over the course of several decades by epidemiologic studies, mainly designed to determine factors related to cardiovascular diseases and coronary heart diseases (Lee, Sesso, Oguma, & Paffenbarger, 2003; Paffenbarger & Hyde, 1988). Since heart diseases include several diseases, that can be related to type 2 diabetes or obesity (Murtagh et al., 2015), and also to a cluster of other diseases (Fuchs, Moreira, Camey, Moreira, & Fuchs, 2008), the observed negative relationship with physical activity (after the adjustments for all other chronic diseases) reinforces the role of physical activity engagement to reduce the clinical manifestation of heart problems. Similarly, there is a relationship between high blood pressure, type 2 diabetes, and obesity (Ahmad et al., 2016; Matsuo, Sairenchi, Suzuki, Tanaka, & Muto, 2011; Patel et al., 2016). Physical activity was independently, and after adjustments for each other, negatively associated with these chronic diseases. These results strengthen the importance of an active lifestyle as a protective factor against these diseases, which have the highest prevalence and incidence in middle and higher income countries (WHO, 2014, 2015). Physical activity should be promoted (WHO, 2010), in order to reverse the increasing prevalence of inactivity and its effects on public health (Lee et al., 2012).

Results showed that physical activity decreases the odds of having breathing problems, even when physical activity was practised more often. In fact, the literature has shown that even light physical activity 3 or more times per week is prospectively associated with

Table III. Relationship between physical activity and having chronic diseases.

	Physical activity in the last 7 days					
	Model 1 OR (95% CI)		Model 2 OR (95% CI)		Model 3 OR (95% CI)	
Men	2–4 times/week	≥5 times/week	2–4 times/week	≥5 times/week	2–4 times/week	≥5 times/week
Heart problems[a]	0.57 (0.50–0.65)***	0.56 (0.49–0.64)***	0.61 (0.53–00.70)***	0.67 (0.59–0.77)***	0.74 (0.64–0.86)***	0.81 (0.70–0.94)**
High blood pressure[a]	0.69 (0.62–0.76)***	0.68 (0.61–0.75)***	0.71 (0.64–0.79)***	0.77 (0.70–0.86)***	0.88 (0.78–1.00)	0.94 (0.84–1.05)
Breathing problems[a]	0.56 (0.48–0.65)***	0.51 (0.44–0.60)***	0.58 (0.50–0.67)***	0.56 (0.48–0.65)***	0.66 (0.57–0.77)***	0.61 (0.52–0.72)***
Allergies[a]	0.96 (0.83–1.10)	1.13 (0.99–1.29)	0.91 (0.80–1.04)	1.03 (0.89–1.18)	0.94 (0.82–1.11)	1.07 (0.93–1.23)
Diabetes[a]	0.62 (0.52–0.73)***	0.48 (0.40–0.58)***	0.66 (0.56–0.78)***	0.57 (0.47–0.68)***	0.85 (0.71–0.99)*	0.68 (0.56–0.83)***
Cancer[a]	0.77 (0.67–0.89)***	0.73 (0.63–0.84)***	0.81 (0.70–0.93)**	0.82 (0.70–0.94)*	0.89 (0.77–1.03)	0.89 (0.77–1.03)
Obesity[a]	0.54 (0.48–0.60)***	0.58 (0.51–0.65)***	0.56 (0.50–0.63)***	0.63 (0.56–0.70)***	0.61 (0.54–0.69)***	0.68 (0.61–0.77)***
Women						
Heart problems[a]	0.61 (0.54–0.69)***	0.47 (0.42–0.54)***	0.69 (0.61–0.78)***	0.59 (0.52–0.68)***	0.80 (0.70–0.91)**	0.68 (0.59–0.79)***
High blood pressure[a]	0.70 (0.63–0.77)***	0.57 (0.52–0.64)***	0.81 (0.73–0.90)***	0.74 (0.67–0.83)***	1.05 (0.94–1.17)	0.94 (0.84–1.06)
Breathing problems[a]	0.74 (0.65–0.84)***	0.63 (0.55–0.73)***	0.76 (0.67–0.89)***	0.69 (0.60–0.79)***	0.81 (0.70–0.93)**	0.73 (0.63–0.85)***
Allergies[a]	1.18 (1.05–1.33)**	1.20 (1.07–1.35)**	1.13 (1.00–1.03)*	1.11 (1.00–1.25)*	1.19 (1.05–1.34)**	1.19 (1.05–1.35)**
Diabetes[a]	0.41 (0.34–0.49)***	0.43 (0.34–0.51)***	0.48 (0.40–0.58)***	0.58 (0.45–0.70)***	0.60 (0.49–0.73)***	0.73 (0.60–0.89)**
Cancer[a]	0.79 (0.70–0.89)***	0.70 (0.62–0.79)***	0.86 (0.76–0.97)*	0.82 (0.72–0.92)***	0.95 (0.84–1.08)	0.90 (0.79–1.02)
Obesity[a]	0.52 (0.47–0.58)***	0.56 (0.50–0.62)***	0.57 (0.50–0.63)***	0.65 (0.58–0.73)***	0.63 (0.56–0.71)***	0.73 (0.65–0.83)***

[a]The reference category was not having the disease.

Note: Model 1: Unadjusted analyses. Model 2: Analyses were adjusted for educational level, age, marital status, living place country and household income. Model 3: Analyses were adjusted for educational level, age, marital status, living place, country, household income, sedentary time watching television, and for all others chronic diseases.

$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

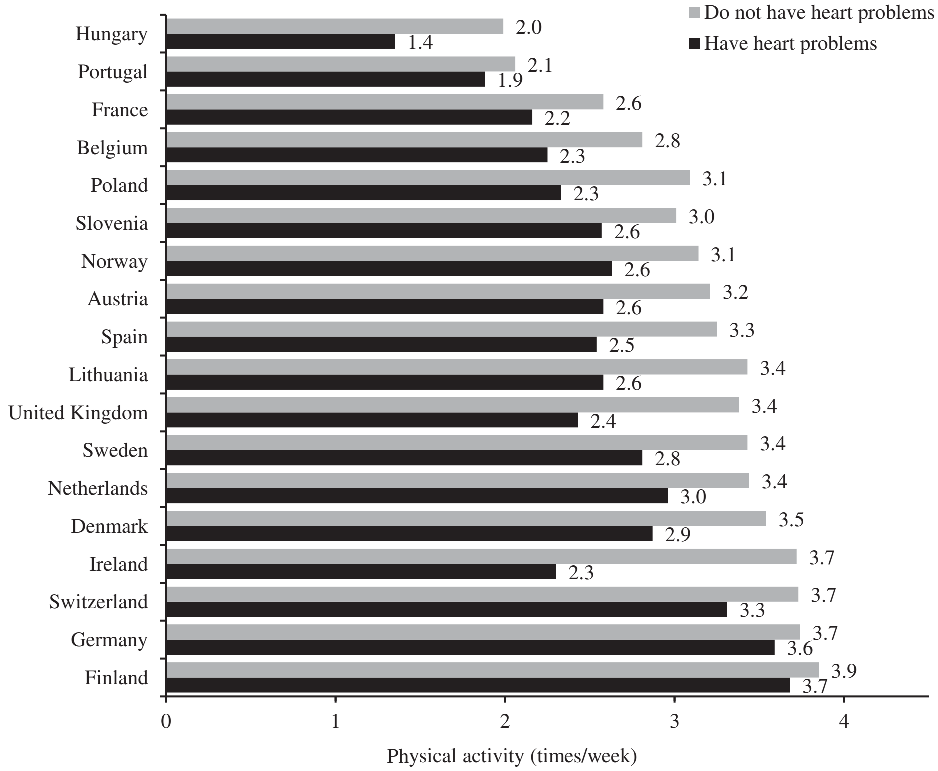

Figure 1. Relationship between physical activity participation and heart problems.

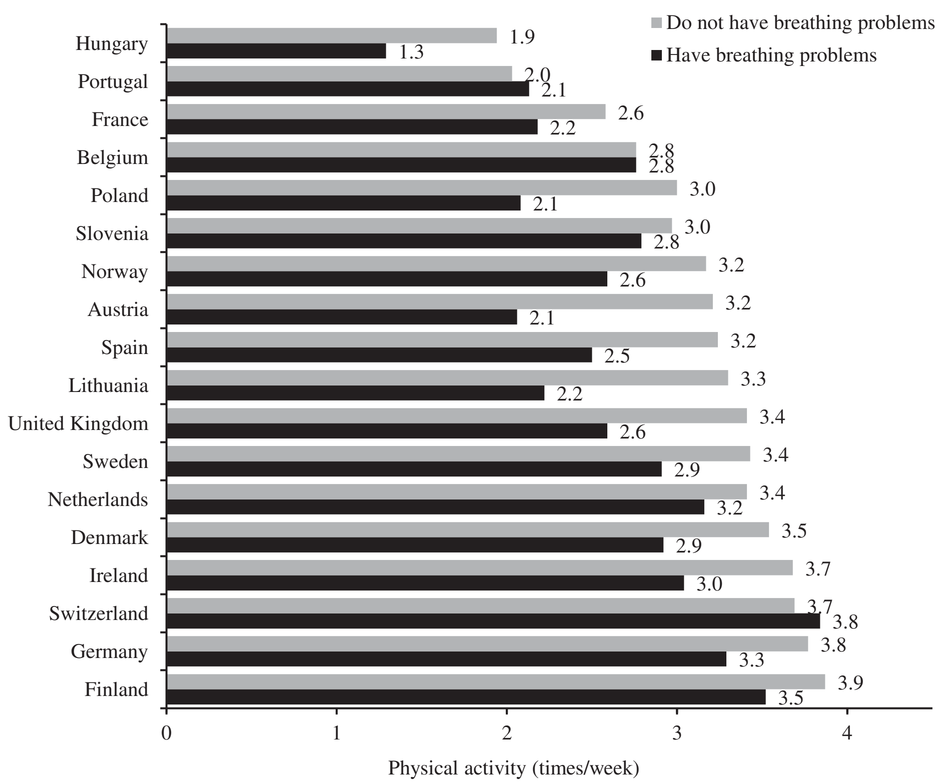

Figure 2. Relationship between physical activity participation and breathing problems.

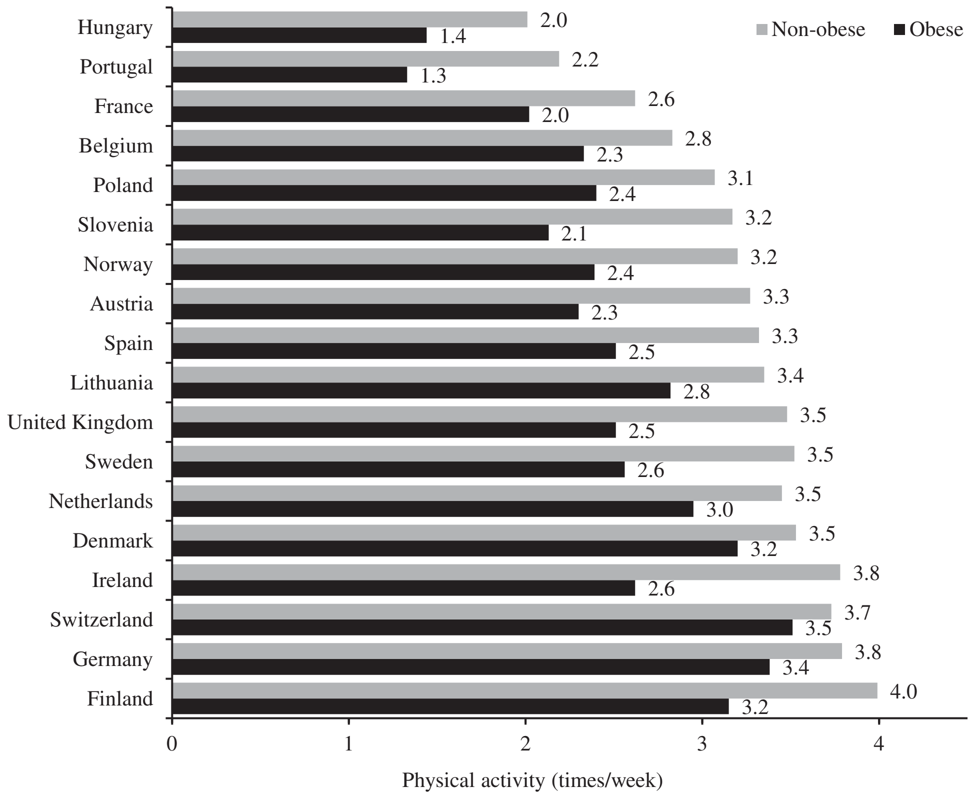

Figure 3. Relationship between physical activity participation and obesity.

less risk ratio of asthma and wheezing, while vigorous physical activity is not associated with any asthma outcomes (Russell et al., 2016). These specific results, and the general present study results, emphasize the idea that increased physical activity does not augment breathing problems or compromise asthma control. On the contrary, it is associated with its improvements (Mancuso et al., 2013).

The result of the relationship between physical activity and cancer seems to point to a negative association. Nevertheless, when the analysis was adjusted for other variables and chronic diseases, the association was no longer significant. Although there is evidence that physical activity is associated with cancer prevention in several organs, strong biases, such as BMI, sex, and age, make it difficult to assess the effect of physical activity to reduce the risk (Anzuini et al., 2011). Furthermore, participants were asked to report whether they had cancer or not, but the type of cancer was not specified. This information would be rather important because there is convincing evidence for a beneficial effect of physical activity on the risk of colon, breast and endometrial cancers, but the evidence is weaker or insufficient for all other types of cancers (Friedenreich, Neilson, & Lynch, 2010). The positive effect of physical activity on cancer is of major importance for Europeans because it is estimated that between 9% and 19% of cancer cases could be attributed to a lack of sufficient physical activity (Friedenreich et al., 2010).

Although the results present similarities between men and women, there are some differences. For instance, physical activity in the last 7 days was positively related to allergies and negatively related to type 2 diabetes in women but not in men, when the model was fully adjusted. Perhaps the differences are due to the diversities in biology, lifestyle, environment, and socioeconomic status, because these factors impact differences between men and women in predisposition, and development of some chronic diseases. Furthermore, sex hormones have an impact on energy metabolism, which can explain the differences observed between men and women in the relationship between physical activity and some chronic diseases (Kautzky-Willer, Harreiter, & Pacini, 2016; Leynaert et al., 2012).

In the interpretation of this study's results, several limitations should be noted. First, the cross-sectional design implies that no causal inferences can be made. Thus, the current study cannot answer the question whether the presence of chronic diseases leads to lower physical activity levels, or vice versa. Second, physical activity and television-viewing time were self-reported rather than objectively measured, which could be subject to bias in terms of over- and under-estimation (Marques, Martins, Ramos, Yazigi, & Carreiro da Costa, 2014; Otten, Littenberg, & Harvey-Berino, 2010). Moreover, physical activity was measured using a single item. However, there is evidence that assessed physical activity with a single question is an acceptable alternative in epidemiologic studies (Wanner et al., 2014). Third, while chronic diseases were also self-reported, studies have suggested that self-report of chronic diseases is fairly to largely accurate for most chronic diseases (Haapanen, Miilunpalo, Pasanen, Oja, & Vuori, 1997; Hansen et al., 2014).

A major strength of this study was the European Social Survey database that includes a large and representative sample size of various European countries, as well as several socio-demographic characteristics of the study sample. Furthermore, due to the large sample, there was an adequate statistical power.

Conclusion

In conclusion, this study broadens the scope of research in physical activity and chronic diseases by using a large population-based European survey. Physical activity is associated with a lower risk of cardiovascular diseases, in particular: heart problems, high blood pressure, breathing problems, allergies, type 2 diabetes, and obesity.

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Article 3

Marques, A., Peralta, M., Sarmento, H., Martins, J., & González Valeiro, M. (2017). Associations between vigorous physical activity and chronic diseases in older adults: a cross-sectional and prospective study in 13 European countries. *European Journal of Public Health.* DOI: 10.1093/eurpub/cky086

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Associations between vigorous physical activity and chronic diseases in older adults: a study in 13 European countries

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Background: This study aimed to assess cross-sectional and prospective relationships between vigorous physical activity (VPA) and the risk of major chronic diseases among European older adults. **Methods:** Participants were 37 524 older adults who responded to the fourth (in 2011) and fifth (in 2013) wave of the SHARE project, from 13 European countries. Participants answered interview questions about the presence of chronic conditions and VPA. The cross-sectional and prospective association between PA and the number of chronic diseases was assessed using logistic regression models. **Results:** Among men and women, the prevalence of chronic diseases was significantly lower among those who reported VPA once a week or more than once a week. For men, VPA once a week was prospectively related with lower odds of heart attack, chronic lung disease, Parkinson's disease and Alzheimer's disease. VPA more than once a week was prospectively related with lower odds of having all chronic diseases. Women who engaged in VPA once a week presented lower odds of having chronic diseases, except for hypertension, high blood cholesterol and cancer. For VPA more than once a week, cancer was the only disease not associated with physical activity. **Conclusion:** VPA is associated with reduced risk of chronic diseases in men and women. Even the practice of VPA once a week seems to be sufficient to reduce risks of chronic diseases.

Introduction

The prevalence of chronic diseases has been growing around the world, mainly among older adults, including: heart diseases, hypertension, diabetes, cancer, obesity, and respiratory diseases.[1] As a result, chronic diseases are now the leading cause of morbidity and mortality worldwide.[2] The main factor identified as being, in part, responsible for the increasing prevalence of chronic diseases is the prevalence of physical inactivity.[3]

Physical activity can reduce chronic diseases and the risk of disease progression.[4,5] Thus, regular practice of physical activity has been recommended[6] because of its effectiveness for primary and secondary prevention of chronic diseases.[7] Even a minimum amount of physical activity has a protective health effect against chronic diseases, and it reduces mortality.[8–11]

Adults and older adults are recommended to practice at least 150 min per week of moderate to vigorous-intensity physical activity (VPA) or 75 min per week of VPA, furthermore older adults with poor mobility are suggested to perform physical activity to enhance balance and prevent falls on three or more days per week.[6] There is evidence that VPA is associated with a greater decrease in the risk of incidence of major chronic diseases than moderate-intensity physical activity.[10,12] Furthermore, VPA also improve static and dynamic daily motor tasks, which are very important for older adults.[13,14] As older adults are less likely to engage in VPA, it is important to better understand the cross-sectional and prospective relationship between VPA and the major chronic diseases among this population.

Several studies have analysed the relationship between physical activity and a particular chronic disease, not considering that a person can have several diseases.[15–17] The use of a more comprehensive approach that evaluates several diseases is needed. Furthermore, a study published recently using data from the Survey of Health, Aging and Retirement in Europe (SHARE) observed that VPA was cross-sectionally and prospectively associated with fewer reported chronic diseases.[18] This study provided general results and did not analyse the relationship between physical activity and particular chronic disease, adjusted for others diseases. Therefore, the purpose of this study was to assess the cross-sectional and prospective relationship between self-reported VPA and the risk of major chronic diseases among European older adults.

Methods

Participants and procedures

This study was based on the fourth and fifth wave of the SHARE. SHARE is an interdisciplinary and cross-national survey on aging that is run every 2 years and collects extensive information of individuals aged 50 and over in several European countries. All SHARE respondents who were interviewed in any previous wave are part of the longitudinal sample. It is fully described elsewhere.[19,20] The fourth wave data was collected in 2011 and the fifth wave in 2013; each included individuals aged 50 and over. 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 this study. The sample includes 16 204 (43.2%) men and 21 320 (56.8%) women from 13 countries from Scandinavia to the Mediterranean (Austria, Belgium, Czech Republic, Denmark, Estonia, France, Germany, Italy, Netherlands, Slovenia, Spain, Sweden and Switzerland). Participants were between the ages of 50 and 102 years (66.2 ± 9.7) in 2011, and between the ages of 52 and 104 years (68.2 ± 9.7) in 2013.

Data were collected face to face by trained interviewers using a computer-assisted personal interviewing programme, supplemented by a self-completed paper-and-pencil questionnaire (available at http://www.share-project.org/methodological-research.html).
Comparable questionnaires were applied in each country. Translation guidelines were applied and pilots were performed to enhance comparability. 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

Physical activity

Participants were asked to report their VPA practice frequency (e.g. sports, heavy housework, a job involving physical labour). The response options were: (i) more than once a week, (ii) once a week, (iii) up to three times a month and (iv) hardly ever or never. The last two response options were grouped into one category called ‘less than once a week’.

Chronic diseases

Participants were asked to report whether their doctor has told them of the presence of the following conditions: heart attack or other heart problems, hypertension, high blood cholesterol, diabetes, chronic lung disease, cancer, stomach or duodenal ulcer, Parkinson’s disease, hip fracture/femoral fracture, Alzheimer’s disease/dementia.

Socio-demographic variables

The following elements were self-reported: age, marital status, education level, and place of residence. Marital status was classified into: married (e.g. married, partnership, co-habitating) or not married (e.g. widowed, divorced, separated or never married). Education was categorized according to the International Standard Classification of Education Degrees[21] and divided into three levels: low educational level (ISCED codes 0–2), middle educational level (ISCED codes 3 and 4) and high educational level (ISCED codes 5 and 6). 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 a rural area.

Statistical analysis

Descriptive statistics were calculated for all variables (means, standard deviation and percentages) for the entire sample, and stratified by gender. The men and women comparison at baseline (in 2011), according to participants’ characteristics, was tested by Chi Square test and Independent sample *t*-test. Bivariate relationship between VPA and the presence of chronic diseases at baseline was tested by Chi-square test. The presence of chronic diseases in 2011 and VPA in 2011 entered in the cross-sectional analyses, while the presence of chronic diseases in 2013 and VPA in 2011 entered in the prospective analyses. The cross-sectional and prospective association between VPA and the presence of chronic diseases was assessed using binary logistic regression. For cross-sectional and prospective analysis, two different models were performed. Model 1 was adjusted for age, marital status, educational level, place of residence, smoking and country. Model 2 was further adjusted for the presence of all other chronic diseases. In all analysis VPA entered as categorical variable and the presence of chronic disease were tested against the practice of physical activity ‘less than once a week’ (reference category). All analyses were stratified by gender, because an interaction effect between gender and some chronic diseases was observed. Data analysis was performed using IBM SPSS Statistics version 24 (SPSS Inc., an IBM Company, Chicago, IL, USA). The significance level was set at $P < 0.05$.

Table 1 Participants’ characteristics at baseline (2011)

	% Unless otherwise stated			
	Total (n = 37 524)	Men (n = 16 204)	Women (n = 21 320)	*P*
Education				<0.001[a]
Low	61.1	62.7	58.9	
Middle	26.1	25.2	27.4	
High	12.8	12.1	13.8	
Age (M±SD)	66.2 ± 9.7	66.0 ± 9.4	66.3 ± 9.9	0.035[b]
Marital status				<0.001[a]
Not married	29.8	20.2	37.2	
Married	70.2	80.0	62.8	
Place of residence				<0.001[a]
Big city	13.7	12.5	14.6	
Suburbs of a big city	10.5	10.9	10.2	
Large town	16.4	15.3	17.1	
Small town	25.1	25.0	25.1	
Rural area	34.3	36.4	32.9	
Doctor said you had				
Heart attack	13.2	15.4	11.5	<0.001[a]
Hypertension	39.2	37.9	40.2	<0.001[a]
High blood cholesterol	23.3	22.4	24.1	<0.001[a]
Diabetes	11.9	13.1	11.0	<0.001[a]
Chronic lung disease	6.5	6.9	6.2	0.005[a]
Cancer	5.1	4.9	5.2	0.158[a]
Stomach or duodenal ulcer	5.6	5.8	5.4	0.123[a]
Parkinson’s disease	0.6	0.8	0.5	0.002[a]
Hip fracture/femoral fracture	2.2	2.0	2.4	0.007[a]
Alzheimer’s disease/dementia	1.1	1.0	1.1	0.140[a]
VPA				<0.001[a]
Less than once a week	51.0	45.4	55.2	
Once a week	14.1	14.0	14.2	
More than once a week	34.9	40.6	30.6	

Abbreviation: M, mean; SD, standard deviation; PA, physical activity.
a: Tested by Chi Square.
b: Tested by *t*-test.

Results

Table 1 presents the participants’ characteristics at baseline. Most participants had a lower level of education (61.1%), were married (70.2%), and lived in a small town or rural areas (59.4%). The most prevalent chronic diseases were hypertension (39.2%), high blood cholesterol (23.3%), heart attack (13.2%) and diabetes (11.9%). More than half of participants reported no VPA (51%), 14.1% did once a week and 34.9% more than once a week.

The results of bivariate analysis between VPA and chronic diseases are presented in table 2. Among men and women, the prevalence of chronic diseases (heart attack, hypertension, high blood cholesterol, diabetes, chronic lung disease, cancer, stomach or duodenal ulcer, Parkinson’s disease, hip fracture/femoral fracture and Alzheimer’s disease) in 2011 and 2013 were significantly lower ($P < 0.001$) among those who reported the practice of VPA once a week or more than once a week.

Table 3 presents the results of the cross-sectional relationship between VPA and chronic diseases. For men, in the adjusted model for socio-demographic variables and smoking habits, engaging in VPA more than once a week was significantly associated with lower odds of having chronic diseases. When the model was further adjusted for the presence of other chronic diseases simultaneously, VPA more than once a week remained

Table 2 Relationship between VPA and chronic diseases, by gender and year (2011 and 2013)

Doctor said you had (yes)	2011				2013			
	Less than once a week	Once a week	More than once a week	*P*	Less than once a week	Once a week	More than once a week	*P*
	Men (%)							
Heart attack	20.9	11.1	10.7	<0.001	18.5	11.1	10.1	<0.001
Hypertension	42.3	38.5	32.9	<0.001	43.5	40.2	35.2	<0.001
High blood cholesterol	25.2	22.5	19.1	<0.001	22.2	21.7	19.0	<0.001
Diabetes	16.8	12.2	9.2	<0.001	17.8	14.0	10.5	<0.001
Chronic lung disease	9.7	5.5	4.4	<0.001	9.2	5.8	4.4	<0.001
Cancer	6.3	4.5	3.5	<0.001	6.1	4.3	3.4	<0.001
Stomach or duodenal ulcer	6.9	4.7	4.8	<0.001	4.2	2.7	2.5	<0.001
Parkinson's disease	1.3	0.3	0.3	<0.001	1.7	0.4	0.5	<0.001
Hip fracture/femoral fracture	2.8	1.2	1.3	<0.001	1.9	1.0	0.8	<0.001
Alzheimer's disease/dementia	1.7	0.3	0.3	<0.001	2.9	0.4	0.7	<0.001
	Women (%)							
Heart attack	15.1	7.7	6.7	<0.001	13.5	6.9	5.7	<0.001
Hypertension	45.3	37.7	32.2	<0.001	46.8	39.2	34.5	<0.001
High blood cholesterol	27.1	20.8	20.3	<0.001	26.6	21.5	20.3	<0.001
Diabetes	14.0	8.2	6.8	<0.001	15.1	9.1	7.8	<0.001
Chronic lung disease	7.6	4.5	4.6	<0.001	7.3	4.6	4.1	<0.001
Cancer	6.0	4.0	4.5	<0.001	4.8	3.3	3.4	<0.001
Stomach or duodenal ulcer	6.1	4.1	4.7	<0.001	4.5	2.7	3.0	<0.001
Parkinson's disease	0.8	0.1	0.1	<0.001	1.1	0.3	0.3	<0.001
Hip fracture/femoral fracture	3.2	1.2	1.2	<0.001	2.8	0.8	0.9	<0.001
Alzheimer's disease/dementia	1.6	0.4	0.3	<0.001	2.7	0.7	0.5	<0.001

Tested by Chi Square.

Table 3 Cross-sectional parameters estimates the association of VPA and chronic diseases

Doctor said you had (in 2011)	Model 1. OR (95% CI)		Model 2. OR (95% CI)	
	Once a week	More than once a week	Once a week	More than once a week
	Men			
Heart attack	0.62 (0.52–0.74)	0.55 (0.48–0.62)	0.65 (0.54–0.78)	0.61 (0.54–0.70)
Hypertension	0.94 (0.83–1.06)	0.74 (0.67–0.81)	0.99 (0.87–1.13)	0.82 (0.75–0.91)
High blood cholesterol	0.90 (0.78–1.03)	0.71 (0.64–0.79)	0.99 (0.85–1.14)	0.84 (0.75–0.94)
Diabetes	0.79 (0.66–0.94)	0.58 (0.51–0.66)	0.83 (0.69–0.99)	0.65 (0.57–0.74)
Chronic lung disease	0.61 (0.48–0.79)	0.49 (0.40–0.59)	0.66 (0.51–0.84)	0.53 (0.44–0.64)
Cancer	0.90 (0.68–1.18)	0.72 (0.58–0.89)	0.77 (0.72–1.27)	0.79 (0.64–0.98)
Stomach or duodenal ulcer	0.55 (0.41–0.73)	0.56 (0.47–0.69)	0.58 (0.34–0.79)	0.63 (0.51–0.76)
Parkinson's disease	0.35 (0.14–0.88)	0.34 (0.18–0.64)	0.38 (0.15–0.96)	0.36 (0.19–0.67)
Hip fracture/femoral fracture	0.49 (0.29–0.80)	0.47 (0.34–0.67)	0.52 (0.31–0.86)	0.51 (0.36–0.72)
Alzheimer's disease/dementia	0.23 (0.07–0.74)	0.39 (0.21–0.72)	0.26 (0.08–0.84)	0.47 (0.25–0.88)
	Women			
Heart attack	0.54 (0.46–0.65)	0.57 (0.50–0.66)	0.61 (0.51–0.73)	0.66 (0.57–0.75)
Hypertension	0.81 (0.73–0.90)	0.68 (0.63–0.74)	0.90 (0.81–1.00)	0.76 (0.70–0.83)
High blood cholesterol	0.79 (0.70–0.89)	0.75 (0.68–0.82)	0.87 (0.77–0.99)	0.86 (0.78–0.94)
Diabetes	0.65 (0.55–0.77)	0.53 (0.47–0.61)	0.73 (0.61–0.86)	0.61 (0.53–0.70)
Chronic lung disease	0.60 (0.48–0.75)	0.69 (0.59–0.81)	0.67 (0.54–0.84)	0.76 (0.65–0.90)
Cancer	0.71 (0.56–1.00)	0.85 (0.72–1.01)	0.75 (0.59–1.00)	0.89 (0.75–1.06)
Stomach or duodenal ulcer	0.67 (0.53–0.85)	0.77 (0.65–0.92)	0.77 (0.61–0.98)	0.87 (0.74–1.04)
Parkinson's disease	0.08 (0.12–0.61)	0.44 (0.22–0.88)	0.10 (0.01–0.71)	0.51 (0.26–1.03)
Hip fracture/femoral fracture	0.50 (0.33–0.75)	0.60 (0.45–0.81)	0.53 (0.35–0.80)	0.63 (0.47–0.85)
Alzheimer's disease/dementia	0.27 (0.11–0.68)	0.25 (0.12–0.52)	0.28 (0.11–0.69)	0.25 (0.12–0.51)

Abbreviation: OR, odds ration; CI, confidence interval.
Model 1: Analyses were adjusted for age, marital status, educational level, place of residence, smoking, and country. Model 2: Analyses were adjusted for age, marital status, educational level, place of residence, smoking, country, and the presence of others chronic diseases. Physical activity ''less than once a week'' was the reference category.

associated with lower odds of having chronic diseases when compared with those who reported VPA less than once a week. For women, the results were similar to men. However, in the adjusted model for socio-demographic variables and smoking habits, the relationship between VPA more than once a week and chronic diseases was not significantly related with cancer when compared to those who engaged in VPA less than once a week. In the further adjusted model for the presence of other chronic diseases, engaging in VPA more than once a week was not significantly associated with cancer, stomach or duodenal ulcer, and Parkinson's disease when compared with less active women.

Results of the prospective relationship between VPA and chronic diseases are presented in the table 4. In both models, compared with men who engaged in VPA less than once a week, those doing VPA

Table 4 Prospective parameters estimate the association of VPA and chronic diseases

Doctor said you had (in 2013)	Model 1. OR (95% CI) Once a week	Model 1. OR (95% CI) More than once a week	Model 2. OR (95% CI) Once a week	Model 2. OR (95% CI) More than once a week
	Men			
Heart attack	0.69 (0.58–0.83)	0.62 (0.54–0.70)	0.73 (0.61–0.88)	0.69 (0.60–0.79)
Hypertension	0.92 (0.81–1.04)	0.76 (0.69–0.83)	0.97 (0.86–1.11)	0.84 (0.77–0.93)
High blood cholesterol	0.85 (0.74–0.98)	0.72 (0.65–0.80)	0.90 (0.78–1.05)	0.83 (0.75–0.93)
Diabetes	0.88 (0.74–0.104)	0.62 (0.54–0.70)	0.94 (0.79–1.12)	0.69 (0.61–0.79)
Chronic lung disease	0.66 (0.52–0.85)	0.53 (0.44–0.64)	0.70 (0.55–0.90)	0.58 (0.48–0.70)
Cancer	0.86 (0.65–1.15)	0.67 (0.54–0.84)	0.93 (0.70–1.23)	0.75 (0.60–0.93)
Stomach or duodenal ulcer	0.63 (0.44–0.90)	0.50 (0.38–0.65)	0.70 (0.49–1.01)	0.59 (0.45–0.77)
Parkinson's disease	0.36 (0.17–0.79)	0.36 (0.21–0.60)	0.38 (0.17–0.84)	0.36 (0.21–0.61)
Hip fracture/femoral fracture	0.69 (0.40–1.18)	0.60 (0.40–0.89)	0.72 (0.42–1.23)	0.65 (0.44–0.97)
Alzheimer's disease/dementia	0.15 (0.05–0.46)	0.53 (0.34–0.83)	0.16 (0.05–0.51)	0.61 (0.39–0.95)
	Women			
Heart attack	0.58 (0.48–0.70)	0.57 (0.48–0.64)	0.64 (0.53–0.77)	0.63 (0.55–0.73)
Hypertension	0.84 (0.76–0.93)	0.72 (0.67–0.78)	0.92 (0.83–1.03)	0.80 (0.74–0.87)
High blood cholesterol	0.83 (0.74–0.94)	0.78 (0.71–0.85)	0.92 (0.82–1.04)	0.90 (0.82–0.99)
Diabetes	0.64 (0.55–0.76)	0.55 (0.48–0.62)	0.71 (0.60–0.84)	0.62 (0.54–0.71)
Chronic lung disease	0.69 (0.55–0.86)	0.61 (0.51–0.72)	0.75 (0.60–0.94)	0.66 (0.56–0.79)
Cancer	0.72 (0.55–0.93)	0.85 (0.70–1.03)	0.77 (0.59–1.01)	0.91 (0.75–1.11)
Stomach or duodenal ulcer	0.57 (0.42–0.76)	0.70 (0.57–0.85)	0.64 (0.48–0.86)	0.79 (0.65–0.97)
Parkinson's disease	0.20 (0.06–0.64)	0.53 (0.30–0.94)	0.21 (0.07–0.67)	0.54 (0.31–0.97)
Hip fracture/femoral fracture	0.41 (0.25–0.67)	0.52 (0.37–0.73)	0.45 (0.28–0.74)	0.56 (0.40–0.80)
Alzheimer's disease/dementia	0.48 (0.28–0.83)	0.43 (0.27–0.69)	0.51 (0.29–0.89)	0.45 (0.28–0.72)

Abbreviation: OR, odds ratio; CI, confidence interval.
Model 1: Analyses were adjusted for age, marital status, educational level, place of residence, smoking and country. Model 2: Analyses were adjusted for age, marital status, educational level, place of residence, smoking, country and the presence of others chronic diseases in 2011. Physical activity ''less than once a week'' was the reference category.

more than once a week presented prospectively lower odds of having chronic diseases. For men, VPA seems to have a greater effect on Parkinson's disease (OR: 0.36, 95% CI: 0.19–0.67, $P < 0.01$) and Alzheimer's disease (OR: 0.47, 95% CI: 0.25–0.88, $P < 0.01$). Practicing VPA once a week, compared to those who do less than once a week, was prospectively related with lower odds of heart attack (OR: 0.73, 95% CI: 0.61–0.88), chronic lung disease (OR: 0.70, 95% CI: 0.55–0.90), Parkinson's disease (OR: 0.38, 95% CI: 0.17–0.84) and Alzheimer's disease (OR: 0.16, 95% CI: 0.05–0.51). In the model adjusted for socio-demographic variables and smoking habits, women who practice VPA at least once a week were prospectively less likely to have chronic diseases, except for cancer, when compared to those who do less VPA. In the fully adjusted model, women who engaged in VPA once a week, compared with those who do VPA less than once a week, presented lower odds of having chronic diseases, except for hypertension, high blood cholesterol, and cancer. As for VPA more than once a week, cancer was the only disease not associated with physical activity.

Discussion

The purpose of this study was to investigate the cross-sectional and prospective associations between self-reported VPA and the risk of major chronic diseases in European older adults. It was found that VPA was associated with a reduced risk of chronic diseases. One of the most relevant findings was that even one session of VPA per week was cross-sectionally and prospectively associated with lower odds of having chronic diseases such as heart attack, chronic lung disease, Parkinson's disease and Alzheimer's disease among both men and women. Practicing VPA more than once per week further increased the number of chronic diseases that were negatively associated with VPA.

These results provide additional support for the documented inverse relationship between physical activity and cardiovascular, metabolic and mental chronic diseases.[4,10,11,22] The results also support that older people benefit from engaging in VPA, as observed previously,[22–24] regardless of adherence to prevailing physical activity guidelines.

The fact that the practice of VPA once a week was cross-sectionally and prospectively associated with lower odds of having some chronic diseases among men and women (e.g. heart attack, chronic lung disease, Parkinson's disease and Alzheimer's disease) reinforces the evidence that even a single weekly bout of exercise of high intensity may reduce the risk of chronic disease or cardiovascular death.[25–27] This fact is a message of hope for those who are unable to fulfil the recommendation for regular practice of physical activity, as being physically active, even below the recommended levels, still carries beneficial health effects. Moreover, if those who are physically inactive resolve to participate in VPA, at least once a week, they will collect its health benefits, regardless of their past sedentary behaviour.[18]

Although the analysis was stratified by gender, it was interesting to observe that cross-sectionally and prospectively VPA had the same effect on heart attack, chronic lung disease, Parkinson's disease and Alzheimer's disease among men and women. On the other hand, VPA once a week was cross-sectionally related to hypertension and high blood cholesterol in women, but not in men. This suggests that the gender has a moderating effect in some chronic diseases.[28,29]

In spite of the benefits of physical activity, its levels among older people are low.[14] Due to a multitude of health problems; older adults hardly achieved the recommended levels of physical activity. Therefore, the implementation of programmes that promote participation in MPA, but mainly VPA, may be considered as a strategy to reduce the number of chronic diseases in the older population. Furthermore, as even the practice of VPA once a week seems to have health benefits, it could be of interest for future studies to investigate the minimum amount of VPA for reduced odds of having chronic diseases in older adults. VPA is associated with lower risk mortality in adults and older adults regardless age.[30] Therefore, future studies have to analyse if the impact of VPA on chronic disease is also the same in adults and older adults.

This study has some limitations. The main limitation is the lack, or the shortage, of information on physical activity type, duration and frequency, which limits a more precise calculation of physical activity volume. Chronic diseases and physical activity were self-reported which is susceptible to bias, and the measurement of VPA includes only frequency, but not duration making it impossible to evaluate adherence to the guidelines. However, self-reported physical activity is considered a reliable method for epidemiologic studies,[31] and is still the backbone of surveillance studies.[32] The follow-up was shorter than that of previous prospective studies.[10,22,27]

The current investigation also had its strengths. A major strength of this study was the SHARE database that includes a large and representative sample size of various European countries, as well as several socio-demographic characteristics of the study sample. Another strength, considering the sample size and the heterogeneity of the participants, is the generality of these results. Furthermore, due to the large sample, there was an adequate statistical power. Prospective analysis allows for the examination of the cause and effect relationship between VPA and chronic diseases.

In conclusion, results from this large and statistically powerful study suggest that VPA is associated with a reduced risk of chronic diseases in men and women. Even the practice of VPA once a week seems to be sufficient to reduce the risk of chronic diseases.

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Conflicts of interest: None declared.

Key points

- There is evidence that vigorous-intensity physical activity (VPA) is associated with a greater decrease in the risk of incidence of major chronic diseases than moderate-intensity physical activity.
- VPA per week is associated with lower odds of having chronic diseases such as heart attack, chronic lung disease, Parkinson's disease, and Alzheimer's disease among both men and women.
- Even the practice of VPA once a week seems to be sufficient to reduce the risk of chronic diseases, regardless of adherence to prevailing physical activity guidelines.

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Thank you for your fine contribution. On behalf of the Editors of the Journal of Aging and Physical Activity, we look forward to your continued contributions to the Journal.

Sincerely,
Dr. Phil Chilibeck
Editor in Chief, Journal of
Aging and Physical
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Article 5

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Regular physical activity eliminates the harmful association of television watching with multimorbidity. A cross-sectional study from the European Social Survey

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ABSTRACT

The aims of the study were to analyse the association of television viewing, physical activity (PA), and multimorbidity; and to understand if PA attenuates or eliminates the detrimental associations between television viewing and multimorbidity. This is a cross-sectional study based on data from the European Social Survey round 7, 2014. Participants were 32,931 adults (15,784 men), aged 18–114 years old, from 18 European countries. Self-reported information regarding chronic diseases (CD), PA and time watching television were collected through interview. Logistic regression analysis was conducted to analyse the association between watching television and PA with the presence of multimorbidity (≥1 CD). Men and women who watched television had increased odds of having multimorbidity. When considering PA it was observed that, independently of television viewing, compared to engaging in PA for ≤1 day/week, engaging in 2–4 days/week and in ≥5 days/week was inversely associated with multimorbidity. Increased odds of multimorbidity were observed for men spending > 3 h/day watching television in the 2–3 days/week and ≤1 day/week categories of PA. For women engaged in 30 min of physical activity 2–3 days/week, spending > 3 h/day watching television was associated with higher odds for multimorbidity. For adults who practiced physical activity on ≥ 5 days/week watching television was not associated with multimorbidity. Time spent watching television is associated with multimorbidity. However, physical activity participation can attenuate or even eliminate this association.

1. Introduction

The prevalence of sedentary behaviours has increased (Hansen et al., 2012; Kohl 3rd et al., 2012). In high-income countries most adults spend their awake time in sedentary behaviours (Dumith et al., 2011), being television viewing time reported as the most prevalent leisure-time sedentary behaviour (Clark et al., 2009; Harvey et al., 2013). Several studies have demonstrated that sedentary behaviours, and particularly the time spent watching television, is associated with increased risk for mortality and chronic diseases, such as obesity, diabetes, cardiovascular diseases, and some cancers (Ekelund et al., 2016; Keadle et al., 2015; Pinto Pereira et al., 2012).

The deleterious associations of television viewing with mortality and chronic diseases in adults have been investigated to be independent of physical activity (Wijndaele et al., 2011). Interestingly, although the detrimental impact of time watching television has been also observed in active people (Healy et al., 2008), higher levels of physical activity may attenuate or even eliminate the increased risk associated with sedentary behaviours (Ekelund et al., 2016; Rao et al., 2016).

Several studies have addressed the association of television viewing and physical activity with specific chronic diseases (Ekelund et al., 2016; Keadle et al., 2015; Pinto Pereira et al., 2012) but few studies have investigated this issue with the presence of multimorbidity. The World Health Organization defines multimorbidity as the coexistence of two or more chronic conditions (WHO, 2016). The prevalence of multimorbidity is considering high (Barnett et al., 2012; Prazeres and Santiago, 2015; Puth et al., 2017), and evidence suggests that the most patients with chronic health conditions do not have a single diagnosis, but various diagnoses coexist within one person (Violan et al., 2014). Furthermore, multimorbidity becomes increasingly more common with age (Barnett et al., 2012; Prazeres and Santiago, 2015; Puth et al., 2017), is linked with high disability and mortality (Barnett et al., 2012),

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increased hospital admissions, use of inpatient and ambulatory health care (Salisbury et al., 2011), and reduced functional status (Fortin et al., 2014). Due to the high prevalence of sedentary behaviours (Hansen et al., 2012; Kohl 3rd et al., 2012), particularly the time watching television (Clark et al., 2009; Harvey et al., 2013), ageing population, and a high proportion of inactive adults (Loyen et al., 2017; Marques et al., 2015), the prevalence of multimorbidity has been rising (Pefoyo et al., 2015; Prazeres and Santiago, 2015; WHO, 2016). Therefore, the aim of this study was twofold: a) to analyse the association of television viewing, physical activity, and multimorbidity; and b) to understand if physical activity attenuates or eliminates the detrimental association between television viewing and multimorbidity.

2. Methods

2.1. Study design and participants

This is a cross-sectional study based on data from the European Social Survey round 7, 2014, including 20 European countries (Austria, Belgium, Switzerland, Czech Republic, Germany, Denmark, Estonia, Spain, Finland, France, Hungary, Ireland, Israel, Lithuania, Netherlands, Norway, Poland, Portugal, Sweden, Slovenia, United Kingdom) and Israel. The European Social Survey is an academically driven survey that has been conducted every two years across Europe since 2001. The survey measures the attitudes, beliefs, and behaviours of European adults. The European Social Survey uses national representative samples among countries. Participants are sampled by means of postal code address files, population registers, social security register data, or telephone books. In each country, the information was collected using a questionnaire filled-in through an hour-long face-to-face interview that included questions on the use of medicine, immigration, citizenship, socio-demographic and socioeconomic issues, health status, and physical activity. The questionnaire was translated into the language of each of the participating countries by language experts. Further details about European Social Survey are available elsewhere (Schnaudt et al., 2014). The study protocol of the European Social Survey subscribes the Declaration on Professional Ethics of the International Statistical Institute (http://www.europeansocialsurvey.org/about/ethics.html).

Probability sampling from residents aged 15 years and older was applied in all countries (excluding only the homeless and the institutionalized population), comprising 40,185 participants. For the present study participants under 18 years old were excluded from the analyses (n = 1215), because the focus was on the adult population. Participants from Czech Republic and Estonia did not report information on chronic diseases and were therefore excluded (n = 3943). Respondents without information in more than two socio-demographic variables were also excluded (n = 2096). These restrictions resulted in a total sample size of 32,931 participants (15,784 men, 17,147 women), aged 18–114 years old.

2.2. Measures

2.2.1. Chronic diseases

Chronic diseases (heart or circulation problems, high blood pressure, breathing problems, allergies, diabetes, and cancer) were assessed by asking participants to indicate whether they currently have, or had chronic diseases (yes/no) in the last 12 months. For obesity, body mass index (BMI) was calculated from self-reported height and weight (kg/m^2). Body mass index categories were calculated in accordance with the WHO guidelines (WHO, 2000) and dichotomized into non-obese (< 30.0 kg/m^2) and obese (≥ 30 kg/m^2). Multimorbidity was defined as the co-occurrence of two or more of these conditions.

2.2.2. Physical activity

Information on physical activity was assessed with a single item asking, “On how many of the last 7 days did you walk quickly, do sports, or other physical activity for 30 minutes or longer?”. Using the reported information on physical activity, a new variable was computed to classify participants into three groups: 1) practice of physical activity ≤ 1 day/week; 2) practice of physical activity 2–4 days/week; and 3) practice of physical activity ≥ 5 days/week. Although physical activity was assessed with a single item, there is evidence in previous studies that a single question is an acceptable alternative (Wanner et al., 2014). The American College of Sports Medicine highlights that, although health and fitness benefits may occur exercising only once per week, this is not recommended due to an increased risk in musculoskeletal injury and adverse cardiovascular events (ACSM, 2014). Accordingly, in this study, performing 0 and 1 days per week were grouped in the same category.

2.2.3. Time watching television

Participants were asked to report how much time, in total, they spend watching television on an average day. Responses were from no time to > 3 h, using intervals of 30 min. Based on previous recodification (Keadle et al., 2015), responses were recoded to “no time at all”, “ < 1-h/day”, “2–3 h/day”, and “ > 3 h/day”.

2.2.4. Covariates

Participants reported their sex and age. The European Social Survey data provides two variables of education attainment: a recoded variable that focuses on achieved levels of education (primary, lower secondary, upper secondary, post-secondary, and tertiary education), according to the International Standard Classification of Education (UNESCO, 2012), and years of full-time education. Participants were asked to describe whether they lived with or without a husband/wife/partner, and their correspondent legal status (e.g. married, civil union, illegally recognized). Response options were dichotomized into live with or without a partner. To determine the living place, participants were asked to report whether they lived in a big city, suburbs or outskirts of a big city, town or small city, country village, or home in countryside. Those who indicated that they lived in a big city, or suburbs, or outskirts of a big city were grouped into a new category named urban areas; those who responded that they lived in country village or home in countryside were grouped into rural areas. Household income was determined based on decile. Using this data, 1st to 3rd, 4th to 7th, and 8th to 10th decile were grouped to create three groups: low, middle and high, respectively.

Participants were asked about their smoking behaviours. Response options ranged from “I have never smoked” to “I smoke every day”. Because there is no threshold of safety for smoking cigarettes, responses were recoded into current smoker, former smoker, and never smoke. Participants were also asked how often they drink alcohol. Responses were recoded into less than once a month, 2–3 times a month, once a week, several times a week, and every day.

These socio-demographic variables were selected as covariates because they are determinant factors of physical activity and sedentary behaviours (Marques et al., 2016). Age, education, socioeconomic status (Barnett et al., 2012; Prazeres and Santiago, 2015; Puth et al., 2017), employment status and family structured (Agborsangaya et al., 2012; Chung et al., 2015) are also related with multimorbidity. Smoking cigarettes was also selected due to its associations to the development of several chronic diseases and mortality (Dhalwani et al., 2017; Loef and Walach, 2012).

2.3. Statistical analysis

Descriptive statistics were calculated (means, standard deviation, and percentages) for the entire sample, and stratified by sex. Chi-square and Student's *t*-test were used to compare men and women according to socio-demographic characteristics, the presence of chronic diseases in the last 12 months, multimorbidity, time spent watching television, and physical activity. To analyse the independent association of the time watching television and physical activity with multimorbidity a Chi-square test was used. Binary logistic regression models were conducted to analyse the association of watching television and practice of physical activity with the presence of multimorbidity. First, an unadjusted model was performed, afterwards analyses were adjusted for age, educational level, marital status, living place, country, and household income, smoking status and drinking alcohol. Finally, the analyses were further mutually adjusted for time watching television and physical activity. To analyse the effect of time spent watching television on multimorbidity, according to physical activity levels, new analyses were then performed stratified for physical activity frequency. These analyses were adjusted for age, educational level, marital status, living place, country, household income, smoking status, and drinking alcohol. Linear trends for odds-ratio were further assessed. All analyses were stratified by sex, because an interaction effect between sex and time spent watching television on chronic diseases was verified. Statistical analysis was performed using IBM SPSS Statistics v.24.0. The significance level was set at $p < 0.05$.

3. Results

In Table 1 are presented the descriptive characteristics of the participants. Considering both males and females, 21.6% of the participants had multimorbidity. Considering the time watching television, the category with fewer participants was 'no time at all' (5%), while in the other extreme 32.9% of the participants spent 1–2 h in this behaviour. Regarding physical activity, the proportion of participants was overall equally distributed by the three categories.

Table 2 represents the prevalence of multimorbidity (≥2 chronic diseases) by television watching and physical activity categories, stratified by sex. Chi-square analysis demonstrated that, for both men and women, there were differences in the distribution of multimorbidity for television watching and physical activity categories.

Table 3 depicts the results for multiple logistic regression analysis. Unadjusted analysis demonstrated that, when comparing to no time watching television, participants that watched television had increased odds of having multimorbidity. When accounting for other social-demographic confounders, men spending > 3 h/day watching television had 1.6 (95% CI: 1.3–2.1) higher odds of multimorbidity than those who did not watch television. In women, results were similar to those of the unadjusted model. After additionally accounting for physical activity it was observed that men spending 2–3 h/day (OR = 1.3, 95% CI: 1.01–1.69) and > 3 h/day watching television had increased odds for multimorbidity. Also, independently of physical activity, increased odds for multimorbidity were observed for women reporting < 1 h/day (OR = 1.33, 95% CI:1.03–1.71), 1–2 h/day (OR = 1.30, 1.02–1.66); 2–3 h/day (OR = 1.55, 1.21–1.99), and > 3 h/day (OR = 1.81, 1.41; 2.32) watching television, compared to those that did not spend any time in this sedentary behaviour.

When considering physical activity it was observed that, independently of television watching, compared to engaging in physical activity for ≤1 day/week, engaging in 2–4 days/week (men: OR = 0.69, 95% CI: 0.61–0.76; women: OR = 0.77, 0.70–0.86) and in ≥5 days/week (men: OR = 0.65, 95% CI: 0.58–0.72; women: OR = 0.74, 95% CI: 0.67–0.82) were significantly and inversely associated with multimorbidity.

The associations of television watching with multimorbidity, stratified by sex and physical activity categories are illustrated in Fig. 1. For participants engaging in 30 min of physical activity at least 5 days/week, time spent watching television and multimorbidity was not associated. Increased odds of multimorbidity were observed for men spending > 3 h/day watching television among those who reported engaging in physical activity 2–3 days/week (OR = 1.76, 95% CI: 1.05–2.94) and ≤1 day/week (OR = 2.13, 95% CI: 1.38–3.28). For women engaged in 30 min of physical activity 2–3 days/week spending > 3 h/day watching television was associated with higher odds for multimorbidity (OR = 2.1, 95% CI: 1.3–3.3). However, when analysing women that reported participating in physical activity ≤1 day/week, those watching television 2–3 h/day and > 3 h/day had higher odds for multimorbidity, 1.7 (95% CI: 1.1–2.6) and 2.0 (95% CI: 1.3–3.0) respectively.

Table 1
Participants' characteristics for total sample and stratified by sex in 2014.

	Total (n = 32,931)	Men (n = 15,784)	Women (n = 17,147)
	% or M ± SD	% or M ± SD	% or M ± SD
Education			
Low	25.6	20.3	30.6
Middle	51.3	57.2	45.8
High	23.1	22.5	23.7
Age	50.2 ± 18.1	49.9 ± 18.0	50.6 ± 18.0
Marital status			
Live with partner	61.5	64.4	58.9
Live without partner	38.5	35.6	41.1
Living place			
Urban area	63.6	63.0	64.2
Rural area	36.4	37.0	35.8
Household income			
Low (1st to 3rd decile)	30.5	26.5	34.3
Middle (4th to 7th decile)	42.4	43.8	41.0
High (8th to 10th decile)	27.1	29.7	24.6
Cigarette smoking			
Current	24.0	27.9	20.5
Former	33.1	38.2	28.3
Never	42.9	33.9	51.2
Drinking alcohol			
Less than once a month	44.7	32.4	56.0
2–3-times/month	12.8	12.8	12.7
Once a week	18.5	21.2	16.0
Several times/week	16.6	22.4	11.3
Every day	7.5	11.2	4.0
Chronic diseases (last 12 month)			
Without chronic diseases	52.8	55.2	50.6
High blood pressure	19.1	18.7	19.4
Obesity	15.6	15.7	15.4
Allergies	11.8	10.1	13.3
Cancer	11.4	9.9	12.8
Heart or circulation problems	10.8	10.4	11.2
Breathing problems	8.7	8.1	9.3
Diabetes	5.8	6.2	5.5
Multimorbidity			
No	78.4	79.7	77.2
Yes	21.6	20.3	22.7
Time watching TV (hours/day)			
No time at all	5.0	5.2	4.8
< 1 h	20.7	21.5	20.0
1–2 h	31.3	31.4	31.2
2–3 h	24.9	24.2	25.3
> 3 h	18.1	17.4	18.7
Physical activity (times/week)			
≤1 time	34.7	33.1	36.3
2–4 times	32.8	33.3	32.6
≥5 times	32.4	33.9	31.1

Abbreviation: M, media; SD, standard deviation.

Table 2
Prevalence of multimorbidity stratified by sex and physical activity and time watching television categories in 2014.

	Chronic diseases		
	≤1 chronic disease	Multimorbidity	*p*
Men (n = 15,784)			
Time watching TV (hours/day)			< 0.001
No time at all	5.8	2.9	
< 1 h	23.2	14.5	
1–2 h	32.4	27.4	
2–3 h	23.5	28.3	
> 3 h	15.0	26.9	
Physical activity			< 0.001
≤1 time/week	30.3	43.8	
2–4 times/week	34.7	26.5	
≥5 times/week	34.9	29.7	
Women (n = 17,147)			
Time watching TV (hours/day)			< 0.001
No time at all	5.4	2.6	
< 1 h	21.8	13.8	
1–2 h	32.9	25.3	
2–3 h	24.1	29.3	
> 3 h	15.7	28.9	
Physical activity			< 0.001
≤1 time/week	33.3	46.4	
2–4 times/week	34.4	26.4	
≥5 times/week	32.3	27.1	

Tested by Chi-square test.

Table 3
Relationship between multimorbidity, and time spend watching television and physical activity in 2014.

	Multimorbidity (≥2 chronic diseases)[a]		
	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)
Men			
Time watching TV (hours/day)			
No time at all	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
< 1 h	1.25 (0.99–1.58)	1.01 (0.77–1.31)	1.02 (0.78–1.33)
1–2 h	1.70 (1.35–2.13)	1.08 (0.84–1.40)	1.10 (0.85–1.42)
2–3 h	2.42 (1.92–3.04)	1.28 (0.99–1.66)	1.30 (1.01–1.69)
> 3 h	3.58 (2.84–4.51)	1.62 (1.25–2.11)	1.60 (1.23–2.09)
Physical activity			
≤1 time/week	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
2–4 times/week	0.53 (0.48–0.58)	0.68 (0.61–0.76)	0.69 (0.61–0.76)
≥5 times/week	0.59 (0.54–0.65)	0.64 (0.57–0.71)	0.65 (0.58–0.72)
Women			
Time watching TV (hours/day)			
No time at all	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
< 1 h	1.29 (1.03–1.62)	1.32 (1.03–1.71)	1.33 (1.03–1.71)
1–2 h	1.56 (1.26–1.94)	1.29 (1.01–1.65)	1.30 (1.02–1.66)
2–3 h	2.48 (1.99–3.08)	1.55 (1.21–1.98)	1.55 (1.21–1.99)
> 3 h	3.74 (3.00–4.66)	1.85 (1.44–2.37)	1.81 (1.41–2.32)
Physical activity			
≤1 time/week	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
2–4 times/week	0.55 (0.50–0.60)	0.76 (0.69–0.84)	0.77 (0.70–0.86)
≥5 times/week	0.60 (0.55–0.66)	0.72 (0.66–0.80)	0.74 (0.67–0.82)

Model 1: Unadjusted analyses.
Model 2: Analyses were adjusted for age, educational level, marital status, living place, country, and household income, smoking cigarettes and drinking alcohol.
Model 3: Analyses were adjusted for age, educational level, marital status, living place, country, household income, smoking cigarettes, drinking alcohol, and mutually adjusted for time spent watching TV and physical activity.
[a] The reference category was not having multimorbidity.

4. Discussion

This study provides data from over thirty thousand European adults and examines the association between television viewing and physical activity with multimorbidity. The main findings from the current investigation envision that television viewing was positively associated with multimorbidity, while physical activity was negatively related to multimorbidity. Interestingly, our results suggest that for participants who more frequently engage in physical activity, the harmful association between television viewing and multimorbidity is attenuated or even eliminated.

In the current investigation it was observed that the prevalence of multimorbidity was higher among those participants spending more time watching television and also for those performing less frequently physical activity. Additionally, the physical activity was related to lower odds, while time spent watching television was related to increased odds for multimorbidity, for both men and women, though in men this was only verified for those watching two or more hours of television. The risk for multiple chronic diseases has been previously investigated to be higher for those spending more time watching television (Keadle et al., 2015; Pinto Pereira et al., 2012) and lower for adults engaging in more physical activity (Cassidy et al., 2016; Jakes et al., 2003). The results from our study further strengthen the negative role of sedentary behaviour in health, particularly watching television.

Previous investigations have observed that sedentary behaviour is deleteriously related to some chronic diseases (Keadle et al., 2015; Pinto Pereira et al., 2012). The findings from the current investigation extend these observations in a large sample of European adults and further verified that in participants engaging more frequently in physical activity (i.e. ≥5 days/week) these associations were not significant. This finding strengthens the evidence that being physically active (i.e. spending ≥30 min/d of moderate-to-vigorous physical activity for at least 5 days/week) is not only beneficial for not having multiple chronic disease, as it also helps to attenuate or eliminate the negative role of watching television. Ekelund et al. (2016) have also observed that the spending up to 4-hour watching television was not associated to all-cause mortality in more active participants (> 35.5 MET-h/week). Although, previous studies have highlighted that higher levels of physical activity may attenuate or even eliminate the increased risk of time spent watching television in other outcomes such as mortality or metabolic syndrome (Ekelund et al., 2016; Rao et al., 2016), the role of physical activity in the relationship between watching television and multimorbidity has been less investigated.

Previous research has reported that, in adults, the association between watching television with mortality and chronic diseases is independent of physical activity (Wijndaele et al., 2011) and the detrimental impact of the time watching television on metabolic risk has been also observed in active people (Healy et al., 2008). Contrary, the findings from the current study suggest otherwise. Dissimilarities in the population studied and in the health outcome that was analysed may be in part responsible for the different conclusions.

Some strengths and limitations of the study should be acknowledged. The main strength of this study was the European Social Survey database, which includes a large and representative sample of adults from several European countries, as well as socio-demographic characteristics and numerous chronic diseases of the study sample. In view of the large sample and the heterogeneity of the participants, the generality of these results should be considered strengths of the study. Moreover, due to the large sample size, there was an adequate statistical power. Also, the use of multimorbidity, instead of specific single chronic diseases, as a health indicator is of importance, mainly because multimorbidity is becoming progressively common (Barnett et al., 2012) and an increasing burden for public health (Pefoyo et al., 2015). On the other hand, the main limitation of the study is the lack of information on physical activity, such as duration and more detail about frequency. This lacking information precludes the calculation of

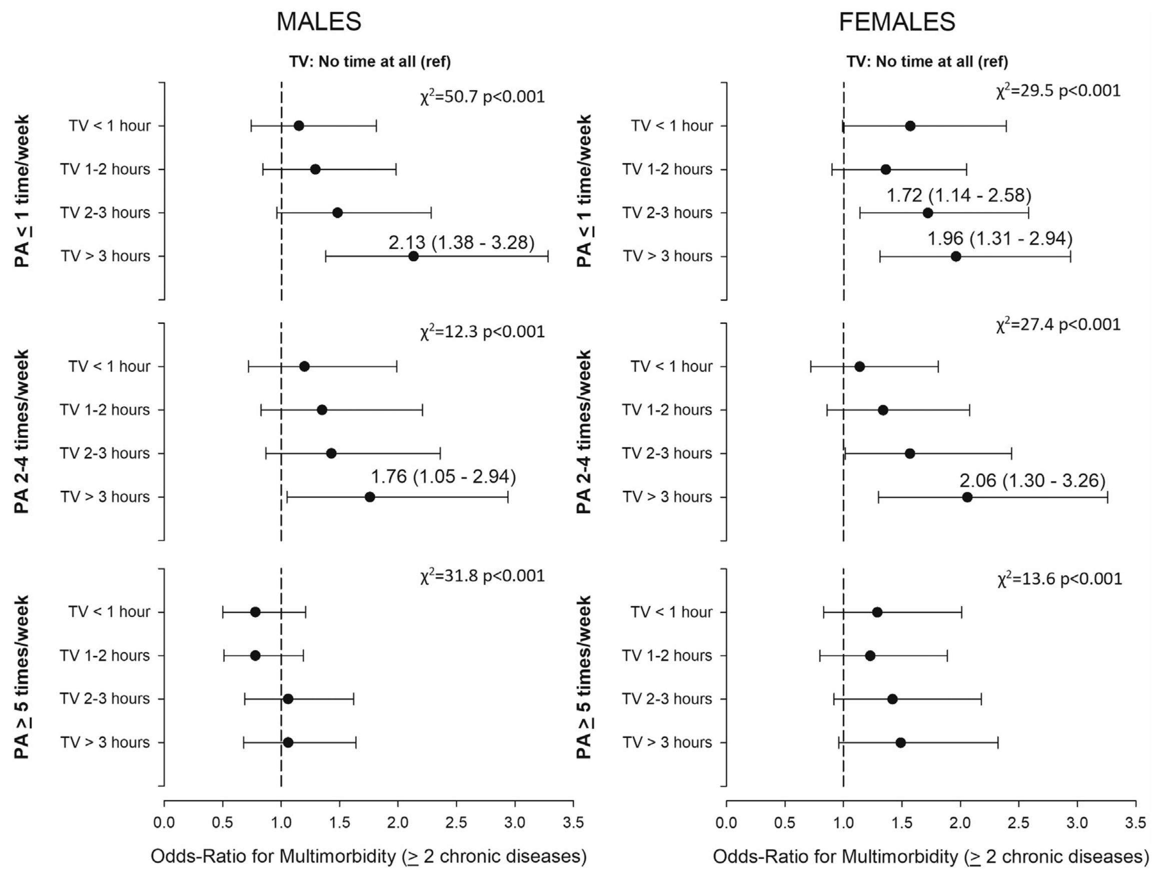

Fig. 1. Relationship between multimorbidity, and time spend watching television stratified by sex and physical activity categories in 2014.
Abbreviations: PA, physical activity; TV, television.
Analyses were adjusted for age, educational level, marital status, living place, country, household income, smoking status, drinking alcohol. χ^2 square was used to analyse linear-by-linear association between odds-ratio.

physical activity volume more accurately. Physical activity was self-reported which is susceptible to bias. Nonetheless, self-reported physical activity is a reliable method for epidemiologic studies (Craig et al., 2003), and is still as the mainstay of surveillance studies (Pedisic and Bauman, 2015). Furthermore, the cross-sectional design implies that no causal inferences can be made. However, the results from this study allow generating hypothesis. It seems that being physically active is not only beneficial for not having multiple chronic disease, as it also helps to attenuate or eliminate the negative role of watching television. This generated hypothesis should stimulate future research using longitudinal design to analyse the cause-effect relationship between multimorbidity, physical activity, and time spending watching television.

5. Conclusion

The present study found that, independently, the time spent watching television and the frequency of physical activity is associated with multimorbidity. However, when combining these behaviours, physical activity participation attenuates or even eliminates the deleterious effect of watching television on the presence multiple chronic diseases. Future interventions to prevent multimorbidity should focus on increasing physical activity, particularly emphasising on accomplishment of physical activity recommendations. Still, whenever higher levels of physical activity are not achievable, for timing or health reasons, reducing screen time, and particularly the time watching television, may be suggested as an effective prevention strategy.

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Competing interests

The authors have no competing interests to declare.

Conflicts of interest

None.

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Article 6

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Physical activity buffers the negative relationship between multimorbidity, self-rated health and life satisfaction

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ABSTRACT

Background This study aimed to examine the relationship between multimorbidity, self-rated health and life satisfaction, and to test the moderating effect of physical activity on the relationship between multimorbidity, self-rated health and life satisfaction.

Methods This is a cross-sectional study based on data from the European Social Survey 2014. Participants were 25 713 adults (12 830 men), aged 18–64 years old, from 18 European countries and Israel. Self-reported information regarding chronic diseases, health perception, life satisfaction and physical activity was collected through interview. Multimorbidity was defined as the co-occurrence of ≥ 2 chronic diseases. Linear regression models were used to estimate the effects of multimorbidity, physical activity and the interaction effect of multimorbidity × physical activity on self-rated health and life satisfaction.

Results Multimorbidity was negatively related to self-rated health (d = 0.03) and life satisfaction (d = 0.03). Physical activity was positively related to self-rated health and life satisfaction. There was a significant interaction effect between multimorbidity and physical activity with regard to self-rated health ($\beta = 0.01$, $P < 0.001$) and life satisfaction ($\beta = 0.04$, $P < 0.001$).

Conclusions Physical activity buffered the negative relationship between multimorbidity, self-rated health and life satisfaction; contributing to better self-rated health and life satisfaction.

Keywords chronic diseases, European, exercise

Introduction

Self-rated health reproduces the subjective experience of health, and it has been shown to be a significant predictor of morbidity and mortality,[1,2] related to several biomarkers such as blood pressure, blood levels of albumin, white blood cell count, haemoglobin, HDL cholesterol, serum creatinine and a barometer of physiological states.[1,3,4] Life satisfaction can be defined as a general evaluation of an individual's personal life, and has been related to several mental adverse health outcomes such as depression and psychiatric problems,[5] along with somatic disability and mortality.[6] The association between self-rated health and life satisfaction with health outcomes enables a conceptual understanding of the health from people's perspective.

Multimorbidity, defined as the co-occurrence of two or more chronic diseases[7] is a consequence of the aging of the population; it results from both an increase in the prevalence of chronic diseases,[8] and the number of diseases from which a patient suffers.[9] Multimorbidity influences health perception and subjective wellbeing perhaps because of its physical and psychological consequences.[10] Chronic diseases affect people ability to manage their daily functioning, and those

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people usually experienced a decline on their quality of life.[11] Thus, the presence of multimorbidity is negatively associated with both self-rated health[2,12,13] and life satisfaction.[14] Most studies relating self-rated health or life satisfaction to chronic diseases focus on specific populations or specific diseases or group of diseases. For example, among middle-aged and older adults, poorer self-rated health is strongly associated with single chronic diseases, particularly cardiovascular diseases, multimorbidity and poor psychosocial function,[2,13,15] while life satisfaction is inversely associated with multimorbidity.[14,15] Similarly, cardiovascular mortality in the general populations with and without prior cardiovascular disease is associated with poor self-rated health.[16] Also, increased risk of specific diseases, such as cancer, stroke and type 2 diabetes mellitus are associated with lower life satisfaction.[17]

In opposition to multimorbidity, physical activity has been shown to have a significant and positive association with self-rated health and life satisfaction.[18,19] Furthermore, physical activity can reduce chronic diseases and the risk of disease progression,[20–22] and it is inversely associated with multimorbidity.[12] However, the possibility for physical activity moderating the relationship between multimorbidity and self-rated health and life satisfaction has yet to be explored. It is thus expected that, by having a positive effect on self-rated health and life satisfaction, and by having a protective health effect against chronic diseases, physical activity might moderate the relationship between multimorbidity and self-rated health and life satisfaction. Therefore, the purpose of this study was two-pronged: (i) to examine the relationship between multimorbidity, self-rated health and life satisfaction; and (ii) to test the moderating effect of physical activity on the relationship between multimorbidity, self-rated health and life satisfaction.

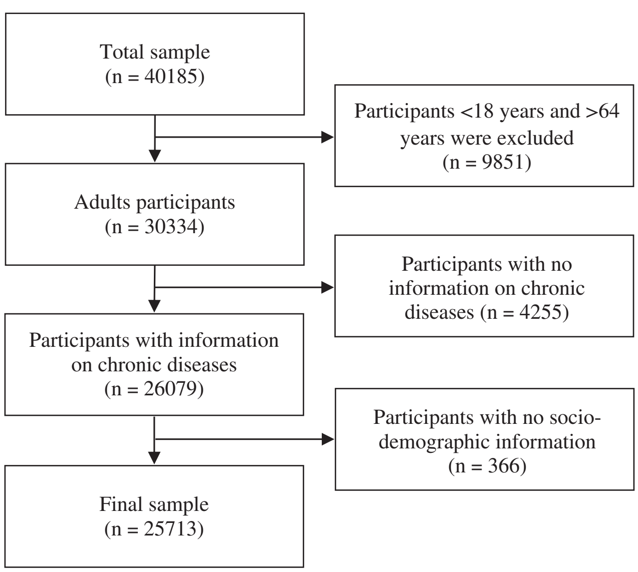

Fig. 1 Flow chart diagram of participants.

Methods

Study design and participants

The present study was based on the seventh wave of the European Social Survey, 2014, which included 20 European countries (Austria, Belgium, Switzerland, Czech Republic, Germany, Denmark, Estonia, Spain, Finland, France, Hungary, Ireland, Lithuania, Netherlands, Norway, Poland, Portugal, Sweden, Slovenia, UK) and Israel. The European Social Survey is a survey that has been conducted every two years to measure the attitudes, beliefs, and behaviours of European adults. The survey uses representative samples among countries. Participants were sampled by postal code, address files, social security registry data, population registers and/or telephone books. The information was collected in each country, using a questionnaire filled-in through an hour-long face-to-face interview. The questionnaire was translated, by language experts, into the language spoken in each of the participating countries. Further details about the European Social Survey are available elsewhere.[23] The study protocol subscribes to the Declaration on Professional Ethics of the International Statistical Institute.

Probability sampling from residents aged 15 years and older was applied (excluding the homeless, and institutionalized people), comprising 40 185 participants. For the present study participants under 18 years and above 64 years of age were excluded ($n = 9851$), because the focus was on the adult population. Participants from Czech Republic and Estonia, and others that also did not report information on chronic diseases and were therefore excluded ($n = 4255$). Respondents without information in more than two socio-demographic variables were also excluded ($n = 366$). These restrictions resulted in a sample of 25 713 participants (12 830 men and 12 883 women) (Fig. 1).

Measures

Chronic diseases

Most of the chronic diseases (heart or circulation problems, high blood pressure, diabetes, stomach or digestion problems, breathing problems, allergies, headaches and cancer) were assessed by asking participants to indicate whether they currently have, or had, chronic diseases (yes/no) in the last 12 months. For obesity, body mass index (BMI) was calculated from self-reported height and weight (kg/m^2). Body mass index categories were calculated in accordance with the WHO guidelines[24] and dichotomized into non-obese (<30.0 kg/m^2)

and obese ($\geq$30 kg/m^2). Multimorbidity was defined as the co-occurrence of two or more of the nine aforementioned diseases.[7]

Physical activity

Physical activity was assessed with a single item asking, 'On how many of the last 7 days did you walk quickly, do sports or other physical activity for 30 min or longer?' Although physical activity was assessed with a single item, there is evidence in previous studies that a single question is an acceptable alternative;[25] this approach was used previously with European Social Survey data.[26,27]

Self-rated health

Self-rated health was assessed with a single item question. Participants were asked, 'How is your health in general?' The response options were very bad, bad, fair, good or very good. This single item question has been widely validated in epidemiological studies.[26–28] Previous studies have found a relationship between levels of self-rated health and adverse health outcomes, indicating its validity.[1,29]

Life satisfaction

Life satisfaction was assessed with the item, 'How satisfied are you with your life as a whole nowadays?' Responses were indicated using a scale ranging from 0 'extremely dissatisfied' to 10 'extremely satisfied'. Studies have shown that life satisfaction is associated to mental health outcomes,[5] can predict mortality,[30] and that one single item is a robust measure capable of reliably estimating life satisfaction.[31]

Covariates

Participants reported sex, age and years of full-time education. Respondents were asked to describe whether they live with or without a husband/wife/partner, and the legal situation. Response options were dichotomized into live with, or without, a partner. Household income was determined based on decile. It is a socioeconomic indicator as important as or more important than education and occupation, because is indicative of a standard of living.[32] Household income also shows relationship with health status.[33] Using household income decile information, first to third decile, fourth to seventh decile and 8th to 10th were grouped to create three groups. Participants were asked to report their occupation. To determine the living place, those who indicated that they lived in a big city, the suburbs or the outskirts of big city were grouped into a new category named urban areas; those who responded that they lived in the country, a village or a home in countryside were grouped into rural areas. Participants answered if they lived with or without children at home, along with the number of people living regularly as a member of the household.

Data analysis

Descriptive statistics were calculated for the entire sample (means, standard deviation and percentages). The relationship between the presence or absence of chronic diseases and multimorbidity, according self-rated health and life satisfaction, was tested by ANCOVA. Linear regression models were used to estimate the principal effects of multimorbidity, physical activity, and the interaction effect of multimorbidity × physical activity on self-rated health and life satisfaction. Multimorbidity enters the models as a dummy variable, and physical activity as a continuous variable. To calculate the variable that expresses the interaction effect (multimorbidity × physical activity), physical activity was transformed using grand mean centring. The grand mean centring was calculated by taking each value of physical activity (times/week) and subtracting from it the mean of the total sample. Physical activity grand mean centring was then multiplied by multimorbidity to have a variable to test the moderation effect (multimorbidity × physical activity). Analyses were not stratified by sex or age because an interaction effect between sex and age on multimorbidity was not verified. For ANCOVA and linear regression, the analysis were adjusted for sex, age, education, marital status, household income, occupation, living place, having children and household members. Statistical analysis was performed using IBM SPSS Statistics v.24.0. The significance level was set at $P < 0.05$.

Results

Table 1 presents the characteristics of the study sample. The most prevalent chronic diseases were: high blood pressure (17.5%), stomach or digestion problems (16.2%) and obesity (15.5%). Almost 30% of the participants had multimorbidity ($\geq$2 chronic diseases). From 1 to 5, the mean value for self-rated health was 3.8 ± 0.9, and from 0 to 10, the mean of life satisfaction was 7.2 ± 2.2. Physical activity was practiced, on average, 3.2 ± 2.6 times/week.

Results of the relationship between the presence or absence of chronic diseases and multimorbidity, according to self-rated health and life satisfaction, are presented in Table 2. For each chronic disease, participants who did not report having the disease had significantly better self-rated health than those who reported having the disease. Similar

Table 1 Participants' characteristics for total sample and stratified by sex in 2014

	Total (n = 25713) *% or M ± SD*
Sex	
Male	48.7
Female	51.3
Age	47.4 ± 18.3
Education (years)	12.5 ± 3.9
Marital status	
Live with partner	62.0
Live without partner	38.0
Household income	
Low (first to third decile)	30.1
Middle (fourth to seventh decile)	43.1
High (8th to 10th decile)	26.8
Occupation	
Employed	61.9
Unemployed	6.8
Student	8.7
Retired	22.5
Living place	
Urban area	61.1
Rural area	38.9
Children	
Do not have children	60.8
Have children	39.2
Household members	2.8 ± 1.4
Chronic diseases (last 12 month)	
Heart or circulation problems	9.8
High blood pressure	17.5
Diabetes	4.9
Obesity	15.5
Stomach/digestion problems	16.2
Breathing problems	8.8
Allergies	12.4
Headaches	14.4
Cancer	10.3
Multimorbidity	
No	70.3
Yes	29.7
Self-rated health	3.8 ± 0.9
Life satisfaction	7.2 ± 2.2
Physical activity (times/week)	3.2 ± 2.6

results were observed for life satisfaction. Those who did not report the presence of the disease had better life satisfaction, with the exception of allergies. Although the effect size was small, multimorbidity was also significantly related to self-rated health and life satisfaction. Those without multimorbidity had better self-rated health (4.08 ± 0.77 versus 3.40 ± 0.89, $F(1) = 2399.93$, $P < 0.001$) and better life satisfaction (7.37 ± 20.00 versus 6.86 ± 2.30, $F(1) = 243.35$, $P < 0.001$).

Table 3 depicts the results for linear regression analysis. Unadjusted analysis demonstrated that multimorbidity was negatively related to self-rated health and life satisfaction. When accounting for other social-demographic confounders, multimorbidity remained negatively related with self-rated health ($\beta = -0.52$, 95% CI: −0.054 to −0.50, $P < 0.001$) and life satisfaction ($\beta = -0.43$, 95% CI: −0.49 to −0.37, $P < 0.001$). In turn, in the unadjusted and adjusted model, physical activity was positively related to self-rated health ($\beta = 0.04$, 95% CI: 0.04–0.05, $P < 0.001$) and life satisfaction ($\beta = 0.07$, 95% CI: 0.05–0.08, $P < 0.001$). There was a significant interaction effect between multimorbidity and physical activity with regard to self-rated health ($\beta = 0.01$, 95% CI: 0.01–0.02, $P < 0.001$) and life satisfaction ($\beta = 0.04$, 95% CI: 0.02–0.06, $P < 0.001$), portraying physical activity as a moderator of the relationship between multimorbidity and these variables.

Discussion

Main finding of this study

This study investigated the relationship between multimorbidity, self-rated health and life satisfaction, as well as the moderating effect of physical activity on the relationship between multimorbidity, self-rated health and life satisfaction. Multimorbidity was negatively related to self-rated health and life satisfaction. On the other hand, physical activity was positively related to self-rated health and life satisfaction, thereby buffering the effect of multimorbidity on self-rated health and life satisfaction. In sum, physical activity moderates the effect of multimorbidity on self-rated health and life satisfaction.

What is already known on this topic

Subjective health expressed, as self-rated health, is associated with single chronic diseases and with multimorbidity. Those with chronic diseases and multimorbidity had lower self-rated health. Results from this study are in line with previous findings in literature.[2,12,13] These results corroborate that self-rated health is a proxy of health biomarkers,[1] and a barometer of physiologic states,[3] because it is sensitive to the presence of chronic diseases or multimorbidity. Self-rated health is correlated with socio-demographic factors.[2,13] However, adjusting the analysis of the relationship between multimorbidity and self-rated health, for socio-demographic

Tables 2 Relationship between, chronic diseases and the presence of multimorbidity and self-rated health of European adults in 2014

Chronic diseases and multimorbidity	*Self-rated health*		*Life satisfaction*	
	Mean ± SD	P	*Mean ± SD*	P
Heart or circulation problems		<0.001		<0.001
No	3.96 ± 0.81		7.28 ± 2.07	
Yes	3.08 ± 0.90		6.62 ± 2.39	
High blood pressure		<0.001		<0.001
No	3.99 ± 0.82		7.29 ± 2.05	
Yes	3.35 ± 0.87		6.89 ± 2.33	
Diabetes		<0.001		<0.001
No	3.92 ± 0.84		7.24 ± 2.09	
Yes	3.09 ± 0.89		6.82 ± 2.38	
Obesity		<0.001		<0.001
No	3.95 ± 0.84		7.28 ± 2.07	
Yes	3.49 ± 0.87		6.90 ± 2.29	
Stomach/digestion problems		<0.001		<0.001
No	3.94 ± 0.84		7.27 ± 2.08	
Yes	3.59 ± 0.91		6.97 ± 2.21	
Breathing problems		<0.001		<0.001
No	3.93 ± 0.84		7.25 ± 2.08	
Yes	3.34 ± 0.96		6.88 ± 2.33	
Allergies		<0.001		0.964
No	3.89 ± 0.86		7.21 ± 2.11	
Yes	3.81 ± 0.87		7.27 ± 2.09	
Headaches		<0.001		<0.001
No	3.92 ± 0.84		7.30 ± 2.05	
Yes	3.64 ± 0.93		6.77 ± 2.37	
Cancer		<0.001		<0.001
No	3.93 ± 0.84		7.25 ± 2.08	
Yes	3.43 ± 0.95		6.93 ± 2.33	
Multimorbidity		<0.001		<0.001
No	4.08 ± 0.77		7.37 ± 2.00	
Yes	3.40 ± 0.89		6.86 ± 2.30	

Tested by ANCOVA.

SD, standard deviation.

Analysis were adjusted for sex, age, education, marital status, household income, occupation, living place, having children and household members.

factors, did not significantly modify the association. This reinforces the strong relationship between the two variables, independently of socio-demographic factors.

Literature shows that chronic diseases and multimorbidity are associated with lower life satisfaction.[14,34] This was observed, in the present study, for all particular chronic diseases (except for allergies) and for multimorbidity, confirming that the presence of these diseases, or a cluster of these diseases, has a negative effect on subjective wellbeing. The observed negative relationship supports the fact that life satisfaction depends on the individual's health status.[35] This finding depicts life satisfaction as an important health outcome used to characterize the population's health and wellbeing.[5,36]

Regarding the relationship between physical activity, self-rated health and life satisfaction, this study's results provide evidence that regular physical activity is associated with better self-rated health and life satisfaction among adults. Previous studies have also demonstrated the positive relationship between these variables.[18,19] The impact of physical activity on self-rated health and life satisfaction is observed even among people with chronic diseases,[37,38] and exists across the spectra of both age and socioeconomic status.[19,39]

Table 3 Main and interaction effect of multimorbidity and physical activity on self-rated health and life satisfaction of European adults in 2014

	Self-rated health		*Life satisfaction*	
	Model 1 β *(95% CI)*	*Model 2* β *(95% CI)*	*Model 1* β *(95% CI)*	*Model 2* β *(95% CI)*
Multimorbidity[a]	−0.60 (−0.68, −0.64)*	−0.52 (−0.54, −0.50)*	−0.48 (−0.54, −0.42)*	−0.43 (−0.49, −0.37)*
Physical activity	0.05 (0.04, 0.05)*	0.04 (0.04, 0.05)*	0.07 (0.06, 0.09)*	0.07 (0.05, 0.08)*
Multimorbidity × physical activity[b]	0.02 (0.02, 0.03)*	0.01 (0.00, 0.02)*	0.04 (0.02, 0.06)*	0.04 (0.02, 0.06)*

CI, confidence interval.

Model 1: Unadjusted analyses.

Model 2: Analyses were adjusted for sex, age, education, marital status, household income, occupation, living place, having children and household members.

$*P < 0.001$.

[a]Multimorbidity enter into the model as a dummy variable.

[b]Physical activity was transformed using grand mean centring. The grand mean centring was achieved by taking each value of physical activity (times/week) and subtracting from it the mean of the total sample.

What this study adds

The identification of physical activity as a mediator between multimorbidity, self-rated health and life satisfaction is of importance because this moderation effect changes the slope of the negative relationship (i.e. physically active people with multimorbidity can have better self-rated health and life satisfaction than their non-active peers). Considering that self-rated health and life satisfaction are directly linked to mortality, health biomarkers and mental health outcomes,[1,2,5] improving self-rated health and life satisfaction can result in improving general health status. This study's results offer potential targets for future public health interventions. In order to enhance overall physical and mental health status, both of which are strongly linked to self-rated health and life satisfaction, physical activity should be promoted. For those who are not physically active, even a minimum amount of physical activity has a protective health effect against chronic diseases and mortality.[20–22]

Limitations of this study

A number of strengths and limitations should be kept in mind. The main strength of this study was the European Social Survey database, which includes a large and representative sample of adults from several European countries, as well as socio-demographic characteristics and numerous chronic diseases of the study sample. In view of the large sample and the heterogeneity of the participants, the generality of these results should be considered strengths of the study. The use of multimorbidity as a predictor variable is of importance, because multimorbidity is becoming progressively common,[40] and is an increasing burden for public health.[41] On the other hand, there are some limitations that should be acknowledged. The cross-sectional design implies that no causal inferences can be made. The current study cannot answer the question whether multimorbidity changes self-rated health and life satisfaction, or vice versa. Although the large and representative sample of adults contributes to the generalization of the results, when doing so and when designing public health interventions the cultural and socio-demographic differences across European countries should be taken into account. Notwithstanding, all the analyses were adjusted to socio-demographic characteristics. Multimorbidity was based on self-reports, and only nine chronic diseases were considered, albeit the major ones.[42] However, studies have suggested that self-reported chronic disease is fairly to largely accurate for most diseases.[43] Physical activity was self-reported which could be subject to bias in terms of over- and under-estimation.[44] Nonetheless, self-reported physical activity is a reliable method for epidemiologic studies, and is still the mainstay of surveillance studies.[45] Considering that only nine chronic diseases were used to calculate multimorbidity, perhaps some participants classified as not suffering from multimorbidity could be included in this group if more diseases had been asked for. Nevertheless, the chronic diseases included in the study were the most prevalent ones. Finally, the European Social Survey had no data on whether individuals had mobility limitations or not. Therefore the analyses were not adjusted for mobility limitations.

Conclusion

Multimorbidity was negatively related to self-rated health and life satisfaction. Physical activity buffered these relationships, contributing to better self-rated health and life satisfaction, even among European adults with multimorbidity. These findings offer potential targets for future public health interventions. Promoting physical activity, and thus improving self-rated health and life satisfaction in order to enhance overall physical and mental health status, is suggested to be an important intervention strategy.

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Conflicts of interest

The authors declare none conflict of interests.

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Expanded abstract in Spanish

Introducción

Las enfermedades crónicas son actualmente la principal causa de morbilidad y mortalidad. Su prevalencia es tan elevada que se considera una epidemia a nivel mundial. Las enfermedades crónicas afectan negativamente la calidad de la vida debido a las consecuencias físicas y psicológicas en el nivel de la salud. En el 2015 han sido responsables del 70% de las muertas en el mundo (WHO, 2017).

Las enfermedades crónicas se asociaban principalmente con las personas mayores. Sin embargo, debido a los cambios de los estilos de vida que han ocurrido en los últimos años, estas presentan altos niveles de incidencia y prevalencia en la población joven y adulta (WHO, 2017). De los 38 millones de muertes ocurridas en 2012 a causa de las enfermedades crónicas, más del 40% fueron prematuras (WHO, 2014). Entre los principales factores de riesgo para contraer algunas enfermedades crónicas se destacan el tiempo pasado en comportamientos sedentarios y los bajos niveles de actividad física. Por lo tanto, ha habido un interés en la promoción de la salud a través del aumento de los niveles de actividad física. Por esto, se ha recomendado la práctica regular de actividad física (European Union, 2008, WHO, 2010), debido a su efecto positivo para la prevención primaria y secundaria de las enfermedades crónicas (Alves et al., 2016).

La práctica regular de actividad física parece reducir el riesgo y la progresión de las enfermedades crónicas (Ekelund et al., 2016, Huai et al., 2013). Para las personas que sufren estas enfermedades, la actividad física mejora la capacidad funcional y la calidad de vida (Kujala, Kukkonen-Harjula, & Tikkanen, 2015). Además, existe evidencia de que la actividad física reduce la mortalidad prematura y la morbilidad asociada con las enfermedades crónicas (Ekelund et al., 2015; Lear et al., 2017), incluso pequeñas cantidades de actividad física parecen tener un efecto protector contra las enfermedades crónicas (Wen et al., 2011). Por ello, la Organización Mundial de la Salud considera que la actividad física es un factor determinante para controlarlas y prevenirlas (WHO, 2014).

Es entonces importante, entender la relación entre la actividad física y las enfermedades crónicas. Como la actividad física puede ser practicada a varios niveles de intensidad, conviene comprender qué niveles tienen un efecto positivo en la prevención de estas enfermedades. Esto es particularmente importante para los ancianos, porque por norma sólo practican actividad física moderada. Por otro lado, muchas personas tienen más que una enfermedad crónica (multimorbilidad), en estos casos es importante comprender la relación entre la actividad física y las enfermedades crónicas, pero controlando la relación para las restantes enfermedades. Más aún, conociendo la relación positiva entre los comportamientos sedentarios y las enfermedades crónicas, es importante percibir si la actividad puede tener un papel moderador en esta relación.

Para responder a estas cuestiones, fueron realizados 6 estudios que componen la tesis. En el primer estudio se procuró analizar transversal y longitudinalmente la relación entre la práctica regular de la actividad física y el número de las enfermedades crónicas. El segundo analizó la relación entre la actividad física y la prevalencia de las enfermedades crónicas más prevalentes, controlando la relación con todas las enfermedades crónicas. El tercer y cuarto analizaron la intensidad de la actividad física y las enfermedades crónicas. El quinto analizó el efecto moderador de la actividad física en la relación entre la multimorbilidad y el tiempo dedicado a ver televisión. Por último, el sexto, analizó el efecto que la actividad física tiene en la relación negativa entre la multimorbilidad, percepción del estado de salud y la satisfacción con la vida.

Objetivos

Considerando la evidencia científica, que muestra que existe una relación entre la actividad física y las enfermedades crónicas, y algunas dudas que persisten sobre los niveles de intensidad recomendados, la existencia de múltiples enfermedades al mismo tiempo y del efecto moderador que la actividad física podrá tener en la relación entre los comportamientos sedentarios y las enfermedades crónicas, los objetivos del presente trabajo fueron: a) analizar prospectivamente la relación entre la actividad física moderada y vigorosa y el número de enfermedades crónicas; b) analizar si los practicantes de actividad física tienen menos probabilidades de tener enfermedades crónicas, cuando los análisis se controlan para una multiplicidad de enfermedades; c) examinar la relación transversal y prospectiva entre la actividad física con diversos niveles de intensidad y ciertas enfermedades crónicas en particular; d) analizar el efecto moderador de la actividad física en la relación entre el tiempo dedicado a ver la televisión (comportamiento sedentario) y la multimorbilidad; e) examinar la relación entre la multimorbilidad, la percepción de la salud y la satisfacción con la vida; y analizar el efecto moderador de la actividad física en esa relación.

Metodología

La presente tesis utilizó datos de las encuestas Survey of Health, Aging, and Retirement in Europe (SHARE) olas cuatro y cinco y del European Social Survey (ESS) ola siete. SHARE es una base de datos transnacional con información sobre una amplia gama de variables que abarcan desde el comportamiento de la salud y la salud psicológica hasta el nivel socioeconómico y las redes sociales y familiares. La muestra en SHARE representa una población no institucionalizada. Los datos para la ola cuarta ola se recogieron en 2011 y para la quinta en 2013; incluyendo personas de cincuenta años o más. El estudio SHARE está completamente descrito en diversos documentos publicados (Börsch-Supan et al., 2013; Börsch-Supan & Jürges, 2005). El European Social Survey es una encuesta internacional que se realiza cada dos años en 20 países europeos e Israel. La encuesta mide las actitudes, las creencias y el comportamiento de las personas europeas. El European Social Survey utiliza muestras representativas de varios países europeos. En cada país, la información se recogió mediante una entrevista personal de una hora de duración que incluyó preguntas sobre el uso de medicina, inmigración, ciudadanía, cuestiones sociodemográficas y socioeconómicas, estado de salud y actividad física. El cuestionario fue traducido por expertos al idioma de cada uno de los países participantes. Más detalles sobre el European Social Survey pueden encontrarse en Schnaudt, Weinhardt, Fitzgerald, & Liebig (2014).

En los datos de SHARE, la actividad física se midió preguntando la frecuencia de la actividad física moderada y vigorosa. La opciones de respuesta para ambas actividades fueron: (1) más de una vez a la semana, (2) una vez a la semana, (3) hasta tres veces al mes y (4) casi nunca o nunca (las dos últimas opciones se agruparon en una categoría llamada menos de una vez a la semana). En el European Social Survey la actividad física se evaluó con una sola pregunta "¿en cuántos de los últimos 7 días caminó rápidamente, hizo deporte u otra actividad física durante 30 minutos o más?". Usando la información facilitada, se calculó una nueva variable para clasificar a los participantes en tres grupos: 1) práctica de actividad física ≤1 tiempo/semana; 2) práctica de actividad física 2-4 veces/semana; y 3) práctica de actividad física ≥5 veces/semana.

En ambas bases de datos, las enfermedades crónicas se evaluaron pidiendo a los participantes que informaran si su médico les dijo que tenían alguna enfermedad crónica, como ataque cardíaco u otros problemas cardíacos, hipertensión, accidente cerebrovascular o enfermedad vascular cerebral, colesterol alto, diabetes, enfermedad pulmonar, cáncer, úlcera de estómago o duodenal, enfermedad de Parkinson, fractura de cadera o fémur, Alzheimer.

Los participantes informaron sobre el tiempo que dedicaban a la semana a ver la televisión, la percepción de su estado de salud, la satisfacción con la vida y hábitos de consumo de alcohol y tabaco. Además, también añadieron datos de carácter sociodemográficos, tales como el sexo, edad, estado civil, si tenían hijos, nivel educativo, local donde vivían e ingreso mensual.

Resultados

En el estudio uno se verificó que, transversalmente, la actividad física a intensidad moderada o vigorosa se asoció negativamente con el número de enfermedades crónicas, tanto para hombres como para mujeres. Esta relación entre la actividad física y el número de enfermedades crónicas no cambió sustancialmente después de que los análisis se ajustan a varias covariables (edad, estado civil, nivel educativo, lugar adonde vive). En el análisis longitudinal, la actividad física moderada (hombres: β = -0.12, 95% CI: -0.20 to -0.04; mujeres: β = -0.22, 95% CI: -0.28 to -0.15) o vigorosa (hombres: β = -0.09, 95% CI: -0.14 to -0.04; mujeres: β = -0.14, 95% CI: -0.19 to -0.09, p<0.001) en 2011 estuvo inversamente relacionada con el número de enfermedades crónicas en 2013. Analizando la trayectoria de la asociación entre la actividad física y un número de enfermedades crónicas, las personas físicamente activas en el pasado y en el presente tenían menos probabilidad de tener enfermedades crónicas que los sujetos físicamente inactivos en 2011 y en 2013 (hombres inactivo-activo: β = -0.12, 95% CI: -0.20 hasta -0.05, p<0.01; hombres activo-activo: β = -0.16, 95% CI: -0.23 hasta -0.08; mujeres inactiva-activa: β = -0.10, 95% CI: -0.16 hasta -0.04, p<0.01; mujeres activa-activa: β = -0.18, 95% CI: -0.25 hasta -0.12, p<0.001).

En el estudio dos se observó que las enfermedades más prevalentes eran hipertensión arterial (19,4%), obesidad (15,6%), alergias (12,2%), cáncer (11,1%), problemas de corazón (11 %) problemas respiratorios (8,9%) y diabetes tipo 2 (5,6%). Para los hombres, la actividad física estaba negativamente relacionada con problemas de corazón, problemas respiratorios y obesidad. Para las mujeres, la actividad estaba negativamente relacionada con problemas de corazón, problemas respiratorios, diabetes tipo 2 y obesidad. Comparando los que practicaban actividad física dos o más veces por semana con los que practicaban una o menos veces, los resultados mostraron que los físicamente más activos tenían menos probabilidades de tener problemas de corazón, hipertensión, problemas respiratorios, diabetes tipo 2, cáncer y obesidad.

Del análisis de la relación entre la actividad física vigorosa y las enfermedades crónicas, del estudio 3, se verificó que entre hombres y mujeres, la prevalencia de enfermedades crónicas (ataque cardíaco, hipertensión, colesterol elevado, diabetes tipo 2, enfermedad pulmonar, cáncer, úlcera de estómago o duodenal, enfermedad de Parkinson, fractura de cadera/femoral, enfermedad de Alzheimer) en 2011 y 2013 fueron significativamente menores entre aquellos que practicaban actividad física vigorosa semanalmente. Al analizar la relación transversal y longitudinal entre la actividad física y las enfermedades crónicas, la práctica de actividad física más de una vez por semana estaba relacionada con una menor probabilidad de tener enfermedades crónicas. En el modelo ajustado para las variables sociodemográficas, el tabaquismo y otras enfermedades crónicas, los hombres y las mujeres físicamente más activos también tenían menos probabilidades de tener ataque cardíaco (hombres: OR = 0,69, 95% CI: 0,60 - 0,79; mujeres: OR = 0,63, 95% CI: 0,55 - 0,73), hipertensión (hombres: OR = 0,84, 95% CI: 0,77 - 0,93; mujeres: OR = 0,80, 95% CI: 0,74 - 0,87), colesterol elevado (hombres: OR = 0,83, 95% CI: 0,75 - 0,93; mujeres: OR = 0,90, 95% CI: 0,82 - 0,89), diabetes tipo 2 (hombres: OR = 0,69, 95% CI: 0,61 - 0,79; mujeres: OR = 0,62, 95% CI: 0,54 - 0,71), enfermedad pulmonar (hombres: OR = 0,58, 95% CI: 0,48 - 0,70; mujeres: OR = 0,66, 95% CI: 0,56 - 0,79), cáncer (hombres: OR = 0,75, 95% CI: 0,60 - 0,93), úlcera de estómago o duodeno (hombres: OR = 0,59, 95% CI: 0,45 - 0,77; mujeres: OR = 0,79, 95% CI: 0,65 - 0,97), enfermedad de Parkinson (hombres: OR = 0,36, 95% CI: 0,21 - 0,61; mujeres: OR = 0,54, 95% CI: 0,31 - 0,97), fractura de cadera/femoral (hombres: OR = 0,54, 95% CI: 0,44 - 0,97; mujeres: OR = 0,56, 95% CI: 0,40 - 0,80) y enfermedad de Alzheimer (hombres: OR = 0,61, 95% CI: 0,39 - 0,95; mujeres: OR = 0,45, 95% CI: 0,28 - 0,72) que los físicamente menos activos. De ese estudio se destaca que incluso los sujetos que practicaban actividad física vigorosa sólo una vez por semana tenían menor probabilidad de tener enfermedades crónicas que los sujetos que no practicaban actividad física vigorosa a lo largo de la semana.

Al igual que el estudio anterior, la práctica de actividad física moderada analizada en el estudio cuatro, también presentaba una relación negativa con la prevalencia de las enfermedades crónicas. Entre los sujetos más activos era significativamente menor que entre los sujetos menos activos físicamente. Los hombres que practicaban actividad física moderada una vez a la semana tenían menor probabilidad de enfermedad de Parkinson (OR = 0,39, 95% CI: 0,24 - 0,65) y fractura de la cadera/fémur (OR = 0,45, 95% CI: 0,21 - 0,98) que los que no practican actividad física semanalmente. Para las mujeres esa relación se observó para las enfermedades pulmonares (OR = 0,61, 95% CI: 0,46 - 0,82). En comparación con los hombres que practicaban actividad física moderada más de una vez por semana con los que nunca practicaban, se encontraron asociaciones con más enfermedades crónicas – cáncer (OR = 0,73, 95% CI: 0,54 - 0,98), úlcera de estómago o duodenal (OR = 0,57, 95% CI: 0,41 - 0,80), enfermedad de Parkinson (OR = 0,53, 95% CI: 0,32 - 0,89), fractura de cadera/femoral (OR = 0,56, 95% CI: 0,35 - 0,89) y enfermedad de Alzheimer (OR = 0,51, 95% CI: 0,31 - 0,83). Para las mujeres, la relación fue observada para la hipertensión (OR = 0,89, 95% CI: 0,79 - 1,00), diabetes tipo 2 (OR = 0,74, 95% CI: 0,64 - 0,87), enfermedades pulmonares (OR = 0,67, 95% CI: 0,55 - 0,82), úlcera de estómago o duodenal (OR = 0,59, 95% CI: 0,47 - 0,75), enfermedad de Parkinson (OR = 0,54, 95% CI: 0,33 - 0,88) y fractura de cadera/femoral (OR = 0,58, 95% CI: 0,43 - 0,78).

El estudio cinco, permitió observar que el 21,6% de los participantes tenían multimorbilidad. Considerando el tiempo dedicado a ver la televisión, la categoría con menos participantes fue “no ver televisión” (5%), mientras que en el otro extremo, el 32.9% de los participantes dedicaban una o dos horas al día a ver televisión. La prevalencia de la multimorbilidad era significativamente mayor entre los sujetos que veían la televisión durante más tiempo. Por otro lado, entre los sujetos más activos físicamente la prevalencia de la multimorbilidad era significativamente menor. Los hombres que pasaron más de tres horas al día frente a la televisión tenían 1,6 (IC 95%: 1.3-2.1) veces más de probabilidades de tener multimorbilidad que aquellos que no vieron la televisión. En las mujeres, los resultados fueron similares. Al considerar la actividad física, se observó que, independientemente del tiempo dedicado a ver la televisión, practicar actividad física dos a cuatro días a la semana (hombres: OR = 0,69, 95% CI: 0,61 - 0.76; mujeres: OR = 0,77, 95% CI: 0,70 - 0,86) o cinco o más días (hombres: OR = 0,65, 95% CI: 0,58 - 0,72; mujeres: OR = 0,74, 95% CI: 0,67 - 0,82) estaba inversamente asociado con la multimorbilidad. Para los sujetos que participaron en 30 minutos de actividad física al menos cinco días a la semana, el tiempo dedicado a ver la televisión y la multimorbilidad no se asociaron. Se observaron mayores probabilidades de multimorbilidad para los hombres que pasaban más de tres horas al día viendo televisión entre aquellos que practicaban actividad física dos o tres días a la semana (OR = 1,76, 95% CI: 1,05 – 2,94) o un o menos días a la semana (OR = 2,13, 95% CI: 1,38 - 3,28). Para las mujeres que realizan 30 minutos de actividad física dos o tres días a la semana, dedicar más de tres horas al día a ver televisión se asoció con mayores probabilidades de multimorbilidad (OR = 2,1, 95% CI: 1,3 - 3,3). Sin embargo, al analizar mujeres que participaban en actividad física un o menos días a la semana, las que veían televisión dos o tres horas (OR = 1,7, 95% CI: 1,1 - 2,6), o más de tres horas al día (OR = 2,0, 95% CI: 1,3 - 3,0) tenían mayores probabilidades de multimorbilidad.

En el sexto estudio, se verificó que casi el 30% de los participantes tenían multimorbilidad (dos o más enfermedades crónicas). Del uno al cinco, el valor medio para la percepción de estado de salud fue de 3,8±0,9, y de cero a diez, la media de satisfacción con la vida fue de 7,2 ± 2,2. La actividad física se practicó, en promedio, 3.2 ± 2.6 veces a la semana. Para cada enfermedad crónica, los participantes que no informaron tener la enfermedad tuvieron mejor percepción de su estado de salud que aquellos que informaron tener la enfermedad. Se observaron resultados similares para la satisfacción con la vida. Aquellos que no informaron la presencia de la enfermedad tenían una mejor satisfacción con la vida, con la excepción de las alergias. Aunque el tamaño del efecto fue pequeño, la multimorbilidad también se relacionó significativamente con la percepción de salud y la satisfacción con la vida. Aquellos sin multimorbilidad tenían una mejor percepción de la salud y una mejor satisfacción con la vida. El análisis no ajustado demostró que la multimorbilidad se relacionó negativamente con la percepción de salud y la satisfacción con la vida. Al tomar en cuenta otras variables de confundimiento, la multimorbilidad se mantuvo negativamente relacionada con la percepción de la salud (β = -0,52, IC 95%: -0,54 a -0,50) y la satisfacción con la vida (β = -0,43, 95% IC: -0,49 a -0,37). En el modelo no ajustado y ajustado, la actividad física se relacionó positivamente con la percepción de la salud (β = 0,04, IC 95%: 0,04 a 0,05) y la satisfacción con la vida (β = 0,07, IC 95%: 0,05 a 0,08). Hubo un efecto de interacción significativo entre la multimorbilidad y la actividad física con respecto a la percepción de la salud (β = 0,01, IC 95%: 0,01 a 0,02) y la satisfacción con la vida (β = 0,04, IC 95%: 0,02 a 0,06), retratando la actividad física como un moderador de la relación entre la multimorbilidad y estas variables.

Conclusiones

A partir del presente estudio, se puede concluir que: a) entre hombres y mujeres, la actividad física moderada o vigorosa es transversal y longitudinalmente asociada con menos enfermedades crónicas; b) la participación en actividad física dos a cuatro 4 veces por semana y cinco o más veces por semana disminuye las probabilidades de tener problemas cardíacos, presión arterial alta, problemas respiratorios, diabetes tipo 2 y obesidad, en comparación con quien realiza actividad física una o menos veces por semana; c) la actividad física moderada o vigorosa está asociada con un menor riesgo de enfermedades crónicas en hombres y mujeres, e incluso la práctica de actividad física vigorosa una vez a la semana parece ser suficiente para reducir los riesgos de enfermedades crónicas; d) el tiempo dedicado a ver televisión está asociado con la multimorbilidad, pero la participación en la actividad física puede atenuar o incluso eliminar esta asociación; e) la actividad física atenúa o elimina la relación negativa entre la multimorbilidad, la percepción de la salud y la satisfacción con la vida; contribuyendo a una mejor percepción de la salud y la satisfacción con la vida.

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Expanded abstract in Galego

Introdución

As enfermidades crónicas son actualmente a principal causa de morbilidad e mortalidade. A súa prevalencia é tan elevada que se considera unha epidemia a nivel mundial. As enfermidades crónicas afectan negativamente a calidade da vida debido ás consecuencias físicas e psicolóxicas no nivel da saúde. No 2015 foron responsables do 70% das mortas no mundo (WHO, 2017).

As enfermidades crónicas asociábanse principalmente coas persoas maiores. Con todo, debido aos cambios dos estilos de vida que ocorreron nos últimos anos, estas presentan altos niveis de incidencia e prevalencia na poboación nova e adulta (WHO, 2017). Dos 38 millóns de mortes ocorridas en 2012 por mor das enfermidades crónicas, máis do 40% foron prematuras (WHO, 2014). Entre os principais factores de risco para contraer algunhas enfermidades crónicas destácanse o tempo pasado en comportamentos sedentarios e os baixos niveis de actividade física. Polo tanto, houbo un interese na promoción da saúde a través do aumento dos niveis de actividade física. Por isto, recomendouse a práctica regular de actividade física (European Union, 2008, WHO, 2010), debido ao seu efecto positivo para a prevención primaria e secundaria das enfermidades crónicas (Alves et al., 2016).

A práctica regular de actividade física parece reducir o risco e a progresión das enfermidades crónicas (Ekelund et ao., 2016, Huai et ao., 2013). Para as persoas que sofren estas enfermidades, a actividade física mellora a capacidade funcional e a calidade de vida (Kujala, Kukkonen-Harjula, & Tikkanen, 2015). Ademais, existe evidencia de que a actividade física reduce a mortalidade prematura e a morbilidad asociada coas enfermidades crónicas (Ekelund et al., 2015; Lear et al., 2017), mesmo pequenas cantidades de actividade física parecen ter un efecto protector contra as enfermidades crónicas (Wen et al., 2011). Por iso, a Organización Mundial da Saúde considera que a actividade física é un factor determinante para controlalas e previlas (WHO, 2014).

É entón importante, entender a relación entre a actividade física e as enfermidades crónicas. Como a actividade física pode ser practicada a varios niveis de intensidade, convén comprender que niveis teñen un efecto positivo na prevención destas enfermidades. Isto é particularmente importante para os anciáns, porque por norma só practican actividade física moderada. Doutra banda, moitas persoas teñen máis que unha enfermidade crónica (multimorbilidade), nestes casos é importante comprender a relación entre a actividade física e as enfermidades crónicas, pero controlando a relación para as restantes enfermidades. Máis aínda, coñecendo a relación positiva entre os comportamentos sedentarios e as enfermidades crónicas, é importante percibir se a actividade pode ter un papel moderador nesta relación.

Para responder a estas cuestións, foron realizados 6 estudos que compoñen a tese. No primeiro estudo procurouse analizar transversal e lonxitudinalmente a relación entre a práctica regular da actividade física e o número das enfermidades crónicas. O segundo analizou a relación entre a actividade física e a prevalencia das enfermidades crónicas máis prevalentes, controlando a relación con todas as enfermidades crónicas. O terceiro e cuarto analizaron a intensidade da actividade física e as enfermidades crónicas. O quinto analizou o efecto moderador da actividade física na relación entre a multimorbilidad e o tempo adicado a ver televisión. Por último, o sexto, analizou o efecto que a actividade física ten na relación negativa entre a multimorbilidad, percepción do estado de saúde e a satisfacción coa vida.

Obxectivos

Considerando a evidencia científica, que amosa que existe unha relación entre a actividade física e as enfermidades crónicas, e algunhas dúbidas que persisten sobre os niveis de intensidade recomendados, a existencia de múltiples enfermidades ao mesmo tempo e do efecto moderador que a actividade física poderá ter na relación entre os comportamentos sedentarios e as enfermidades crónicas, os obxectivos do presente traballo foron: a) analizar prospectivamente a relación entre a actividade física moderada e vigorosa e o número de enfermidades crónicas; b) analizar se os practicantes de actividade física teñen menos probabilidades de ter enfermidades crónicas, cando as análises contrólanse para unha multiplicidade de enfermidades; c) examinar a relación transversal e prospectiva entre a actividade física con diversos niveis de intensidade e certas enfermidades crónicas en particular; d) analizar o efecto moderador da actividade física na relación entre o tempo dedicado a ver a televisión (comportamento sedentario) e a multimorbilidade; e) examinar a relación entre a multimorbilidade, a percepción da saúde e a satisfacción coa vida; e analizar o efecto moderador da actividade física nesa relación.

Metodoloxía

A presente tese utilizou datos das enquisas Survey of Health, Aging, and Retirement in Europe (SHARE) ondas catro e cinco e do European Social Survey (ESS) onda sete. SHARE é unha base de datos transnacional con información sobre unha ampla gama de variables que abarcan desde o comportamento da saúde e a saúde psicolóxica ata o nivel socioeconómico e as redes sociais e familiares. A mostra en SHARE representa unha poboación non institucionalizada. Os datos para a cuarta onda recolléronse en 2011 e para a quinta en 2013; incluíndo persoas de cincuenta anos ou máis. O estudo SHARE está completamente descrito en diversos documentos publicados (Börsch-Supan et al., 2013; Börsch-Supan & Jürges, 2005). O European Social Survey é unha enquisa internacional que se realiza cada dous anos en 20 países europeos e Israel. A enquisa mide as actitudes, as crenzas e o comportamento das persoas europeas. O European Social Survey utiliza mostras representativas de varios países europeos. En cada país, a información recolleuse mediante unha entrevista persoal dunha hora de duración que incluíu preguntas sobre o uso de medicamento, inmigración, cidadanía, cuestións sociodemográficas e socioeconómicas, estado de saúde e actividade física. O cuestionario foi traducido por expertos ao idioma de cada un dos países participantes. Máis detalles sobre o European Social Survey poden atoparse en Schnaudt, Weinhardt, Fitzgerald, & Liebig (2014).

Nos datos de SHARE, a actividade física mediuse preguntando a frecuencia da actividade física moderada e vigorosa. As opcións de resposta para ambas as actividades foron: (1) máis dunha vez á semana, (2) unha vez á semana, (3) ata tres veces ao mes e (4) case nunca ou nunca (as dúas últimas opcións agrupáronse nunha categoría chamada menos dunha vez á semana). No European Social Survey a actividade física avaliouse cunha soa pregunta “en cantos dos últimos 7 días camiñou rapidamente, fixo deporte ou outra actividade física durante 30 minutos ou máis”. Usando a información facilitada, calculouse unha nova variable para clasificar aos participantes en tres grupos: 1) práctica de actividade física tempo/semana; 2) práctica de actividade física 2-4 veces/semana; e 3) práctica de actividade física 5 veces/semana.

En ambas bases de datos, as enfermidades crónicas avaliáronse pedindo aos participantes que informasen se o seu médico díxolles que tiñan algunha enfermidade crónica, como ataque cardíaco ou outros problemas cardíacos, hipertensión, accidente cerebrovascular ou enfermidade vascular cerebral, colesterol alto, diabetes, enfermidade pulmonar, cancro, úlcera de estómago ou duodenal, enfermidade de Parkinson, fractura de cadeira ou fémur, Alzheimer.

Os participantes informaron o tempo que dedicaban á semana a ver a televisión, a percepción do seu estado de saúde, a satisfacción coa vida e hábitos de consumo de alcol e tabaco. Ademais, tamén engadiron datos de carácter sociodemográficos, tales como o sexo, idade, estado civil, se tiñan fillos, nivel educativo, local onde vivían e ingreso mensual.

Resultados

No estudo uno verificouse que, transversalmente, a actividade física a intensidade moderada ou vigorosa asociouse negativamente co número de enfermidades crónicas, tanto para homes como para mulleres. Esta relación entre a actividade física e o número de enfermidades crónicas non cambiou substancialmente despois de que as análises axústanse a varias covariables (idade, estado civil, nivel educativo, lugar onde vive). Na análise longitudinal, a actividade física moderada (homes: β = -0.12, 95% CI: -0.20 to -0.04; mulleres: β = -0.22, 95% CI: -0.28 to -0.15) o vigorosa (homes: β = -0.09, 95% CI: -0.14 to -0.04; mulleres: β = -0.14, 95% CI: -0.19 to -0.09, $p<0.001$) en 2011 estivo inversamente relacionada co número de enfermidades crónicas en 2013. Analizando a traxectoria da asociación entre a actividade física e un número de enfermidades crónicas, as persoas fisicamente activas no pasado e no presente tiñan menos probabilidade de ter enfermidades crónicas que os suxeitos fisicamente inactivos en 2011 e en 2013 (homes inactivo-activo: β = -0.12, 95% CI: -0.20 ata -0.05, $p<0.01$; homes activo-activo: β = -0.16, 95% CI: -0.23 ata -0.08; mulleres inactiva-activa: β = -0.10, 95% CI: -0.16 hasta -0.04, $p<0.01$; mulleres activa-activa: β = -0.18, 95% CI: -0.25 hasta -0.12, $p<0.001$).

No estudo dous observouse que as enfermidades máis prevalentes eran hipertensión arterial (19,4%), obesidade (15,6%), alerxias (12,2%), cancro (11,1%), problemas de corazón (11 %) problemas respiratorios (8,9%) e diabetes tipo 2 (5,6%). Para os homes, a actividade física estaba negativamente relacionada con problemas de corazón, problemas respiratorios e obesidade. Para as mulleres, a actividade estaba negativamente relacionada con problemas de corazón, problemas respiratorios, diabetes tipo 2 e obesidade. Comparando os que practicaban actividade física dúas ou máis veces por semana cos que practicaban unha ou menos veces, os resultados mostraron que os fisicamente máis activos tiñan menos probabilidades de ter problemas de corazón, hipertensión, problemas respiratorios, diabetes tipo 2, cancro e obesidade.

Da análise da relación entre a actividade física vigorosa e as enfermidades crónicas, do estudo 3, verificouse que entre homes e mulleres, a prevalencia de enfermidades crónicas (ataque cardíaco, hipertensión, colesterol elevado, diabetes tipo 2, enfermidade pulmonar, cancro, úlcera de estómago ou duodenal, enfermidade de Parkinson, fractura de cadeira/femoral, enfermidade de Alzheimer) en 2011 e 2013 foron significativamente menores entre aqueles que practicaban actividade física vigorosa semanalmente. Ao analizar a relación transversal e longitudinal entre a actividade física e as enfermidades crónicas, a práctica de actividade física máis dunha vez por semana estaba relacionada cunha menor probabilidade de ter enfermidades crónicas. No modelo axustado para as variables sociodemográficas, o tabaquismo e outras enfermidades crónicas, os homes e as mulleres fisicamente máis activos tamén tiñan menos probabilidades de ter ataque cardíaco (homes: OR = 0,69, 95% CI: 0,60 - 0,79; mulleres: OR = 0,63, 95% CI: 0,55 - 0,73), hipertensión (homes: OR = 0,84, 95% CI: 0,77 - 0,93; mulleres: OR = 0,80, 95% CI: 0,74 - 0,87), colesterol elevado (homes: OR = 0,83, 95% CI: 0,75 - 0,93; mulleres: OR = 0,90, 95% CI: 0,82 - 0,89), diabetes tipo 2 (homes: OR = 0,69, 95% CI: 0,61 - 0,79; mulleres: OR = 0,62, 95% CI: 0,54 - 0,71), enfermedade pulmonar (homes: OR = 0,58, 95% CI: 0,48 - 0,70; mulleres: OR = 0,66, 95% CI: 0,56 - 0,79), cancro (homes: OR = 0,75, 95% CI: 0,60 - 0,93), úlcera de estómago o duodeno (hombres: OR = 0,59, 95% CI: 0,45 - 0,77; mulleres: OR = 0,79, 95% CI: 0,65 - 0,97), enfermedade de Parkinson (homes: OR = 0,36, 95% CI: 0,21 - 0,61; mulleres: OR = 0,54, 95% CI: 0,31 - 0,97), fractura de cadeira/femoral (homes: OR = 0,54, 95% CI: 0,44 - 0,97; mulleres: OR = 0,56, 95% CI: 0,40 - 0,80) e enfermedad de Alzheimer (homes: OR = 0,61, 95% CI: 0,39 - 0,95; mulleres: OR = 0,45, 95% CI: 0,28 - 0,72) que os fisicamente menos activos. Dese estudo destácase que mesmo os suxeitos que practicaban actividade física vigorosa só unha vez por semana tiñan menor probabilidade de ter enfermidades crónicas que os suxeitos que non practicaban actividade física vigorosa ao longo da semana..

Do mesmo xeito que o estudo anterior, a práctica de actividade física moderada analizada no estudo catro, tamén presentaba unha relación negativa coa prevalencia das enfermidades crónicas. Entre os suxeitos máis activos era significativamente menor que entre os suxeitos menos activos fisicamente. Os homes que practicaban actividade física moderada unha vez á semana tiñan menor probabilidade de enfermidade de Parkinson (OR = 0,39, 95% CI: 0,24 - 0,65) e fractura da cadeira/fémur (OR = 0,45, 95% CI: 0,21 - 0,98) que os que non practican actividade física semanalmente. Para as mulleres esa relación observouse para as enfermidades pulmonares (OR = 0,61, 95% CI: 0,46 - 0,82). En comparación cos homes que practicaban actividade física moderada máis dunha vez por semana cos que nunca practicaban, atopáronse asociacións con máis enfermidades crónicas – cancro (OR = 0,73, 95% CI: 0,54 - 0,98), úlcera de estómago ou duodenal (OR = 0,57, 95% CI: 0,41 - 0,80), enfermidade de Parkinson (OR = 0,53, 95% CI: 0,32 - 0,89), fractura de cadeira/femoral (OR = 0,56, 95% CI: 0,35 - 0,89) e enfermidade de Alzheimer (OR = 0,51, 95% CI: 0,31 - 0,83). Para as mulleres, a relación foi observada para a hipertensión (OR = 0,89, 95% CI: 0,79 - 1,00), diabetes tipo 2 (OR = 0,74, 95% CI: 0,64 - 0,87), enfermidades pulmonares (OR = 0,67, 95% CI: 0,55 - 0,82), úlcera de estómago ou duodenal (OR = 0,59, 95% CI: 0,47 - 0,75), enfermidade de Parkinson (OR = 0,54, 95% CI: 0,33 - 0,88) e fractura de cadeira/femoral (OR = 0,58, 95% CI: 0,43 - 0,78).

O estudo cinco, permitiu observar que o 21,6% dos participantes tiñan multimorbilidade. Considerando o tempo dedicado a ver a televisión, a categoría con menos participantes foi "ver televisión" (5%), mentres que no outro extremo, o 32.9% dos participantes dedicaban unha ou dúas horas ao día a ver televisión. A prevalencia da multimorbilidad eera significativamente maior entre os suxeitos que vían a televisión durante máis tempo. Doutra banda, entre os suxeitos máis activos fisicamente a prevalencia da multimorbilidade era significativamente menor. Os homes que pasaron máis de tres horas ao día fronte á televisión tiñan 1,6 (IC 95%: 1.3-2.1) veces máis de probabilidades de ter multimorbilidade que aqueles que non viron a televisión. Nas mulleres, os resultados foron similares. Ao considerar a actividade física, observouse que, independentemente do tempo dedicado a ver a televisión, practicar actividade física dúas a catro días á semana (homes: OR = 0,69, 95% CI: 0,61 - 0.76; mulleres: OR = 0,77, 95% CI: 0,70 - 0,86) ou cinco ou máis días (homes: OR = 0,65, 95% CI: 0,58 - 0,72; mulleres: OR = 0,74, 95% CI: 0,67 - 0,82) estaba inversamente asociado coa multimorbilidade. Para os suxeitos que participaron en 30 minutos de actividade física polo menos cinco días á semana, o tempo dedicado a ver a televisión e a multimorbilidade non se asociaron. Observáronse maiores probabilidades de multimorbilidade para os homes que pasaban máis de tres horas ao día vendo televisión entre aqueles que practicaban actividade física dúas ou tres días á semana (OR = 1,76, 95% CI: 1,05 – 2,94) ou un ou menos días á semana (OR = 2,13, 95% CI: 1,38 - 3,28). Para as mulleres que realizan 30 minutos de actividade física dúas ou tres días á semana, dedicar máis de tres horas ao día a ver televisión asociouse con maiores probabilidades de multimorbilidade (OR = 2,1, 95% CI: 1,3 - 3,3). Con todo, ao analizar mulleres que participaban en actividade física un ou menos días á semana, as que vían televisión dúas ou tres horas (OR = 1,7, 95% CI: 1,1 - 2,6), ou máis de tres horas ao día (OR = 2,0, 95% CI: 1,3 - 3,0) tiñan maiores probabilidades de multimorbilidade.

No sexto estudo, verificouse que case o 30% dos participantes tiñan multimorbilidade (dous ou máis enfermidades crónicas). Do un ao cinco, o valor medio para a percepción de estado de saúde foi de 3,8±0,9, e de cero a dez, a media de satisfacción coa vida foi de 7,2±2,2. A actividade física practicouse, en media, 3.2±2.6 veces á semana. Para cada enfermidade crónica, os participantes que non informaron ter a enfermidade tiveron mellor percepción do seu estado de saúde que aqueles que informaron ter a enfermidade. Observáronse resultados similares para a satisfacción coa vida. Aqueles que non informaron a presenza da enfermidade tiñan unha mellor satisfacción coa vida, coa excepción das alerxias. Aínda que o tamaño do efecto foi pequeno, a multimorbilidade tamén se relacionou significativamente coa percepción de saúde e a satisfacción coa vida. Aqueles sen multimorbilidad tiñan unha mellor percepción da saúde e unha mellor satisfacción coa vida. A análise non axustada demostrou que a multimorbilidade relacionouse negativamente coa percepción de saúde e a satisfacción coa vida. Ao tomar en conta outras variables de confundimiento, a multimorbilidade mantívose negativamente relacionada coa percepción da saúde (β = -0,43, 95% IC: -0,49 a -0,37) e a satisfacción coa vida (β = -0,43, 95% IC: -0,49 a -0,37). No modelo non axustado e axustado, a actividade física relacionouse positivamente coa percepción da saúde (β = -0,52, IC 95%: -0,54 a -0,50) e a satisfacción coa (β = 0,07, IC 95%: 0,05 a 0,08). Houbo un efecto de interacción significativo entre a multimorbilidade e a actividade física con respecto á percepción da saúde (β = 0,01, IC 95%: 0,01 a 0,02) e a satisfacción coa vida (β = 0,04, IC 95%: 0,02 a 0,06), retratando a actividade física como un moderador da relación entre a multimorbilidade e estas variables.

Conclusións

A partir do presente estudo, pódese concluír que: a) entre homes e mulleres, a actividade física moderada ou vigorosa é transversal e lonxitudinalmente asociada con menos enfermidades crónicas; b) a participación en actividade física dúas a catro 4 veces por semana e cinco ou máis veces por semana diminúe as probabilidades de ter problemas cardíacos, presión arterial alta, problemas respiratorios, diabetes tipo 2 e obesidade, en comparación con quen realiza actividade física unha ou menos veces por semana; c) a actividade física moderada ou vigorosa está asociada cun menor risco de enfermidades crónicas en homes e mulleres, e mesmo a práctica de actividade física vigorosa unha vez á semana parece ser suficiente para reducir os riscos de enfermidades crónicas; d) o tempo dedicado a ver televisión está asociado coa multimorbilidade, pero a participación na actividade física pode atenuar ou mesmo eliminar esta asociación; e) a actividade física atenúa ou elimina a relación negativa entre a multimorbilidade, a percepción da saúde e a satisfacción coa vida; contribuíndo a unha mellor percepción da saúde e a satisfacción coa vida.

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