Do sleep problems explain the association between work stress and the trajectories of work ability from midlife to pensionable age?

Marika Kontturi, MA[1], 0000-0002-6245-4337 – Prakash KC, PhD[2,3], 0000-0003-1510-3216 – Jenni Ervasti, PhD[4], 0000-0001-9113-2428 – Jaana Pentti, BSc[3,5], – Saana Myllyntausta, PhD[6], 0000-0002-6503-3829 – Petri Karkkola, PhD[1], 0000-0003-3414-0020 – Kirsi Honkalampi, PhD[1], 0000-0002-4328-5291 – Jussi Vahtera, PhD[3,7], 0000-0002-6036-061X – Sari Stenholm[*], PhD[3,7], 0000-0001-7560-0930 – Marianna Virtanen[*], PhD[1,8], 0000-0001-8361-3301.

[1]School of Educational Sciences and Psychology, University of Eastern Finland, Joensuu, Finland

[2]Unit of Health Sciences, Faculty of Social Sciences, Tampere University, Tampere, Finland

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

[4]Finnish Institute of Occupational Health, Helsinki, Finland

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

[6]Department of Psychology and Speech-Language Pathology, Faculty of Social Sciences, University of Turku, Turku, Finland

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

[8]Division of Insurance Medicine, Karolinska Institutet, Stockholm, Sweden

[*]Shared senior authorship

Corresponding author

Marika Kontturi, MA

School of Educational Sciences and Psychology, University of Eastern Finland, Joensuu, Finland

P.O. Box 111, 80101 Joensuu, Finland

Telephone number: +358503085385

Email address: marika.kontturi@uef.fi

FUNDING SOURCES

This work was supported by grants 286294, 294154, 319246, 321409, 329240, and 332030 from Academy of Finland, 118060 and 190172 from Finnish Work Environment Fund, 202100488 and 202100245 from Juho Vainio Foundation, and Postdoc grant 2021 from Ella and Georg Ehrnrooth Foundation. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

CONFLICTS OF INTERESTS

None Declared.

ACKNOWLEDGMENTS

None Declared.

We largely adhered the STROBE guidelines in writing this article.

ETHICAL CONSIDERATIONS AND DISCLOSURES

The FPS and FIREA Study were conducted in line with the Declaration of Helsinki. FIREA Study was approved by the Ethics Committee of Hospital District of Southwest Finland and FPS Study by the Ethics Committee of Hospital District of Helsinki and Uusimaa. The participants are volunteers who have given written informed consent to participate in the study. For the analyses, anonymized data were used.

CONTRIBUTORS

SS, MV and JV conceived and designed the studies and designed the data collection. MV, SS, MK, PKC, SM and JP contributed to the planning, conception, design and implementation of the study. MK, JP, PKC, MV and SM contributed to the finalization and analysis of the data. MK drafted the first manuscript, with critical revisions from MV, SS, PKC, SM, JP, PK, KH, JV and JE. All authors approved the final version of the manuscript.

RUNNING HEAD TITLE

Work ability, work stress and sleep problems

CLINICAL SIGNIFICANCE

The findings from this study will help employers, health professionals, and employees themselves notice that work ability in the last years of work before pensionable age could be supported by paying more attention to employees who have work stress or sleep problems in mid-life.

ABSTRACT

Objective: This study examined whether mid-life work stress, defined as job strain and effort-reward imbalance (ERI), predicts work ability trajectories observed 12 years preceding the individual pensionable age. Additionally, the role of sleep problems as a mediator in these associations was examined.

Methods: Survey data were collected from 2707 Finnish municipal employees.

Results: Identified work ability trajectories were: 'Stable Excellent', 'Stable Good', 'Moderate' and 'Low decreasing'. Baseline job strain and ERI were associated with a greater likelihood of belonging to impaired work ability trajectories when compared to 'Stable Good' trajectory. Baseline sleep problems explained the association of job strain by 38% and of ERI by 54%.

Conclusions: Mid-life work stress is associated with work ability in the last years preceding pensionable age. Sleep problems might be a potential mediator in these associations.

Keywords: work ability, work stress, job strain, effort-reward imbalance, sleep problems, pensionable age, aging employee

LEARNING OUTCOMES

Upon completion of this reading activity, participants should be able to:

- Explain how mid-life work stress affects long-term work ability in the end of the working career.
- Appraise the meaning of sleep as a mediator between work stress and work ability.

INTRODUCTION

Work ability refers, for example, to the balance between work demands and individual resources, which can change across the life course. Health and functional capacity form the basis of work ability.[1] Maintenance of good work ability has been associated with later retirement,[2] work motivation, and better self-rated health.[3] Poor work ability, in turn, has been associated with sickness absence,[4] early retirement intention,[5] and disability pension.[6]

One important work-related factor associated with work ability is work stress which is often described through two theoretical frameworks. The Job strain model defines job strain as a situation in which employees have high demands and little control over their work.[7,8] The effort-reward (ERI) -model assumes that employees expect adequate reward for their efforts, and beneficial effects of employment, and the perceived effort-reward balance depends on the fairness of the relationship between the employer and employee.[9]

A systematic review[10] has shown that high physical and psychological work demands, and poor job autonomy are important determinants of work ability. Similar results have been found in other longitudinal studies.[4,11] In addition, ERI has been shown to predict work ability.[12] The previous longitudinal studies have had short follow-ups and they have concentrated on employees of all ages,[4,12] not particularly to the last years of the working career where changes in work ability often occur. The only exception is a Finnish 28-year follow-up study which examined the association between job strain and the development of work ability among initially 44–58 years employees.[11] However, the follow-up ended in 2009, thus an updated view on the role of work stress on work ability is warranted.

One important health factor associated with work stress and work ability, is sleep problems. Insomnia is the most common sleep problem, and it has become one of the foremost health concerns for workers internationally.[13] In a conceptual framework of Mullins,[14] sleepiness may serve as a mediating variable that connects job demands to important organizational outcomes (e.g. job performance). Good sleep has been found to predict improved work ability,[15] while sleep problems have been found to predict work disability.[16] According to a meta-analysis, work stress has been associated with a greater risk of suffering from insomnia.[13]

Most of the studies concerning the association between work stress and sleep problems and between sleep problems and work ability have focused on employees of all ages,[13,15] not particularly on the last years of the working career. In the case of longitudinal studies, the follow-up time has rarely exceeded 5 years.[13,15] Additionally, to the best of our knowledge, there is no studies about the mediating role of sleep problems in the association between work stress and long-term trajectories of work ability. A Finnish 4-year follow-up study among working-age physicians suggested that sleep problems acted as a mediator between physicians' on-call work and poor work ability,[17] but the study did not consider the role of work stress.

Although it is possible that there is a two-way association between work stress and work ability, we specifically wanted to study the association from work stress to work ability. In addition, there is strong evidence that psychosocial factors affect work ability.[18] To fill the gaps in previous literature, we aimed to identify long-term trajectories of work ability from midlife to pensionable age and to examine work stress (job strain and ERI) at baseline as a predictor for those trajectories. Additionally, sleep problems were examined as a potential mediator between work stress and the work ability trajectories.

METHODS

Study population and design

This 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 eligible population for the FIREA study cohort included all public sector employees whose individual pensionable age was set between 2014 and 2019 and who were working either one of the 27 municipalities in Southwest Finland or in one of the selected nine cities or five hospital districts around Finland in 2012.[19] In this study, the estimated individual pensionable age was obtained from the pension insurance institute for the public sector in Finland (Keva).

The eligible study population for the present study included those FIREA cohort members who completed the first questionnaire while they were still working by the end of the December 2019 (n=6783), had previously participated in another cohort study, Finnish Public Sector Study (FPS), had given their permission to link their data to the FPS Study, and had responded to at least one FPS survey in 2000–2018 (n=5029). The FPS Study is an ongoing dynamic cohort study with repeated questionnaire follow-ups every two years. The FPS was established in 1997–1998, consisting of employees in the municipal services of 11 Finnish towns and 6 hospital districts providing specialized health care.[20]

To enable accurate estimation of work ability over 12 years before pensionable age, we included only those participants who had responded to a question about work ability at least twice before the pensionable age so that the latter answer was given 2 or 4 years before the pensionable age, and the former answer was given 6, 8, 10, or 12 years before the pensionable age (n=3656).

Information on work ability two years before the pensionable age was taken from the FIREA survey in 2013–2018 or in the case of missing information, from the FPS survey in 2012–2018. Other information of work ability was taken from the FPS survey in 2004–2016.

Baseline information on work stress (job strain and ERI), sleep problems, and lifestyle factors (body mass index, physical activity, alcohol risk use and smoking) before the assessment of work ability trajectories was taken from the FPS survey 14 years before the pensionable age or, in the case of missing information, 16 years before the pensionable age, so that the baseline comprised data from 2–4 years before the assessment of work ability trajectories in 2000–2006 (n=2707). Figure 1 shows how the data were collected during the study.

The FPS and FIREA studies were conducted in line with the Declaration of Helsinki. The FIREA Study was approved by the Ethics Committee of Hospital District of Southwest Finland and the FPS Study by the Ethics Committee of Hospital District of Helsinki and Uusimaa. The participants are volunteers who have given written informed consent to participate in the study. For the analyses, anonymized data were used.

Study context: pensionable age

In Finland, the Public Sector Pensions Act regulates the pensionable age of the public sector employees. From 2005 to 2016 the individual pensionable age in the public sector was generally 63–68 years. With the pension reform in January 2017, the lower and upper limits of the individual pensionable age slightly rose depending on the year of birth and life expectancy of the age group.

The individual pensionable age is flexible, which means that the pension may be taken out within a certain age range and there is also an upper limit for how long a person can continue working.[21]

Measures

Work ability

Work ability was assessed with a single question derived from the Work Ability Index (WAI) known as the Work Ability score (WAS): 'Assume that your work ability as its best has a value of 10 points. What score would you give your current work ability?'.[22] Previous studies have shown that this single-item WAS is a reasonable alternative to the seven-item WAI.[23] The designers of WAI have suggested the same categorization for WAS as for WAI, namely: excellent (10 points), good (8–9 points), moderate (6–7 points) and poor (0–5 points).[24]

Work stress

The assessment of work stress consisted of measures of job strain and ERI. Job strain was assessed by the shorter version[25] of the Job Content Questionnaire (JCQ).[8] Participants responded to nine items concerning job control and five items concerning psychological demands of job by a 5-point Likert Scale (1=totally agree, 5=totally disagree). Mean values were calculated for each scale. Participants with job strain, that is, having high demands and low control, (yes vs. no), were identified using previously defined median-based cutoff points from the FPS Study in 2012,[26] which were 3.33 for job demands and 3.76 for job control.

ERI was assessed by four questions from the 10-item scale by Siegrist.[9,27,28] Participants responded to one question concerning effort and three questions concerning reward by 5-point Likert Scale (1=very little, 5=very much). ERI was calculated by dividing the effort score by the mean score of reward variables. Participants with ERI (yes vs. no) were identified by defining the highest quartile

(>1.71) of ERI score as indicating ERI and the remaining three quartiles (≤1.71) not indicating, as previously.[26]

Sleep problems

Sleep problems were assessed with the Jenkins Sleep Problems Scale,[29] which includes four items: difficulties falling asleep, difficulties maintaining sleep during the night, waking up too early in the morning and nonrestorative sleep. Participants were asked to estimate the occurrence of these difficulties over the past 4 weeks (never, 1–3 nights per month, one night per week, 2–4 nights per week, 5–6 nights per week or almost every night). If the frequency of the most frequent symptom participants reported was >4 nights per week, participants were considered to have sleep difficulties (yes vs. no), as previously.[30]

Covariates

Covariates included sociodemographic factors (sex, age and occupational status) and lifestyle factors (body mass index, physical activity, alcohol risk use, and smoking), which all have shown to associate with work stress or work ability in previous studies.[10,11,15,23,31,32] All the covariates were defined in the baseline preceding the assessment of work ability trajectories. Demographic factors were defined from the registers and lifestyle factors from the questionnaires.

Information on sex and birth year (transformed to age) was obtained from the pension insurance institute for the public sector in Finland (Keva). The occupational titles were obtained from employers' records, and they were coded according to the International Standard Classification of Occupations (ISCO) 2001 and categorized into three groups: upper grade nonmanual workers (ISCO classes 1–2 e.g. teachers, physicians), lower grade nonmanual workers (ISCO classes 3–4 e.g. technicians, registered nurses), and manual workers (ISCO classes 5–9 e.g. cleaners, maintenance workers).[33]

Body mass index (BMI, kg/m^2) was calculated based on self-reported body weight and height and BMI ≥30 kg/m^2 was defined as obesity (yes vs. no).[34] Physical activity was assessed by asking participants to estimate their average weekly hours of leisure-time physical activity (including commuting) within the previous year in walking, brisk walking, jogging, and running, or their equivalent activities. Weekly physical activity was expressed in metabolic equivalent (MET) hours which was dichotomized into two groups (yes vs. no) and <14 MET hours/week was defined as low physical activity.[35,36] Alcohol risk use was calculated based on self-reported habitual frequencies of beer, wine and spirits consumption and women with >16 drinks/week and men with >24 drinks/week was assessing having alcohol risk use (yes vs. no).[37] Smoking was assessed by asking whether the respondent currently smoked or had ever smoked and dichotomized into current smoker vs. non-smoker (never and ex-smokers).

Statistical analyses

Characteristics of the participants at baseline were calculated as frequencies and proportions for categorical variables and as mean and standard deviation (SD) for age. A comparison between the characteristics of the study population (n=2707) and the FIREA survey cohort (n=6783) was carried out for the variables available for every participant. The $\chi 2$ test was used for percentages (sex and occupational status) and the t-test was used for means (age and work ability) about two years before the pensionable age.

Statistical analysis was conducted in three phases. First, we identified the development of work ability prior to pensionable age using the latent trajectory analysis. Every participant reported their work ability 2 to 6 times in 12 years preceding pensionable age. Responses were given an average of 3.2 (SD 0.6) times. PROC TRAJ macro in SAS 9.4 (SAS Institute) was used to estimate latent trajectories. The two-step procedure formulated by Nagin and Odgers[38] was used to determine the optimal numbers of latent trajectories and to choose the number and order of regression parameters. In the first step, increasing number of work ability trajectory models (1–8) were fitted with polynomial shape and in the next step we additionally used the quadratic and liner trajectories models to test the models chosen in first step. Assessment of model fit was based on Bayesian information criterion values (BIC), Akaike information criterion values (AIC), log-likelihood, posterior probabilities, prevalence of latent classes and odds of correct classification (OCC) (Model-fit statistics for trajectory models (1-8) are presented in Table, Supplemental Digital Content 1). Based on the model fit criteria, we chose a four-class polynomial model as the best fitted model. It displayed high BIC and AIC values, high log-likelihood, the prevalence of ≥5% for all four latent classes, and OCC values ≥5 in all trajectories, indicating better reliability for further analyses. Our manuscript largely meets the guidelines for latent trajectory analysis described in the GRoLTS Checklist[39] (Table, Supplemental Digital Content 2).

In the second phase of the statistical analysis, we examined whether job strain and ERI predicted the membership of the different trajectory groups. Multinomial logistic regression analysis was used to calculate odds ratios (ORs) and their 95% confidence intervals (CIs) for job strain and ERI. 'Stable good' work ability was used as a reference group, because it was the largest of the groups. The models were initially adjusted for demographic factors (Model 1) and additionally adjusted for lifestyle factors (Model 2).

In the third phase of the statistical analysis, we examined whether sleep problems mediate the association between work stress and work ability trajectories. Requirements for mediation include that there is a main effect between the exposure and the outcome, and that the mediator is associated with both the exposure and the outcome. A $\chi 2$ test was used to examine the association between baseline work stress and baseline sleep problems (see Table, Supplemental Digital Content 3, which demonstrates the association between work stress and sleep problems). Multinomial logistic regression analysis was used to calculate ORs and their 95% CIs for sleep problems to examine whether baseline sleep problems predict the membership of different trajectory groups (see Table, Supplemental Digital Content 4, which demonstrates the associations of sleep problems with different trajectory groups). To examine mediation, sleep problems were added to Model 3 for the association between job strain/ERI and work ability trajectory membership. Percentage of excess risk mediated (PERM) was then calculated. The variables with higher PERM values are regarded as mediators in the concept of traditional difference method which is based on the Baron's and Kenny's method.[40,41] The PERM was calculated using the following formula:[2]

$$PERM = \frac{OR\begin{pmatrix} demographics\ and \\ lifestyle\ related \\ factors\ adjusted \end{pmatrix} - OR\begin{pmatrix} demographics\ and \\ lifestyle\ related\ factors, \\ and\ sleep\ problems\ adjusted \end{pmatrix}}{OR\begin{pmatrix} demographics\ and \\ lifestyle\ related \\ factors\ adjusted \end{pmatrix} - 1} X\ 100$$

However, the traditional mediation analysis described above does not assume the interaction between exposure and mediator. This omission has been noted in the new causal interference methods that are based on the counterfactual framework. Using the SAS macro, we used the counterfactual mediation analysis that allows the presence of exposure-mediation interaction and decomposes the effects into natural direct and natural indirect effects. In the total effect, both natural direct and indirect effects are considered to estimate the ORs for the association between exposure and outcome. We also calculated the proportion (%) of the total effect the mediator in question explains. We performed a counterfactual meditation analysis, as presented by Valeri and VanderWeele,[42,43] using dichotomous exposures (job strain and effort-reward imbalance), dichotomous mediator (sleep problems), and dichotomous outcome variables (stable excellent, moderate and low decreasing work ability vs. stable good work ability). The outcomes were modelled using logistic regression.

All statistical analyses were performed using SAS statistical software, version 9.4 (SAS Institute).

RESULTS

The majority of the participants were women (84%), and the mean age at baseline was 49.6 years (SD 1.57). The participants were evenly divided into different occupational groups, so that 35% of the respondents were manual workers, 35% lower-grade nonmanual workers and 30% upper-grade nonmanual workers. A total of 21–22 % reported job strain or ERI. The most typical (17%) sleep problem among participants was difficulties maintaining sleep during the night. Any kind of sleep problem was reported by 23% of the participants (see Table, Supplemental Digital Content 5, which demonstrates the characteristics of the participants at baseline). Compared to the eligible population approximately two years before the pensionable age (n=6783), the study population (n=2707) included slightly fewer individuals working in manual occupations (34% vs. 40%) than the eligible population. The other comparisons regarding sex, age and work ability were negligible.

Four different work ability trajectories were identified (Figure 2). Predicted probabilities of the trajectory group membership ranged from 0.83–0.92 (see Table, Supplemental Digital Content 1, which presents the model-fit statistics for trajectory models). The largest trajectory was ‘Stable good’ (71%) indicating individuals who consistently defined their work ability as good. The second largest trajectory was ‘Moderate’ (19%) which included individuals who mostly defined their work ability as moderate. Finally, both the ‘Stable excellent’ trajectory, indicating individuals who consistently defined their work ability as excellent, and the ‘Low decreasing’ trajectory, including individuals whose work ability was low in the beginning of the trajectory and got even lower over time, included 5% of the participants.

Tables 1 and 2 show the associations of job strain and ERI with the membership of different trajectory groups, with ‘Stable good’ as the reference group. After adjusting for sociodemographic and lifestyle factors, job strain was associated with lower odds of belonging to ‘Stable excellent’ (OR 0.40, 95% CI 0.21 to 0.75) and higher odds of belonging to ‘Moderate’ (OR 1.65, 95% CI 1.30 to 2.09) or ‘Low decreasing’ (OR 1.69, 95% CI 1.12 to 2.57) trajectory as compared to the ‘Stable good’ trajectory. ERI was associated with higher odds of belonging to ‘Moderate’ (OR 1.70, 95% CI 1.34 to 2.16) or ‘Low decreasing’ (OR 1.92, 95% CI 1.27 to 2.88) trajectory as compared to the ‘Stable good’ trajectory. Regarding ERI, there was no difference between ‘Stable excellent’ and ‘Stable good’ trajectories.

Sleep problems were more common for those who reported job strain ($p<.0001$) or ERI ($p<.0001$) than those who did not (see Table, Supplemental Digital Content 3, which demonstrates the association between work stress and sleep problems). Sleep problems were also associated with the trajectory groups. After adjusting for sociodemographic factors, sleep problems were associated with higher odds of belonging to ‘Moderate’ (OR 1.92, 95% CI 1.54 to 2.40) and ‘Low decreasing’ (OR 2.97, 95% CI 2.04 to 4.32) trajectory as compared to the ‘Stable good’ trajectory (see Table, Supplemental Digital Content 4, which demonstrates the associations of sleep problems with different trajectory groups). There was no difference between ‘Stable excellent’ and ‘Stable good’ trajectories, thus in these trajectory group comparisons, the requirements of mediation were not fulfilled.

Tables 1 and 2 show the analyses of sleep problems as a mediator between job strain and ERI in the association with work ability trajectories. Considering job strain, the percentage of excess risk mediated (PERM) for sleep problems was 12% (‘Moderate’ vs. ‘Stable good’) and 22% (‘Low decreasing’ vs. ‘Stable good’). Considering ERI, the PERM for sleep problems was 22% (‘Moderate’ vs. ‘Stable good’) and 33% (‘Low decreasing’ vs. ‘Stable good’) in the association with work ability.

We complemented traditional analyses by counterfactual mediation analysis, which allows the interaction between the exposure (work stress) and mediator (sleep problems), and which decomposes the exposure effect into direct and indirect effects (Tables 1 and 2). The natural direct effect refers to the association between work stress and work ability trajectories in a scenario where sleep problems would be at the same level despite job strain. Those with high job strain were 1.59 times (95% CI 1.26–2.01) more likely to belong to ‘Moderate’ trajectory instead of ‘Stable good’ trajectory. The natural indirect effect, which indicates the excess risk of poorer work ability trajectory that is due to poorer sleep (more problems with sleep), was OR 1.17 (95% CI 1.05–1.30) for ‘Low decreasing’ trajectory compared to ‘Stable good’ trajectory. No excess risk due to poorer sleep was observed when comparing ‘Moderate’ and ‘Stable good’ trajectories. This indicates that by being associated with having sleep problems, job strain indirectly increases the likelihood belong to ‘Low decreasing’ trajectory instead of ‘Stable good’ trajectory. The mediator explains 38% of the total effect (‘Low decreasing’ vs. ‘Stable good’) which was higher than obtained from the traditional mediation analyses (22%). Thus, the mediating effect of sleep problems analyzed by traditional mediation analyses was confirmed in counterfactual analysis in the comparison between ‘Low decreasing’ and ‘Stable good’ trajectories.

With regard to ERI, those who had high ERI were 1.49 times (95% CI 1.17–1.89) more likely to belong to ‘Moderate’ trajectory instead of ‘Stable good’ trajectory in a scenario where sleep problems would be at the same level regardless of ERI (=the natural direct effect). The natural indirect effect was OR=1.30 (95% CI 1.11–1.52) when comparing ‘Low decreasing’ to ‘Stable good' trajectory. No excess risk due to poorer sleep was observed when comparing 'Moderate' and 'Stable good' trajectories. This indicates that by being associated with having sleep problems, ERI indirectly increases the likelihood belong to 'Low decreasing' trajectory instead of 'Stable good' trajectory. The mediator explains 54% of the total effect ('Low decreasing' vs. 'Stable good'), which was higher than that obtained from the traditional mediation analyses (33%). Again, the mediating effect of sleep problems analyzed by traditional mediation analyses was confirmed in counterfactual analyses in the comparison between 'Low decreasing' and 'Stable good' trajectories.

DISCUSSION

The current study is, to best of our knowledge, the first study to examine whether work stress is associated with long-term work ability trajectories from midlife to pensionable age and whether sleep problems mediate their association. We found that after considering sociodemographic and lifestyle risk factors, job strain and ERI were associated with a greater likelihood of belonging to poorer work ability trajectories, and the association was partly mediated by sleep problems. These findings are consistent with the previous longitudinal studies showing negative associations of job strain[4,10,11] and ERI[12] with work ability, although only one of those studies[11] considered long-term trajectories.

We also examined the extent to which the associations between work stress and work ability were mediated by sleep problems. Sleep problems have been found to be associated with work ability[15] and in previous meta-analysis work stress has been found to be associated with insomnia.[13] However, studies examining the mediating role of sleep problems between work stress and work ability are scarce[17] and to our knowledge, they have not addressed job strain or ERI as sources of stress. In line with the previous evidence, the role of sleep problems as a mediator was supported in our study. Those who had job strain or ERI at baseline, experienced more sleep problems at baseline compared to those without job strain or ERI. Additionally, those who had sleep problems at baseline belonged more often to ‘Moderate’ or ’Low decreasing’ work ability trajectory than the ’Stable good’ trajectory. We measured the mediating effect of sleep problems using the traditional mediation analysis and counterfactual mediation analysis. The mediating effect of sleep problems was clearly evident when comparing ‘Low decreasing’ trajectory with ‘Stable good’ trajectory, but less when comparing ‘Moderate’ trajectory with ‘Stable good’ trajectory. Thus, sleep problems seem to be one potential mechanism explaining the relationship between work stress in mid-life and the declining work ability when approaching the pensionable age.

The specific strength of this study is a considerably large cohort of older public sector employees with repeated work ability measurements over 12 years. The study provided new information on the associations between work stress and long-term work ability described through a data-driven approach, trajectory analysis, as well as with an assessment of the meditating role of sleep problems in this association.

However, the findings of this study have to be considered with the following limitations. The participants were employed in the public sector in Finland and therefore, the findings may not necessarily be generalizable to other sectors and the general population. In addition, the results should be generalized cautiously to male employees, as 84% of our study population were women. However, a greater proportion (78%) of municipal employees in Finland are women.[44] Additionally, the attrition analysis approximately two years before the pensionable age showed that there were slightly less individuals working in manual occupations in the study population than in the eligible group. Differences were small, so we assume that they have not had a major impact on the results. Because of the longitudinal study design, health-related selection is a major limitation as the findings were based on only those who had the ability to work until the pensionable age.

Information on work stress and sleep problems was collected before the information on work ability trajectories but the time order between the exposure (work stress) and the hypothesized mediator (sleep problems) remains open in our study. Therefore, the findings related to the mediating role of sleep should be interpreted cautiously. However, sleep problems have shown great persistence over time[45] which suggests that their role as a mechanism between work stress and long-term work ability may be substantial. We measured the work stress only at baseline and not during the follow-up. We chose to do this because the aim was to examine the long-term effects of work stress on work ability and avoid the effect of reverse causality. However, it is possible that for some participants, work stress has changed during the follow-up, for example, due to a job change.

This study was based on self-report measures, which may cause recall bias and common method bias.[46] Because the WAS is only a one question concerning respondent's own opinion of his/her current work ability compared with the life-time best[22] it is not known whether the results of work ability in this study are due to a personal response style or external conditions affecting employee's work ability. However, previous studies have shown that the WAS is a reasonable alternative to the seven-item WAI,[23] which also includes objective questions about work ability, such as diagnosed diseases that describe health.[22] In addition, a person's subjective experience may have a greater impact on future labor market participation than an objective measure of capacity for work[1,4] which advocates the use of self-report measures. In the future, however, it would be important to examine the topic of this article with more objective indicators of work stress, work ability and sleep problems.

Finally, we set the limit of sleep problems according to the limits of the Jenkins Scale[29] (at least one sleep difficulty had occurred more often than 4 nights per week during the past 4 weeks). This was little higher than the cut-point in the ICD-10[47] diagnostic criteria where the frequency of sleeping difficulties for the diagnosis is at least three times per week during the past one month. In addition to the Jenkins Scale, future studies are warranted to consider alternative ways of measuring sleep and determining the cut-point of sleep problems.

We found that work stress was a significant predictor of impaired work ability towards the end of the working career, although a large part of the association with the poorest work ability trajectory was mediated by sleep problems. Therefore, in order to prevent impaired work ability potentially leading to premature retirement, it is important for employers, policy makers and professionals to develop intervention programs that allow both identifying work stress and dealing with it appropriately. Managers should invest in stress-related competence, as they play a key role in the workplaces. In addition, it is important that employees recognize their stress level, know how to manage with stress and associated sleep problems, and if necessary, seek help for it.

We largely adhered the STROBE guidelines in writing this article (see Table, Supplemental Digital Content 6).

CONCLUSIONS

During a 12-year follow-up, job strain and ERI at baseline were associated with decreasing work ability suggesting that work stress may have role in employees' work ability several years forward, from midlife to pensionable age. Sleep problems seem to be a potential mediator between work stress and long-term work ability in the last years of the working career.

REFERENCES

1. Ilmarinen J, Gould R, Järvikoski A, Järvisalo J. Diversity of work ability. In: Gould R, Ilmarinen J, Järvisalo J, Koskinen S, eds. *Dimensions of Work Ability. Results of the Health 2000 Survey*. Finnish Centre for Pensions, The Social Insurance Institution, National Public Health Institute and Finnish Institute of Occupational Health. 2008;13-24. Accessed June 21, 2022. https://sivusto.kykyviisari.fi/wp-content/uploads/2018/09/Gould-Dimensions-of-work-ability.pdf

2. Virtanen M, Oksanen T, Pentti J, et al. Occupational class and working beyond the retirement age: a cohort study. *Scand J Work Environ Health*. 2017;43(5):426-435. doi:10.5271/sjweh.3645

3. Feißel A, Swart E, March S. The Impact of Work Ability on Work Motivation and Health: A Longitudinal Study Based on Older Employees. *J Occup Environ Med*. 2018;60(5):e238-e244. doi:10.1097/JOM.0000000000001244

4. McGonagle AK, Fisher GG, Barnes-Farrell JL, Grosch JW. Individual and Work Factors Related to Perceived Work Ability and Labor Force Outcomes. *Journal of applied psychology*. 2015;100(2):376-398. doi:10.1037/a0037974

5. KC P, Oakman J, Nygård CH, et al. Intention to Retire in Employees over 50 Years. What is the Role of Work Ability and Work Life Satisfaction? *Int J Environ Res Public Health*. 2019;16(14):2500. doi:10.3390/ijerph16142500

6. Kinnunen U, Nätti J. Work ability score and future work ability as predictors of register-based disability pension and long-term sickness absence. *Scand J Public Health*. 2018;46(3):321-330. doi:10.1177/1403494817745190

7. Karasek Robert. *Healthy Work : Stress, Productivity, and the Reconstruction of Working Life*. (Theorell T, ed.). Basic Books; 1990.

8. Karasek R, Brisson C, Kawakami N, Houtman I, Bongers P, Amick B. The Job Content Questionnaire (JCQ). *J Occup Health Psychol*. 1998;3(4):322-355. doi:10.1037/1076-8998.3.4.322

9. Siegrist J. Adverse Health Effects of High-Effort/Low-Reward Conditions. *J Occup Health Psychol*. 1996;1(1):27-41. doi:10.1037/1076-8998.1.1.27

10. van den Berg TIJ, Elders LAM, de Zwart BCH, Burdorf A. The effects of work-related and individual factors on the Work Ability Index: a systematic review. *Occupational and environmental medicine (London, England)*. 2009;66(4):211-220. doi:10.1136/oem.2008.039883

11. von Bonsdorff ME, Kokko K, Seitsamo J, et al. Work Strain in Midlife and 28-year Work Ability Trajectories. *Scand J Work Environ Health*. 2011;37(6):455-463. doi:10.5271/sjweh.3177

12. Bethge M, Radoschewski FM. Adverse effects of effort–reward imbalance on work ability: longitudinal findings from the German Sociomedical Panel of Employees. *Int J Public Health*. 2011;57(5):797-805. doi:10.1007/s00038-011-0304-2

13. Yang B, Wang Y, Cui F, et al. Association between insomnia and job stress: a meta-analysis. *Sleep & breathing*. 2018;22(4):1221-1231. doi:10.1007/s11325-018-1682-y

14. Mullins HM, Cortina JM, Drake CL, Dalal RS. Sleepiness at Work: A Review and Framework of How the Physiology of Sleepiness Impacts the Workplace. *Journal of applied psychology*. 2014;99(6):1096-1112. doi:10.1037/a0037885

15. Camerino D, Conway PM, Sartori S, et al. Factors Affecting Work Ability in Day and Shift-Working Nurses. *Chronobiol Int*. 2008;25(2-3):425-442. doi:10.1080/07420520802118236

16. Leino-Arjas P, Seitsamo J, Nygard CH, Prakash KC, Neupane S. Process of Work Disability: From Determinants of Sickness Absence Trajectories to Disability Retirement in A Long-Term Follow-Up of Municipal Employees. *Int J Environ Res Public Health*. 2021;18(5):2614. doi:10.3390/ijerph18052614

17. Heponiemi T, Puttonen S, Elovainio M. On-call work and physicians' well-being: testing the potential mediators. *Occupational medicine (Oxford)*. 2014;64(5):352-357. doi:10.1093/occmed/kqu036

18. Knardahl S, Johannessen HA, Sterud T, et al. The contribution from psychological, social, and organizational work factors to risk of disability retirement: a systematic review with meta-analyses. *BMC Public Health*. 2017;17(1):176-176. doi:10.1186/s12889-017-4059-4

19. Leskinen T, Pulakka A, Heinonen OJ, et al. Changes in non-occupational sedentary behaviours across the retirement transition: the Finnish Retirement and Aging (FIREA) study. *Journal of epidemiology and community health (1979)*. 2018;72(8):695-701. doi:10.1136/jech-2017-209958

20. Sjösten N, Vahtera J, Salo P, et al. Increased Risk of Lost Workdays Prior to the Diagnosis of Sleep Apnea. *Chest*. 2009;136(1):130-136. doi:10.1378/chest.08-2201

21. Finnish Centre for Pensions. Eläketurvakeskus. Pension reforms. Published 2022. Accessed October 7, 2022. https://www.etk.fi/en/finnish-pension-system/pension-reforms/

22. Tuomi K, Ilmarinen J, Jahkola A. *Work Ability Index*. 2nd ed. Finnish Institute of Occupational Health; 1998.

23. El Fassi M, Bocquet V, Majery N, Lair ML, Couffignal S, Mairiaux P. Work ability assessment in a worker population: comparison and determinants of Work Ability Index and Work Ability score. *BMC Public Health*. 2013;13(1):305-305. doi:10.1186/1471-2458-13-305

24. Gould R, Koskinen S, Seitsamo J, Tuomi K, Polvinen A, Sainio P. Data and methods. In: Gould R, Ilmarinen J, Järvisalo J, Koskinen S, eds. *Dimensions of Work Ability. Results of the Health 2000 Survey*. Finnish Centre for Pensions, The Social Insurance Institution, National Public Health Institute and Finnish Institute of Occupational Health ; 2008:25-32. Accessed June 21, 2022. https://sivusto.kykyviisari.fi/wp-content/uploads/2018/09/Gould-Dimensions-of-work-ability.pdf

25. Fransson EI, Nyberg ST, Heikkilä K, et al. Comparison of alternative versions of the job demand-control scales in 17 European cohort studies: the IPD-Work consortium. *BMC Public Health*. 2012;12(1):62-62. doi:10.1186/1471-2458-12-62

26. Myllyntausta S, Salo P, Kronholm E, et al. Does removal of work stress explain improved sleep following retirement? The Finnish Retirement and Aging study. *Sleep (New York, NY)*. 2019;42(8):1. doi:10.1093/sleep/zsz109

27. Siegrist J, Wege N, Pühlhofer F, Wahrendorf M. A short generic measure of work stress in the era of globalization: effort–reward imbalance. *Int Arch Occup Environ Health*. 2008;82(8):1005-1013. doi:10.1007/s00420-008-0384-3

28. Juvani A, Oksanen T, Salo P, et al. Effort-Reward Imbalance as a Risk Factor for Disability Pension: The Finnish Public Sector Study. *Scand J Work Environ Health*. 2014;40(3):266-277. doi:10.5271/sjweh.3402

29. Jenkins CD, Stanton BA, Niemcryk SJ, Rose RM. A scale for the estimation of sleep problems in clinical research. *J Clin Epidemiol*. 1988;41(4):313-321. doi:10.1016/0895-4356(88)90138-2

30. Salo P, Ala-Mursula L, Rod NH, et al. Work time control and sleep disturbances: prospective cohort study of Finnish public sector employees. *Sleep (New York, NY)*. 2014;37(7):1217-1225. doi:10.5665/sleep.3842

31. Ng JYK, Chan AHS. The Work Ability of Hong Kong Construction Workers in Relation to Individual and Work-Related Factors. *Int J Environ Res Public Health*. 2018;15(5):990. doi:10.3390/ijerph15050990

32. Malińska M, Bugajska J. Assessment of the impact of lifestyle and psychosocial working conditions on older employees' work ability. *International journal of occupational safety and ergonomics*. 2021;27(3):946-955. doi:10.1080/10803548.2020.1829317

33. Statistics Finland. *Classifications of Occupations 2001*. 2001. Accessed July 5, 2021. https://www2.tilastokeskus.fi/fi/luokitukset/ammatti/

34. World Health Organization. *Obesity: Preventing and Managing the Global Epidemic. Report of a WHO Consultation*.; 2001.

35. Kujala UM, Kaprio J, Sarna S, Koskenvuo M. Relationship of Leisure-Time Physical Activity and Mortality: The Finnish Twin Cohort. *JAMA : the journal of the American Medical Association*. 1998;279(6):440-444. doi:10.1001/jama.279.6.440

36. Leskinen T, Stenholm S, Heinonen OJ, et al. Change in physical activity and accumulation of cardiometabolic risk factors. *Prev Med (Baltim)*. 2018;112:31-37. doi:10.1016/j.ypmed.2018.03.020

37. Finnish Institute of Occupational Health and Finnish Ministry of Social Affairs and Health. *Työterveyslaitos Ja Sosiaali- Ja Terveysministeriö. Riskikulutuksen Varhainen Tunnistaminen Ja Mini-Interventio -Hoitosuosituksen Yhteenveto [Adapted Translation into Finnish Based on "Alcohol and Primary Health Care: Clinical Guidelines on Identification and Brief Interventions. Department of Health of the Government of Catalonia. Barcelona." by Anderson, P., Gual, A., Colom, J. (2005).]*.; 2006.

38. Nagin DS, Odgers CL. Group-based trajectory modeling in clinical research. *Annu Rev Clin Psychol*. 2010;6(1):109-138. doi:10.1146/annurev.clinpsy.121208.131413

39. van de Schoot R, Sijbrandij M, Winter SD, Depaoli S, Vermunt JK. The GRoLTS-Checklist: Guidelines for Reporting on Latent Trajectory Studies. *Structural equation modeling*. 2017;24(3):451-467. doi:10.1080/10705511.2016.1247646

40. Jiang Z, VanderWeele TJ. When is the difference method conservative for assessing mediation? *Am J Epidemiol*. 2015;182(2):105-108. doi:10.1093/aje/kwv059

41. Baron RM, Kenny DA. The Moderator-Mediator Variable Distinction in Social Psychological Research. *J Pers Soc Psychol*. 1986;51(6):1173-1182. doi:10.1037/0022-3514.51.6.1173

42. Valeri L, VanderWeele TJ. Mediation Analysis Allowing for Exposure-Mediator Interactions and Causal Interpretation: Theoretical Assumptions and Implementation With SAS and SPSS Macros. *Psychol Methods*. 2013;18(2):137-150. doi:10.1037/a0031034

43. Richiardi L, Bellocco R, Zugna D. Mediation analysis in epidemiology: methods, interpretation and bias. *Int J Epidemiol*. 2013;42(5):1511-1519. doi:10.1093/ije/dyt127

44. Statistics Finland. *Women and Men in Finland 2016*. 2016. Statistics Finland: Edita Publishing Oy

45. Saltychev M, Juhola J, Arokoski J, et al. Persistence of sleep difficulties for over 16 years amongst 66,948 working-aged adults. *PLoS One*. 2021;16(11):e0259500-e0259500. doi:10.1371/journal.pone.0259500

46. Podsakoff PM, MacKenzie SB, Lee JY, Podsakoff NP. Common Method Biases in Behavioral Research: A Critical Review of the Literature and Recommended Remedies. *Journal of applied psychology; J Appl Psychol*. 2003;88(5):879-903. doi:10.1037/0021-9010.88.5.879

47. World Health Organization. *International Statistical Classification of Diseases and Related Health Problems 10th Ed. (ICD-10).*; 2016.

Figure Legends

1 Data collection during the study

2 Work ability trajectories over 12 years prior to pensionable age

List of Supplemental Digital Content

Supplemental Digital Content 1. pdf

Supplemental Digital Content 2. pdf

Supplemental Digital Content 3. pdf

Supplemental Digital Content 4. pdf

Supplemental Digital Content 5. pdf

Supplemental Digital Content 6. pdf

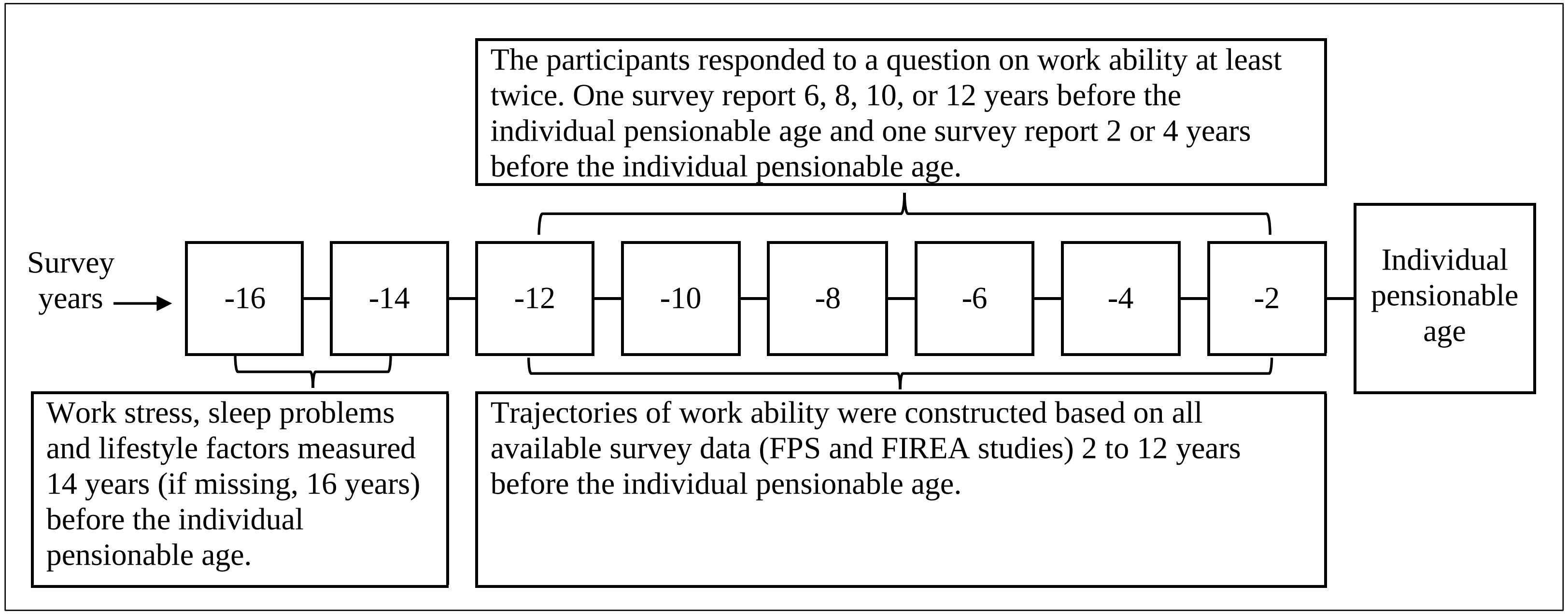

Figure 1 Data collection during the study

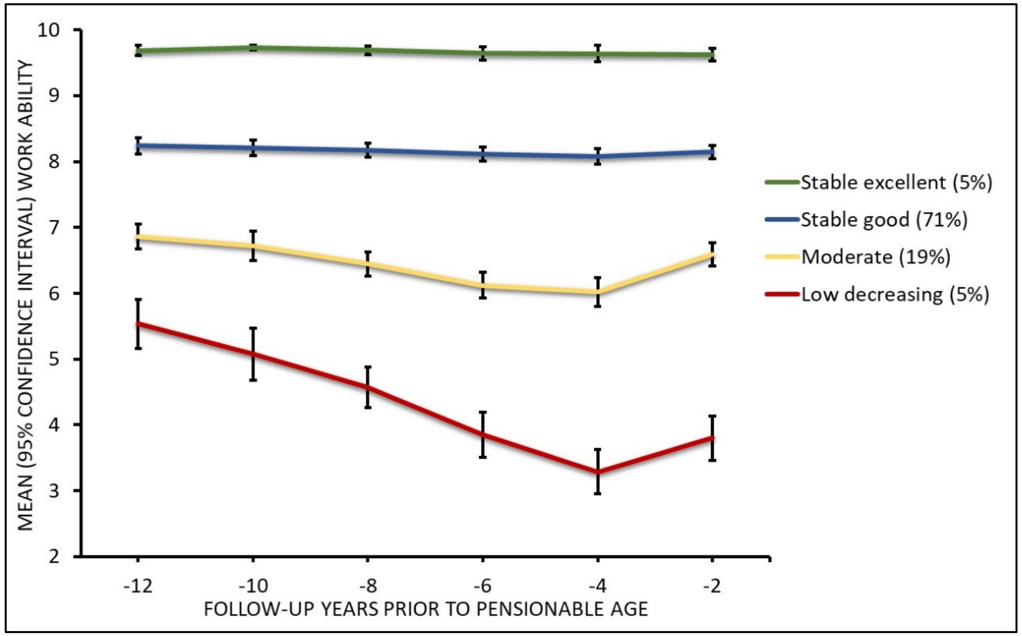

Figure 2 Work ability trajectories over 12 years prior to pensionable age

Table 1 Associations of job strain with different work ability trajectory groups, and the mediation effect of sleep problems

	Stable excellent work ability[d] vs. Stable good work ability[e]			Moderate work ability[f] vs. Stable good work ability			Low decreasing work ability[g] vs. Stable good work ability		
	OR	95% CI	PERM/ Proportion mediated	OR	95% CI	PERM/ Proportion mediated	OR	95% CI	PERM/ Proportion mediated
Model 1[a]									
Job strain (yes/no)	0.42	0.23 to 0.77		1.65	1.31 to 2.07		1.72	1.15 to 2.58	
Model 2[b]									
Job strain (yes/no)	0.40	0.21 to 0.75		1.65	1.30 to 2.09		1.69	1.12 to 2.57	
Model 3[c]									
Job strain (yes/no)	0.41	0.22 to 0.76	2%	1.57	1.24 to 2.20	12%	1.54	1.01 to 2.34	22%
Counterfactual mediation analysis									
Natural direct effect	0.37	0.19 to 0.70		1.59	1.26 to 2.01		1.36	0.90 to 2.07	
Natural indirect effect	0.95	0.86 to 1.05		1.03	0.98 to 1.07		1.17	1.05 to 1.30	
Total effect	0.35	0.19 to 0.66		1.63	1.29 to 2.07		1.59	1.04 to 2.42	
Proportion mediated			3%			7%			38%

[a] Model 1 adjusted for demographic factors (sex, age and occupational status)

[b] Model 2 additionally adjusted for lifestyle factors (body mass index, physical activity, alcohol risk use and smoking)

[c] Model 3 additionally adjusted for sleep problems

OR= odds ratio, CI= confidence level, PERM= percentage of excess risk mediated

Note: [d]Stable excellent n=149 (5%), [e]Stable good n=1927 (71%), [f]Moderate n=505 (19%), [g]Low decreasing n=126 (5%)

Table 2 Associations of effort-reward imbalance with different work ability trajectory groups, and the mediation effect of sleep problems

	Stable excellent work ability[d] vs. Stable good work ability[e]			Moderate work ability[f] vs. Stable good work ability			Low decreasing work ability[g] vs. Stable good work ability		
	OR	95% CI	PERM/ Proportion mediated	OR	95% CI	PERM/ Proportion mediated	OR	95% CI	PERM/ Proportion mediated
Model 1[a]									
Effort-reward imbalance (yes/no)	1.08	0.70 to 1.67		1.82	1.45 to 2.29		1.98	1.33 to 2.96	
Model 2[b]									
Effort-reward imbalance (yes/no)	1.14	0.74 to 1.76		1.70	1.34 to 2.16		1.92	1.27 to 2.88	
Model 3[c]									
Effort-reward imbalance (yes/no)	1.21	0.78 to 1.89	n.a.	1.55	1.21 to 1.97	22%	1.61	1.06 to 2.45	33%
Counterfactual mediation analysis									
Natural direct effect	1.06	0.67 to 1.66		1.49	1.17 to 1.89		1.34	0.88 to 2.03	
Natural indirect effect	0.94	0.83 to 1.06		1.07	0.99 to 1.17		1.30	1.11 to 1.52	
Total effect	0.99	0.64 to 1.53		1.60	1.26 to 2.02		1.73	1.15 to 2.62	
Proportion mediated			n.a.			18%			54%

[a] Model 1 adjusted for demographic factors (sex, age and occupational status)

[b] Model 2 additionally adjusted for lifestyle factors (body mass index, physical activity, alcohol risk use and smoking)

[c] Model 3 additionally adjusted for sleep problems

OR= odds ratio, CI= confidence level, PERM= percentage of excess risk mediated

Note: [d]Stable excellent n=149 (5%), [e]Stable good n=1927 (71%), [f]Moderate n=505 (19%), [g]Low decreasing n=126 (5%)

Supplemental Digital Content 2. Guidelines for Reporting on Latent Trajectory Studies (GRoLTS Checklist)

Question/ checklist items	**Response**
1. Is the metric of time used in the statistical model reported? Yes/No	Yes.
2. Is information presented about the mean and variance of time within a wave? Yes/No	Yes. We have information about the year of collection, of the possible 6 responses in 12 years (our respondents averaged 3.2 with a standard deviation of 0.6), the data was collected in every two years.
3a. Is the missing data mechanism reported? Yes/No	No. However, we used our predefined selection criteria where we selected those who answered to workability item at baseline and at least one of the follow-ups.
3b. Is a description provided of what variables are related to attrition/missing data? Yes/No	Yes.
3c. Is a description provided of how missing data in the analyses were dealt with? Yes/No	There were no major differences in terms of baseline characteristic between the final analytical sample and the eligible population. Therefore no imputations were done.
4. Is information about the distribution of the observed variables included? Yes/No	Yes.
5. Is the software mentioned? Yes/No	Yes. (we used PROJ TRAJ macro in SAS 9.4)
6a. Are alternative specifications of within-class heterogeneity considered (e.g., LGCA vs. LGMM) and clearly documented? If not, was sufficient justification provided as to eliminate certain specifications from consideration? Yes/No	Yes, the justification is provided.
6b. Are alternative specifications of the between-class differences in variance–covariance matrix structure considered and clearly documented? If not, was sufficient justification provided as to eliminate certain specifications from consideration? Yes/No	Yes, the justification is provided.
7. Are alternative shape/functional forms of the trajectories described? Yes/No	Yes, it’s clearly described and supplied as Suppl. Dig. Cont. 1.

8. If covariates have been used, can analyses still be replicated? Yes/No	Covariates were not added to the model.
9. Is information reported about the number of random start values and final iterations included? Yes/No	We were interested in trajectories of workability in the first step without the predictors of trajectory membership, we just defined the model and orders (Suppl. Dig. Cont. 1).
10. Are the model comparison (and selection) tools described from a statistical perspective? Yes/No	Yes. Based on the model fit criteria, we chose a four-class polynomial model as the best fitted model. It displayed high BIC and AIC values, high log-likelihood, the prevalence of ≥5% for all four latent classes, and OCC values ≥5 in all trajectories, indicating better reliability for further analyses.
11. Are the total number of fitted models reported, including a one-class solution? Yes/No	Yes.
12. Are the number of cases per class reported for each model (absolute sample size, or proportion)? Yes/No	Yes.
13. If classification of cases in a trajectory is the goal, is entropy reported? Yes/No	We have reported average posterior probability and OCC instead of entropy for class separations.
14a. Is a plot included with the estimated mean trajectories of the final solution? Yes/No	Yes. We have presented figure based on selected solution.
14b. Are plots included with the estimated mean trajectories for each model? Yes/No	No.
14c. Is a plot included of the combination of estimated means of the final model and the observed individual trajectories split out for each latent class? Yes/No	The figure is supplied with 95% Confidence interval.
15. Are characteristics of the final class solution numerically described (i.e., means,SD/SE, n, CI, etc.)? Yes/No	Yes. The tables of results are presented for the final solution. We have presented the estimates of association of trajectories with major baseline characteristics such as job strain and effort-reward imbalance studied in the manuscript. The estimates are presented as: OR and 95 % CI (adjusted for other baseline characteristics, in Table 1 and Table 2).
16. Are the syntax files available (either in the appendix, supplementary materials, or from the authors)? Yes/No	No, but they could be made available upon reasonable request due to data policy.

Supplemental Digital Content 3. Association between baseline work stress and baseline sleep problems

	Sleep problems (any)		p-value[a]
Job strain	n	%	<.0001
Yes	166	30%	
No	442	21%	
Effort-reward imbalance			<.0001
Yes	201	36%	
No	376	19%	

[a] A χ^2 test was used to examine the association between work stress and sleep problems. A p-value is for the difference in participants having or not having sleep problems

Supplemental Digital Content 4. Associations of baseline sleep problems with different work ability trajectory groups

	Stable excellent work ability[b] vs. Stable good work ability[c]		Moderate work ability[d] vs. Stable good work ability		Low decreasing work ability[e] vs. Stable good work ability	
	OR	95% CI	OR	95% CI	OR	95% CI
Sleep problems (any) (yes/no)[a]	0.71	0.45 to 1.13	1.92	1.54 to 2.40	2.97	2.04 to 4.32

[a] Adjusted for demographic factors (sex, age, and occupational status)

OR= odds ratio, CI= confidence level

Note: [b]Stable excellent n=149 (5%), [c]Stable good n=1927 (71%), [d]Moderate n=505 (19%), [e]Low decreasing n=126 (5%)

Supplemental Digital Content 5. Characteristics of participants at baseline before the assessment of work ability trajectories

Baseline characteristics	Study population (n=2707)	
Age, Mean, SD	49.6	1.6
Sex, n, %		
Men	427	16
Women	2280	84
Occupational status, n, %		
Upper-grade nonmanual workers	801	30
Lower-grade nonmanual workers	958	35
Manual workers	945	35
Job strain, n, %		
No	2125	79
Yes	550	21
Effort-reward imbalance, n, %		
No	1963	78
Yes	563	22
Sleep problems (any), n, %		
No	2092	77
Yes	613	23
Difficulties falling asleep, n, %		
No	2585	96
Yes	94	4
Difficulties maintaining sleep during the night, n, %		
No	2209	83

Yes	465	17
Waking too early in the morning, n, %		
No	2393	90
Yes	263	10
Nonrestorative sleep, n, %		
No	2405	90
Yes	274	10
Low physical activity, n, %		
No	1801	67
Yes	896	33
Obesity, n, %		
No	2415	90
Yes	266	10
Alcohol risk use, n, %		
No	2385	88
Yes	316	12
Current smoking, n, %		
No	2255	85
Yes	385	15

Supplemental Digital Content 1. Model fit statistics of the latent trajectory analysis from polynomial models with 1 to 8 trajectories for work ability

Number of trajectories	Shape	BIC[c]:	AIC[d]:	Log-likelihood:	Average posterior probabilities Prevalence of latent class (%) OCC[e]	Smallest group
1	4[a]	-16099.2	-16081.5	-16075.56	100	100
2	33[b]	-15146.08	-15116.56	-15106.56	0.91/0.97 16.6/83.4 50.8/6.4	16.6
2	44	-15152.90	-15117.4	-15105.48	0.91/0.97 16.5/83.5 51.2/6.4	16.5
3	333	-14881.0	-14836.72	-14821.72	0.91/0.93/0.84 13/74.2/12.9 67.7/4.6/35.4	12.9
3	444	-14891.09	-14837.96	-14819.96	0.91/0.92/0.84 12.9/73.9/13.3 68.3/4.7/34.2	12.9
4	3333	-14708.12	-14649.09	-14629.09	0.91/0.84/0.91/0.89 4.6/19.9/68.7/6.8 209.7/21.1/4.6/110.9	4.6
4	4444	-14722.49	-14651.65	-14627.65	0.90/0.83/0.92/0.88 4.6/18.7/71.2/5.5 187.0/21.0/5.0/126	4.6

5	33333	-14677.39	-14603.59	-14578.59	0.88/0.80/0.73/0.86/0.86	3
					3/8.4/25.7/57.6/5.3	
					237.1/43.6/7.8/4.5/131.0	
5	44444	-14620.91	-14532.36	-14502.36	0.89/0.87/0.83/0.92/0.84	2.3
					4.4/2.3/18/67.6/7.7	
					175.8/284.3/22.2/5.5/62.9	
6	333333	-14518.41	-14429.85	-14399.85	0.90/0.84/0.92/0.81/0.93/0.79	1.6
					3.6/2.4/1.6/17.2/66.6/8.5	
					241/213.5/707.3/20.5/6.7/40.5	
6	444444	-14525.62	-14419.35	-14383.35	0.90/0.80/0.91/0.83/0.93/0.80	1.7
					3.5/2.2/1.7/17.3/66.6/8.6	
					248.1/177.8/584.7/23.3/6.7/42.5	
7	3333333	-14452.15	-14348.84	-14313.84	0.90/0.83/0.86/0.81/0.78/0.78/0.86	2.1
					2.7/3.2/2.1/8.2/35/43.9/4.8	
					324.3/158.8/286.4/51/6.6/4.5/121.8	
7	4444444	-14461.01	-14337.03	-14295.03	0.91/0.82/0.82/0.87/0.74/0.83/0.86	2.1
					3/3.1/9.2/2.1/48.1/40.1/4.4	
					326.9/142.4/45/312/4.6/7.3/133.5	
8	33333333	-14413.40	-14295.33	-14255.33	0.93/0.84/0.86/0.78/0.80/0.79/0.82/0.88	1.8
					2.7/2.2/1.8/3.1/47.4/9/30.9/2.8	
					478.8/233.4/335.2/110.8/4.4/38/10.2/254.6	
8	44444444	-14404.6	-14262.95	-14214.95	0.91/0.81/0.91/0.79/0.78/0.77/0.81/0.87	1.5
					3/2.4/1.5/3.6/8/39.7/37.4/4.4	

	327/173.4/664/100.7/40.8/5.4/7.2/145.4

[a]Polynomial function 4 refers to curvi-linear shape of trajectory, [b]3 refers to cubic shape of trajectory, [c]BIC= Bayesian Information Criterion, [d]AIC= Akaike Information Criterion, [e]OCC= Odds of Correct Classification