

**The relationship between sleep characteristics and unmet physical activity need in
older women**

Abstract

Objectives: We examined among older women the association of sleep quality, daytime tiredness and sleep duration with unmet physical activity need i.e. wishing to be more physically active but perceiving no opportunity for it.

Methods: Cross-sectional logistic regression analyses among women aged 74-86 years (Finnish Twin Study on Aging, third wave, n=302).

Results: Thirty-one participants reported unmet physical activity need. Short sleepers had five-fold and long sleepers three-fold odds for unmet physical activity need compared to normative sleepers, while for daytime tiredness the odds were double. Presence of daytime tiredness and unmet physical activity coincided with higher prevalence of chronic diseases, depressive symptoms and walking difficulties, which partly explains the observed associations. Poor sleep quality was not associated with unmet physical activity need.

Discussion: Older women with non-optimal sleep characteristics who perceive unmet physical activity need may benefit from solutions that improve their perceived opportunities for physical activity.

Keywords: unmet physical activity need, sleep duration, sleep quality, daytime tiredness, aging

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Physical activity has been defined as “any bodily movement produced by skeletal muscles that results in energy expenditure” (Caspersen, Powell, & Christenson, 1985, p. 126) and can be considered as a basic human need. Both physiological and psychological basic needs can be defined as “energizing states that, if satisfied, conduce toward health and wellbeing but, if not satisfied, contribute to pathology and ill-being” (Ryan & Deci, 2000, p. 74). Remaining physically active and having the opportunity to participate in physical activities in old age is important, due to its positive effects on physical and psychological health (Penedo & Dahn, 2005; Warburton, Nicol, & Bredin, 2006). However, many older adults perceive that they do not have the opportunity to be more physically active even though they would want to do so and thus experience unmet need for physical activity (Rantakokko et al., 2010). Unmet physical activity need refers to a person’s own experience of inadequate physical activity (Rantakokko et al., 2010) and is therefore distinct from fulfilling the level of physical activity that is recommended in the physical activity guidelines for older adults (Nelson et al., 2007). Prior research on unmet needs has mainly focused on issues such as safety, financial resources and assistance in self-care and mobility-related tasks. Unmet basic needs have been associated with several adverse consequences among older people. Unmet need of assistance in mobility-related activities can lead to inability to leave one’s home or even bed (Allen, Piette, & Mor, 2014). Furthermore, unmet basic needs have been found to predict depressive symptoms (Blazer, D. G., Sachs-Ericsson, & Hybels, 2007), functional decline (Sachs-Ericsson, Schatschneider, & Blazer, 2006) and mortality (Blazer, Dan G., Sachs-Ericsson, & Hybels, 2005) and thus, unmet physical activity need may potentially have very harmful consequences in the lives of older people.

In earlier population-based studies in Finland 14% of respondents experienced unmet physical activity need making it a relatively common phenomenon (Eronen et al., 2014; Rantakokko et al., 2010). The few studies among older adults have shown that unmet physical activity need is more common among older adults with mobility limitations, depressive symptoms and musculoskeletal diseases (Rantakokko et al., 2010), and that persons with severe mobility limitations are at an increased risk for unmet need for physical activity (Eronen et al., 2014). Studies on the associations of sleep and daytime tiredness with unmet physical activity need are, however, lacking.

As people age, their sleep goes through several changes and the prevalence of sleep disturbances increases (Ohayon, Carskadon, Guilleminault, & Vitiello, 2004); this is often related to physical and mental disorders and diseases (Vitiello, Moe, & Prinz, 2002). Poor sleep is associated with lower physical activity levels (Li et al., 2018), decreased health-related quality of life (Reid et al., 2006), various adverse health outcomes and diseases (Ancoli-Israel, 2009), less healthy and disease-free life years (Stenholm et al., 2018) and mortality (Hublin, Partinen, Koskenvuo, & Kaprio, 2011). Many studies have found a U-shaped relationship between sleep duration and different adverse health outcomes, showing that both short (≤ 5 -6 hours) and long (> 8 -9 hours) sleep duration are associated with adverse health outcomes, less disease-free and healthy life years and mortality (Cappuccio, D'Elia, Strazzullo, & Miller, 2010a; Cappuccio, D'Elia, Strazzullo, & Miller, 2010b; Cappuccio, Cooper, D'Elia, Strazzullo, & Miller, 2011; Hublin, Partinen, Koskenvuo, & Kaprio, 2007; Stenholm et al., 2018). In addition, short sleep duration has been found to be associated with mobility limitations (Lorenz, Budhathoki, Kalra, & Richards, 2014; Stenholm, S. et al., 2010) and both long sleep duration and short subjective sleep duration have been found to predict functional decline (Stenholm, S., Kronholm, Bandinelli, & Guralnik, 2011). Although tiredness is commonly known as one of the symptoms of sleep disorders or a

symptom of other physiological and psychological diseases, many older adults experience tiredness with no clear cause (Avlund, 2010). Previous studies have shown that mobility-related and general tiredness is associated with lower physical activity levels (Egerton, Chastin, Stensvold, & Helbostad, 2016) and can predict the onset of adverse health outcomes, such as walking limitations (Avlund et al., 2004), poorer physical functioning and disability (Avlund, Damsgaard, Sakari-Rantala, Laukkanen, & Schroll, 2002; Manty, Kuh, & Cooper, 2015; Schultz-Larsen & Avlund, 2007) and mortality (Hardy & Studenski, 2008; Moreh, Jacobs, & Stessman, 2010).

Since people who sleep poorly or experience daytime tiredness are more likely to have activity limitations, it is plausible that they also perceive reduced possibilities for physical activity. However, information on the relationship between sleep, tiredness and unmet physical activity need is lacking. The aim of this study was to examine whether poor perceived sleep, daytime tiredness and sleep duration are associated with unmet physical activity need among older women. We hypothesized that older women with poor perceived sleep quality, daytime tiredness and short or long sleep duration are more likely to report unmet physical activity need.

Methods

Study design and participants

Participants were 344 women, aged 74-86, who took part in the third wave of Finnish Twin Study on Ageing (FITSA) in 2011-2012 when the assessment of unmet physical activity need was added to the study protocol. The FITSA sample (N=434) was drawn in 2000-2001 based on age, female sex, zygosity and willingness to participate in the study from the Finnish Twin Cohort Study, a population based sample of twins initially recruited from a population register. Compared to the 90 drop outs, the 344 people who took part also in the third wave were younger, had better financial situation, and experienced less

walking difficulties and daytime tiredness, but were similar in terms of depressive symptoms, sleep quality and sleep duration.

The third data collection wave was conducted as a postal questionnaire (Viljanen et al., 2013). Questionnaires were supplemented with telephone interviews in cases where participants had difficulties in answering the postal questionnaire. The concept of unmet physical activity need was launched in 2010 (Rantakokko et al., 2010) and consequently data on it are only available in this third data collection wave of FITSA. Data on unmet physical activity need were missing for 42 participants, and thus 302 women were included in the present analyses.

Unmet physical activity need

Unmet physical activity need was measured with two questions. These were: “Do you feel that you would have the opportunity to increase your level of physical activity if someone recommended you do so?” and “Would you like to increase your level of physical activity?” For both questions, the response options were “yes” and “no”. Persons, who wanted to increase their level of physical activity but felt they did not have the opportunity to do so, were defined as having unmet physical activity need (Rantakokko et al., 2010).

Sleep duration, perceived sleep quality, napping and daytime tiredness

Sleep characteristics were assessed with questions that measured perceived overall sleep quality, napping and sleep duration. Sleep duration was measured with the question “How many hours on average do you habitually sleep per night?” For the analyses of this study the response options were recoded into short (<6 hours), normative (6-8 hours) and long (>8 hours) sleep duration. A similar classification for short and long sleep duration has been used previously (Chien, Wang, & Chen, 2015). Self-reported sleep quality was measured with the question “How well do you usually sleep?” and for the analyses the

answers were dichotomized as “well” (quite well and well) and “poor” (quite poorly or poorly). Participants who answered “I am not sure” (n=7) were excluded from the corresponding analyses. Napping was measured with the question “Do you usually sleep in the daytime?” and perceived daytime tiredness was measured with the question “Do you feel tired in the daytime daily or nearly daily?” The response options for these two questions were “yes” and “no”.

Covariates

Age and financial situation of the participants were regarded as potential confounding factors. Other covariates were included in the models based on their theoretical and statistically significant association with unmet physical activity need and at least one of the sleep characteristics.

Perceived financial situation. Perceived financial situation was self-reported and dichotomized as “very good or good” and “moderate, poor or very poor”.

Walking difficulties. Mobility limitations can increase the risk for unmet physical activity need (Eronen et al., 2014) and daytime tiredness and sleep duration are associated with mobility limitations (Avlund et al., 2004; Stenholm, S. et al., 2010). Participants’ mobility limitations were assessed as walking difficulties, which were measured by asking whether the participant perceived difficulty walking 2 kilometers without stopping to rest. For the analyses, the response alternatives were dichotomized as “no difficulties” (able to manage without difficulty) and “difficulties” (minor difficulties, major difficulties, I need help or I am not able to).

Number of chronic diseases. Although in an earlier study unmet physical activity need has been found to be more common among older people with musculoskeletal diseases (Rantakokko et al., 2010), in this study we decided to adjust for number of chronic diseases because of its relevance also for sleep (Vitiello et al., 2002) and daytime tiredness

(Avlund, 2010). Number of chronic diseases was self-reported and measured with a list of 22 common chronic diseases and participants were asked to state for each condition whether they had been diagnosed with that condition by a physician or not. Participants were also asked to report any other physician-diagnosed chronic diseases.

Depressive symptoms. Depressive symptoms often coincide with unmet physical activity need (Rantakokko et al., 2010) and have also been associated with poor sleep and daytime tiredness (Maglione et al., 2012). Depressive symptoms were measured with the Center for Epidemiologic Studies Depression Scale (CES-D, range 0-60, higher scores indicate more depressive symptoms) (Radloff, 1977).

Physical activity. Unmet physical activity need has been found to be more common among inactive older people (Eronen, von Bonsdorff, Rantakokko, & Rantanen, 2012) and daytime tiredness and poor sleep have been associated with lower activity levels (Egerton et al., 2016; Lambiase, Gabriel, Kuller, & Matthews, 2013). Physical activity was self-reported (Grimby, 1986) and categorized into sedentary (no more than light activity two or fewer times per week), moderate activity (light activity at least three times per week) and high activity (moderate or vigorous activity three or more times per week).

Sleep medication. Use of sleep medication was measured with a yes/no question.

Statistical analyses

Participant characteristics were analyzed using means and standard deviations for continuous variables and percentages and frequencies for categorical variables according to unmet physical activity need. Comparisons of demographic characteristics, health and walking limitations between the groups were made using Wald tests adjusted for the interdependency within twin pairs. The associations of daytime tiredness, perceived sleep quality and sleep duration with unmet physical activity need were analyzed using logistic

regression models. First model was age-adjusted, second model was adjusted for age, number of chronic diseases and depressive symptoms, third model for age and walking difficulties, fourth model for age and physical activity, and the final model for age, chronic diseases, depressive symptoms, walking difficulties and physical activity. The dependency within twin pairs was controlled for in all the analyses. Missing observations in the explanatory variables (perceived sleep quality (n=4), daytime tiredness (n=6) and sleep duration (n=3) were imputed based on data from the previous data collection wave. Sensitivity analyses showed imputation strengthened the associations slightly but did not materially change the results.

Statistical analyses were conducted using Stata Statistical software version 14 and IBM SPSS Statistics version 24. The results were considered statistically significant when P value was <0.05 or when 95% confidence intervals did not contain 1.

Results

The mean age of the participants (n=302) was 79.0 years, and 10 % (n=31) of them reported unmet physical activity need. The participant characteristics are shown in Table 1 according to whether they experienced unmet physical activity need or not. The largest proportion of participants in both groups reported habitual sleep duration of 6-8 hours, although this was more common in the group of participants without unmet physical activity need. Participants with unmet physical activity need were more likely to report very short and long habitual sleep duration (p=0.020) and daytime tiredness (p=0.043) than participants not experiencing unmet physical activity need. The proportion of the participants using sleep medication was larger in the group reporting unmet physical activity need than in the group not experiencing unmet physical activity need; however, the difference was not statistically significant (p=0.090). Participants with unmet physical activity need were more likely to have walking difficulties (p<0.001), more chronic diseases (p=0.009), more

depressive symptoms ($p=0.004$) and to be sedentary ($p=0.001$) than the participants who did not experience unmet physical activity need. The groups were similar in mean age, financial situation, perceived sleep quality and taking naps (Table 1). Of the covariates associated with unmet physical activity need, depressive symptoms, chronic diseases, walking difficulties and physical activity were also associated with at least one sleep characteristic, and were thus included in the multivariate models.

The results of the logistic regression analyses are presented in Table 2. For participants with short habitual sleep duration (<6 hours) the age-adjusted odds for unmet physical activity need were nearly five-fold compared to participants with normative sleep duration (Odds Ratio (OR) 4.62, 95% Confidence interval (CI) 1.95-10.98). Adjusting for number of chronic diseases and depressive symptoms attenuated the association, but it remained statistically significant (OR 3.23, 95% CI 1.21-8.65). While for participants with long habitual sleep duration the age-adjusted odds for unmet physical activity need were three-fold, the association did not reach statistical significance (OR 2.96, 95% CI 0.88-9.90). Adjusting for walking difficulties slightly increased the odds for unmet physical activity need among short and long sleepers.

For participants who experienced daytime tiredness, the odds for unmet physical activity need were two-fold when adjusted for age only (OR 2.25, 95% CI 1.04-4.85), but after adjusting for the other covariates the association was attenuated (OR 0.87, 95% CI 0.38-2.01) (table 2). Higher prevalence of chronic diseases, depressive symptoms, physical activity and walking difficulties attenuated the association between daytime tiredness and unmet physical activity need. For participants perceiving poor sleep quality, the odds for unmet physical activity need were two-fold, but the association did not reach statistical significance (OR 1.95, 95% CI 0.88-4.32). We conducted additional analyses and

adjusted the models separately for sleep medication use, but observed no material effect on the association between sleep duration and unmet physical activity need.

Discussion

To the best of our knowledge, the present study is the first to examine the relationship of sleep- and rest-related factors with unmet physical activity need i.e. the will to be more physically active while perceiving poor opportunities to do so. Studies focusing on physical activity and sleep among older people have mainly targeted the positive effects of physical activity on sleep (Yang, Ho, Chen, & Chien, 2012) and fewer on the bidirectional association of physical activity and sleep (Holfeld & Ruthig, 2014; Lambiase et al., 2013). The present study adds to the current knowledge about the relationship between sleep and physical activity by showing that although insufficient sleep and daytime tiredness may coexist with perceiving decreased opportunities for physical activity the wish to be physically more active remains. This finding will lay grounds for future studies on physical activity promotion among older people with sleeping problems.

There may be several explanations for the association between short sleep duration and unmet physical activity need. People who sleep insufficiently more often report lack of energy for performing daytime activities (Groeger, Zijlstra, & Dijk, 2004). Getting tired performing specific standard activities has been termed fatigability (Eldadah, 2010). Unfortunately, we did not have data on fatigability, but speculate that it may underlie the association between short sleep duration and unmet physical activity need. A recent study suggests an association between sleep duration and fatigability (Aldughmi, Huisinga, Lynch, & Siengsukon, 2016), while others report that fatigability reduces physical activity and increases the risk of functional decline (Simonsick et al., 2016; Wanigatunga et al., 2017). Older adults who get fatigued while participating in physical activities may start feeling that

physical activity is not possible for them, a situation which may lead to unmet physical activity need.

While perceived fatigability is related to specific tasks (Eldadah, 2010), tiredness refers to a general subjective lack of energy and need for recovery (Ream & Richardson, 1996; Söderberg, Lundman, & Norberg, 2002). Perceived tiredness is a barrier to physical activity for many older people (Wilcox et al., 2006) and is associated with reduced levels of physical activity (Egerton et al., 2016). In the present age-adjusted models, daytime tiredness was associated with unmet physical activity need, but adjustment for the presence of walking limitations, depressive symptoms and comorbidity attenuated the association. Tiredness predicts poorer physical functioning and disability (Avlund et al., 2002; Manty et al., 2015; Schultz-Larsen & Avlund, 2007) and can therefore affect older people's ability to walk. Since walking is a popular form of physical activity among older people (Lim & Taylor, 2005) and participation in other forms of physical activity may also require ability to walk (Rantakokko et al., 2010), difficulties in walking may substantially hinder a person's possibilities to be physically active and so lead to unmet physical activity need. Furthermore, since tiredness is associated with a variety of physiological and psychological conditions (Avlund, 2010), the medical conditions underlying tiredness may also cause physical limitations and hinder possibilities to engage in physical activity, which, again, may lead to unmet need for physical activity. Poor health has previously been found to be a risk factor for unmet physical activity need (Eronen et al., 2014) and depressive symptoms have been found to coincide with unmet physical activity need (Rantakokko et al., 2010a).

Poorer general health and physical limitations caused by diseases may also limit older people's perceived opportunities for physical activity (Franco et al., 2015). Several studies have reported previously, that sleep disturbances in late life often coincide

with comorbidities (Ancoli-Israel, 2009; Vitiello et al., 2002), while short sleep may also indicate a tendency to have unhealthier habits (Stranges et al., 2008).

It is also possible that unmet physical activity need precedes a reduction in habitual sleep duration through reduced level of physical activity. Previous studies have shown that physical activity has beneficial effects on sleep (Yang et al., 2012), and consequently a reduction in physical activity, a known risk factor of unmet physical activity need (Rantakokko et al., 2010) may disturb sleep. In the current study, the association between short sleep duration and unmet physical activity need remained strong also after adjusting for self-reported physical activity, however, the question was rather crude and may not have captured all the variation in physical activity among the participants.

In the current study, long sleep duration showed three-fold odds for unmet physical activity compared to those sleeping six to eight hours. The association did not quite reach statistical significance due to small number of long sleepers in our sample (n=22). Because long sleep duration has previously been associated with poor health and functioning (Cappuccio et al., 2010a; Cappuccio et al., 2010b; Cappuccio et al., 2011; Stenholm, S. et al., 2011), we speculate that it may also be associated with unmet physical activity need. This preliminary observation warrants more research in larger samples.

Sleep quality was not associated with unmet physical activity need in the present study. This may, however, be partly explained by the measure used to assess sleep quality, which was a single question designed to elicit participants' general perception of their overall sleep quality. Buysse et al. (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989) have described sleep quality as "a complex phenomenon that is difficult to define and measure objectively". Thus, while subjective perception of sleep quality is important, the fact that sleep quality comprises several objective and subjective dimensions (Buysse et al., 1989) means that these were not likely captured with a single question.

The main strength of this study is that it is based on population-based sample of older twin women. A further strength is that it yielded novel findings on the associations of sleep characteristics with unmet physical activity need, along with more information on the phenomenon of unmet physical activity need in the lives of older people. Furthermore, the study generated new hypotheses to be tested in future studies and the findings lay grounds for research on solutions for improving older people's opportunities for physical activity participation.

The study also has its limitations. First, the cross-sectional study setting does not allow conclusions to be drawn about the direction of the association between sleep duration and unmet physical activity need, leaving this topic for further study. Second, the relatively low prevalence of unmet physical activity need, although in line with previous findings, (Eronen et al., 2014; Rantakokko et al., 2010) resulted in lack of statistical power in the analyses. This is likely due to the relatively good health and functional ability of the participants due to the study protocol of FITSA, which required the participants to be able to travel to the research laboratory from their town of residence at baseline (Viljanen et al., 2009). The findings are, therefore, limited to relatively high-functioning individuals and it is possible, therefore, that the results of this study underestimate the prevalence of unmet physical activity need among Finnish older women. Twin individuals are largely similar compared to singletons in terms of their health status (Andrew et al., 2001; Simmons et al., 1997) and do not differ in mortality (Kaprio, 2013), and therefore it is not likely that this affects the findings of this study. Third, this study was based on secondary analyses of the FITSA study, which was not specifically designed to study unmet physical activity need and sleep. Thus, sleep quality and sleep duration were assessed solely with single self-reports. Self-reported measures of sleep are commonly used in research but they may lead to over- or underestimations of sleep duration or sleep disturbances. People appear to overestimate their

sleep duration in comparison to objectively measured sleep (Matthews et al., 2018), except for those reporting poor sleep quality who are more likely to underestimate their sleep duration (Vallières & Morin, 2003; Van Den Berg, Julia F et al., 2008). In addition, self-reports of sleep duration often do not distinguish time spent sleeping from time spent in bed (Cappuccio et al., 2011; Stenholm, S. et al., 2011). The correspondence between subjective and objective measures of sleep seems to change with advancing age and older people who sleep poorly objectively, may perceive their sleep quality as good (Åkerstedt, Schwarz, Gruber, Lindberg, & Theorell-Haglöw, 2016; Vitiello, Larsen, & Moe, 2004). It is therefore likely that with increasing age the present participants had already modified their criteria of what constitutes good sleep quality, which may affect the results. Fourth, we cannot rule out the possibility that some other factor that we did not adjust for confounds the association between sleep and unmet physical activity need. Finally, the measure of unmet physical activity need was dichotomous and thus, the group of participants not experiencing unmet physical activity need is relatively heterogeneous.

Conclusions

The findings show that older women who sleep less than six hours per night may be more likely to experience unmet physical activity need. This study suggests that older women with other than normative sleep duration or daytime tiredness, who also experience unmet physical activity need, may benefit from solutions that promote their perceived opportunities for physical activity participation. In the future, larger studies including men and women and objective and subjective measures of sleep are needed to confirm the temporal order of events and eventually to lay grounds for potential interventions.

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Conflict of interests

The authors declare no conflicts of interest.

Research ethics

The FITSA study was approved by the Ethics Committee of the Central Finland Health Care District. The study protocol has followed the good scientific and clinical practices laid out by the 1964 Declaration of Helsinki.

Consent to participate

Written informed consent was obtained from all individual participants included in the study.

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Table 1. Demographic characteristics of the participants; Means, Standard Deviations (SD), Percentages, frequencies are shown (n=302)

	Unmet physical activity need		P ^a
	Yes (n=31)	No (n=271)	
	Mean (SD)	Mean (SD)	
Age	79.0 (3.4)	79.0 (3.3)	0.986
Number of chronic diseases	5.1 (2.2)	3.9 (2.3)	0.009
Depressive symptoms	19.7 (10.3)	13.6 (7.3)	0.004
	% (n)	% (n)	
Sleep duration			
less than 6 hours	32 (10)	11 (29)	0.020
6-8 hours	55 (17)	82 (224)	
more than 8 hours	13 (4)	7 (18)	
Sleep quality			
Good	68 (21)	80 (212)	0.150
Poor	32 (10)	20 (52)	
Daytime tiredness	61 (19)	41 (112)	0.043
Taking naps	45 (13)	48 (129)	0.846
Sleep medication use	40 (12)	22 (60)	0.090
Walking difficulties	90 (27)	55 (145)	<0.001
Physical activity			
sedentary	71 (22)	39 (102)	0.001

moderate activity	26 (8)	43 (113)	
high activity	3 (1)	18 (47)	
Financial situation			
good	20 (6)	31 (81)	0.171
moderate or poor	80 (24)	69 (184)	

^aWald test adjusted for interdependency within twin pairs, SD=Standard deviation,

n=number of participants

Table 2. Associations of sleep characteristics with unmet physical activity need among older women

	Model 1 ^a	Model 2 ^b	Model 3 ^c	Model 4 ^d	Model 5 ^e
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Sleep duration					
< 6 hours vs. 6-8 hours	4.62 (1.95-10.98)	3.03 (1.14-8.02)	4.71 (1.88-11.84)	4.48 (1.84-10.95)	3.23 (1.21-8.65)
> 8 hours vs. 6-8 hours	2.96 (0.88-9.90)	2.04 (0.55-7.55)	3.74 (1.08-12.86)	2.74 (0.83-9.03)	2.70 (0.74-9.81)
Daytime tiredness					
	2.25 (1.04-4.85)	1.15 (0.48-2.78)	1.42 (0.67-3.03)	1.70 (0.77-3.74)	0.87 (0.38-2.01)
Poor sleep quality					
	1.95 (0.88-4.32)	1.35 (0.52-3.57)	1.87 (0.83-4.24)	1.93 (0.84-4.36)	1.44 (0.55-3.77)

^aModel 1 adjusted for age ^bModel 2 adjusted for age, depressive symptoms and number of chronic diseases ^cModel 3 adjusted for age and walking difficulties ^dModel 4 adjusted for age and physical activity ^eModel 5 adjusted for age, depressive symptoms, number of chronic diseases, walking difficulties and physical activity. All models were adjusted for interdependency between twin pairs.

OR=Odds Ratio, CI=Confidence interval