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Psychosocial work demands and physical workload decrease with aging in blue and white-collar workers: A prospective study based on the SLOSH cohort

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TÅ defined the research question, designed the study and wrote the manuscript
AD analyzed the data and commented on the manuscript
HW provided the cohort and commented on the manuscript

ABSTRACT

Objectives

Psychosocial work demands and physical work load are important causes of ill health. The dramatic demographic changes in society make it imperative to understand if such factors change with aging, but this is presently not known. The purpose of the present study was to investigate whether psychosocial work demands and physical workload change across eight years of aging, whether occupational groups show different trajectories of change, and if such trajectories are reflected in sleep or fatigue.

Methods: Cohort of 5000 participants was measured in 5 biannual waves across 8 years. Mixed model regression analyses was used to investigate change across aging.

Results:

Psychosocial work demands decreased markedly across 8 years, with the strongest decrease in the high white-collar group, and the oldest group. Physical workload also decreased markedly, particularly in the blue-collar group, and in the oldest group. Fatigue decreased, and sleep problems increased with aging, but with similar slopes in the occupational groups.

Conclusions:

The decrease in psychosocial work demands and physical workload suggests that the burden of work becomes lighter over time. The mechanism could be “pure” aging and/or increased experience, or related factors. The gradual improvement in the work situation should be considered in the discussion of the place of older individuals in the labor market, and of a suitable age for retirement. The results also mean that prospective studies of work and health need to consider the improvement in working life with aging.

Key words: work demands, stress, physical workload, fatigue, sleep, aging, occupational group

Strength and limitations of this study

- A strength of this study is the longitudinal approach and relatively large sample size
- A limitation is the subjective nature of the data, although both main variables are, by nature, subjective
- Another limitation is that we can not determine the mechanism behind the decreases with aging

What this paper adds:

What is already known about this subject?

We do not know if psychosocial workload and physical workload change with aging. No studies have been carried out.

What this paper adds:

We show that both if psychosocial work demands and physical workload decrease with aging, and that the decrease in psychosocial work demands is steepest for high white-collar workers and that the decrease in physical workload is steepest in blue-collar workers

How might it impact on clinical practice in the foreseeable future?

Occupational health services may develop a more positive view of the capacity of older employees. However, the major impact should be observed in the discussion of age and a sustainable working life, as well as on decisions on a temporal extension of working life

INTRODUCTION

Psychosocial work demands are a central factor in research on occupational stress,[1 ,2] and is also associated with cardiovascular and other diseases.[3] It involves a need to work fast, to handle difficult tasks or to have too little time for ones task. There is also a prospective link between work demands and disturbed sleep,[4-7] and with fatigue.[8 ,9] Sleep problems, in turn, predict a high utilization of health resources [10] and sickness absence.[11] Fatigue is associated with similar effects.[12-14]

Considering the demographic changes in western society it is an interesting question whether psychosocial work demands increase or decrease with aging. There are no previous studies of this issue, but there is a need to provide knowledge for the discussion of working life sustainability, and the feasibility of a later retirement age.

If there are changes in psychosocial work demands with aging, the patterns are likely to be different for blue and white-collar workers. The demands are higher among white-collar workers and one may speculate that changes with time might be larger in that group. [15 ,16]

Since work demands are linked to (poor) sleep and to fatigue, one might expect these variables to reflect changes in work demands. However, there are no data available, but we have seen that fatigue actually decreases with aging whereas sleep problems increase moderately.[17]

Another work related factor that should be considered in connection with work demands is physical workload. It is particularly associated with musculoskeletal pain, [18 ,19] but also with cardiovascular disease,[20 ,21] as well as with fatigue.[22] It is, for obvious reasons highest in blue-collar workers. As to effects of aging, the reasoning is similar to that for psychosocial work demands and no longitudinal studies of the effects of aging are available.

The purpose of the present study was to investigate whether work demands and physical workload change across eight years of work, whether occupational groups show different trajectories of change, and if such trajectories are reflected in trajectories of sleep or fatigue. Hypotheses are difficult to develop since aging involves reduced physical and cognitive work capacity, [23] [24] that should be linked to a perception of increased demands or workload, while increased work experience and career changes may be counterforces.

METHODS

Design and participants

The study was based on the Swedish Longitudinal Occupational Survey of Health, SLOSH. It is an initially nationally representative longitudinal study with follow-up every second year (from 2006). It has its origins in the Swedish Work Environment Survey (SWES, www.scb.se), which, in turn, is based on nationally representative samples of the working population.

In the present paper we use data from waves 1-5 (T1-T5), including only employed individuals, and information on occupational group (from T2). This resulted in 5377 participants.

The sample at T1 contained 43.2% males; 33.9% 18-42 year olds, 42.1% 43-56 year olds, and 24.1 % 57-68 year olds; 55.3% married; 53.4% with children (living at home); 80.2% in very or rather good health. Mean age ± SD was 47.6±11.6 years; 3.5% were not working.

Variables

Information regarding gender, age and occupation (blue-collar worker, white-collar workers, and managers), were derived from national register data at T2. The occupational categories are based on the Statistics Sweden official classification of occupations (SSYK) to produce the categories blue-collar workers (BCW), lower whicte collar workers (LWC) and professionals and managers (HWC - high white-collar workers). The N for the three groups was 2163, 2226, and 988, respectively.

Work demands were measured using the Swedish version of the Demand-Control-Support Questionnaire.[1] This scale has been extensively psychometrically investigated, [2 ,25] and used to predict health outcomes of psychosocial work factors.[26 ,27] The five items used were: ”Do you have to work very intensively?” ”Does your work demand too much effort?” ”Do you have enough time to do everything?” (reverse coded) ”Do you have to work very fast?” and ”Does your work often involve

conflicting demands?". The response alternatives ranged from 1: Hardly ever/never, to 4:Yes, often (scaled reversed from the original 4-1). Cronbach's α was 0.67 at T3.

Four items representing disturbed sleep were selected from the Karolinska Sleep Questionnaire (KSQ) (Cronbach's alpha > 0.70).[5 ,28-30] The scale differentiates patients with insomnia from healthy individuals [29], and correlates with perceived stress, anxiety, depression and burnout (r >.40).[30] The items included are: difficulties falling asleep, restless sleep, repeated awakenings, and premature awakening. The responses range from "never" to "most days of the week" (1-6). Cronbach's alpha was 0.84 at time T3, and the correlation between time points was r = .71.

Ratings of fatigue were obtained from a single item phrased as "to what extent have you been suffering from sluggishness or lack of energy", with response alternatives from 1 (not at all) to 5 (very much). It is significantly correlated (r = 0.60, p<.001) with persistent fatigue and mental fatigue (r=0.57, p<.001) at T3.

Physical workload was measured as an index of three questions: "Is your work such that you have to use bent, twisted or otherwise unsuitable positions?" "Do you have to lift at least 15 kilos several times a day?" "Does your work sometimes involve heavy physical labor, that is, do you physically exert yourself more than when walking and standing and moving around in a normal way?". Response alternatives ranged from 1: No, not at all, to 6: Almost all the time. Cronbach's α was 0.89 for at T1, and the test-retest reliability between T1 and T2 was r = .85.

Statistical analysis

To describe the mean trajectories of the outcomes over time (waves T1 – T5) for different occupational groups we used mixed-effects linear regression models.[31] Regression models included occupational group (level-2 variable), time (level-1 variable) and their two interaction (product) terms as fixed effects. Moreover, they included subject-specific random intercept and time slope to account for potential dependence among repeated values of the outcome variables over time. The analyses were adjusted for gender and age (level-2 variables). The overall difference in the slopes over time across the three occupational groups was assessed with a joint Wald test with 2 degrees of freedom on the 2 interaction terms. Waves when an individual was not employed were not used in the analyses.

In a second analysis, the subject-specific time slopes for work demands and physical workload were used as predictors for the other outcomes. More specifically, we first modelled work demands and physical workload using 2 mixed-effects linear regression models. These models included time as fixed effect with random intercept and slope. We then calculated subject-specific slopes by adding to the fixed-effects time coefficient the subject-specific best linear unbiased predictions (BLUPs) of the random slope. Finally, we used the subject-specific slopes as a fixed-effect in a separate mixed-effects linear regression model, adjusted for age and gender, with random intercept and random time slope.

In a third analysis, we described the age-group–specific mean trajectories of the outcomes over time. This was done in an analogous fashion to what we described for the

main analysis. Age groups at were defined as: 18-42, 43-56, and 57-68 years of age. This was also repeated with stratification within each occupational group.

Data sharing, ethics, funding

The data of this study cannot be directly shared, but applications for research using the data base may submitted after discussions with the SLOSH scientific committee.
The Regional Research Ethics Board in Stockholm approved the study. This study was funded by the AFA Insurance company, Sweden.

Patient and public involvement statement

Patients were not involved in the present study

RESULTS

Figure 1 and Table 1 show the effects of time on self reported work demands The decrease across time was significant for all occupational groups, and for each group separately, although the effect for BCW was weak. The interaction between the occupational groups was highly significant, that is, the three groups showed different slopes over time. In addition, BCW showed (at T3) lower demands than HWC (0.06±.02,, Z=3.2, p=.000), but LWC did not (-0.03±.02, Z=1.5, p=.147). Women showed higher values (higher demands) than men (0.05±01, Z=3.5, p=.000). The oldest group showed

significantly lower work demands (0.14±.02, Z=7.8, p=.000) than the youngest group, but the intermediate group did not (_0.02±.01, Z= ,p=.147).

Figure 1 shows the effects of aging/work experience on physical workload in the three occupational groups. Table 1 shows that the decrease in workload was significant for the group as a whole and for LWC, and in particular for BCW. The interaction between groups was highly significant. BCW showed (at T3) a significantly higher physical workload than HWC (1.948±.044, Z=44.5, p=.000), which also LWC did (0.521±.044, Z=11.9, p=.000). Women showed higher physical workload than men 0.145±.032, Z=4.6, p=.000). The oldest group showed significantly lower physical load (0.115±.041, Z=2.8, p=.006) than the youngest group.

Figure 1 shows the effect of time on fatigue in the three occupational groups. Table 1 shows that the reduction in fatigue was significant in all three groups. The interaction was not significant and the level between groups did not differ significantly. However, women had a significantly higher level of fatigue (0.25±.02, Z=10.4, p=.000). In addition, older individuals showed significantly less fatigue (-0.37±.03, Z=11.7, p=.000) than the young group. The intermediate age group also showed lower fatigue (-0.16±.03, Z=5.9, p=.000}.

Figure 1 shows the effects of time on sleep problems in the three occupational groups. Table 1 shows that the increase in sleep problems was significant in all three groups. The interaction was not significant and the level between groups did not differ significantly. Women reported more sleep problems than men (0.28±.03, Z=10.8,

p=.000). The oldest individuals reported more sleep problems than the young (0.07±.03, Z=2.17, p=.03); as did the intermediate group 0.17±.03 (Z=5.9, p=.000).

As a sensitivity analysis we repeated the previous analyses for those participants who had complete data for all five waves (N=1888). The results were very similar to the previous results. The only differences was that the significant decrease in work demands for blue collar workers (p<.05) and the significant decrease in fatigue for high white-collar workers (p<.05) did not remain significant.

Figure 1

Table 1. Slopes of the different occupational groups for each variable. Coefficients of slope, standard error, Z-value, and p-value. N=5377

Occup groups	Coeff±se	Z	Chi2	Coeff±se	Z	Chi2
	Work demands	.		**Physical workload**		
All	-0.016±.001	12.2[c]		-0.033±.002	14.3[c]	
HWC	-0.031±.003	10.6[c]		-0.008±.005	1.7	
LWC	-0.029±.002	9.4[c]		-0.019±.003	5.5[c]	
BCW	-0.005±.002	2.5[a]		-0.050±.004	16.3[c]	
Interaction			53.5[c]			94.0[c]
	Fatigue_rec			**Sleep problems**		
All,	-0.018±.002	7.5[c]	.	0.020±.002	9.4[c]	
HWC	-0.014±.005	2.6[a]		0.019±.005	4.2[a]	
LWC	-0,022±,004	5.9[c]		0.017±.003	5.2[c]	
BCW	-0.016±.004	4.1[a]		0.023±.003	6.8[c]	
Interaction:			1.9			2.0

Results are adjusted for age and gender. a=p<.05, b=p<.01, c=p<.001

To test the direct association of changes between work demands and the other variables we used a mixed model regression and computed the relation between the individual slopes in work demands and in the other variables. Table 2 shows that when work demands decreased, also physical work demands, fatigue, and sleep problems decreased. Fatigue and sleep problems also decreased when physical workload decreased, but the association was weaker.

Table 2. The regression of the slopes of work demands and physical workload vs other slopes. Mixed model regression

Work demand slope vs slope of:	Work demands vs Coeff±se	Z	p	Physical workload vs Coeff±se	Z	p
Phys workolad	0.204±.031	6.5	.000			
Fatigue	0.106±.010	10.9	.000	0.010±.004	2.4	.018
Sleep problems	0.243±.022	11.1	.000	0.028±.010	2.9	.004

Adjusted for age and gender. Z=Z value, p=significance level. a=p<.05, b=p<.01, c=p<.001

Since there is a possibility that the change across time in the main analysis might be different in different age groups we also analyzed the trajectories within three age groups – 18-42 years, 42-56 years, and 57-68 years, adjusted for gender. Table 3 shows a strong interaction between work demands and age groups, with the largest decrease in the oldest group, although all three trajectories were significant. For physical workload, the trajectories of each age group was significant, but the interaction was not.

There was a similar pattern for fatigue and sleep problems. In both cases the interaction was significant. For fatigue the oldest group showed the strongest decrease, whereas for sleep problems the youngest group showed the strongest increase, while the oldest group showed a decrease. In all cases the decrease was largest in the oldest group. For sleep problems, the interaction between age groups was significant, but here the oldest group had the smallest reduction.

The same analysis subdivided on occupational group showed similar results. For work demands the interaction between time and age group was significant in all three occupational groups and the decrease strongest in the oldest group. For physical work demands no significant interactions were obtained. For fatigue the interaction was significant in the LWC and BWC groups, with the strongest decrease in the oldest group.

For sleep problems all three occupational groups showed significant interactions, with the lowest increase in the oldest group.

Table 3. Trajectories across 8 years of work demands and physical workload for 3 age groups for the full group and for each occupational group

Age groups, All participants	Coeff±se	Z	Chi2	Coeff±se	Z	Chi2
	Work demands			**Physical workload**		
18-42	-0.006±.002	3.0[b]		-0.038±.004	9.6[c]	
43-56	-0.017±.002	9.1[c]		-0.033±.003	10.2[c]	
57-68	-0.039±.004	10.6[a]		-0.028±.006	5.1[c]	
Interaction			61.1[c]			1.9
	Fatigue			**Sleep problems**		
18-42	-0.014±.004	3.3[c]		0.028±.003	8.0[c]	
43-56	-0.014±.003	4.0[c]		0.023±.003	7.7[c]	
57-68	-0.044±.006	7.7[c]		-0.011±.005	2.3[a]	
Interaction			20.3[c]			39.5[c]
	Work demands			**Physical workload**		
HWC						
Age groups						
18-42	-0.018±.004	4.9[c]		-0.012±.004	3.0[b]	
43-56	-0.033±.003	7.8[c]		-0.007±.003	2.4[b]	
57-68	-0.055±.008	6.6[c]		-0.003±.006	0.4	
Interaction			19.5c			2.1
LWC						
Age groups						
18-42	-0.006±.003	1.7		-0.023±.006	4.1[c]	
43-56	-0.021±.003	7.7[c]		-0.018±.005	3.9[c]	
57-68	-0.040±.005	7.4[c]		-0.019±.008	2.5[a]	
Interaction			33.3c			0.7
BCW						
Age groups						
18-42	-0.001±.003	0.3		-0.065±.008	8.0[c]	
43-56	-0.004±.003	1.3		-0.058±.006	9.1[c]	
57-68	-0.024±.006	4.1[c]		-0.051±.013	3.9[c]	
Interaction			11.9c			1.0
	Fatigue			**Sleep problems**		
HWC						
Age group						
18-42	-0.017±.009	1.9		0.017±.007	2.4[c]	
43-56	-0.008±.007	1.0		0.029±.007	4.1[c]	
57-68	-0.025±.012	2.1[a]		-0.025±.012	2.1	
Interaction			1.5			6.2[a]
LWC						
Age groups						
18-42	-0.016±.007	2.4[a]		0.027±.005	5.1[c]	
43-56	-0.017±.006	3.0[b]		0.020±.005	4.3[c]	
57-68	-0.051±.009	5.7[c]		-0.015±.007	2.0[a]	
Interaction			10.6[b]			20.6[c]
BCW						
Age groups						
18-42	-0.009±.007	1.4		0.033±.006	5.7[c]	
43-56	-0.014±.005	2.5[a]		0.024±.005	5.8[c]	
57-68	-0.047±.010	4.0[c]		-0.012±.008	1.4	
Interaction			10.6[b]			16.4[c]

HWC=high white collar workers, LWC=low white collar workers, BCW=Blue collar workers
a=p<.05, b=p<.01, c=p<.001

DISCUSSION

Work demands decreased significantly within individuals over time in all three occupational groups, but also the interaction was highly significant. The steepest decrease was seen in HWC. The latter group also showed the overall highest level of work demands. Physical workload showed a decrease for the BCW and LWC groups and a significant interaction across occupational groups, with BCW showing the highest mean level. The changes in both variables were strongest in the oldest group. Sleep problems increased and fatigue decreased in all three occupational groups, but there was no interaction between groups. There was also a strong association between the decreased work demands and sleep and fatigue variables. For physical workload the associations were less strong.

The decrease in work demands across time is a new finding. The decrease was pronounced and present in all three occupational groups. The impression is that the work demand situation improves with time, which should be a positive finding for individuals in high demand situations. The results should have implications for discussions of sustainable work and for the temporal extension of working life. In addition, the results have implications for the interpretation of results of prospective research studies, since a follow-up time of eight years or more would mean a lower exposure to work demands across time, leading to a likely attenuation of the effects of high work demand levels on later disease outcomes.

We are not able to determine the reason for the decrease in work demands, but it is likely that increased experience makes one more competent to handle work tasks. Aging

could possibly contribute considering the associated reduction in fatigue,[17] together with what seems to be a reduced need for sleep.[32] Both may result in better resources to handle difficult work situations. This reasoning clearly needs empirical support, however.

The difference in steepness in the decrease of work demands in the three occupational groups could possibly be interpreted as differences in the positive effects of work experience or fatigue. Professional groups and managers usually have more complex work tasks for which experience may have more dramatic effects on master than what may be the cases for blue-collar workers. Again, this notion lacks support in the literature.

The difference in steepness in the decrease of physical workload in the three occupational groups was large. Thus, the decrease in BCW was very pronounced, while no decrease was seen in the HWC, and the latter group also had a lower level of physical workload. As with the decrease in work demands in HWC, one could speculate that experience may increase the physical capacity and perhaps the skill to handle physical workload in BCW. One might also conceive of experience leading to a move to work tasks with less physical load. These lines of reasoning are speculation, however, and studies specifically focused on these issues are needed.

As expected, the individual slopes of the decrease in work demands were associated with a decrease in fatigue, as well as a lower increase in sleep problems (or a decrease). This is in line with the day-to-day association between the three variables in a diary study across 42 days and strengthens the notion of a link between work demands and

sleep quality, as well as with fatigue.[33] However, aging is probably also involved in this, as demonstrated in a previous study, [17] but the changes in aging and work demands are not possible to separate in the present design.

The slope of sleep problems and fatigue showed a similar change for all occupational groups and, thus, did not reflect the different trajectories for psychosocial work demands and physical workload of the occupational groups. This was unexpected, particularly since at least psychosocial work demands have been linked to fatigue and sleep problems in previous studies,[17 ,34], and since the present data (table 2) shows clear associations between work demands and sleep problems on the individual level.

The stratification on age showed that the decrease in work demands was largest in the oldest group, less in the middle group, and smallest in the young group. All participants were still employed at the last point of measurement, so formal retirement does not seem to be implicated as a cause. However, we have no information on possible reductions in work hours. It might be argued that there is no reason why work demands, which describes speed, difficulty, effort, etc, should be reduced, but the overall impression of workload may have such an effect. In a recent experiment with a 25% reduction of work hours, one main result was a reduction in work demands.[35] The fact that the reduction in the present study was considerable also in the middle age group suggests that reduced work hours should not have been the only cause, since part-time work is unusual in that group. This is also supported by the significant effect in the youngest group. Another, probably important, factor should be the effect of experience on the ability to handle work demands, and possibly, also the effect of promotion to positions with more control over the work situation. Furthermore, loss of, particularly

physical work capacity might result in transfer to less demanding work tasks. However, the present study did not contain variables that make it possible to judge effects of increased experience, promotion or change of work tasks.

Also fatigue showed a pattern of largest reduction in the oldest group, which agrees with findings of lower fatigue in older individuals.[36] Sleep problems showed a similar pattern, although here the oldest group lacked the impairment over time over time that the younger groups had. Previous work has consistently found sleep problems to increase with age, but there is no previous data on the lack of increase in sleep problems in older individuals across time, except for our own previous study on the same material.[17] The same factors as discussed above may be invoked also in this case, but there may also be effects of aging itself.

The age effect was comparable within the three occupational groups, the only exception being HWC, who lacked a significant interaction between time and age group for fatigue. The reason for this is unknown, but that group had a very weak coefficient for change over time when all subjects were combined.

The decrease of psychosocial work demands and physical workload across time leaves a positive impression of the aging process in working life. Work appears to become easier with time. The observation that the effect is largest in the oldest groups indicates that from this point of view working life is sustainable. It also indicates that a temporal extension of working life could well be acceptable to many individuals, at least those still in good health. This is further accentuated by the reduction of fatigue with time.

There are some limitations to the present study. Firstly, all data are subjective, but this is difficult to avoid since there are no objective measures of work demands, or of sleep quality. Actigraphy measurement of sleep duration, [37] would have been preferable to self-reports, but was not used in the present case. With the present analysis we cannot draw any conclusions regarding causation, but that was not the purpose of the study. Rather, the purpose was to study whether aging or time at work would affect work demands, and that steered the analysis towards the approach of evaluating slopes over time. The strength of the study is the longitudinal approach, which makes it possible to evaluate the effects of time.

The results suggest that increased time of exposure to work markedly reduces psychosocial work demands and physical workload with the strongest effects among high white-collar workers and blue-collar workers, respectively. The results also suggest a link between decreased work demands and decreased fatigue, mainly in high white-collar workers. The results suggest a positive development of psychosocial work demands and physical workload across time and this observation should be useful in the discussions of a sustainable working life and of a temporal extension of working life.

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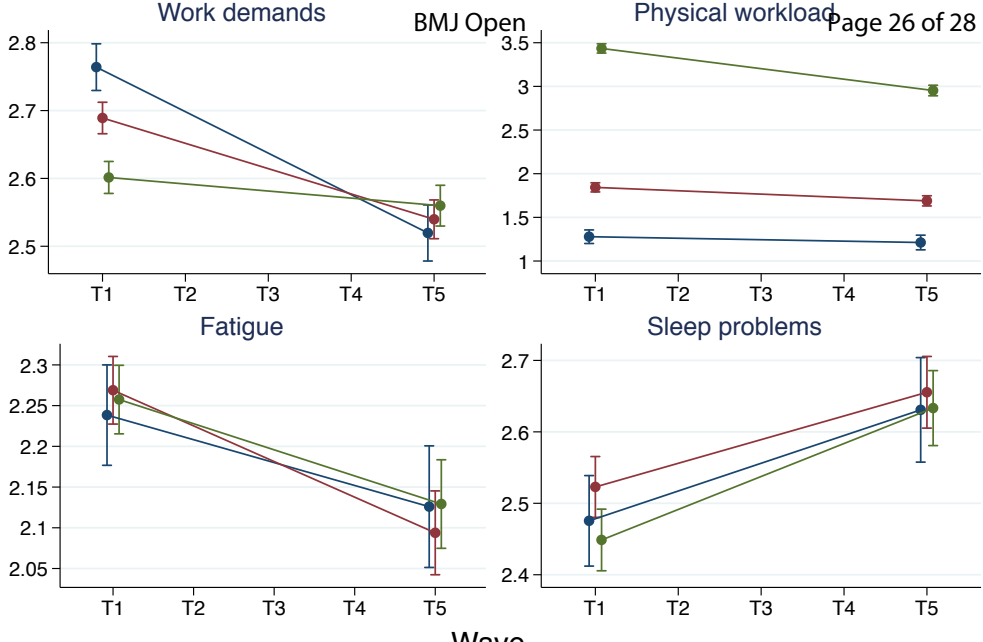
Figure legends

Figure 1. Trajectories of work demands, physical workload, sleep quality, fatigue, sleep duration weekdays, and sleep duration weekends in three occupational groups. Mean predicted outcomes at T1 and T5, marginalized over the age and gender distribution at T1



STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
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
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) If applicable, explain how loss to follow-up was addressed
		(*e*) Describe any sensitivity analyses
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
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) Summarise follow-up time (eg, average and total amount)
Outcome data	15*	Report numbers of outcome events or summary measures over time
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
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
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

*Give information separately for exposed and unexposed groups.

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 http://www.strobe-statement.org.

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Psychosocial work demands and physical workload decrease with aging in blue and white-collar workers: A prospective study based on the SLOSH cohort

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Psychosocial work demands and physical workload decrease with aging in blue and white-collar workers: A prospective study based on the SLOSH cohort

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ABSTRACT

Objectives

Psychosocial work demands and physical workload are important causes of ill health. The dramatic demographic changes in society make it important to understand if such factors change with aging, but this is presently not known. The purpose of the present study was to investigate whether psychosocial work demands and physical workload change across eight years of aging, whether occupational groups show different trajectories of change, and if such trajectories are reflected in sleep or fatigue.

Methods: A cohort of 5377 participants (mean age:47.6±11.6(SD) years, 43.2% males, 40.2% blue-collar workers) was measured through self-report in 5 biannual waves across 8 years. Mixed model regression analyses was used to investigate change across aging.

Results:

Psychosocial work demands decreased significantly across 8 years (Coeff:-0.016±.001), with the strongest decrease in the high white-collar group (Coeff=-0.031±.003), and the oldest group. Physical workload also decreased significantly (Coeff=-0.032±.002), particularly in the blue-collar group (Coeff=-0.050±.004), and in the oldest group. Fatigue decreased, and sleep problems increased with aging, but with similar slopes in the occupational groups. All effect sizes were small, but extrapolation suggests substantial decreases across a working life career.

Conclusions:

The decrease in psychosocial work demands and physical workload suggests that the burden of work becomes somewhat lighter over 8 years. The mechanism could be "pure" aging and/or increased experience, or related factors. The gradual improvement in the work situation should be considered in the discussion of the place of older individuals in

the labor market, and of a suitable age for retirement. The results also mean that prospective studies of work and health need to consider the improvement in working life with aging.

Key words: work demands, stress, physical workload, fatigue, sleep, aging, occupational group

Strength and limitations of this study

• A strength of this study is the longitudinal approach and relatively large sample size

• A limitation is the subjective nature of the data, although both main variables are, by nature, subjective

• Another limitation is that we can not determine the mechanism behind the decreases with aging

• A third limitation is that generalization is difficult beyond the North-Western European labor market

1. INTRODUCTION

Psychosocial work demands are a central factor in research on occupational stress,[1 ,2] that is associated with cardiovascular and other diseases.[3] It involves a need to work fast, to handle difficult tasks or to have too little time for one's tasks. There is also a prospective link between work demands and disturbed sleep,[4-7] and with fatigue.[8 ,9] Sleep problems, in turn, predict a high utilization of health care resources [10] and sickness absence.[11] Fatigue is associated with similar effects.[12-14] The link between psychosocial work demands and health, sleep, and fatigue is usually seen as a stress reaction with increased physiological and mental arousal due to attempts to handle the demands. [3]

Considering the increasing proportion of elderly in society it is an interesting question whether psychosocial work demands increase or decrease with aging. There are no previous studies on this issue, but there is a need to provide knowledge for the discussion of working life sustainability, and the feasibility of a later retirement age. For lack of empirical data one might entertain two hypotheses. Thus, one might assume that aging may lead to more responsibility and, thus, a higher load of psychosocial work demands. Also the opposite could be true, since aging is associated with increased experience, which could increase the capacity to handle demands. The latter may well be perceived as a reduction of demands.

If there are changes in psychosocial work demands with aging, the patterns are likely to be different for blue and white-collar workers. The demands are higher among white-collar workers and one may speculate that changes with time might be larger in that group. [15 ,16]

Since psychosocial work demands are linked to (poor) sleep and to fatigue, one might expect these variables to reflect changes in work demands, that is, trajectories across aging should be correlated. There are no such data available, but we have seen that fatigue actually decreases with aging, whereas sleep problems increase moderately.[17] One would also expect trajectories of sleep and fatigue to reflect any differences in trajectories in psychosocial work demands between occupational groups.

Another work related factor that should be considered in connection with psychosocial work demands is physical workload. It is particularly associated with musculoskeletal pain, [18 ,19] but also with cardiovascular disease,[20 ,21] as well as with fatigue.[22] It is, for obvious reasons highest in blue-collar workers. As to effects of aging, the reasoning is similar to that for psychosocial work demands, but no longitudinal studies are available. With respect to sleep, one study failed to find a longitudinal association between physical work demands and sleep, [7] but very little work has been done in this area. Fatigue, in contrast, is well established as an outcome of physical workload. [23]. One would expect that the trajectories of the two variables are correlated, and that any differences between occupational groups in physical workload would be reflected in corresponding differences in fatigue.

The purpose of the present study was to investigate whether work demands and physical workload change across eight years, whether occupational groups show different trajectories of change, and if such trajectories are reflected in trajectories of sleep or fatigue. Specific hypotheses are difficult to develop since aging involves reduced physical and cognitive work capacity, [24] [25] that should be linked to a perception of increased demands or workload, while increased work experience and career changes may be counterforces.

METHODS

Design and participants

The study was based on the Swedish Longitudinal Occupational Survey of Health, SLOSH. It is a nationally representative longitudinal cohort survey of at entry (T0) gainfully employed individuals in the age range of 16–64 years, from the entire country, stratified by county, sex and citizenship. [26] Participants have been followed up by postal questionnaires every two years, since 2006. This survey has its origins in the Swedish Work Environment Survey (SWES, www.scb.se), which, in turn, is based on nationally representative samples of the working population. In the present paper we use data from waves 1-5 (T1-T5), including only individuals employed at the start of follow-up (T1), and with available information on occupational group (from T2). This resulted in 5377 participants.

The sample at T1 contained 43.2% males; 33.9% 18-42 year olds, 42.1% 43-56 year olds, and 24.1 % 57-68 year olds; 55.3% married; 53.4% with children (living at home);

80.2% in very or rather good health. Mean age ± SD was 47.6±11.6 years; 3.5% were not working. The latter were removed from the analyses.

Variables

Information regarding gender, age and occupational category (blue-collar worker, white-collar workers, and managers), were derived from self-report at T2. The occupational categories are based on the Statistics Sweden official classification of occupations (SSYK) to produce the categories blue-collar workers (BCW), lower white collar workers (LWC) and professionals and managers (HWC - high white-collar workers). The N for the three groups was 2163, 2226, and 988, respectively.

Work demands were measured using the Swedish version of the Demand-Control-Support Questionnaire.[1] This scale has been extensively psychometrically investigated, [2 ,27] and used to predict health outcomes of psychosocial work factors.[28 ,29] The five items used were: "Do you have to work very intensively?" "Does your work demand too much effort?" "Do you have enough time to do everything?" (reverse coded), "Do you have to work very fast?" and "Does your work often involve conflicting demands?". The response alternatives ranged from 1: Hardly ever/never, to 4: Yes, often (scaled reversed from the original 4-1). Cronbach's α was 0.67 at T3.

Four items representing disturbed sleep were selected from the Karolinska Sleep Questionnaire (KSQ) (Cronbach's alpha > 0.70).[5 ,30-32] The scale differentiates patients with insomnia from healthy individuals [31], and correlates with perceived stress, anxiety, depression and burnout (r >.40).[32] The items included are: difficulties

falling asleep, restless sleep, repeated awakenings, and premature awakening. The responses range from "never" to "most days of the week" (1-6). Cronbach's alpha was 0.84 at time T3, and the correlation between time points was r = .71.

Ratings of fatigue were obtained from a single item phrased as "to what extent have you been suffering from sluggishness or lack of energy", with response alternatives from 1 (not at all) to 5 (very much). It is significantly correlated (r = 0.60, p<.001) with persistent fatigue and mental fatigue (r=0.57, p<.001) at T3.

Physical workload was measured as an index of three questions: "Is your work such that you have to use bent, twisted or otherwise unsuitable positions?" "Do you have to lift at least 15 kilos several times a day?" "Does your work sometimes involve heavy physical labor, that is, do you physically exert yourself more than when walking and standing and moving around in a normal way?". Response alternatives ranged from 1: No, not at all, to 6: Almost all the time. Cronbach's α was 0.89 for at T1, and the test-retest reliability between T1 and T2 was r = .85.

Statistical analysis

To describe the mean trajectories of the outcomes over time (waves T1 – T5) for different occupational groups we used mixed-effects linear regression models.[33] Regression models included occupational group (level-2 variable), individual (across time) (level-1 variable) and their two interaction (product) terms as fixed effects. Moreover, they included subject-specific random intercept and time slope to account for potential dependence among repeated values of the outcome variables over time. The

analyses were adjusted for gender and age (level-2 variables). The overall difference in the slopes over time across the three occupational groups was assessed with a joint Wald test with 2 degrees of freedom on the 2 interaction terms. Waves when an individual was not employed were not used in the analyses. Effect size was computed as the coefficient of the slope divided by the within-subject standard deviation, as suggested in https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3743548/#FD8

-In a second analysis, the subject-specific time slopes for work demands and physical workload were used as predictors for the other outcomes. More specifically, we first modeled work demands and physical workload using 2 mixed-effects linear regression models. These models included time as fixed effect with random intercept and slope. We then calculated subject-specific slopes by adding to the fixed-effects time coefficient the subject-specific best linear unbiased predictions (BLUPs) of the random slope. Finally, we used the subject-specific slopes as a fixed-effect in a separate mixed-effects linear regression model, adjusted for age and gender, with random intercept and random time slope.

In a third analysis, we described the age group–specific mean trajectories of the outcomes over time. This was done in an analogous fashion to what we described for the main analysis. Age groups were defined as: 18-42, 43-56, and 57-68 years of age. This was also repeated with stratification within each occupational group.

Patient and public involvement statement

Patients were not involved in the present study

Results

The mean values and standard deviation at T1 for the four main variables were: 2.67±.58 for psychosocial work demands, 2.38±1.56 for physical workload, 2.47±1.06 for sleep problems, and 2.26±1.09 for fatigue. Medians for the four variables were: 2.75, 1.67, 2,25, and 2.00, respectively.

Figure 1 and Table 1 show the effects of aging on self reported work demands. The decrease across time was significant for the total sample, and for each group separately. For reference, the decrease in the total sample, represented by the coefficient -0.016, corresponds to a change of -0.08 units on the 1-4 unit scale across 8 years. The interaction between the occupational groups was highly significant, that is, the three groups showed different slopes over time, with the largest slope (and effect size) for HWC, for which the coefficient -0.031 corresponds to -0.15 units on a 1-6 point scale across 8 years.

In addition, BCW showed (at T3) lower demands than HWC (0.06±.02,, Z=3.2, p=.000), but LWC did not (-0.03±.02, Z=1.5, p=.147). Women showed higher values (higher demands) than men (0.05±01, Z=3.5, p=.000). The oldest group showed significantly lower work demands (0.14±.02, Z=7.8, p=.000) than the youngest group, but the intermediate group did not (0.02±.01, Z= 1.4, p=.147).

Figure 1 shows the effects of aging on physical workload in the three occupational groups. Table 1 shows that the decrease in workload was significant for the total sample. The coefficient for the total sample (-0.033) corresponds to a decrease of -0.16 units (scale=1-6) across the 8 years. The interaction between groups was highly significant, with the largest coefficient (and effect size) for BCW (-0.05 units across the 5 waves), corresponding to a decrease of 0.25 units across the 8 years.

BCW showed (at T3) a significantly higher physical workload than HWC (1.948±.044, Z=44.5, p=.000), which also LWC did (0.521±.044, Z=11.9, p=.000). Women showed higher physical workload than men 0.145±.032, Z=4.6, p=.000). The oldest group showed significantly lower physical load (0.115±.041, Z=2.8, p=.006) than the youngest group.

Figure 1 shows the effect of aging on fatigue in the three occupational groups. Table 1 shows that the reduction in fatigue was significant for the total group and each occupational group. The interaction was not significant and the level between groups did not differ significantly. However, at T3 women had a significantly higher level of fatigue (0.25±.02, Z=10.4, p=.000). In addition, older individuals showed significantly less fatigue (-0.37±.03, Z=11.7, p=.000) than the young group. The intermediate age group also showed lower fatigue (-0.16±.03, Z=5.9, p=.000}.

Figure 1 shows the effects of aging on sleep problems in the three occupational groups. Table 1 shows that the increase in sleep problems was significant for the total group, as well as in all three occupational groups. The interaction was not significant and the level between groups did not differ significantly. At T3 Women reported more sleep problems

than men (0.28±.03, Z=10.8, p=.000). The oldest individuals reported more sleep problems than the young (0.07±.03, Z=2.17, p=.03); as did the intermediate group 0.17±.03 (Z=5.9, p=.000).

As a sensitivity analysis we repeated the previous analyses for those participants who had complete data for all five waves (N=1888). The results were very similar to the previous results. The only difference was that the significant decrease in work demands for blue collar workers (p<.05) and the significant decrease in fatigue for high white-collar workers (p<.05) did not remain significant.

Figure 1

Table 1. Slopes of the different occupational groups for each variable. Coefficients of slope, standard error, Z-value, p-value. Chi2 value for interaction, and effect sizes. N=5377

Occup groups	Coeff±se	Z Chi2	Eff size		Coeff±se	Z Chi2	Eff size
	Work demands	.			**Physical workload**		
All	-0.016±.001	12.2[c]	.043		-0.033±.002	14.3[c]	.057
HWC	-0.031±.003	10.6[c]	.084		-0.008±.005	1.7	.014
LWC	-0.029±.002	9.4[c]	.078		-0.019±.003	5.5[c]	.033
BCW	-0.005±.002	2.5[a]	.014		-0.050±.004	16.3[c]	.087
Interaction Chi2		53.5[c]				94.0[c]	
	Fatigue_rec				**Sleep problems**		
All,	-0.018±.002	7.5[c]	.022		0.020±.002	9.4[c]	.033
HWC	-0.014±.005	2.6[a]	.017		0.019±.005	4.2[a]	.032
LWC	-0,022±,004	5.9[c]	.027		0.017±.003	5.2[c]	.028
BCW	-0.016±.004	4.1[a]	.020		0.023±.003	6.8[c]	.038
Interaction Chi2		1.9				2.0	

Results are adjusted for age and gender. HWC=high white-collar workers, LWC=low white-collar workers, BCW=Blue collar workers. a=p<.05, b=p<.01, c=p<.001

To test the direct association of changes between work demands and the other variables we used a mixed model regression and computed the relation between the individual slopes in work demands and in the other variables. Table 2 shows significant positive regression coefficients for all analyses. Note that the regression is computed between

subject-specific *slopes*. Thus, the positive regression coefficient between psychosocial work demands and sleep problems means that steep decreases in work demands (constituting negative values of the slope for that variable) are associated with decreases, or low increases, in sleep problems (low values of the slope for that variable). Positive regression coefficients were seen also between physical workload and fatigue.

Table 2. The regression of the slopes of work demands and physical workload vs the slopes of fatigue and sleep problems. Mixed model regression

Work demand slope vs slope of:	**Work demands vs Coeff±se**	**Z**	**p**	**Physical workload vs Coeff±se**	**Z**	**p**
Phys workolad	0.204±.031	6.5	.000			
Fatigue	0.106±.010	10.9	.000	0.010±.004	2.4	.018
Sleep problems	0.243±.022	11.1	.000	0.028±.010	2.9	.004

Adjusted for age and gender. Z=Z value, p=significance level. a=p<.05, b=p<.01, c=p<.001

Since there is a possibility that the change across time in the main analysis might be different in different age groups we also analyzed the trajectories within three age groups – 18-42 years, 42-56 years, and 57-68 years, adjusted for gender. Table 3 shows a strong interaction between work demands and age groups, with the largest decrease (and effect size) in the oldest group, although all three trajectories were significant. For physical workload, the trajectories of each age group was significant, but the interaction was not.

There was a similar pattern for fatigue and sleep problems. In both cases the interaction was significant. For fatigue the oldest group showed the strongest decrease (and effect size), whereas for sleep problems the youngest group showed the strongest increase (and effect size), while the oldest group showed a significant *decrease*. In all cases the decrease was largest in the oldest group. For sleep problems, the interaction between age groups was significant, but here the oldest group had the smallest decrease.

The same analysis subdivided on occupational group showed similar results. For work demands the interaction between time and age group was significant in all three occupational groups and the decrease strongest in the oldest group. For physical work demands no significant interactions were obtained. For fatigue the interaction was significant in the LWC and BWC groups, with the strongest decrease in the oldest group. For sleep problems all three occupational groups showed significant interactions, with the lowest increase in the oldest group.

Table 3. Trajectories across 8 years of work demands, physical Workload, fatigue, and sleep problems for 3 age groups for the full group and for each occupational group, adjusted for gender.

Age groups, All participants	**Coeff±se**	**Z Chi2**	**Effect size**	**Coeff±se**	**Z Chi2**	**Effect size**
	Work demands			**Physical workload**		
18-42 yrs	-0.006±.002	3.0[b]	.016	-0.038±.004	9.6[c]	.063
43-56 yrs	-0.017±.002	9.1[c]	.048	-0.033±.003	10.2[c]	.053
57-68 yrs	-0.039±.004	10.6[a]	.105	-0.028±.006	5.1[c]	.048
Interaction Chi2		61.1[c]			1.9	
	Fatigue			**Sleep problems**		
18-42 yrs	-0.014±.004	3.3[c]	.025	0.028±.003	8.0[c]	.044
43-56 yrs	-0.014±.003	4.0[c]	.018	0.023±.003	7.7[c]	.039
57-68 yrs	-0.044±.006	7.7[c]	.059	-0.011±.005	2.3[a]	.019
Interaction Chi2		20.3[c]			39.5[c]	
	Work demands			**Physical workload**		
HWC						
Age groups						
18-42 yrs	-0.018±.004	4.9[c]	.050	-0.012±.004	3.0[b]	.039
43-56 yrs	-0.033±.003	7.8[c]	.091	-0.007±.003	2.4[b]	.027
57-68 yrs	-0.055±.008	6.6[c]	.146	-0.003±.006	0.4	.009
Interaction Chi2		19.5c			2.1	
LWC						
Age groups						
18-42 yrs	-0.006±.003	1.7	.002	-0.023±.006	4.1[c]	.043
43-56 yrs	-0.021±.003	7.7[c]	.058	-0.018±.005	3.9[c]	.038
57-68 yrs	-0.040±.005	7.4[c]	.107	-0.019±.008	2.5[a]	.040
Interaction Chi2		33.3[c]			0.7	
BCW						
Age groups						
18-42 yrs	-0.001±.003	0.3	.003	-0.065±.008	8.0[c]	.006
43-56 yrs	-0.004±.003	1.3	.012	-0.058±.006	9.1[c]	.080
57-68 yrs	-0.024±.006	4.1[c]	.066	-0.051±.013	3.9[c]	.066

Interaction Chi2		11.9[c]			1.0	
	Fatigue			**Sleep problems**		
HWC						
Age group						
18-42 yrs	-0.017±.009	1.9	.019	0.017±.007	2.4[c]	.028
43-56 yrs	-0.008±.007	1.0	.010	0.029±.007	4.1[c]	.054
57-68 yrs	-0.025±.012	2.1[a]	.034	-0.025±.012	2.1	.006
Interaction Chi2		1.5			6.2[a]	
LWC						
Age groups						
18-42 yrs	-0.016±.007	2.4[a]	.018	0.027±.005	5.1[c]	.041
43-56 yrs	-0.017±.006	3.0[b]	.022	0.020±.005	4.3[c]	.033
57-68 yrs	-0.051±.009	5.7[c]	.087	-0.015±.007	2.0[a]	.026
Interaction Chi2		10.6[b]			20.6[c]	
BCW						
Age groups						
18-42 yrs	-0.009±.007	1.4	.011	0.033±.006	5.7[c]	.053
43-56 yrs	-0.014±.005	2.5[a]	.018	0.024±.005	5.8[c]	.038
57-68 yrs	-0.047±.010	4.0[c]	.063	-0.012±.008	1.4	.021
Interaction Chi2		10.6[b]			16.4[c]	

HWC=high white collar workers, LWC=low white collar workers, BCW=Blue collar workers
a=p<.05, b=p<.01, c=p<.001

Discussion

Work demands decreased significantly within individuals over time in all three occupational groups, but also the interaction was highly significant. The steepest decrease was seen in HWC. The latter group also showed the overall highest level of work demands. Physical workload showed a decrease for the BCW and LWC groups and a significant interaction across occupational groups, with BCW showing the highest mean level. The changes in both variables were strongest in the oldest group. Sleep problems increased and fatigue decreased in all three occupational groups, but there was no interaction between groups. There was also a significant association between the decreased work demands and sleep and fatigue variables. For physical workload the associations were weaker.

The effect size of the decrease in psychosocial work demands is relatively small. However, considering the change across a working life career of 40 years, the decrease corresponds to a reduction of 0.4 units for the total group, and 0.75 for HWC. This represents 2/3 of the standard deviation of the present sample. The implications of such a change are not straightforward to evaluate since most studies of psychosocial work demands seldom report scale values in relation to health. They rather present results after dichotomization of scale values into high and low demands. The dichotomization is usually made at the median or highest quartile to identify "high" demands. However, in a study of psychosocial work demands and musculoskeletal problems scale values were presented (mean±SD = 2.42±.54 units) with a cut-off for high demands at the 67th percentile = 3.04 units, and with intermediate level (median) cut-off at 2.40 units. Thus, using our results, a person at an intermediate level of demands (≈2.72) would be expected to change into the low demand category (at 2.32 units) from the beginning to the end of working life, as long as the extrapolation of the eight-years coefficients may be assumed to be linear. WCW would be expected to change about twice as much. Thus, it seems that the decrease in psychosocial work demands with age/experience should have practical implications, particularly for high white-collar workers.

The improvement in work demands across time should be a positive finding for individuals in situations with high psychosocial work demands. The results should have implications for discussions of a sustainable working life and of a reasonable retirement age. In addition, the results have implications for the interpretation of results of prospective research studies, since a long follow-up time would mean a lower exposure to work demands across time, leading to a likely attenuation of the effects of high work demand levels on later disease outcomes.

We are not able to determine the reason for the decrease in work demands, but it is likely that increased experience with aging makes the individual more competent at handling work tasks. Aging was also associated with reduction in fatigue, which might contribute. It is also likely that the possibility to step down increases with increasing age, and career motives may become less salient; both may reduce perceived psychosocial work demands. The suggested causes discussed here clearly need increased research efforts.

The difference in steepness in the decrease of work demands in the three occupational groups could possibly be interpreted as differences in the positive effects of work experience. Professional groups and managers usually have more complex work tasks for which experience may have more dramatic effects on mastery than what may be the cases for blue-collar workers. In addition, professional groups may have better possibilities to step down from responsibilities than workers. Again, these notions need further research.

The decrease in physical workload also seems to be a new finding, and we lack data to compare with. Even if the effect size was modest, one might, again, consider the size of the decrease across 40 years of work, which amounts to approximately 0.8 units, if linear extrapolation is permissible. One might compare this with results from a study using the same items for physical load to predict lower back pain [34]. This study set values of 1-3 as "no exposure", 4 as intermediate, and 5+6 as high exposure (with significant prediction of back pain for both exposed groups). A decrease of 0.8 units across a working life career would then bring many highly exposed individuals into the

intermediate exposure category, and those with intermediate exposure into the unexposed category. Thus, the estimated reduction in physical workload across a working life career appears considerable.

The difference in steepness in the decrease of physical workload in the three occupational groups probably partly reflects the fact that most white-collar workers have low levels of physical workload from the start. As with the decrease in psychosocial work demands in HWC, one could speculate that experience may increase the physical capacity and perhaps the skill to handle physical workload in BCW. One might also conceive of experience leading to a move to work tasks with less physical load. These lines of reasoning are speculation, however, and there is a need for studies on how age itself, experience at work, move to another job, improvement in work tasks, and similar factors lead to a perception of a reduced physical workload. Note that the coefficient for BCW is approximately 50% larger than that of the total group. This suggests that the decrease across a working life career should have implications for the ability to sustain a long working life for blue-collar workers.

As expected, the individual slopes of the decrease in work demands were associated with a decrease in fatigue, as well as a lower increase in sleep problems (or even a decrease). This is in line with the day-to-day association between the three variables in a diary study across 42 days,[35] and strengthens the notion of a link between work demands and sleep quality, as well as with fatigue.

The similar slope of sleep problems and fatigue for all occupational groups failed to reflect the different trajectories for psychosocial work demands and physical workload

for those groups. This was unexpected, particularly since at least psychosocial work demands have been linked to fatigue and sleep problems in previous studies,[17 ,36], and since the present data (table 2) shows clear associations between work demands and sleep problems on the individual level.

The age-related difference in trajectories of the decrease in work demands does not have an obvious explanation. All participants were still employed at the last point of measurement, so formal retirement does not seem to be implicated as a cause. However, work hours could have been reduced, which is in line with the decrease being largest in the oldest group, and reduced work hours are associated with reduced demands.[37] We lack specific information on work hours in the present study, however. The fact that the reduction of psychosocial work demands in the present study was significant also in the middle age group suggests that reduced work hours should not have been the only cause, since part-time work is unusual in that group. This is also supported by the significant decrease also in the youngest group. Another, probably important, factor should be the effect of experience on the ability to handle work demands, and possibly, also the effect of promotion to positions with more control over the work situation. Furthermore, loss of, particularly physical work capacity, might result in transfer to less demanding work tasks. However, the present study did not contain variables that make it possible to judge effects of increased experience, promotion or change of work tasks.

The reduction of fatigue with time agrees with findings of lower fatigue in older individuals.[38] The observation that the effect was largest in the oldest group is a new observation, but the mechanism may be the same as discussed for work demands above. Sleep problems showed a similar trajectory as fatigue, although here the oldest group

lacked the impairment over time over time that the younger groups had. Previous work has consistently found sleep problems to increase with age, but there is no previous data on the lack of increase in sleep problems in older individuals across time, except for our own previous study on the same material.[17] The same factors as discussed above may be invoked also in this case, but there may also be effects of biological aging..

The decrease of psychosocial work demands and physical workload across time leaves a positive impression of the aging process in working life. Work appears to become easier with time. The observation that the effect is largest in the oldest groups indicates that from this point of view working life is sustainable. It also indicates that a temporal extension of working life could well be acceptable to many individuals, at least those still in good health. This is further accentuated by the reduction of fatigue with time. It is an interesting question for future work to determine if the observed improvement in psychosocial work demands and physical workload also leads to improved productivity.

There are some limitations to the present study. Firstly, all data are subjective, but this is difficult to avoid since objective measures of the variables is difficult with > 5000 participants. Another limitation is that there was a substantial loss of participants across time, possibly indicating a healthy worker effect. However, an analysis of the completers did not change the results appreciably. Among the drop-outs there are probably individuals who died. This would have been interesting information to analyze, but unfortunately we did not have access to such data. With the present analysis we cannot draw any conclusions regarding causation, but that was not the purpose of the study. Rather, the purpose was to study whether aging or time at work would affect work demands, and that steered the analysis towards the approach of evaluating slopes

over time. The strength of the study is the longitudinal approach, which makes it possible to evaluate the effects of time.

Conclusion:

The results indicate that psychosocial work demands and physical workload decrease with time, which may have implications for discussions of a sustainable working life and of a temporal extension of working life. The study has some limitations and there is need for replication in studies with objective measures.

The Regional Research Ethics Board in Stockholm approved this study.

A.TÅ defined the research question, designed the study and wrote the draft. AD analyzed the data and commented on the manuscript. HW provided the cohort and commented on the manuscript. HH provided statistical advice and commented on the manuscript.

B.No conflicts of interest have been reported.

C.This work was supported by the AFA Insurance Company.

D.A strategy for data access has been developed, which strives to make SLOSH data as accessible as possible while satisfying legal requirements and ethical principles as well as protecting the personal privacy of the participants. Requests for data for specific research projects or collaborations can be addressed to [data@slosh.se].

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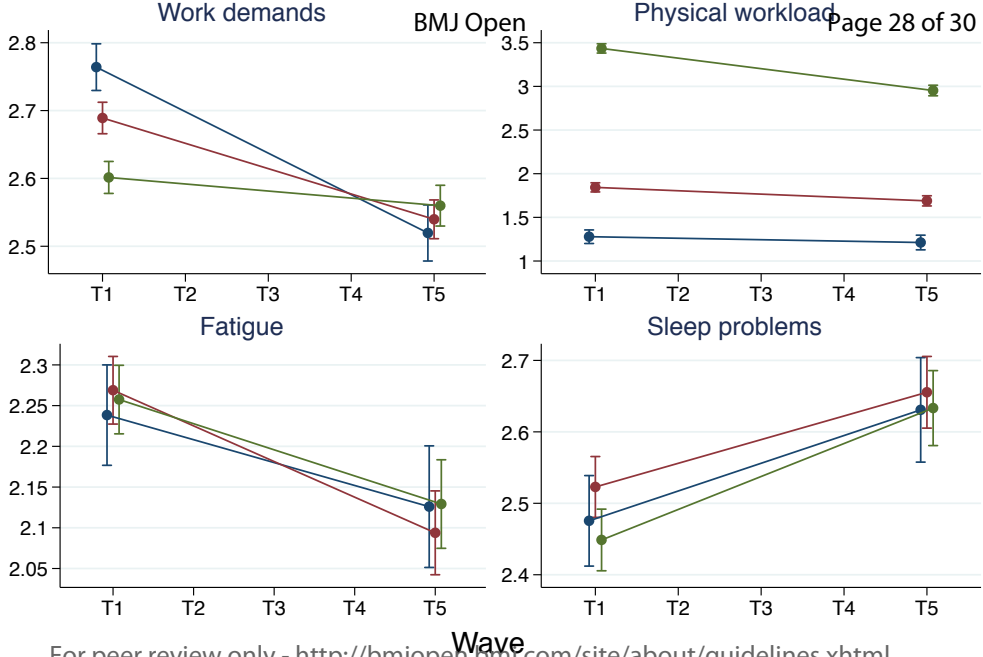
Figure legends

Figure 1. Trajectories of work demands, physical workload, sleep quality, fatigue, sleep duration weekdays, and sleep duration weekends in three occupational groups. Mean predicted outcomes at T1 and T5, marginalized over the age and gender distribution at T1



STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
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
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) If applicable, explain how loss to follow-up was addressed
		(*e*) Describe any sensitivity analyses
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
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) Summarise follow-up time (eg, average and total amount)
Outcome data	15*	Report numbers of outcome events or summary measures over time
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
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
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

*Give information separately for exposed and unexposed groups.

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 http://www.strobe-statement.org.