Concurrent changes in sleep and physical activity during the transition to retirement: a prospective cohort study

Maria Alhainen[1, 2], Saana Myllyntausta[1, 2], Jaana Pentti[1, 2, 3], Jussi Vahtera[1, 2], Sari Stenholm[1, 2]

[1] Department of Public Health, University of Turku and Turku University Hospital, Turku, Finland;

[2] Centre for Population Health Research, University of Turku and Turku University Hospital, Finland;

[3] Clinicum, Faculty of Medicine, University of Helsinki, Helsinki, Finland

Contact author:

Prof. Sari Stenholm, Department of Public Health, University of Turku, Finland, email: sari.stenholm@utu.fi

Abstract

Background: Little is known about whether changes in physical activity are associated with changes in sleep in general population. The aim of this study was to examine the association between changes in physical activity and changes in sleep duration and difficulties at retirement transition point.

Methods: Data from the prospective Finnish Retirement and Aging study of 2,745 retired public sector employees was used. Participants answered questionnaires before and after the retirement with one year interval, in which they reported average weekly hours of physical activity, sleep duration and the frequency of sleep difficulties. The level of physical activity, classified as ‘low’, ‘moderate’ or ‘high’, before and after retirement was used to classify the participants to five physical activity groups. Changes in sleep duration (in minutes) and sleep difficulties (no, moderate, severe) were examined in these physical activity groups.

Results: Before retirement, high physical activity was associated with longest sleep duration (7h 8 min) and low physical activity was associated with severe sleep difficulties (OR 1.23, 95% CI 1.06-1.44) in comparison to high physical activity. During retirement transition, sleep duration increased in all physical activity change groups and sleep difficulties decreased significantly in ‘stable’, ‘increase from moderate’, ‘decrease from moderate’ and ‘decrease from high’ groups. Changes in sleep duration and sleep difficulties were not statistically significantly different between the physical activity change groups.

Conclusion: Sleep duration increases and sleep difficulties decrease after retirement. Changes in sleep during retirement transition seem to be independent of changes in physical activity during the same time period.

Key words: Cohort study, physical activity, retirement, sleep, sleep duration, sleep difficulties

Abbreviations:

BMI=Body mass index

GEE=Generalized estimating equations

MET=Metabolic equivalent

1. Introduction

Disturbed sleep is common among older adults [1,2] and it predisposes to several health problems. Growing evidence suggests that both short and long sleep duration are associated with many chronic diseases that concern older adults, such as coronary heart disease, stroke [3] and type 2 diabetes [4]. Similarly, sleep difficulties are associated with cardiovascular diseases [5], depression [6], cognitive impairment [7], premature death [7] and shorter health expectancy [8]. In addition, the risk of injuries and falls is also higher among older adults who suffer from sleep difficulties. [7,9] More detailed information on the effect of modifiable health behaviours on sleep is needed to find ways to treat and alleviate disturbed sleep.

The association between physical activity and sleep is widely studied and recently two meta-analyses of randomized controlled trials (RCT) examined the effects of aerobic and resistance training programs on the quantity and quality of sleep as primary outcomes [10,11]. The meta-analysis by Rubio-Arias et al. [10]including 5 RCTs (n=660) found that programmed low-moderate exercise and moderate exercise improved sleep quality compared to a control group among participants who initially had sleep difficulties. Furthermore, the meta-analysis by Kovacevic et al. [11] including 13 RCTs (n=652) reported that among participants with wide range of chronic diseases and with no primary insomnia, chronic resistance exercise (6 RCTs) significantly improved subjective sleep quality and acute resistance exercise (3 RCTs) improved arousal index and relative time spent in NREM stage. However, the strict inclusion criteria used in these meta-analyses limit generalizability of the results. For example, the meta-analysis conducted by Rubio-Arias et al. [10] excluded studies in which the study participants had some other medical or psychiatric condition besides sleep disturbance. On the contrary, the meta-analysis of Kovacevic et al. consisted also of participants who had psychiatric conditions, but

excluded studies where participants had primary insomnia. In both meta-analyses, the level of habitual physical activity of most of the participants was low before entering the study. Further research is needed on how the increase in physical activity is associated with changes in sleep in general population.

The transition to retirement is considered as an important turning point in life, that is accompanied by changes in many aspects of life such as time availability and daily routines [12], including increase in physical activity. Increase in sleep duration and reduction in sleep difficulties have also been observed during the retirement transition. [1314] However, it is not known whether changes in sleep associate with changes in physical activity or are these changes taking place independently of each other. Retirement transition offers a quasi-experimental setting where this association can be examined.

By using annually measured self-reported physical activity, sleep duration and sleep difficulties around retirement transition, we aimed at examining the relationship between the change in physical activity and changes in sleep duration and sleep difficulties among people in their 60s.

2. Methods

2.1 Study population

The study is based on the Finnish Retirement and Aging Study (FIREA), which is an ongoing longitudinal cohort study of older adults in Finland established in 2013. The aim of the FIREA study is to follow aging workers from work to full-time retirement and to determine how health behaviors and clinical risk factors change during the transition to

statutory retirement [15]. The eligible population for the FIREA study cohort included public sector employees whose individual retirement date was between the years of 2014 and 2019 and who were working in one of the 27 municipalities in Southwest Finland or in the 9 selected cities or 5 hospital districts around Finland during the year 2012. Information on the estimated individual retirement date was derived from the pension insurance institute for the municipal sector in Finland (Keva). Participants were first contacted 18 months prior to their estimated retirement date by sending a questionnaire, which was thereafter sent annually, four times in total.

By the end of 2018, 6,783 of the FIREA cohort members (64% of eligible sample, n=10,629) had responded to at least one questionnaire. Of them 4,311 had responded to the questionnaires at least twice, of which 2,820 participants both prior to and after the actual retirement date. To be included in this study, the participants had to respond to questions on physical activity, sleep duration and sleep difficulties immediately before and after the transition to statutory retirement (N=2,745).

The FIREA study was conducted in line with the Declaration of Helsinki and was approved by the Ethics Committee of Hospital District of Southwest Finland.

2.2 Assessment of physical activity

Each intensity grade had five response options of which the class mid-points were used for the calculation of time spent in physical activity: no activity, less than 0.5 hours activity (15 min used for the calculation), ~1 hour (45 min), 2-3 h (2.5 h), and ≥ 4h/week (5 h). Time spent on activity at each intensity level in hours per week was multiplied by the average energy expenditure of each activity, expressed in metabolic equivalent (MET). [16] We used the latest available MET-values for each intensity level: walking, brisk walking,

jogging, and running corresponded to 3.5, 5, 8, and 11 METs, respectively [17]. The amount of physical activity, including both leisure-time and commuting activity, was quantified as weekly MET-hours [16] by summing up the amount of activity at each intensity level together. Participants, whose physical activity was less than 14 MET hours per week, were classified as 'low-active'. Those, whose physical activity was more than 14 MET hours but less than 30 MET hours per week were classified as 'moderate-active' and those, whose physical activity was more than 30 MET hours per week, were classified as 'high-active' [18] .

Five groups were created based on participants' physical activity before and after the retirement transition. The first group was the 'stable' group, in which the participants' level of physical activity did not increase or decrease during the transition to retirement. In the second group, 'increase from low', the level of physical activity increased from 'low' level to higher level. The third group was 'increase from moderate' group, the fourth 'decrease from moderate' and the fifth 'decrease from high' group.

2.3 Assessment of sleep duration and sleep difficulties

Sleep duration and sleep difficulties were assessed with questionnaires completed both before and after retirement. To measure changes in sleep duration, the participants were requested to report how many hours they usually sleep per 24 hours using of the following options: '6 hours or less', '6,5 hours', '7 hours', '7,5 hours', '8 hours', '8,5 hours', ' 9 hours', '9,5 hours' or '10 hours or longer'. At the extremes of the scale, 5.5 hours and 10.5 hours were assigned for the calculation to categories '6 hours or less' and '10 hours or more', respectively. The reported hours were converted to minutes and the change in sleep duration was measured in minutes.

Sleep difficulties were measured with the Jenkins Sleep Problem Scale [19] . This scale consists of four questions that address the incidence of difficulties falling asleep, difficulties maintaining sleep during the night (i.e. ‘waking up several times during the night’), waking up too early in the morning (i.e. ‘having troubles staying asleep’), and nonrestorative sleep (i.e. ’feeling fatigue or drowsiness despite a typical night’s rest’). Participants were asked to report the frequency of each type of these difficulties during the past four weeks (never, one night per month, one night per week, 2 - 4 times per week, 5 - 6 nights per week and nearly every night). Sleep difficulties were categorized into three groups based on the most frequent symptom the participant reported: ‘no sleep difficulties’ (≤ 1 night per week), ‘moderate sleep difficulties’ (2 - 4 nights per week) and ‘severe sleep difficulties’ (≥ 5 nights per week).

2.4 Covariates

Gender, date of birth, and occupational status were obtained from the pension insurance institute for the municipal sector in Finland (Keva). Occupational status was categorized into three groups according to the occupational titles by the last known occupation preceding retirement: upper-grade non-manual workers (e.g. teachers, physicians), lower-grade non-manual workers (e.g. registered nurses, technicians) and manual workers (e.g. cleaners, maintenance workers).

Information about participants’ body mass index (BMI), alcohol use, smoking, chronic diseases and depression was obtained from the questionnaire completed before retirement. BMI was calculated with self-reported weight and height and categorized into: normal weight (18.5 to < 25.0 kg/m^2), overweight (25 to < 30 kg/m^2) and obese (≥ 30 kg/m^2) [20] . There were only ten (0.4%) underweight persons (BMI < 18.5) in our study

population and, thus, the underweight persons were combined to the normal weight category. Smoking status was categorized into non-smokers (never and former) and current smokers. The participants reported their habitual frequency and amount of beer, wine, and spirits consumption, in weekly units of alcohol. Heavy alcohol use was defined as over 16 drinks per week for women and over 24 drinks per week for men. These limits correspond with the lower limit for heavy use of alcohol set by the Finnish Ministry of Health and Social Affairs [21] .

The information regarding chronic diseases, which may confound the association between physical activity and sleep difficulties, was based on the question “Has your doctor ever told that you have or have had ….?” and following diseases were taken into account: angina pectoris, myocardial infarction, chronic bronchitis, diabetes, cancer, sleep apnea, restless legs syndrome and osteoarthritis. For the analyses, participants were categorized into having no chronic disease, having one chronic disease or having more than one chronic disease.

2.5 Statistical Analyses

Characteristics of the study population before retirement are presented for the whole study population and by pre-retirement physical activity groups as percentages for categorical variables and as means and standard deviations for continuous variables. The differences in the pre-retirement characteristics between different physical activity groups before retirement were tested with chi-square test for categorical variables and with analysis of variance for continuous variables. To measure the cross-sectional association between physical activity and sleep before retirement, we used analysis of variance for sleep duration

and multinomial logistic regression analysis for sleep difficulties while adjusting for age, gender and occupational status.

Since the outcome sleep difficulty was an ordinal variable that was measured before and after retirement, we used cumulative logistic regression analysis with generalized estimating equations (GEE), which controls for the intraindividual correlation between repeated measurements. The model included an interaction term (physical activity x time) which was used to examine changes in sleep difficulties during retirement transition in different physical activity change groups. We used contrast statements to calculate the estimates and the results are reported as cumulative odds ratios (cOR) and their 95% confidence intervals (CI). The first model was adjusted for age, gender and occupational status. Second model was further adjusted for lifestyle factors (smoking, alcohol-use and BMI) and number of chronic diseases before retirement. Third model was additionally adjusted for depression.

Changes in sleep duration (in minutes) was assessed using linear regression analysis with GEE. The model included an interaction term physical activity x time to derive estimates of changes in sleep duration in different physical activity groups. The first model was adjusted for age, gender and occupational status. The second model was additionally adjusted for lifestyle factors (smoking, alcohol-use and BMI) and number of chronic diseases, and the third model was additionally adjusted for depression. These models provided also estimates for the interaction between physical activity and time on changes in sleep.

All analyses were conducted using the SAS 9.4 Statistical Package (SAS Institute Inc., Cary, NC).

3. Results

The characteristics of the study population before retirement are shown in **Table 1**. The average age before the retirement was 63.2 years (SD = 1.3) and the majority of the study population were women (84%). There were no differences in age, gender, occupational status, alcohol consumption or depression across the pre-retirement physical activity groups. In comparison to the low active group, those who had high physical activity before retirement had less obesity, fewer chronic diseases and were less often smokers. Before retirement, the mean sleep duration was 7 hours 4 minutes (95% CI 7 h 1 min – 7 h 6 min) in the low, 7 hours 4 minutes (95% CI 7 h 1 min – 7 h 7 min) in the moderate and 7 hours 8 minutes (95% CI 7 h 5 min - 7 h 11 min) in the high physical activity group (p=0.03) after adjusting for age, gender, and occupational status. In addition, pre-retirement low physical activity in comparison to high physical activity was associated with severe sleep difficulties (OR 1.23, 95% CI 1.06-1.44) after adjusting for age, gender and occupational status.

Figure 1 shows the average sleep duration before and after retirement in different levels of physical activity before retirement. The changes in sleep duration in different physical activity change groups during the transition to retirement and p values for comparison between 'stable' group and other physical activity change groups are shown in **Table 2.** Sleep duration increased on average by 19 minutes and the increase was observed in all physical activity change groups (physical activity x time interaction [p=0.35]). The increase in sleep duration tended to be greater among those whose level of physical activity increased ('increase from low': mean change 21.9 min, 95% CI 17.8-25.9 min and 'increase from moderate': mean change 21.9 min, 95% CI 16.6-27.2 min) than among those whose level of physical activity decreased ('decrease from moderate': mean change 14.6 min, 95% CI 8.6-20.6 min). Compared to the latter group, sleep duration increased more on average 7.3 min (95% CI 0.03-14.6 min) and 7.3 min (95% CI -0.7-15.3 min) among those whose level of physical activity increased from low or moderate baseline

level, respectively. After further adjustment for lifestyle factors, number of chronic diseases (Model 2), and depression (Model 3), the results did not noticeably change.

The prevalence of sleep difficulties before and after retirement in different levels of physical activity before retirement is shown in **Figure 2**. In general, the prevalence of sleep difficulties decreased after the transition to retirement across all levels of physical activity, but the proportion of those who had no sleep difficulties increased more among those who had 'moderate' level of physical activity before retirement (8%)

Table 3 shows the cORs and 95% CIs for reduced sleep difficulties for each physical activity change group and p values for comparison between 'stable' group and other physical activity change groups. Sleep difficulties decreased significantly in 'stable' (cOR 0.83, 95% CI 0.76-0.91), 'increase from moderate' (cOR 0.70, 95% CI 0.57-0.87) and decrease from high' (cOR 0.73, 95% CI 0.60-0.89) groups after adjusting for age, gender and occupational status (Model 1). When the analyses were further adjusted for lifestyle factors and number of chronic diseases (Model 2) and depression (Model 3), statistically significant changes were observed also in the 'decrease from moderate' (cOR 0.77, 95% CI 0.62-0.96) group, but otherwise the results did not noticeably change. There was no physical activity x time interaction (p=0.21) on sleep difficulties and there were no significant differences in reduction of sleep difficulties between the other groups compared to the 'stable' group.

4. Discussion

We used retirement transition as a quasi-experiment design and examined concomitant changes in annually measured physical activity and sleep characteristics before and after

retirement. We observed that sleep duration increased in all physical activity change groups. The increase in sleep duration tended to be greater among those whose level of physical activity increased than among those whose level of physical activity decreased from moderate level to low level. We also found that sleep difficulties decreased significantly after retirement in every physical activity change group expect 'increase from low' group. However, the interaction between physical inactivity and time on sleep was not statistically significant

Our findings confirm previous observations, that retirement is associated with both improved sleep [13,14] and increase in leisure-time physical activity [22]. It has been suggested that both aspects are due to the reduction of work-related strain and the increase of leisure-time after retirement. [12,23] However, to our knowledge this was the first study to examine simultaneous changes in sleep and physical activity during this particular time window. Although the increase in sleep duration tended to be slightly smaller if the activity level decreased from moderate to low level, no statistically significant differences were observed between the group. The smaller increase in sleep duration in this group might be associated with an unhealthy lifestyle or chronic diseases which could have negative impact on both level of physical activity and sleep. In general, after the transition to retirement there is more time to sleep as the working hours no longer determine the timing of sleep. The increase in sleep duration could also result from the removal of work-related stress, as work-related stress is removed after retirement and, thus, also the quality of sleep may improve as a result. [23]

The results concerning the decrease in sleep difficulties suggests that significant relief in sleep difficulties was observed in some of the physical activity change groups, but no differences between physical activity change groups were observed. Some earlier findings based on randomized controlled trials have shown, that the increase in physical activity is

associated with a reduction of sleep difficulties among those who are sedentary or whose level of physical activity is low. [10,11] One explanation to these noncorresponding findings may lie in the study populations. In contrast to previous studies using relatively strict inclusion criteria and excluding people with primary insomnia and chronic diseases [10,11] , our population-based study sample consisted of people with different levels of physical activity and we also included participants with chronic conditions, which often co-exist with sleep difficulties.

There has been discussion about the indirect relationship between sleep and physical activity [24], as some previous studies have also shown non-significant associations between sleep and physical activity [25]. For example, it is known that physical inactivity is a major risk factor for many chronic diseases [26], and in our study population those who were less active had more chronic diseases. As chronic diseases are known to be associated with sleep difficulties [27], higher physical activity could help to alleviate the sleep difficulties via preventing the development of chronic diseases. Depression is known to associate with sleep [28], as well, and depressive symptoms have been observed to reduce more when the level of physical activity is higher [29] . As the association between sleep difficulties and depression is known to be bidirectional [28], it is possible that physical activity might improve sleep by reducing depressive symptoms. In addition, many of the life-style factors, such as alcohol use, smoking and obesity, are known to associate with both lower levels of physical activity and a higher prevalence of sleep difficulties [30,31,32,27,33,34] and could also mediate the effects of physical activity on sleep. In our analyses we controlled the effect of life-style factors, chronic diseases, and depression on sleep in different physical activity change groups and this did not influence our results markedly.

Previous studies have also examined the effect of activity intensity or duration on sleep difficulties in older adults and shown that when the intensity or duration of the exercise

session was increased over the national recommendations, the improvements were greater in sleep [35] . In this study we operated with total amount of physical activity in weekly MET hours calculated based on the activity intensity and duration. Due to the relatively crude physical activity measurement, we could not specifically examine the effects of the intensity and duration of physical activity on sleep difficulties, but we did observe, however, that moderately or highly active participants reported less sleep difficulties before retirement.

An important strength of this study was the reasonably large study population which also included participants with chronic diseases and sleep difficulties. The level of the study population's physical activity varied from low to high and many people also changed their level of activity after retirement. Annual measurement of physical activity and sleep during retirement transition provided us an exceptional opportunity to study concurrent changes in these factors. However, due to the short time interval, future studies with longer follow-up are needed to provide more information on the long-term benefits of physical activity on sleep.

This study has also some limitations which need to be addressed. Firstly, we used self-reported measurements to measure both physical activity and sleep, which are prone to reporting bias. However, self-reported physical activity and sleep measures are frequently used in epidemiological surveys and they are shown to be sensitive in detecting change in a longitudinal setting [13,14]. To confirm our findings, future studies that utilize objective measurements of both physical activity and sleep are needed. For example, accelerometers provide a feasible method to measure movement behavior (including physical activity and sleep) during the entire 24-hour period and over multiple days. This would allow detailed examination of, for example physical activity and sleep duration during workdays and weekend days. Secondly, this study population consisted of Northern

European public sector employees (mainly women) who were relatively healthy and transitioned to statutory retirement, which may limit the generalizability of the findings to other age groups and countries.

In conclusion, increase in sleep duration and decrease in sleep difficulties at retirement seem to occur relatively independently of changes in physical activity. Further studies with objective measurements for physical activity and sleep are needed to examine closer the interrelationship between physical activity and sleep.

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Table 1. The characteristics of the study population in different physical activity group before retirement

Characteristics			Physical activity before retirement			
	All		Low	Moderate	High	p
N	2745		1051	823	871	
Age, mean (SD)	63.2 (1.3)		63.2 (1.3)	63.2 (1.4)	63.3 (1.4)	0.84
Gender, n (%)						0.93
Women	2298 (84)		877 (83)	692 (84)	729 (84)	
Men	447 (16)		174 (17)	131 (16)	142 (16)	
Occupational status, n (%)						0.09
Higher grade non-manual	897 (33)		319 (31)	299 (37)	279 (32)	
Lower grade non-manual	839 (31)		332 (32)	244 (30)	263 (31)	
Manual	985 (36)		389 (37)	263 (33)	322 (37)	
Alcohol-use, n (%)						0.54
No risk-use	2512 (92)		955 (91)	753 (92)	804 (92)	
Risk-use	227 (8)		93 (9)	69 (8)	65 (8)	
BMI, n (%)						< 0.0001
Normal weight (≤ 25 kg/m²)	1043 (39)		283 (27)	347 (42)	413 (48)	
Over weight (25-30 kg/m²)	1092 (40)		411 (40)	326 (40)	355 (41)	
Obese (≥ 30 kg/m²)	578 (21)		341 (33)	143 (18)	94 (11)	
Smoking, n (%)						< 0.0001
Non-smoker	2461 (91)		912 (88)	749 (92)	800 (93)	
Smoker	242 (9)		125 (12)	61 (8)	56 (7)	
Chronic diseases, n (%)						< 0.0001
No	1015 (39)		343 (35)	309 (39)	363 (44)	
One	1141 (44)		427 (43)	356 (45)	358 (43)	
Two or more	456 (17)		219 (22)	127 (16)	110 (13)	
Depression, n (%)						0.23
No	2115 (85)		780 (84)	638 (85)	697 (87)	
Yes	368 (15)		150 (16)	112 (15)	106 (13)	

Notes: Physical activity categories low < 14 MET hours per week, moderate 14-30 MET hours per week, high > 30 MET hours per week

Figure 1. Sleep duration in minutes in different levels of physical activity before and after the retirement.

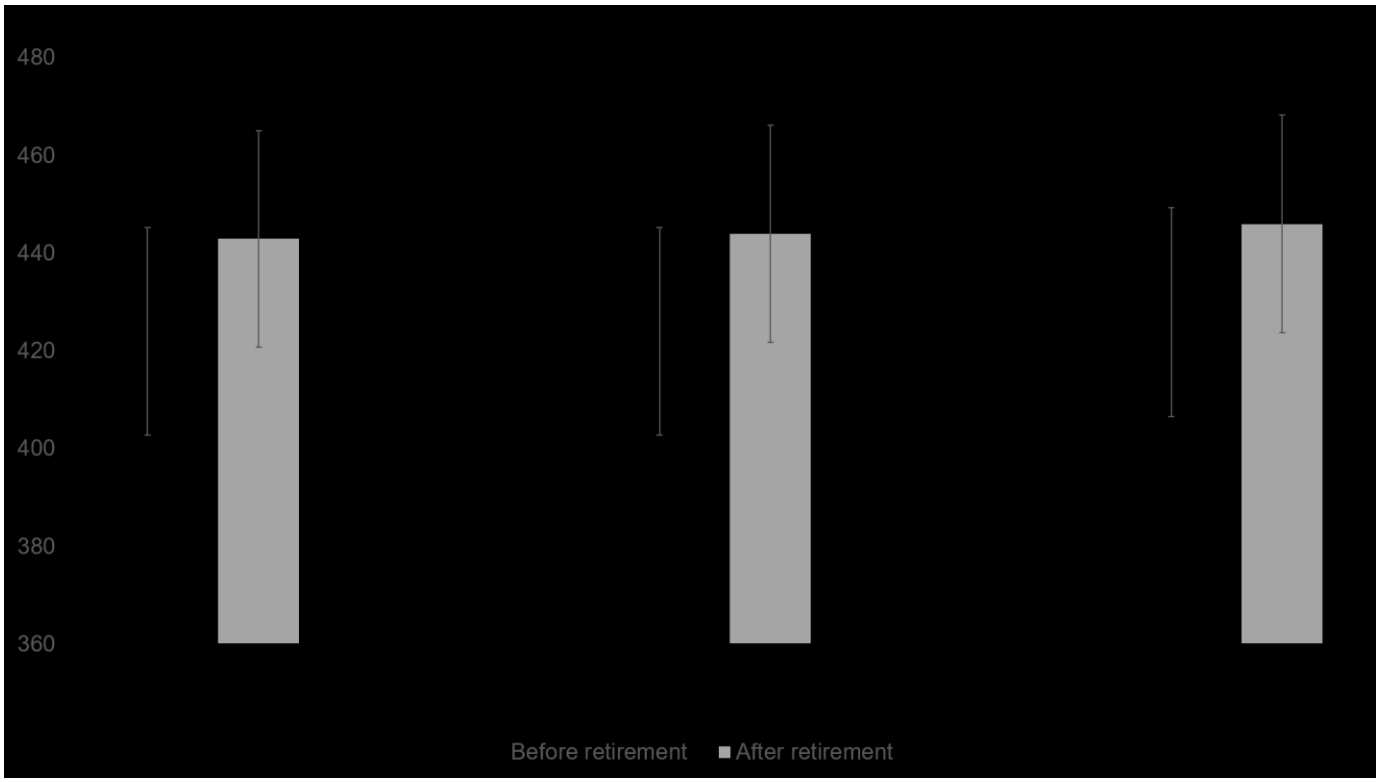

Table 2. Mean change and 95% confidence intervals for sleep duration in different physical activity change groups.

		Model 1				Model 2				Model 3		
	N	Mean change (minutes)	95% CI	p value*		Mean change (minutes)	95% CI	p value*		Mean change (minutes)	95% CI	p value*
Stable	1450	18.2	16.0-20.5	ref		18.5	16.1-20.9	ref		18.4	15.9-20.9	ref
Increase from low	467	21.9	17.8-25.9	0.13		22.4	18.2-26.7	0.11		22.5	18.1-26.9	0.11
Increase from moderate	290	21.9	16.6-27.2	0.21		22.2	16.8-27.7	0.22		20.9	15.6-26.2	0.40
Decrease from moderate	213	14.6	8.6-20.6	0.26		14.7	8.4-21.0	0.27		15.3	8.9-21.8	0.39
Decrease from high	325	19.9	15.7-24.2	0.49		20.0	15.7-24.4	0.54		19.9	15.5-24.3	0.56
Physical activity * time interaction		0.22					0.22				0.35	

Notes: Change in sleep duration is calculated by comparing the estimates of sleep duration after retirement to the estimates of sleep duration before retirement.

* comparison between 'stable' group and the other physical activity change groups

Model 1 is adjusted for gender, age and occupational status
Model 2 is adjusted for all covariates in Model 1 and additionally for alcohol use, smoking, BMI and chronic diseases
Model 3 is adjusted for all covariates in Model 2 and additionally for depression

Figure 2. The prevalence of unadjusted estimates of sleep difficulties before and after retirement in different levels of physical activity before retirement.

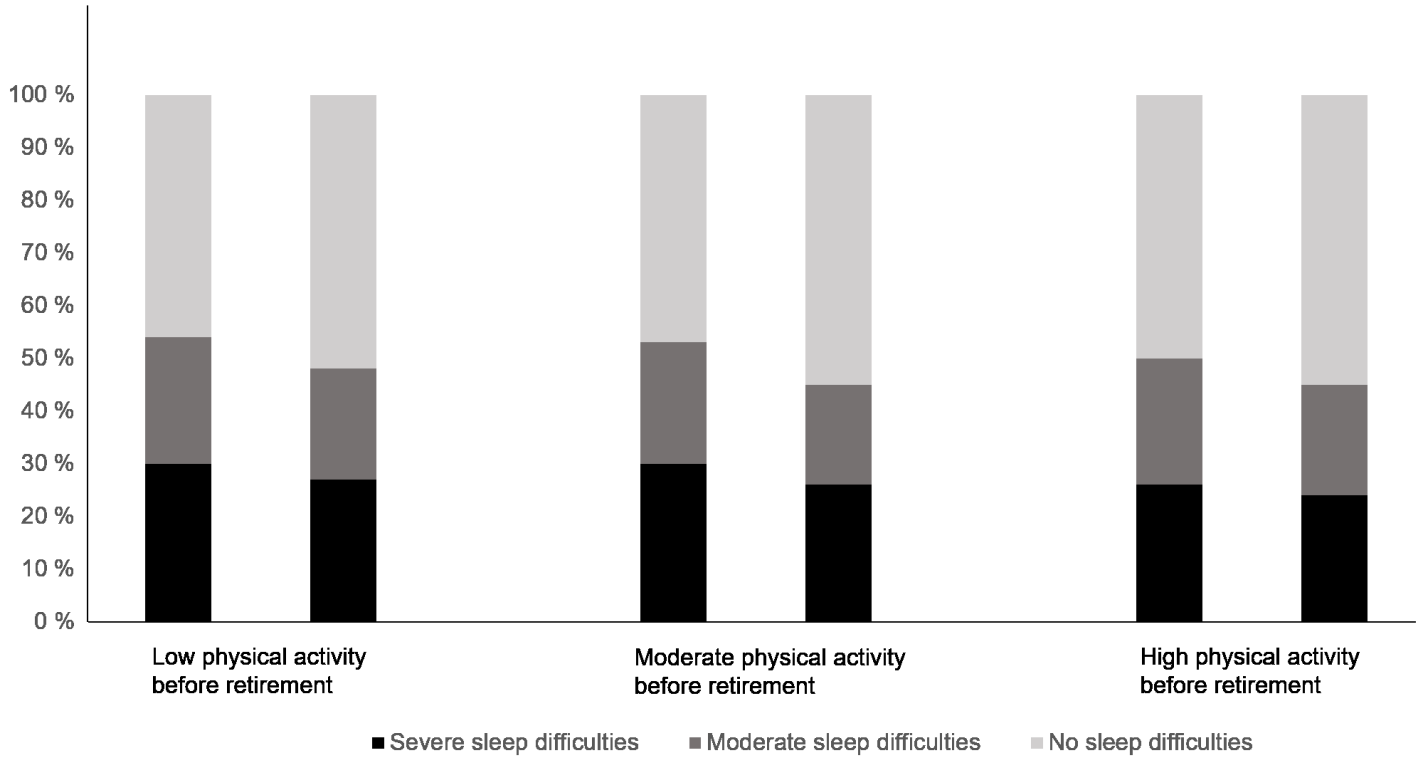

Table 3. Cumulative odd ratios (cORs) and 95% confidence intervals (CI) for reduced sleep difficulties in different physical activity change groups

		Model 1				Model 2				Model 3		
	N	cOR	95% CI	p value		cOR	95% CI	p value		cOR	95% CI	p value
Stable	1450	0.83	0.76-0.91	ref		0.85	0.77-0.93	ref		0.85	0.77-0.94	ref
Increase from low	467	0.88	0.76-1.04	0.55		0.89	0.75-1.05	0.78		0.91	0.76-1.08	0.65
Increase from moderate	290	0.70	0.57-0.87	0.14		0.68	0.54-0.85	0.053		0.69	0.55-0.87	0.087
Decrease from moderate	213	0.82	0.67-1.01	0.74		0.74	0.60-0.91	0.18		0.77	0.62-0.96	0.36
Decrease from high	325	0.73	0.60-0.89	0.24		0.70	0.57-0.86	0.11		0.71	0.58-0.88	0.16
Physical activity * time interaction term		0.38				0.13				0.21		

Notes: cORs are calculated by comparing the estimates of sleep difficulties after retirement to the estimates of sleep difficulties before retirement.

* comparison between 'stable' group and other physical activity change groups

Model 1 is adjusted for gender, age and occupational status
Model 2 is adjusted for all covariates in Model 1 and additionally for alcohol use, smoking, BMI and chronic diseases
Model 3 is adjusted for all covariates in Model 2 and additionally for depression.