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Associations of within-individual changes in working conditions, health behaviour and BMI with work ability and self-rated health: a fixed-effects analysis among Dutch workers

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Key terms

Work ability; working conditions; ageing workforce; fixed effects; occupational health

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ABSTRACT (272/300 words)

Objectives

This study assessed the associations of 1) within-individual improvements, and 2) within-individual deteriorations in working conditions, health behaviour and BMI with changes in work ability and self-rated health among workers.

Design

Prospective cohort study

Setting

The Netherlands

Participants

Persons in paid employment, aged 45 to 64 years, who participated in the Dutch Study on Transitions in Employment, Ability and Motivation (STREAM) between 2010 and 2017, and improved (N=14,045) or deteriorated (N=14,066) at least once with respect to working conditions (psychological- and emotional job demands, autonomy, social support, physical workload), health behaviour (moderate- and vigorous physical activity, smoking status), or BMI between any of two consecutive measurements during the 7 year follow-up.

Primary and secondary outcome measures

Changes in self-reported work ability on a scale from 0 to 10 (1st item of the work ability index) and self-rated health on a scale from 1 to 5 (SF-12).

Results

Workers with deteriorated working conditions decreased in work ability (β's:-0.21 (95%CI:-0.25;-0.18) to -0.28 (95%CI: -0.33;-0.24)) and health (β's:-0.07 (95%CI: -0.09;-0.06) to -0.10 (95%CI: -0.12;-0.08)), whereas improvements were to a lesser extent associated with increased work ability (β's: 0.06

(95%CI: 0.02; 0.09) to 0.11 (95%CI:0.06;0.16)) and health (β's: 0.02 (95%CI: 0.00;0.03) to 0.04 (95%CI: 0.02;0.06)). Workers with increased BMI or decreased physical activity reduced in work ability and health. Likewise, decreased BMI or increased vigorous physical activity was associated with improved health. An increase in moderate or vigorous physical activity was modestly associated with a reduced work ability. Quitting smoking was associated with reduced work ability and health.

Conclusions

Preventing deteriorations in working conditions, health behaviour and BMI could be of importance for sustainable employability.

Strengths and limitations of this study

- The main strength was that the fixed-effects approach controlled for bias due to unobserved heterogeneity, because each individual served as its own control by making comparisons within-individuals over time.
- Other strengths were the variety of working conditions and health behaviours included in the analyses, and the high number of observations of within-individual changes over a follow-up period of 7 years.
- The independent and dependent variables were based on self-reports.
- Changes in working conditions and health behaviour and changes in work ability and health were measured at the same time and may have a reciprocal effect.
- The generalizability of the findings is limited to workers aged between 45 and 64 years old.

INTRODUCTION

In response to an ageing workforce, many countries have increased their statutory retirement age. Therefore, European labour market policies focus on prolongation of working lives and maintaining a healthy workforce.[1] As workers age, physical health declines,[2] and cognitive functions deteriorate.[3] This could negatively influence the balance between individual resources (i.e. health, functional capacity) and job demands (i.e. work content, work demands), which is referred to as work ability.[4] Work ability declines with age, with a stronger decline rate among workers aged older than 50 years.[5] Workers who maintain good work ability are more productive,[6] have less sickness absence,[7-9] and are less likely to exit paid employment early due to disability.[8, 9] Hence, research on how to improve work ability and health of workers is essential for prolonging working lives.

Many studies examined the determinants of work ability and health. They have shown that workers with unfavourable working conditions have lower work ability and poorer self-rated health. Workers with high job demands and high physical workload as well as workers with low levels of job control and social support have a lower work ability.[7, 10-12] In addition, unhealthy behaviours, such as a lack of physical activity and smoking, as well as obesity are associated with lower work ability.[10-12] Unfavourable working conditions,[13-15] unhealthy behaviour and obesity [16, 17] are also important determinants of poor health. However, the associations in these studies may be biased due to unobserved heterogeneity. Unmeasured personal characteristics could be correlated with working conditions, health behaviours, and obesity as well as with work ability and self-rated health.[18] This is especially problematic in case of self-reports. For example, a study showed that persons with more work-related anxiety symptoms were more likely to report both poorer working conditions as well as low work ability,[19] which results in a confounded association between working conditions and work ability.

Fixed effects models have been advocated as suitable approaches to control for potential bias due to unobserved heterogeneity. In these models, comparisons within individuals over time are made. Therefore, each individual is treated as its own control,[20] which rules out the confounding effects of unmeasured time-invariant personal characteristics.[21] With fixed effects models the effects of within-individual improvements and deteriorations in working conditions, health behaviour, and body mass

index (BMI) on within-individual changes in work ability and self-rated health can be examined. To date, only a few studies have investigated the effects of within-individual changes in working conditions and health behaviour on within-individual changes in work ability or health. These studies showed that improvements in psychosocial and physical working conditions and an increase in leisure time physical activity were associated with an increase in work ability,[22] and that deteriorations in psychosocial working conditions were associated with decreased self-rated health.[23] From these studies it remains unclear to what extent within-individual changes in working conditions, health behaviour and BMI are associated with work ability as well as health of older workers, and whether these associations are different for within-individual improvements in exposure compared to within-individual deteriorations.

Insight in the associations of within-individual changes in working conditions, health behaviour and BMI with changes in work ability and self-rated health is essential to develop effective policies aimed at prolonging working lives. Therefore, this study aims to investigate to what extent 1) within-individual improvements and 2) within-individual deteriorations in working conditions, health behaviour, and BMI are associated with changes in work ability and health.

METHODS

Study design and population

The study was embedded within the Study on Transitions in Employment, Ability and Motivation (STREAM); a Dutch longitudinal study. Participants aged 45–64 years filled in online questionnaires on sociodemographic factors, work characteristics and health.[24] The first measurement in 2010 consisted of 15,118 participants. In 2015, a new sample of an additional 6,728 persons participated.

For the current study, seven waves of STREAM (2010-2013, 2015-2017) were used. In 2014, no questionnaire was administered. Of the 21,865 STREAM participants, 18,349 persons were in paid employment (excluding self-employment) with data on at least one dependent and one independent variable. To be included in the fixed effects analyses employed participants had to improve or deteriorate at least once with respect to working conditions, health behaviour, or BMI between any of two consecutive waves (T_n and T_n+1). Hence, 14,159 participants were selected for the fixed effects analyses. Of these 14,159 participants, 14,045 (with a total of 39,527 observations) improved at least once between two waves with respect to working conditions, health behaviour or BMI during follow-up and 14,066 participants (39,862 observations) deteriorated at least once between two waves on these measures (see Figure 1).

The Medical Ethical Committee of the VU University Medical Centre Amsterdam (ID: 2012-080) declared that the Medical Research Involving Human Subjects Act does not apply to STREAM. The medical ethical committee did not object to the execution of the current study. Participants were informed that their privacy would be guaranteed, that answers would be treated as confidential, and that all data would be stored on secured computer systems.

Patient and public involvement

Patients or members of the public were not involved in the design, conduct, reporting, or dissemination plans of the research.

Work ability

The first question of the work ability index (WAI) was used to measure work ability, in which respondents were asked to indicate their current work ability as compared to their lifetime best.[25] The answer scale ranged from 0 (unable to work) to 10 (work ability in the best period of my life) points. This single item is highly correlated with the total WAI.[26, 27]

Self-rated health

Health was measured with a single item from the SF-12 asking respondents to rate their general health on a 5-point scale ranging from 1 (excellent) to 5 (poor).[28] Self-rated health was recoded in a way that a higher score indicates better health. We recalibrated the scale of self-rated health in order to take the unequal distances between answer categories into account.[29]

Working conditions

Psychological job demands were measured with four questions from the Job Content Questionnaire (JCQ) on whether respondents have to work fast, perform a lot of work, work extra hard, and have hectic work (Cronbach's alpha=0.87).[30] Emotional job demands were measured with three items from the Copenhagen Psychosocial Questionnaire (COPSOQ)on emotional demands, emotional involvement, and emotionally difficult situations (Cronbach's alpha=0.85).[31] Autonomy was measured with five JCQ items on possibilities to make decisions, determine the order of work, control the work pace, taking leave, and whether people have to think of solutions (Cronbach's alpha=0.78).[30] Social support was measured with four items derived from the COPSOQ on the frequency with which people receive support from colleagues and supervisors, and the willingness of colleagues and supervisors to listen to work-related problems (Cronbach's alpha=0.81).[31] Physical workload was measured with five items on the use of extensive force during work, vibration, uncomfortable work posture, working in standing or kneeled positions (Cronbach's alpha=0.85).[32] Answer categories of all these questions ranged from 1 (always) to 5 (never). For each working condition a mean score was calculated. The answer categories were transformed in such a way that higher mean scores indicated poorer working conditions.

Health behaviour and body mass index

Moderate physical activity was measured with the question 'How many days a week do you usually perform physical activity for at least 30 minutes?'. This included activities like brisk walking or cycling, both at work and outside work. Vigorous physical activity was measured with the question 'How many days a week do you usually perform intensive physical activity for at least 20 minutes?'. Vigorous physical activity was defined as activities at work or outside work which cause persons to sweat and running out of breath'. Smoking was measured with one question 'Do you smoke?' with three answer categories 'Yes', 'No, but I used to smoke' and 'No, I have never smoked' and was dichotomized into smoking and not smoking. BMI was derived from self-reported weight and height of participants and expressed in kg/m^2.

Statistical analyses

An analysis of variance was used to disentangle variation between individuals from variation within individuals over time. For the outcomes and independent variables the mean number of observations, percentages of within-individual improvements and deteriorations were calculated.

Linear fixed-effects regression models were used to investigate the contemporary associations of within-individual improvements and deteriorations in independent variables (between T_n and T_n+1) with changes in dependent variables (between T_n and T_n+1) during the same time window.[33] For this purpose, change scores were calculated as the difference in scores on the respective scales of independent and dependent variables between two consecutive waves (T_n and T_n+1). For the outcomes, working conditions, moderate- and vigorous physical activity, and BMI change were measured on continuous scales and for smoking, change in smoking status was assessed. Changes towards more favourable working conditions, decreased BMI, and healthier behaviour were considered as improvements and changes towards more adverse working conditions, unhealthier behaviour and increased BMI were included as deteriorations in the analyses. The associations of within-individual improvements and deteriorations in exposure with changes in outcomes were investigated for each predictor independently.

Sensitivity analyses were performed in which the percentages of within-individual improvements and deteriorations in outcomes and independent variables were investigated for changes of at least 1 standard deviation. In addition, we investigated the associations of within-individual improvements and deteriorations in working conditions, health behaviour, and BMI of at least one standard deviation with changes in work ability and health.[34] IBM SPSS Statistics version 25 was used to perform the analyses.

RESULTS

Table 1 shows a mean score for work ability of 7.93 (SD=1.56) and for self-rated health of 3.62 (SD=0.87). The variance within workers was higher for work ability (45%) than for health (27%). For working conditions, the variance within workers was highest for social support (32%) and lowest for physical workload (11%). For health behaviours, individuals showed the most change over time in vigorous physical activity (within-individual variance=41%) and the least change in BMI (within-individual variance=8%). The mean number of observations for each outcome and independent variable ranged between 3.80 (SD=1.74) and 3.88 (SD=1.75). For work ability, working conditions, BMI, and moderate- and vigorous physical activity almost half of these observations were improvements (40% to 46%), whereas the other half of the observations were deteriorations (41% to 52%) (supplementary table S1). About one third of the observations for self-rated health and smoking were improvements and another third were deteriorations. Results from the independent sample t-test and chi-square tests showed that the persons in the fixed effects analysis were slightly younger, more often male and higher educated compared to persons not included in the analysis (supplementary table S2).

Table 1. Sample mean, variation between individuals and variation within individuals for work ability, self-rated health, working conditions, health behaviours and BMI across seven waves of a longitudinal study among 14,159 workers.

	Sample mean (SD)	Between-individual variation (SD)	Within-individual variation (SD)	% Within-individual variance [a]
Outcome measures				
Work ability (0-10)	7.93 (1.56)	1.14	1.03	45%
Self-rated health (1-5)	3.62 (0.87)	0.75	0.45	27%
Working conditions				
Psychological job demands (1-5)	3.15 (0.78)	0.67	0.38	25%
Emotional job demands (1-5)	2.44 (0.84)	0.74	0.41	24%
Autonomy (1-5)	2.21 (0.71)	0.63	0.33	22%
Social support (1-5)	2.43 (0.78)	0.64	0.44	32%
Physical workload (1-5)	1.82 (0.90)	0.84	0.29	11%
Health behaviours and BMI				
Moderate physical activity (0-7)	4.31 (2.13)	1.72	1.20	33%
Vigorous physical activity (0-7)	2.47 (2.00)	1.54	1.28	41%
Smoking (%yes)	19%	0.35	0.14	14%
BMI (kg/m^2)	26.92 (4.45)	4.23	1.24	8%

SD standard deviation

[a] % within-individual variance is the percentage of the total variance attributable to variance within-individuals

Improvements in working conditions and health behaviour, and decrease in BMI

The fixed effects analyses showed that within-individual improvements in working conditions in a given year, except for a decrease in psychological job demands, were associated with improvements in work ability in the same year (β's ranging from 0.06 (95%CI: 0.02; 0.09) to 0.11 (95%CI:0.06;0.16) (Table 2).Within-individual improvements in working conditions, except for an improvement in social support, were also associated with improvements in self-rated health, with β's between 0.02 (95%CI: 0.00;0.03) and 0.04 (95%CI: 0.02;0.06).

Workers who increased in vigorous physical activity (β=0.01, 95%CI: 0.00;0.01) or decreased in BMI (β=0.03, 95%CI: 0.02;0.03) had a modest improvement in health in the same year. However, with regard to work ability, workers who increased in moderate (β=-0.01, 95%CI: -0.03;-0.00) or vigorous physical activity (β=-0.01, 95%CI: -0.02;-0.00) had a small decrease in work ability. In addition, persons who quit smoking in a given year decreased in work ability with 0.40 points (95%CI: -0.53;-0.26) and decreased in health with 0.13 points (95%CI: -0.17;-0.08). Overall, the effect sizes of the improvements in working conditions, expressed by Cohen's d, varied between 0.03 and 0.07. For health behaviours and BMI effect sizes varied between -0.01 and -0.24.

Deteriorations in working conditions and health behaviour, and increase in BMI

Within-individual deteriorations in working conditions in a given year were associated with decreases in work ability (β's ranging from -0.21 (95%CI: -0.25;-0.18) to -0.28 (95%CI: -0.33;-0.24)), and to a lesser extent with decreases in self-rated health (β's ranging from -0.07 (95%CI: -0.09;-0.06) to -0.10 (95%CI: -0.12;-0.08)) (Table 3).

Workers who increased in BMI or decreased in moderate or vigorous physical activity had a modest decrease in work ability (β's ranging from -0.04 (95%CI: -0.05; -0.02) to -0.05 (95%CI: -0.06;-0.03)) and health (β's ranging from -0.02 (95%CI: -0.03;-0.02) to -0.03 (95%CI: -0.03;-0.02)). The effect sizes for working conditions varied between -0.10 to -0.17, while the effect sizes for health behaviours and BMI ranged between -0.02 and -0.04.

Table 2. Within-individual **improvements** in working conditions, health behaviours and BMI in a given year and changes in work ability and self-rated health in the same year among 14,045 workers aged 45–63 years.

	Change in self-reported work ability (0-10)		Change in self-rated health (1-5)	
	N [a]	b (95% CI)	N [a]	b (95% CI)
Working conditions				
Decrease of psychological job demands (1-5)	15360	0.04 (-0.00;0.08)	15376	**0.02** (0.00;0.03)
Decrease of emotional job demands (1-5)	14380	**0.07** (0.03;0.10)	14390	**0.03** (0.01;0.04)
Increase of autonomy (1-5)	15537	**0.07** (0.02;0.11)	15539	**0.03** (0.01;0.05)
Increase of social support (1-5)	15597	**0.06** (0.02;0.09)	15607	0.01 (-0.00;0.02)
Decrease of physical workload (1-5)	12148	**0.11** (0.06;0.16)	12145	**0.04** (0.02;0.06)
Health behaviours and BMI				
Increase in moderate physical activity (0-7)	13287	**-0.01** (-0.03;-0.00)	13302	0.00 (-0.00;0.01)
Increase in vigorous physical activity (0-7)	13341	**-0.01** (-0.02;-0.00)	13354	**0.01** (0.00;0.01)
Stop smoking (1=yes, 0=no)	1002	**-0.40** (-0.53;-0.26)	1000	**-0.13** (-0.17;-0.08)
Decrease in BMI (kg/m^2)	14370	-0.00 (-0.02;0.01)	14387	**0.03** (0.02;0.03)

Bold: estimate is statistically significant at the 0.05 level

[a] N=number of observations. Individuals may be included in the analyses several times since they could experience multiple improvements in working conditions and healthy behaviour during follow-up

Table 3. Within-individual **deteriorations** in working conditions, health behaviours and BMI in a given year and changes in work ability and self-rated health in the same year among 14,066 workers aged 45–63 years.

	Change in self-reported work ability (0-10)		Change in self-rated health (1-5)	
	N [a]	b (95% CI)	N [a]	b (95% CI)
Working conditions				
Increase of psychological job demands (1-5)	15375	**-0.23** (-0.27;-0.19)	15381	**-0.07** (-0.09;-0.06)
Increase of emotional job demands (1-5)	13996	**-0.25** (-0.29;-0.21)	14004	**-0.08** (-0.10;-0.07)
Decrease of autonomy (1-5)	16141	**-0.28** (-0.33;-0.24)	16148	**-0.10** (-0.12;-0.08)
Decrease of social support (1-5)	16594	**-0.21** (-0.25;-0.18)	16601	**-0.07** (-0.09;-0.06)
Increase of physical workload (1-5)	12551	**-0.26** (-0.31;-0.20)	12555	**-0.10** (-0.12;-0.08)
Health behaviours and BMI				
Decrease in moderate physical activity (0-7)	12900	**-0.04** (-0.05;-0.03)	12908	**-0.02** (-0.03;-0.02)
Decrease in vigorous physical activity (0-7)	13137	**-0.04** (-0.05;-0.02)	13142	**-0.02** (-0.03;-0.02)
Start smoking (1=yes, 0=no)	599	-0.05 (-0.21;0.11)	597	0.02 (-0.04;0.08)
Increase in BMI (kg/m^2)	17757	**-0.05** (-0.06;-0.03)	17766	**-0.03** (-0.03;-0.02)

Bold: estimate is statistically significant at the 0.05 level

[a] N=number of observations. Individuals may be included in the analyses several times since they could experience multiple deteriorations in working conditions and healthy behaviour during follow-up

Sensitivity analysis

When only including changes of at least 1 standard deviation, the percentages of within-individual improvements and deteriorations were slightly lower for the outcomes and independent variables; approximately one third of the observations were improvements with at least 1 standard deviation (31% to 34%), and another third of the observations were deteriorations with at least 1 standard deviation (31% to 34%; supplementary table S1). The results of the sensitivity analysis on the impact of within-individual improvements or deteriorations in working conditions, health behaviour or BMI on work ability and health of at least 1 standard deviation were largely comparable to the results including also smaller changes. The differences were that in these sensitivity analyses no significant associations were found between increasing moderate vigorous physical activity and changes in work ability, and between decreasing psychological job demands and health. In addition, in the sensitivity analyses a decrease in psychological job demands was associated with improved work ability, and an increase in social support was associated with improved health (supplementary tables S3 and S4).

DISCUSSION

This study showed that workers with improved working conditions in a given year had improved work ability and health in the same year. Those with deteriorated working conditions decreased in work ability, and to a lesser extent reduced in health. Within-individual deteriorations in working conditions were more strongly associated with changes in work ability and health compared to within-individual improvements in working conditions. With regard to health behaviour and BMI, workers who decreased in BMI and increased in vigorous physical activity were more likely to have improved health. Workers who increased in BMI and decreased in physical activity had decreased work ability and health. In contrast, within-individual increases in moderate and vigorous physical activity were associated with slightly reduced work ability. Quitting smoking was associated with both reduced work ability and health.

The findings on the associations of within-individual improvements and deteriorations in working conditions with changes in work ability and health confirm findings from previous studies. In line with our findings, Tuomi et al.[22] showed that workers in the retail trade and metal industry with decreased physical- and mental demands and increased autonomy had increased work ability. Milner et al.[23] reported that male physicians with deteriorated psychological job demands and job control were more likely to have poorer self-rated health. While these studies were performed among workers in distinct occupational groups and the workers were on average younger compared to the workers in the current study, our findings suggested that modification of working conditions might also be important for maintaining good work ability and health of older Dutch workers in varying work sectors.

An important finding is that the associations of within-individual deteriorations in working conditions with changes in work ability and health did not exactly mirror the associations of within-individual improvements in working conditions with the outcomes. We showed that within-individual deteriorations in working conditions were more strongly associated with work ability and health in the short-term than within-individual improvements in working conditions. Previous research on associations of changes in working conditions with sickness absence and exit from paid employment underline the relative importance of adverse changes by showing that adverse changes in psychological working conditions increased the risk of sickness absence[35] and exit from paid employment,[34]

while favourable changes in most working conditions did not have such effects. Workers in the current study were generally exposed to favourable working conditions at the start of the study. Since this implies less room for improvements this could explain why within-individual improvements in working conditions were less strongly associated with health and work ability.

Our findings on the associations of within-individual deteriorations in health behaviour and BMI with work ability and health mostly confirm findings from previous longitudinal studies investigating associations between unhealthy behaviour, and obesity with work ability and health. For instance, they showed that lack of physical activity and obesity are important risk factors for lower work ability[10-12] and poor health.[16, 17] However, because they did not investigate the associations of within-individual changes in exposure, the potential of preventing unhealthy behaviour and high BMI for sustained employability might have been overestimated in these studies. The results in the current study regarding the associations of within-individual improvements in health behaviour with changes in work ability were not in line with previous studies. While Tuomi et al.[22] found that workers with increased leisure time activity increased in work ability, we showed that workers who increased in moderate or vigorous physical activity slightly decreased in work ability. In the current study, we could not distinguish between physical activity at work and leisure-time physical activity. Evidence suggests that physical activity during work is detrimental to health,[36] which could outweigh the benefits of leisure time physical activity for work ability.

Workers who quit smoking in a given year had decreased work ability and health in the same year. These findings suggest that quitting smoking may be harmful to work ability and health among older workers in the short-term. This is in contrast to most research on the associations between smoking and work ability[10, 37] and health.[16, 17] A possible explanation for our findings is that the older workers under study quit smoking because of existing health problems, which negatively affect work ability and health.[38] Another explanation is that the beneficial effects of smoking cessation on work ability and health might become visible after a longer period. One study showed that persons who had quit smoking within 1 year had lower productivity than smokers, and higher productivity after 1 to 5 years.[39]

The current study showed that within-individual changes in working conditions, health behaviour and BMI were modestly associated with changes in work ability and health within 1 year, with effect sizes up to -0.24. This indicates that interventions aimed at modification of the working environment or health promotion interventions might provide small benefits to work ability and workers' health in the short-term. Oakman et al.[40] also found in a systematic review that workplace interventions have small positive effects on work ability in the short term. These results indicate that sustained effort in the workplace is needed over several years to further improve in work ability and health or prevent further decline in these outcomes.

Strengths and limitations

This study has several strengths and limitations. First, the fixed-effects models allowed for investigation of the associations of within-individual improvements and deteriorations in working conditions, health behaviour, and BMI with changes in work ability and health. By making comparisons within-individuals, each individual served as its own control. Therefore, we controlled for potential bias due to unobserved heterogeneity. The findings are important for policies aimed at prolongation of working lives, since they provide better insight in the potential effects of modifying the working environment, health behaviour and BMI on work ability and health. Other strengths are the inclusion of a variety of working conditions and health behaviours in the analysis, and a high number of observations of within-individual change in working conditions and health behaviour over a 7 year follow-up period.

The following limitations need to be addressed. First, the independent variables and outcome measures were based on self-report. Since self-reports are less reliable than objective measurements, small within-individual changes between time points could reflect variability in reporting rather than actual change.[41] However, we additionally investigated the associations of greater changes (≥ 1 SD) in working conditions and health behaviour with changes in health and work ability between measurements with fixed effects analysis and found similar results (supplementary table S3 and S4). Secondly, changes in working conditions and health behaviour and changes in work ability and health were measured within the same year, making it difficult to draw conclusions about causal relationships. We considered to investigate the effects of within-individual changes in exposure in a given year on

changes in work ability and health one year later. However, changes in working conditions, health behaviour and BMI in a given year were more strongly associated with changes in work ability and health in that same year compared to changes in exposure in the previous year. As the changes in working conditions and health behaviours fluctuated strongly overtime, we decided not to use a time lag in this study. A third limitation is that the study population includes workers aged 45 years and older. Therefore, the findings of the current study may not be generalizable to younger workers.

Conclusion

This study suggests that workers aged 45 years and older who change in working conditions and health behaviour modestly change in work ability and self-rated health within the same year. Compared to improvements in working conditions, healthy behaviour and BMI, prevention of deteriorations in these factors may contribute more strongly to maintaining good work ability and health among midlife workers. Prevention of deteriorations in working conditions could be of particular importance for sustainable employability.

DECLARATIONS

Contributors

DV, SR, AB, and MS designed the models and analytical framework. DV and MS prepared the data. DV conducted the analyses. The analytical models and results were discussed by all authors. DV drafted and revised the manuscript with input from all authors. All authors approved the final version.

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Competing interest

The authors have no competing interests to declare that are relevant to the content of this article.

Patient consent for publication

Not required.

Ethics approval

The Medical Ethical Committee of the VU University Medical Centre Amsterdam declared that the Medical Research Involving Human Subjects Act does not apply to STREAM. The medical ethical committee did not object to the execution of the current study. Participants were informed that their privacy would be guaranteed, that answers would be treated as confidential, and that all data would be stored on secured computer systems

Data availability statement

The data that support the findings of this study are available from TNO Healthy Living (Leiden, the Netherlands) but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available upon reasonable request

by the author KM Oude Hengel (karen.oudehengel@tno.nl) and with permission of TNO Healthy Living (Leiden, the Netherlands).

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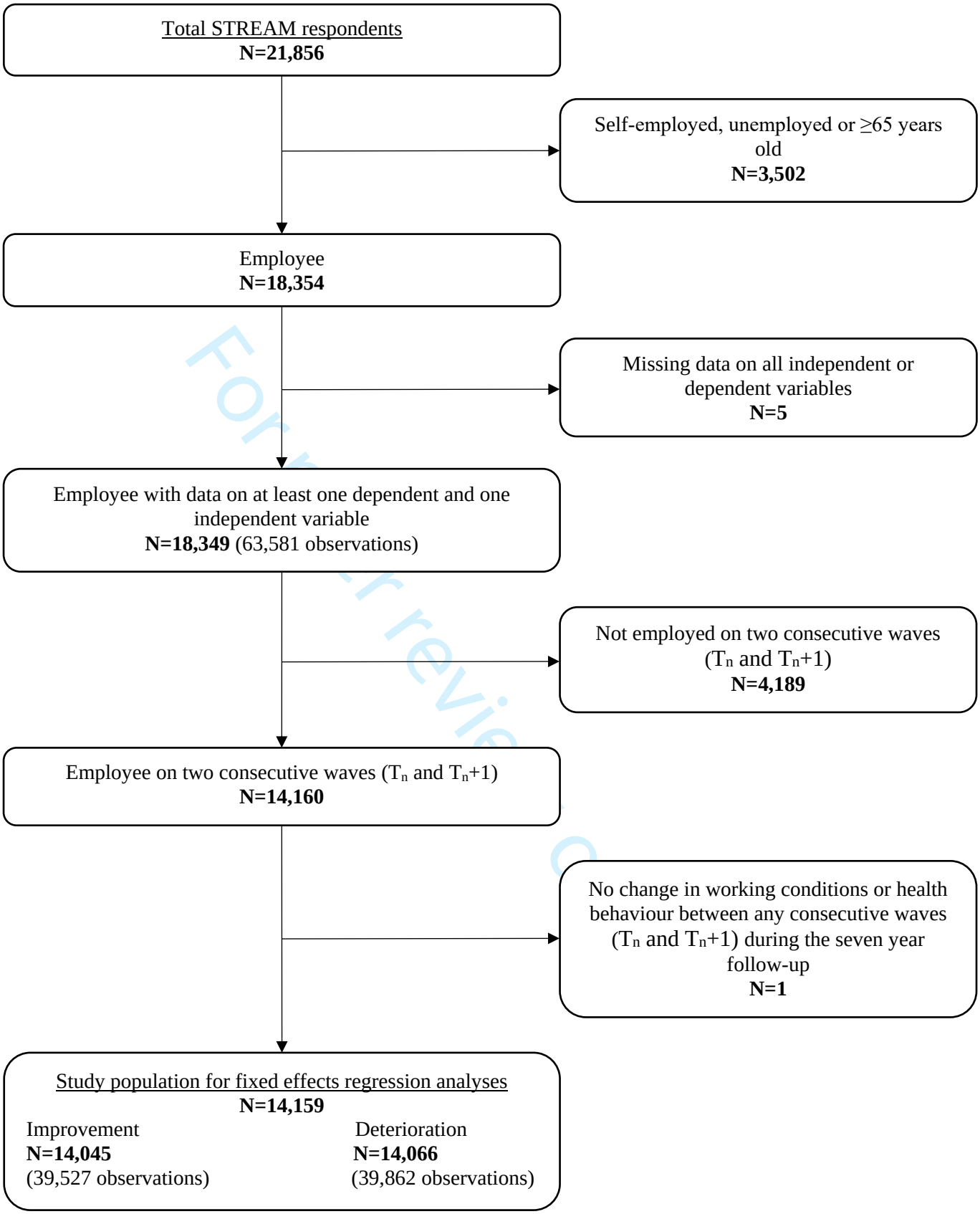
FIGURES

Figure 1. Flowchart of the selection of the study population



STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2, 3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4, 5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	6
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7, 8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7, 8
Bias	9	Describe any efforts to address potential sources of bias	4, 8
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7, 8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8, 9
		(*b*) Describe any methods used to examine subgroups and interactions	8, 9
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, explain how loss to follow-up was addressed	6
		(*e*) Describe any sensitivity analyses	9
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	6
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10
		(b) Indicate number of participants with missing data for each variable of interest	6
		(c) Summarise follow-up time (eg, average and total amount)	10
Outcome data	15*	Report numbers of outcome events or summary measures over time	10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11, 12
		(*b*) Report category boundaries when continuous variables were categorized	12
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	13, supplementary tables S1-S4
Discussion			
Key results	18	Summarise key results with reference to study objectives	14
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-17
Generalisability	21	Discuss the generalisability (external validity) of the study results	17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

SUPPLEMENTARY MATERIAL

Table S1. Percentage of within-individual improvements and within-individual deteriorations in outcomes and predictors for all persons included in the fixed effects analysis (N=14,159) and persons with changes of at least 1 standard deviation.

	Within-individual improvements %		**Within-individual deteriorations %**	
Outcome measures	**All**	**≥1 SD**	**All**	**≥1 SD**
Work ability (0-10)	40%	31%	41%	32%
Self-rated health (1-5)	33%	32%	34%	33%
Working conditions				
Psychological job demands (1-5)	45%	32%	45%	31%
Emotional job demands (1-5)	44%	34%	43%	34%
Autonomy (1-5)	45%	32%	46%	32%
Social support (1-5)	45%	32%	47%	33%
Physical workload (1-5)	43%	31%	44%	32%
Health behaviours and BMI				
Moderate physical activity (0-7)	43%	34%	42%	33%
Vigorous physical activity (0-7)	42%	34%	42%	34%
Smoking (%yes)	29%	n/a	29%	n/a
BMI (kg/m^2)	46%	31%	52%	32%

SD standard deviation.

Table S2. Baseline sociodemographic characteristics of persons included in the fixed effects analysis (N=14,159) and persons not included in the fixed effects analysis (N=7,697).

	Fixed effects analysis	**Not included in fixed effects analysis**
Age	51.1 years old (SD 6.4)*	52.3 years old (SD=7.6)
Gender (male)	54.1%**	48.3%
Educational level		
Low	26.1%	34.3%
Intermediate	39.5%	37.4%
High	34.4%**	28.2%

SD standard deviation.

*Independent sample t-test, $p<0.05$.

**Chi-square, $p<0.05$.

Table S3. Sensitivity analysis of the effects of within-individual **improvements** (≥SD of differences scores) in working conditions, health behaviours and BMI in a given year on changes in work ability and self-rated health in the same year among employed individuals aged 45–63 years.

	Change in self-reported work ability (0-10)		Change in self-rated health (1-5)	
	N [a]	b (95% CI)	N [a]	b (95% CI)
Working conditions				
Decrease of psychological job demands (1-5)	4787	**0.05** (0.00;0.10)	4792	0.02 (-0.00;0.04)
Decrease of emotional job demands (1-5)	7579	**0.07** (0.03;0.11)	7580	**0.03** (0.02;0.05)
Increase of autonomy (1-5)	4964	**0.09** (0.04;0.14)	4969	**0.03** (0.01;0.06)
Increase of social support (1-5)	5726	**0.07** (0.03;0.11)	5733	**0.02** (0.00;0.03)
Decrease of physical workload (1-5)	3771	**0.16** (0.09;0.22)	3776	**0.05** (0.03;0.08)
Health behaviours and BMI				
Increase in moderate physical activity (0-7)	6972	-0.01 (-0.03;0.00)	6979	0.00 (-0.00;0.01)
Increase vigorous physical activity (0-7)	7186	-0.01 (-0.02;0.00)	7192	**0.01** (0.00;0.01)
Stop smoking (1=yes, 0=no)	1002	**-0.40** (-0.53;-0.26)	1000	**-0.13** (-0.17;-0.08)
Decrease in BMI (kg/m^2)	2753	0.00 (-0.01;0.02)	2759	**0.03** (0.02;0.03)

Bold: estimate is statistically significant at the 0.05 level

[a] N=number of observations. Individuals may be included in the analyses several times since they could experience multiple improvements in working conditions and healthy behaviour during follow-up.

Table S4. Sensitivity analysis of the effects of within-individual **deteriorations** (≥SD of differences scores) in working conditions, health behaviours and BMI in a given year on changes in work ability and self-rated health in the same year among employed individuals aged 45–63 years.

	Change in self-reported work ability (0-10)		Change in self-rated health (1-5)	
	N [a]	b (95% CI)	N [a]	b (95% CI)
Working conditions				
Increase of psychological job demands (1-5)	4766	**-0.22** (-0.27;-0.17)	4773	**-0.06** (-0.08;-0.05)
Increase of emotional job demands (1-5)	7295	**-0.23** (-0.27;-0.19)	7302	**-0.08** (-0.09;-0.06)
Decrease of autonomy (1-5)	5276	**-0.24** (-0.30;-0.19)	5280	**-0.09** (-0.11;-0.07)
Decrease of social support (1-5)	6165	**-0.20** (-0.24;-0.17)	6172	**-0.07** (-0.09;-0.06)
Increase of physical workload (1-5)	3806	**-0.23** (-0.30;-0.17)	3811	**-0.09** (-0.11;-0.06)
Health behaviours and BMI				
Decrease in moderate physical activity (0-7)	6625	**-0.04** (-0.05;-0.02)	6632	**-0.02** (-0.03;-0.02)
Decrease in vigorous physical activity (0-7)	6788	**-0.03** (-0.04;-0.02)	6790	**-0.02** (-0.03;-0.02)
Start smoking (1=yes, 0=no)	599	-0.05 (-0.21;0.11)	597	0.02 (-0.04;0.08)
Increase in BMI (kg/m^2)	2852	**-0.04** (-0.05;-0.02)	2853	**-0.02** (-0.03;-0.01)

Bold: estimate is statistically significant at the 0.05 level

[a] N=number of observations. Individuals may be included in the analyses several times since they could experience multiple deteriorations in working conditions and healthy behaviour during follow-up.

BMJ Open

Associations of within-individual changes in working conditions, health behaviour and BMI with work ability and self-rated health: a fixed-effects analysis among Dutch workers

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Associations of within-individual changes in working conditions, health behaviour and BMI with work ability and self-rated health: a fixed-effects analysis among Dutch workers

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Key terms

Work ability; working conditions; ageing workforce; fixed effects; occupational health

Word count: 3706

ABSTRACT (296/300 words)

Objectives

This study assessed the associations of 1) within-individual improvements, and 2) within-individual deteriorations in working conditions, health behaviour and BMI with changes in work ability and self-rated health among workers.

Design

Prospective cohort study

Setting

The Netherlands

Participants

Persons in paid employment, aged 45 to 64 years, who participated in the Dutch Study on Transitions in Employment, Ability and Motivation (STREAM) between 2010 and 2017, and improved or deteriorated at least once with respect to working conditions (psychological- and emotional job demands, autonomy, social support, physical workload), health behaviour (moderate- and vigorous physical activity, smoking status), or BMI between any of two consecutive measurements during the 7 year follow-up.

Primary and secondary outcome measures

Changes in self-reported work ability on a scale from 0 to 10 (1st item of the work ability index) and self-rated health on a scale from 1 to 5 (SF-12).

Results

Of the 21,856 STREAM participants, ultimately 14,159 workers were included in the fixed-effects analyses on improvements (N=14,045) and deteriorations (N=14,066). Workers with deteriorated working conditions decreased in work ability (β's:-0.21 (95%CI:-0.25;-0.18) to -0.28 (95%CI: -0.33;-

0.24)) and health (β's:-0.07 (95%CI: -0.09;-0.06) to -0.10 (95%CI: -0.12;-0.08)), whereas improvements were to a lesser extent associated with increased work ability (β's: 0.06 (95%CI: 0.02; 0.09) to 0.11 (95%CI:0.06;0.16)) and health (β's: 0.02 (95%CI: 0.00;0.03) to 0.04 (95%CI: 0.02;0.06)). Workers with increased BMI or decreased physical activity reduced in work ability and health. Likewise, decreased BMI or increased vigorous physical activity was associated with improved health. An increase in moderate or vigorous physical activity was modestly associated with a reduced work ability. Quitting smoking was associated with reduced work ability and health.

Conclusions

Compared to improvements, preventing deteriorations in working conditions, health behaviour and BMI, might be more beneficial for work ability and workers' health.

Strengths and limitations of this study

- The main strength was that the fixed-effects approach controlled for bias due to unobserved heterogeneity, because each individual served as its own control by making comparisons within-individuals over time.
- Other strengths were the variety of working conditions and health behaviours included in the analyses, and the high number of observations of within-individual changes over a follow-up period of 7 years.
- The independent and dependent variables were based on self-reports.
- Changes in working conditions and health behaviour and changes in work ability and health were measured at the same time and may have a reciprocal effect.
- The generalizability of the findings is limited to workers aged between 45 and 64 years old.

INTRODUCTION

In response to an ageing workforce, many countries have increased their statutory retirement age. Therefore, European labour market policies focus on prolongation of working lives and maintaining a healthy workforce.[1] As workers age, physical health declines,[2] and cognitive functions deteriorate.[3] This could negatively influence the balance between individual resources (i.e. health, functional capacity) and job demands (i.e. work content, work demands), which is referred to as work ability.[4] Work ability declines with age, with a stronger decline rate among workers aged older than 50 years.[5] Workers who maintain good work ability are more productive,[6] have less sickness absence,[7-9] and are less likely to exit paid employment early due to disability.[8, 9] Hence, research on how to improve work ability and health of workers is essential for prolonging working lives.

Many studies examined the determinants of work ability and health. They have shown that workers with unfavourable working conditions have lower work ability and poorer self-rated health. Workers with high job demands and high physical workload as well as workers with low levels of job control and social support have a lower work ability.[7, 10-12] In addition, unhealthy behaviours, such as a lack of physical activity and smoking, as well as obesity are associated with lower work ability.[10-12] Unfavourable working conditions,[13-15] unhealthy behaviour and obesity [16, 17] are also important determinants of poor health. However, the associations in these studies may be biased due to unobserved heterogeneity. Unmeasured personal characteristics could be correlated with working conditions, health behaviours, and obesity as well as with work ability and self-rated health.[18] This is especially problematic in case of self-reports. For example, a study showed that persons with more work-related anxiety symptoms were more likely to report both poorer working conditions as well as low work ability,[19] which results in a confounded association between working conditions and work ability.

Fixed effects models have been advocated as suitable approaches to control for potential bias due to unobserved heterogeneity. In these models, comparisons within individuals over time are made. Therefore, each individual is treated as its own control,[20] which rules out the confounding effects of unmeasured time-invariant personal characteristics.[21] With fixed effects models the effects of within-individual improvements and deteriorations in working conditions, health behaviour, and body mass

index (BMI) on within-individual changes in work ability and self-rated health can be examined. To date, only a few studies have investigated the effects of within-individual changes in working conditions and health behaviour on within-individual changes in work ability or health. These studies showed that improvements in psychosocial and physical working conditions and an increase in leisure time physical activity were associated with an increase in work ability,[22] and that deteriorations in psychosocial working conditions were associated with decreased self-rated health.[23] From these studies it remains unclear to what extent within-individual changes in working conditions, health behaviour and BMI are associated with work ability as well as health of older workers, and whether these associations are different for within-individual improvements in exposure compared to within-individual deteriorations.

Therefore, this study aims to investigate to what extent 1) within-individual improvements and 2) within-individual deteriorations in working conditions, health behaviour, and BMI are associated with changes in work ability and health.

METHODS

Study design and population

The study was embedded within the Study on Transitions in Employment, Ability and Motivation (STREAM); a Dutch longitudinal study. Persons aged 45-64 years from an online panel were invited, and reminded up to two times, to fill-out online questionnaires on sociodemographic factors, work characteristics and health between the end of October and the end of November in the years 2010 to 2013, 2015 to 2017, and 2019.[24]. Of the 26,601 persons who were invited at the first measurement in 2010, 15,118 persons ultimately participated, of which 5,103 persons filled out the questionnaires in each year. In 2015, a new sample of an additional 6,738 persons participated. The study population consists of a large variety of occupations from different industries, among others, healthcare (18.7%), education (11.4%), public services (11.3%), chemical industry (8.8%), and commerce (8.1%).

For the current study, seven waves of STREAM (2010-2013, 2015-2017) were used. To be included in the fixed effects analyses employed participants (excluding self-employed participants), with data on at least one dependent and one independent variable, had to improve or deteriorate at least once with respect to working conditions, health behaviour, or BMI between any of two consecutive waves (T_n and T_n+1).

The Medical Ethical Committee of the VU University Medical Centre Amsterdam (ID: 2012-080) declared that the Medical Research Involving Human Subjects Act does not apply to STREAM, because filling out the questionnaires did not involve any risk nor violation of the psychological or physical integrity of the study participants. Since the study involves human subjects, the Institutional Review Board (IRB) of the Netherlands Organisation for applied scientific research (TNO) assessed design of the study, social importance, safety aspects, privacy of the participants, data storage and burden and risks to research participants. STREAM received a positive recommendation. Participants were informed that their privacy would be guaranteed, that answers would be treated as confidential, and that all data would be stored on secured computer systems.

Patient and public involvement

Patients or members of the public were not involved in the design, conduct, reporting, or dissemination plans of the research.

Work ability

The first question of the work ability index (WAI) was used to measure work ability, in which respondents were asked to indicate their current work ability as compared to their lifetime best.[25] The answer scale ranged from 0 (unable to work) to 10 (work ability in the best period of my life) points. This single item is highly correlated with the total WAI.[26, 27]

Self-rated health

Health was measured with a single item from the SF-12 asking respondents to rate their general health on a 5-point scale ranging from 1 (excellent) to 5 (poor).[28] Self-rated health was recoded in a way that a higher score indicates better health. We recalibrated the scale of self-rated health in order to take the unequal distances between answer categories into account.[29]

Working conditions

The Job Demand-Control-Support (JDCS) model was used as the theoretical basis for the included working conditions.[30, 31] Following this model, the STREAM cohort mainly focusses on psychological factors at work and physical work load as main risk factors for transitions in employment. Psychological job demands were measured with four questions from the Job Content Questionnaire (JCQ) on whether respondents have to work fast, perform a lot of work, work extra hard, and have hectic work (Cronbach's alpha=0.87).[32] Emotional job demands were measured with three questions from the Copenhagen Psychosocial Questionnaire (COPSOQ) on emotional demands, emotional involvement, and emotionally difficult situations (Cronbach's alpha=0.85).[33] Autonomy was measured with five JCQ items on possibilities to make decisions, determine the order of work, control the work pace, taking leave, and whether people have to think of solutions (Cronbach's alpha=0.78).[32] Social support was measured with four items derived from the COPSOQ on the frequency with which

people receive support from colleagues and supervisors, and the willingness of colleagues and supervisors to listen to work-related problems (Cronbach's alpha=0.81).[33] Physical workload was measured with five items on the use of extensive force during work, vibration, uncomfortable work posture, working in standing or kneeled positions (Cronbach's alpha=0.85).[34] Answer categories of all these questions ranged from 1 (always) to 5 (never). For each working condition a mean score was calculated. The answer categories were transformed in such a way that higher mean scores indicated poorer working conditions.

Health behaviour and body mass index

Moderate physical activity was measured with the question 'How many days a week do you usually perform physical activity for at least 30 minutes?'. This included activities like brisk walking or cycling, both at work and outside work. Vigorous physical activity was measured with the question 'How many days a week do you usually perform intensive physical activity for at least 20 minutes?'. Vigorous physical activity was defined as activities at work or outside work which cause persons to sweat and running out of breath'. Smoking was measured with one question 'Do you smoke?' with three answer categories 'Yes', 'No, but I used to smoke' and 'No, I have never smoked' and was dichotomized into smoking and not smoking. BMI was derived from self-reported weight and height of participants and expressed in kg/m^2.

Statistical analyses

An analysis of variance was used to disentangle variation between individuals from variation within individuals over time. For the dependent and independent variables the mean number of observations, percentages of within-individual improvements and deteriorations were calculated.

Linear fixed-effects regression models were used to investigate the contemporary associations of within-individual improvements and deteriorations in independent variables (between T_n and T_n+1) with changes in dependent variables (between T_n and T_n+1) during the same time window.[35] For this purpose, change scores were calculated as the difference in scores on the respective scales of independent and dependent variables between two consecutive waves (T_n and T_n+1). For work ability,

health, working conditions, moderate- and vigorous physical activity, and BMI change were measured on continuous scales and for smoking, change in smoking status was assessed. Changes towards more favourable working conditions, decreased BMI, and healthier behaviour were considered as improvements and changes towards more adverse working conditions, unhealthier behaviour and increased BMI were included as deteriorations in the analyses. The associations of within-individual improvements and deteriorations in exposure with changes in dependent variables were investigated for each predictor independently.

Sensitivity analyses were performed in which the percentages of within-individual improvements and deteriorations in dependent and independent variables were investigated for changes of at least 1 standard deviation. In addition, we investigated the associations of within-individual improvements and deteriorations in working conditions, health behaviour, and BMI of at least one standard deviation with changes in work ability and health.[36] IBM SPSS Statistics version 25 was used to perform the analyses.

RESULTS

Of the 21,856 STREAM participants, 14,159 workers were selected for the fixed effects analyses. Of these 14,159 participants, 14,045 (with a total of 39,527 observations) improved at least once between two waves with respect to working conditions, health behaviour or BMI during follow-up and 14,066 participants (39,862 observations) deteriorated at least once between two waves on these measures (see Figure 1).

Table 1 shows a mean score for work ability of 7.93 (SD=1.56) and for self-rated health of 3.62 (SD=0.87). The variance within workers was higher for work ability (45%) than for health (27%). For working conditions, the variance within workers was highest for social support (32%) and lowest for physical workload (11%). For health behaviours, individuals showed the most change over time in vigorous physical activity (within-individual variance=41%) and the least change in BMI (within-individual variance=8%).

The mean number of observations for each dependent and independent variable ranged between 3.80 (SD=1.74) and 3.88 (SD=1.75). For work ability, working conditions, BMI, and moderate- and vigorous physical activity almost half of these observations were improvements (40% to 46%), whereas the other half of the observations were deteriorations (41% to 52%) (supplementary table S1). About one third of the observations for self-rated health and smoking were improvements and another third were deteriorations. Results from the independent sample t-test and chi-square tests showed that the persons in the fixed effects analysis were slightly younger, more often male and higher educated compared to persons not included in the analysis (supplementary table S2).

Table 1. Mean, variation between individuals and variation within individuals for work ability, self-rated health, working conditions, health behaviours and BMI across seven waves of a longitudinal study among 14,159 workers.

	Mean (SD)	Between-individual variation (SD)	Within-individual variation (SD)	% Within-individual variance [a]
Work ability and health				
Work ability (0-10)	7.93 (1.56)	1.14	1.03	45%
Self-rated health (1-5)	3.62 (0.87)	0.75	0.45	27%
Working conditions				
Psychological job demands (1-5)	3.15 (0.78)	0.67	0.38	25%
Emotional job demands (1-5)	2.44 (0.84)	0.74	0.41	24%
Autonomy (1-5)	2.21 (0.71)	0.63	0.33	22%
Social support (1-5)	2.43 (0.78)	0.64	0.44	32%
Physical workload (1-5)	1.82 (0.90)	0.84	0.29	11%
Health behaviours and BMI				
Moderate physical activity (0-7)	4.31 (2.13)	1.72	1.20	33%
Vigorous physical activity (0-7)	2.47 (2.00)	1.54	1.28	41%
Smoking (%yes)	19%	0.35	0.14	14%
BMI (kg/m^2)	26.92 (4.45)	4.23	1.24	8%

SD standard deviation

[a] % within-individual variance is the percentage of the total variance attributable to variance within-individuals

Improvements in working conditions and health behaviour, and decrease in BMI

The fixed effects analyses showed that within-individual improvements in working conditions in a given year, except for a decrease in psychological job demands, were associated with improvements in work ability in the same year (β's ranging from 0.06 (95%CI: 0.02; 0.09) to 0.11 (95%CI:0.06;0.16) (Table 2).Within-individual improvements in working conditions, except for an improvement in social support, were also associated with improvements in self-rated health, with β's between 0.02 (95%CI: 0.00;0.03) and 0.04 (95%CI: 0.02;0.06).

Workers who increased in vigorous physical activity (β=0.01, 95%CI: 0.00;0.01) or decreased in BMI (β=0.03, 95%CI: 0.02;0.03) had a modest improvement in health in the same year. However, with regard to work ability, workers who increased in moderate (β=-0.01, 95%CI: -0.03;-0.00) or vigorous physical activity (β=-0.01, 95%CI: -0.02;-0.00) had a small decrease in work ability. In addition, persons who quit smoking in a given year decreased in work ability with 0.40 points (95%CI: -0.53;-0.26) and decreased in health with 0.13 points (95%CI: -0.17;-0.08). Overall, the effect sizes of

the improvements in working conditions, expressed by Cohen's d, varied between 0.03 and 0.07. For health behaviours and BMI effect sizes varied between -0.01 and -0.24.

Deteriorations in working conditions and health behaviour, and increase in BMI

Within-individual deteriorations in working conditions in a given year were associated with decreases in work ability (β's ranging from -0.21 (95%CI: -0.25;-0.18) to -0.28 (95%CI: -0.33;-0.24)), and to a lesser extent with decreases in self-rated health (β's ranging from -0.07 (95%CI: -0.09;-0.06) to -0.10 (95%CI: -0.12;-0.08)) (Table 3).

Workers who increased in BMI or decreased in moderate or vigorous physical activity had a modest decrease in work ability (β's ranging from -0.04 (95%CI: -0.05; -0.02) to -0.05 (95%CI: -0.06;-0.03)) and health (β's ranging from -0.02 (95%CI: -0.03;-0.02) to -0.03 (95%CI: -0.03;-0.02)). Starting smoking was not statistically significantly associated with changes in work ability (β=-0.05, 95%CI: -0.21;0.11) and health (β=0.02, 95%CI: -0.04;0.08). The effect sizes for working conditions varied between -0.10 to -0.17, while the effect sizes for health behaviours and BMI ranged between -0.02 and -0.04.

Table 2. Within-individual **improvements** in working conditions, health behaviours and BMI in a given year and changes in work ability and self-rated health in the same year among 14,045 workers aged 45–63 years.

	Change in self-reported work ability (0-10)		Change in self-rated health (1-5)	
	N [a]	b (95% CI)	N [a]	b (95% CI)
Working conditions				
Decrease of psychological job demands (1-5)	15360	0.04 (-0.00;0.08)	15376	**0.02** (0.00;0.03)
Decrease of emotional job demands (1-5)	14380	**0.07** (0.03;0.10)	14390	**0.03** (0.01;0.04)
Increase of autonomy (1-5)	15537	**0.07** (0.02;0.11)	15539	**0.03** (0.01;0.05)
Increase of social support (1-5)	15597	**0.06** (0.02;0.09)	15607	0.01 (-0.00;0.02)
Decrease of physical workload (1-5)	12148	**0.11** (0.06;0.16)	12145	**0.04** (0.02;0.06)
Health behaviours and BMI				
Increase in moderate physical activity (0-7)	13287	**-0.01** (-0.03;-0.00)	13302	0.00 (-0.00;0.01)
Increase in vigorous physical activity (0-7)	13341	**-0.01** (-0.02;-0.00)	13354	**0.01** (0.00;0.01)
Stop smoking (1=yes, 0=no)	1002	**-0.40** (-0.53;-0.26)	1000	**-0.13** (-0.17;-0.08)
Decrease in BMI (kg/m^2)	14370	-0.00 (-0.02;0.01)	14387	**0.03** (0.02;0.03)

Bold: estimate is statistically significant at the 0.05 level

[a] N=number of observations. Individuals may be included in the analyses several times since they could experience multiple improvements in working conditions and healthy behaviour during follow-up

Table 3. Within-individual **deteriorations** in working conditions, health behaviours and BMI in a given year and changes in work ability and self-rated health in the same year among 14,066 workers aged 45–63 years.

	Change in self-reported work ability (0-10)		Change in self-rated health (1-5)	
	N [a]	b (95% CI)	N [a]	b (95% CI)
Working conditions				
Increase of psychological job demands (1-5)	15375	**-0.23** (-0.27;-0.19)	15381	**-0.07** (-0.09;-0.06)
Increase of emotional job demands (1-5)	13996	**-0.25** (-0.29;-0.21)	14004	**-0.08** (-0.10;-0.07)
Decrease of autonomy (1-5)	16141	**-0.28** (-0.33;-0.24)	16148	**-0.10** (-0.12;-0.08)
Decrease of social support (1-5)	16594	**-0.21** (-0.25;-0.18)	16601	**-0.07** (-0.09;-0.06)
Increase of physical workload (1-5)	12551	**-0.26** (-0.31;-0.20)	12555	**-0.10** (-0.12;-0.08)
Health behaviours and BMI				
Decrease in moderate physical activity (0-7)	12900	**-0.04** (-0.05;-0.03)	12908	**-0.02** (-0.03;-0.02)
Decrease in vigorous physical activity (0-7)	13137	**-0.04** (-0.05;-0.02)	13142	**-0.02** (-0.03;-0.02)
Start smoking (1=yes, 0=no)	599	-0.05 (-0.21;0.11)	597	0.02 (-0.04;0.08)
Increase in BMI (kg/m^2)	17757	**-0.05** (-0.06;-0.03)	17766	**-0.03** (-0.03;-0.02)

Bold: estimate is statistically significant at the 0.05 level

[a] N=number of observations. Individuals may be included in the analyses several times since they could experience multiple deteriorations in working conditions and healthy behaviour during follow-up

Sensitivity analysis

When only including changes of at least 1 standard deviation, the percentages of within-individual improvements and deteriorations were slightly lower for the dependent and independent variables; approximately one third of the observations were improvements with at least 1 standard deviation (31% to 34%), and another third of the observations were deteriorations with at least 1 standard deviation (31% to 34%; supplementary table S1). The results of the sensitivity analysis on the impact of within-individual improvements or deteriorations in working conditions, health behaviour or BMI on work ability and health of at least 1 standard deviation were largely comparable to the results including also smaller changes. The differences were that in these sensitivity analyses no significant associations were found between increasing moderate vigorous physical activity and changes in work ability, and between decreasing psychological job demands and health. In addition, in the sensitivity analyses a decrease in psychological job demands was associated with improved work ability, and an increase in social support was associated with improved health (supplementary tables S3 and S4).

DISCUSSION

This study showed that workers with improved working conditions in a given year had improved work ability and health in the same year. Those with deteriorated working conditions decreased in work ability, and to a lesser extent reduced in health. Within-individual deteriorations in working conditions were more strongly associated with changes in work ability and health compared to within-individual improvements in working conditions. With regard to health behaviour and BMI, workers who decreased in BMI and increased in vigorous physical activity were more likely to have improved health. Workers who increased in BMI and decreased in physical activity had decreased work ability and health. In contrast, within-individual increases in moderate and vigorous physical activity were associated with slightly reduced work ability. Quitting smoking was associated with both reduced work ability and health.

The findings on the associations of within-individual improvements and deteriorations in working conditions with changes in work ability and health confirm findings from previous studies. In line with our findings, Tuomi et al.[22] showed that workers in the retail trade and metal industry with decreased physical- and mental demands and increased autonomy had increased work ability. Milner et al.[23] reported that male physicians with deteriorated psychological job demands and job control were more likely to have poorer self-rated health. While these studies were performed among workers in distinct occupational groups and the workers were on average younger compared to the workers in the current study, our findings suggested that modification of working conditions might also be important for maintaining good work ability and health of older Dutch workers in varying work sectors.

An important finding is that the associations of within-individual deteriorations in working conditions with changes in work ability and health did not exactly mirror the associations of within-individual improvements in working conditions with the dependent variables. We showed that within-individual deteriorations in working conditions were more strongly associated with work ability and health in the short-term than within-individual improvements in working conditions. Previous research on associations of changes in working conditions with sickness absence and exit from paid employment underline the relative importance of adverse changes by showing that adverse changes in psychological working conditions increased the risk of sickness absence[37] and exit from paid employment,[36]

while favourable changes in most working conditions did not have such effects. Workers in the current study were generally exposed to favourable working conditions at the start of the study. Since this implies less room for improvements this could explain why within-individual improvements in working conditions were less strongly associated with health and work ability.

Our findings on the associations of within-individual deteriorations in health behaviour and BMI with work ability and health mostly confirm findings from previous longitudinal studies investigating associations between unhealthy behaviour, and obesity with work ability and health. For instance, they showed that lack of physical activity and obesity are important risk factors for lower work ability[10-12] and poor health.[16, 17] However, because they did not investigate the associations of within-individual changes in exposure, the potential of preventing unhealthy behaviour and high BMI for sustained employability might have been overestimated in these studies. The results in the current study regarding the associations of within-individual improvements in health behaviour with changes in work ability were not in line with previous studies. While Tuomi et al.[22] found that workers with increased leisure time activity increased in work ability, we showed that workers who increased in moderate or vigorous physical activity slightly decreased in work ability. In the current study, we could not distinguish between physical activity at work and leisure-time physical activity. Evidence suggests that physical activity during work is detrimental to health,[38] which could outweigh the benefits of leisure time physical activity for work ability.

Workers who quit smoking in a given year had decreased work ability and health in the same year. These findings suggest that quitting smoking may be harmful to work ability and health among older workers in the short-term. This is in contrast to most research on the associations between smoking and work ability[10, 39] and health.[16, 17] A possible explanation for our findings is that the older workers under study quit smoking because of existing health problems, which negatively affect work ability and health.[40] Another explanation is that the beneficial effects of smoking cessation on work ability and health might become visible after a longer period. One study showed that persons who had quit smoking within 1 year had lower productivity than smokers, and higher productivity after 1 to 5 years.[41]

The current study showed that within-individual changes in working conditions, health behaviour and BMI were modestly associated with changes in work ability and health within 1 year, with effect sizes up to -0.24. This indicates that interventions aimed at modification of the working environment or health promotion interventions might provide small benefits to work ability and workers' health in the short-term. Oakman et al.[42] also found in a systematic review that workplace interventions have small positive effects on work ability in the short term. These results indicate that sustained effort in the workplace is needed over several years to further improve in work ability and health or prevent further decline in these outcomes.

Strengths and limitations

This study has several strengths and limitations. First, the fixed-effects models allowed for investigation of the associations of within-individual improvements and deteriorations in working conditions, health behaviour, and BMI with changes in work ability and health. By making comparisons within-individuals, each individual served as its own control. Therefore, we controlled for potential bias due to unobserved heterogeneity. The findings are important for policies aimed at prolongation of working lives, since they provide better insight in the potential effects of modifying the working environment, health behaviour and BMI on work ability and health. Other strengths are the inclusion of a variety of working conditions and health behaviours in the analysis, and a high number of observations of within-individual change in working conditions and health behaviour over a 7 year follow-up period.

The following limitations need to be addressed. First, the independent and dependent variables were based on self-report. Since self-reports are less reliable than objective measurements, small within-individual changes between time points could reflect variability in reporting rather than actual change.[43] However, we additionally investigated the associations of greater changes (≥ 1 SD) in working conditions and health behaviour with changes in health and work ability between measurements with fixed effects analysis and found similar results (supplementary table S3 and S4). Secondly, changes in working conditions and health behaviour and changes in work ability and health were measured within the same year, making it difficult to draw conclusions about causal relationships. We considered to investigate the effects of within-individual changes in exposure in a given year on

changes in work ability and health one year later. However, changes in working conditions, health behaviour and BMI in a given year were more strongly associated with changes in work ability and health in that same year compared to changes in exposure in the previous year. As the changes in working conditions and health behaviours fluctuated strongly overtime, we decided not to use a time lag in this study. A third limitation is that the study population includes workers aged 45 years and older. Therefore, the findings of the current study may not be generalizable to younger workers.

Conclusion

This study suggests that workers aged 45 years and older who change in working conditions and health behaviour modestly change in work ability and self-rated health within the same year. Compared to improvements in working conditions, healthy behaviour and BMI, prevention of deteriorations in these factors may contribute more strongly to maintaining good work ability and health among midlife workers. Prevention of deteriorations in working conditions could be of particular importance for sustainable employability.

DECLARATIONS

Contributors

DV, SR, AB, and MS designed the models and analytical framework. DV and MS prepared the data. DV conducted the analyses. The analytical models and results were discussed by DV, SR, KMOH, SKRvZ, SB, PO, AB, and MS. DV drafted and revised the manuscript with input from SR, KMOH, SKRvZ, SB, PO, AB, and MS. DV, SR, KMOH, SKRvZ, SB, PO, AB, and MS approved the final version.

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Competing interest

The authors have no competing interests to declare that are relevant to the content of this article.

Patient consent for publication

Not required.

Ethics approval

The Medical Ethical Committee of the VU University Medical Centre Amsterdam (ID: 2012-080) declared that the Medical Research Involving Human Subjects Act does not apply to STREAM, because filling out the questionnaires did not involve any risk nor violation of the psychological or physical integrity of the study participants. Since the study involves human subjects, the Institutional Review Board (IRB) of the Netherlands Organisation for applied scientific research (TNO) assessed design of the study, social importance, safety aspects, privacy of the participants, data storage and burden and risks to research participants. STREAM received a positive recommendation. Participants were informed that their privacy would be guaranteed, that answers would be treated as confidential, and that all data would be stored on secured computer systems.

Data availability statement

The data that support the findings of this study are available from TNO Healthy Living (Leiden, the Netherlands) but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available upon reasonable request by the author KM Oude Hengel (karen.oudehengel@tno.nl) and with permission of TNO Healthy Living (Leiden, the Netherlands).

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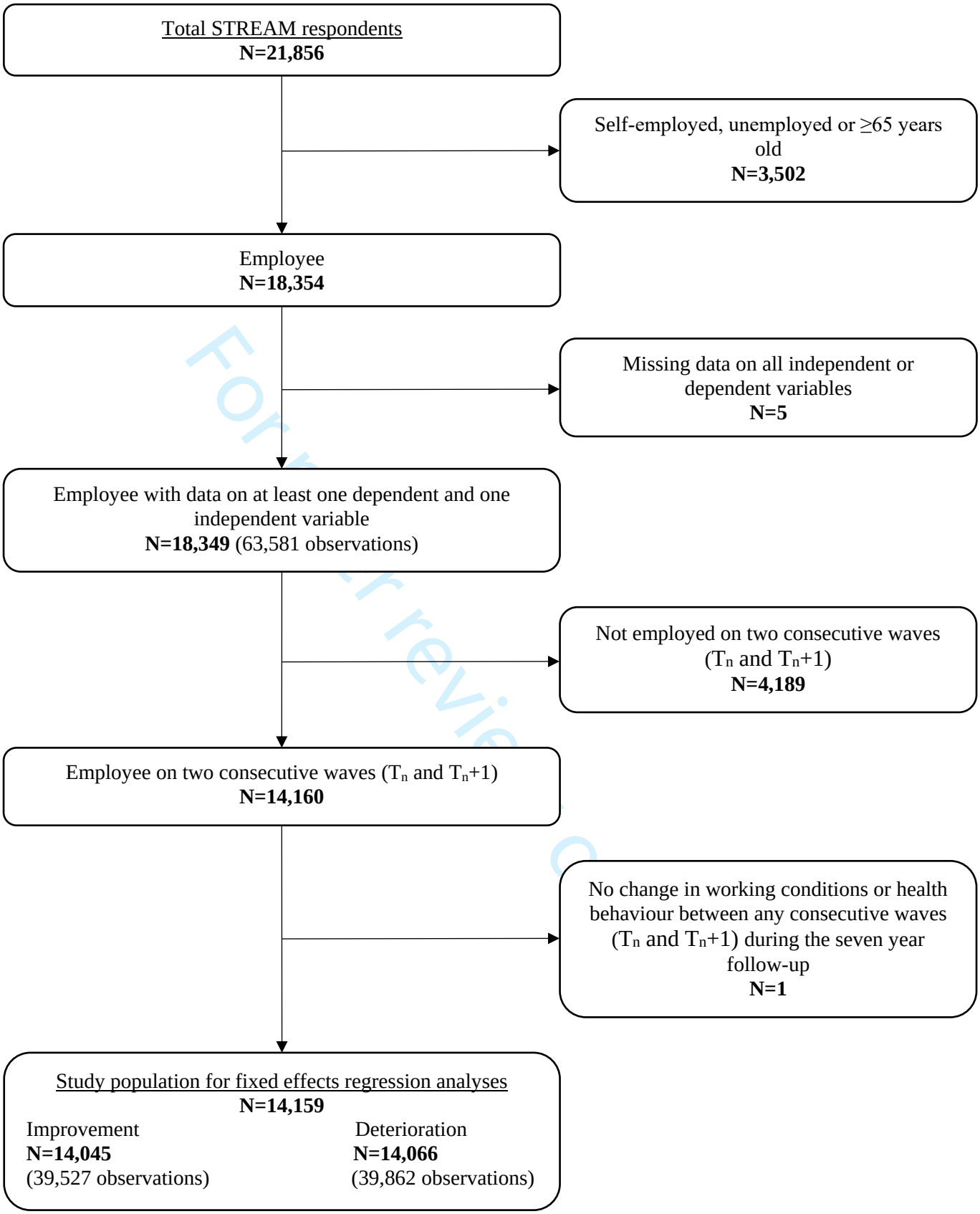
FIGURES

Figure 1. Flowchart of the selection of the study population



SUPPLEMENTARY MATERIAL

Table S1. Percentage of within-individual improvements and within-individual deteriorations in outcomes and predictors for all persons included in the fixed effects analysis (N=14,159) and persons with changes of at least 1 standard deviation.

	Within-individual improvements %		Within-individual deteriorations %	
Outcome measures	**All**	**≥1 SD**	**All**	**≥1 SD**
Work ability (0-10)	40%	31%	41%	32%
Self-rated health (1-5)	33%	32%	34%	33%
Working conditions				
Psychological job demands (1-5)	45%	32%	45%	31%
Emotional job demands (1-5)	44%	34%	43%	34%
Autonomy (1-5)	45%	32%	46%	32%
Social support (1-5)	45%	32%	47%	33%
Physical workload (1-5)	43%	31%	44%	32%
Health behaviours and BMI				
Moderate physical activity (0-7)	43%	34%	42%	33%
Vigorous physical activity (0-7)	42%	34%	42%	34%
Smoking (%yes)	29%	n/a	29%	n/a
BMI (kg/m^2)	46%	31%	52%	32%

SD standard deviation.

Table S2. Baseline sociodemographic characteristics of persons included in the fixed effects analysis (N=14,159) and persons not included in the fixed effects analysis (N=7,697).

	Fixed effects analysis	**Not included in fixed effects analysis**
Age	51.1 years old (SD 6.4)*	52.3 years old (SD=7.6)
Gender (male)	54.1%**	48.3%
Educational level		
Low	26.1%	34.3%
Intermediate	39.5%	37.4%
High	34.4%**	28.2%

SD standard deviation.

*Independent sample t-test, $p<0.05$.

**Chi-square, $p<0.05$.

Table S3. Sensitivity analysis of the effects of within-individual **improvements** (≥SD of differences scores) in working conditions, health behaviours and BMI in a given year on changes in work ability and self-rated health in the same year among employed individuals aged 45–63 years.

	Change in self-reported work ability (0-10)		Change in self-rated health (1-5)	
	N [a]	b (95% CI)	N [a]	b (95% CI)
Working conditions				
Decrease of psychological job demands (1-5)	4787	**0.05** (0.00;0.10)	4792	0.02 (-0.00;0.04)
Decrease of emotional job demands (1-5)	7579	**0.07** (0.03;0.11)	7580	**0.03** (0.02;0.05)
Increase of autonomy (1-5)	4964	**0.09** (0.04;0.14)	4969	**0.03** (0.01;0.06)
Increase of social support (1-5)	5726	**0.07** (0.03;0.11)	5733	**0.02** (0.00;0.03)
Decrease of physical workload (1-5)	3771	**0.16** (0.09;0.22)	3776	**0.05** (0.03;0.08)
Health behaviours and BMI				
Increase in moderate physical activity (0-7)	6972	-0.01 (-0.03;0.00)	6979	0.00 (-0.00;0.01)
Increase vigorous physical activity (0-7)	7186	-0.01 (-0.02;0.00)	7192	**0.01** (0.00;0.01)
Stop smoking (1=yes, 0=no)	1002	**-0.40** (-0.53;-0.26)	1000	**-0.13** (-0.17;-0.08)
Decrease in BMI (kg/m^2)	2753	0.00 (-0.01;0.02)	2759	**0.03** (0.02;0.03)

Bold: estimate is statistically significant at the 0.05 level

[a] N=number of observations. Individuals may be included in the analyses several times since they could experience multiple improvements in working conditions and healthy behaviour during follow-up.

Table S4. Sensitivity analysis of the effects of within-individual **deteriorations** (≥SD of differences scores) in working conditions, health behaviours and BMI in a given year on changes in work ability and self-rated health in the same year among employed individuals aged 45–63 years.

	Change in self-reported work ability (0-10)		Change in self-rated health (1-5)	
	N [a]	b (95% CI)	N [a]	b (95% CI)
Working conditions				
Increase of psychological job demands (1-5)	4766	**-0.22** (-0.27;-0.17)	4773	**-0.06** (-0.08;-0.05)
Increase of emotional job demands (1-5)	7295	**-0.23** (-0.27;-0.19)	7302	**-0.08** (-0.09;-0.06)
Decrease of autonomy (1-5)	5276	**-0.24** (-0.30;-0.19)	5280	**-0.09** (-0.11;-0.07)
Decrease of social support (1-5)	6165	**-0.20** (-0.24;-0.17)	6172	**-0.07** (-0.09;-0.06)
Increase of physical workload (1-5)	3806	**-0.23** (-0.30;-0.17)	3811	**-0.09** (-0.11;-0.06)
Health behaviours and BMI				
Decrease in moderate physical activity (0-7)	6625	**-0.04** (-0.05;-0.02)	6632	**-0.02** (-0.03;-0.02)
Decrease in vigorous physical activity (0-7)	6788	**-0.03** (-0.04;-0.02)	6790	**-0.02** (-0.03;-0.02)
Start smoking (1=yes, 0=no)	599	-0.05 (-0.21;0.11)	597	0.02 (-0.04;0.08)
Increase in BMI (kg/m^2)	2852	**-0.04** (-0.05;-0.02)	2853	**-0.02** (-0.03;-0.01)

Bold: estimate is statistically significant at the 0.05 level

[a] N=number of observations. Individuals may be included in the analyses several times since they could experience multiple deteriorations in working conditions and healthy behaviour during follow-up.

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2, 3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4, 5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	6
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	n/a
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7, 8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7, 8
Bias	9	Describe any efforts to address potential sources of bias	4, 8
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7, 8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8, 9
		(*b*) Describe any methods used to examine subgroups and interactions	8, 9
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, explain how loss to follow-up was addressed	6
		(*e*) Describe any sensitivity analyses	9
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	10
		(b) Give reasons for non-participation at each stage	10
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10
		(b) Indicate number of participants with missing data for each variable of interest	10
		(c) Summarise follow-up time (eg, average and total amount)	10
Outcome data	15*	Report numbers of outcome events or summary measures over time	10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11-13
		(*b*) Report category boundaries when continuous variables were categorized	13
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	14, supplementary tables S1-S4
Discussion			
Key results	18	Summarise key results with reference to study objectives	15
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	19

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.