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ORIGINAL ARTICLE

Is fatigue after work a barrier for leisure-time physical activity? Cross-sectional study among 10,000 adults from the general working population

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Abstract

Aim: In spite of the many health-related benefits of regular physical activity, fatiguing work may be a barrier to performing leisure-time physical activity. This study investigates the association between work-related fatigue and the duration of low- and high-intensity leisure-time physical activity in workers with sedentary and physically demanding jobs. *Methods:* From the 2010 round of the Danish Work Environment Cohort Study, currently employed wage earners from the general working population (N=10,427) replied to questions about work-related fatigue (predictor) and duration of low- and high-intensity leisure-time physical activity (outcome). Associations were modelled using general linear models controlling for various confounders. *Results:* Among workers with physically demanding jobs, higher levels of work-related fatigue were associated with gradually lower levels of leisure-time physical activity – for low, moderate and high levels of work-related fatigue the duration of high-intensity leisure-time physical activity was 133 (95% confidence interval (CI) 127–178), 134 (95% CI 109–160) and 113 (95% CI 86–140) min per week, respectively (trend test p<0.001). The duration of high-intensity leisure-time physical activity was lower among older workers (≥50 years) compared to younger workers (<50 years) (132 ± 126 vs 168 ± 150 min per week) (p<0.0001). ***Conclusions:*** **The duration of high-intensity leisure-time physical activity gradually decreases with increased work-related fatigue in workers with physically demanding jobs. Older workers perform less high-intensity physical activity than younger workers. Workplaces should consider initiatives to allow workers with physically demanding jobs and older workers to perform physical exercise during working hours and thereby increase physical capacity to meet the job demands.**

Keywords: *Occupational Health, exercise, fatigue, muscle fatigue, mental fatigue, life style, epidemiology*

Background

The positive impact of leisure-time physical activity on general health and prevention of diseases is well documented [1–4]. The American College of Sports Medicine recommends adults to participate in moderate-intensity aerobic exercise ≥30 min daily 5 days per week, vigorous-intensity aerobic exercise ≥20 min 3 days per week, or to combine moderate- and vigorous-intensity aerobic exercise to reach a total energy expenditure of 500–1000 MET/min/week [1]. Additionally, adults should perform resistance training for improving muscular strength and exercises for improving balance, agility and coordination two to three times per week [1].

Besides improving general health and preventing diseases, physical activity during leisure may also reduce experienced work-related fatigue [5,6]. Work-related fatigue is a common experience among workers; for example, 38% of US workers

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reported being fatigued after work [7]. In terms of reducing both general fatigue and work-related fatigue by physical activity, studies have reported an association between higher levels of fatigue and reduced physical activity; a high level of physical activity, on the other hand, is associated with decreased fatigue [5,6,8]. Thus, while regular physical activity may be effective in preventing fatigue, work-related fatigue can also be a barrier to performing physical activity after work.

In comparison with sedentary jobs, physically demanding jobs require higher physical capacity to manage work demands. Consequently, high physical work demands are associated with higher levels of fatigue than sedentary work [9–11]. Workers with physically demanding jobs are also at increased risk of musculoskeletal disorders, premature exit from the labour market and sickness absence [12–15]. Health-related challenges associated with high physical work demands appear to increase with age [14,16]. Because physical capacity naturally decreases with ageing [15,17] while work demands may remain the same [15], older workers, especially with physically demanding jobs, may experience increased fatigue after work due to an imbalance between demands and capacity [14,15]. This underscores the importance of maintaining a high physical capacity among workers with physically demanding jobs to maintain good work ability and health throughout working life and especially among older workers. High physical capacity can be obtained by performing targeted physical activity in terms of aerobic and/or resistance training, and good work ability is associated in a dose-response fashion with high-intensity physical activity during leisure [18]. Paradoxically, work-related fatigue after physically demanding work may be a barrier to engage in moderate to vigorous physical activity in leisure-time [10]. This reduced leisure-time physical activity may therefore eventually contribute to decreased physical capacity resulting in increased work-related fatigue and hence increasing the risk of work-related injury, sickness absence and premature exit from the labour market [4,15].

Aims

The aim of this study was to investigate the association between work-related fatigue and duration of low- and high-intensity leisure-time physical activity in workers with sedentary and physically demanding jobs. We hypothesized that fatigue was negatively associated with the duration of low- and high-intensity leisure-time physical activity.

Methods

Study design

The present study is a cross-sectional study, where we used data from the 2010 round of the Danish Work Environment Cohort Study (DWECS) [19]. DWECS consists of questionnaires concerning work environment and health among the general working population in Denmark. The specific questions used for this study are specified below. The reporting of this study conforms to the guideline 'Strengthening the Reporting of Observational Studies in Epidemiology' (STROBE) [20].

Ethics

The study has been reported to and registered by Datatilsynet (the Danish Data Protection Agency; journal number 2007-54-0059). According to Danish law, questionnaires and register-based studies do not need approval by ethical and scientific committees, or informed consent [21]. All data were de-identified and analyzed anonymously.

Participants

The questionnaire used in the present study was sent to approximately 20,000 Danish workers; a total of 10,605 (approximately 53%) responded [18]. In this study, we included only currently employed wage earners (N=10,427), i.e. excluding self-employed people and people not affiliated with the labour market. Not all participants filled in all survey questions, whereas the exact number of participants for each analysis varies. Characteristics of the study population are reported in Table I.

Outcome variable

Leisure-time physical activity. The participant's leisure-time physical activity level was determined by asking the question, 'How much time did you on average spend on the following activities during the past year': (1) 'Walking, cycling or other low-intensity activity without being out of breath or sweaty (e.g. Sunday walks, light gardening, etc.)'; (2) 'Exercise sports, heavy gardening or fast walk/cycling, where you get out of breath and sweaty'; and (3) 'Vigorous exercise or competitive sports' [18].

The response options for each sub-question were: (1) '>4 h weekly'; (2) '2–4 h weekly'; (3) '<2 h weekly'; or (4) 'do not perform this activity'. For subsequent analyses, the first, second, third and fourth answers were recoded to be 5, 3, 1 or 0 h weekly for our subsequent analyses of duration of leisure-time

Table I. Demographics and lifestyle characteristics.

		Sedentary workers			Physical workers		
	Total	*N*	Mean (SD)	%	*N*	Mean (SD)	%
Age, years	10427	4744	44.2 (11.0)	46.9	5377	43.0 (12.2)	53.1
Gender							
Men	4762	2170		45.7	2451		45.6
Women	5665	2574		54.3	2926		54.4
BMI ($kg.m^{-2}$)							
Underweight	86	39		0.9	46		0.9
Normal	5319	2504		54.2	2665		51.2
Overweight	3399	1547		33.5	1767		33.9
Obese	1291	528		11.4	729		14.0
Smoking							
Yes	2356	846		18.2	1415		27.0
Ex-smoker	2916	1395		30.0	1456		27.8
No, never	4897	2408		51.8	2374		45.3

BMI: Body Mass Index.

physical activity [18]. Low-intensity leisure-time physical activity was defined as the number of hours spent on the activities from question 1, while high-intensity leisure-time physical activity was defined as the sum of hours spent on the activities from questions 2 and 3 (i.e. 0–10 h).

Explanatory variables

Physical activity at work. Participants were divided into either sedentary work or physically demanding work based on their answers to the following question: 'How will you describe your physical activity in your main profession?' [18]. Sedentary workers represent those who replied positive to the sub-question: 'Mostly sedentary work that does not require physical exertion'. Participants were allocated as having physically demanding work if they replied positive to one of the following three sub-questions regarding their physical activity in their profession: 'Mostly standing or walking work that otherwise does not require physical exertion', 'Standing or walking work with some lifting or bearing tasks', or 'Heavy or fast work, which is physically demanding'.

Work-related fatigue. To determine work-related fatigue, participants answered the following questions: 'How physically tired are you after a typical day at work in: (1) your body in general; (2) your back; (3) your neck/shoulder; (4) your arms/wrists; and (5) your lower limbs?' [22]. The response options were: (1) 'Not tired'; (2); 'A little tired'; (3) 'Somewhat tired'; (4) 'Very tired'; or (5) 'Completely exhausted'. A mean score of the five sub-questions was calculated for the exertion level of the participants. In the data analyses, answers 1 and 2 were grouped together as were answers 4 and 5, resulting in the following three answer groups used in the article: (1) 'Not tired'; (2) 'Somewhat tired'; or (3) 'Very tired'.

Control variables

The analyses were controlled for the following variables: gender (categorical), age (continuous), smoking status (categorical; 'No, never', 'Ex-smoker' and 'Yes'), body mass index (BMI, continuous), physical activity at work for those in the 'physical work' group (categorical; 'Mostly standing or walking work, that otherwise doesn't require physical exertion', 'Standing or walking work with some lifting or bearing tasks', or 'Heavy or fast work, that is physically demanding'), psychosocial work factors (continuous; emotional demands and influence at work) from the Copenhagen Psychosocial Questionnaire (COPSOQ) [23] and chronic disease (categorical). Chronic disease was determined from the question, 'Has a doctor ever told you that you have or have had one or more of the following diseases?' with the response options being 'Yes' and 'No, never' to the following diseases: Depression, asthma, diabetes (all types), cardiovascular disease, cancer and back disease. Health-related factors such as BMI, smoking and chronic disease may be associated with increased fatigue and lower amount of leisure-time physical activity [10,11,24]. Furthermore, gender, age, physical activity at work and psychosocial factors may also influence both fatigue and physical activity level [10,11,15,25,26].

Statistical analysis

All statistical analyses were performed using the SAS statistical software for Windows (SAS Institute, Cary,

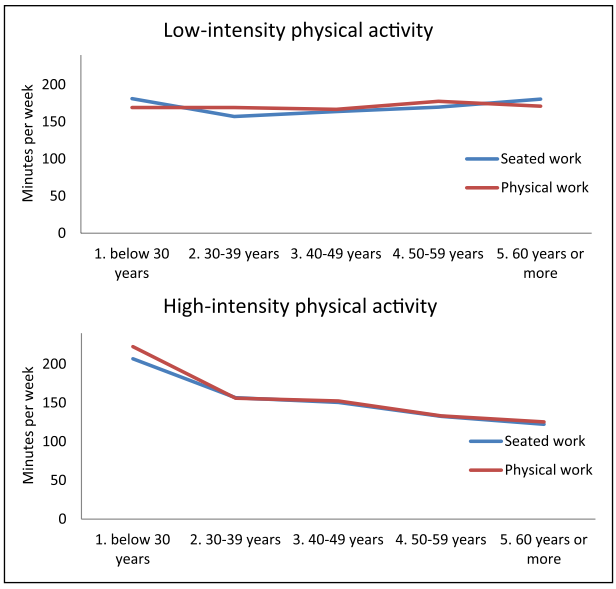

Figure 1. Illustration of the development in low- and high-intensity leisure-time physical activity with age among sedentary and physical workers.

NC). Using the general linear models procedure, we estimated the association between leisure physical activity (dependent continuous variable) and perceived exertion at work (independent variable) for workers with physically demanding and sedentary job-tasks, respectively. Analyses were performed stratified for work type (sedentary and physical) and additionally for workers <50 years and ≥50 years in both sedentary and physical work. All analyses were adjusted for the control variables mentioned above. Additionally, differences in the volume of leisure-time physical activity in younger and older workers were analyzed using an unpaired Student's *t*-test. An alpha level of <0.05 was accepted as statistically significant. Results are reported as least square means and differences of least square means (95% confidence limits) unless otherwise stated.

Results

Table I illustrates that the percentage of workers doing sedentary and physical work was 46.9 and 53.1%, respectively. An additional finding in the present study was that older workers performed more low-intensity leisure-time physical activity compared with younger workers (174 ± 102 vs 168 ± 102 min per week) (p<0.001). However, the duration of high-intensity leisure-time physical activity was lower among older workers compared with their younger counterparts (132 ± 126 vs 168 ± 150 min per week) (p<0.0001). The development in low- and high-intensity leisure-time physical activity with ageing (in 10-year intervals) among sedentary and physical workers is visually presented in Figure 1. Low-intensity physical activity does not seem to change with age neither among sedentary nor physical workers. High-intensity physical activity seems to decrease equally in sedentary and physical workers.

Work-related fatigue and low-intensity leisure-time physical activity

No association was observed between the level of work-related fatigue and low-intensity physical activity in sedentary workers, neither overall nor stratified for age (Table II). In workers with physically demanding jobs, workers reporting 'Somewhat tired' after a day at work performed less low-intensity leisure-time physical activity, with a difference of −8 min per week (95% confidence interval (CI) −16 to −1) from those reporting 'Not tired'.

Work-related fatigue and high-intensity leisure-time physical activity

In sedentary workers, those reporting 'Somewhat tired' after work performed less high-intensity leisure-time physical activity than 'Not tired' workers, with a difference of −20 mins per week (95% CI −33 to −7) (Table III). Stratified to sedentary workers <50 years, workers reporting 'Somewhat tired' performed less high-intensity leisure-time physical activity, with a difference of −26 mins per week (95% CI −44 to −8) from 'Not tired'.

In workers with physically demanding jobs at all ages, workers reporting 'Somewhat tired' performed less high-intensity leisure-time physical activity than 'Not tired' workers, with a difference of −19 min per week (95% CI −29 to −8). Furthermore, 'Very tired' workers with physically demanding jobs performed less high-intensity physical activity, with a difference of −40 min per week (95% CI −56 to −23) from 'Not tired'. The same pattern was observed in workers with physically demanding jobs, both in those <50 years and ≥50 years. Workers <50 years reporting 'Somewhat tired' after work performed less high-intensity leisure-time physical activity than those reporting 'Not tired', with a difference of −16 min per week (95% CI −31 to −2). Workers <50 years reporting 'Very tired' performed less high-intensity physical activity compared with 'Not tired', with a difference of −50 min per week (95% CI −74 to −27). Furthermore, workers with physically demanding jobs ≥50 years reporting 'Somewhat tired' performed less high-intensity physical activity compared with workers reporting 'Not tired', with a difference of −21 min per week (95% CI −36 to −6). In workers

Table II. Amount of low-intensity physical activity during leisure (minutes per week) among workers with sedentary and physical work, respectively.

Age group	Fatigue after work	*N*	%	Sedentary work		*N*	%	Physical work	
				Lsmeans (95% CI)	Diff.			Lsmeans (95% CI)	Diff.
All	Not tired	3965	84.1	162 (143–181)		3259	61.1	168 (149–186)	
	Somewhat tired	660	14.0	160 (139–180)	−2 (−12 to 7)	1554	29.1	160 (141–178)	**−8 (−16 to −1)**
	Very tired	92	2.0	175 (144–205)	13 (−12 to 38)	522	9.8	159 (139–178)	−9 (−21 to 3)
<50 yrs	Not tired	2645	86.2	171 (142–200)		2233	64.5	155 (126–183)	
	Somewhat tired	372	12.1	171 (140–202)	0 (−13 to 13)	922	26.7	150 (122–178)	−5 (−15 to 5)
	Very tired	50	1.6	181 (135–227)	10 (−29 to 48)	305	8.8	146 (116–176)	−9 (−25 to 7)
≥50 yrs	Not tired	1320	80.0	158 (131–186)		1026	54.7	174 (147–201)	
	Somewhat tired	288	17.5	155 (125–184)	−4 (−18 to 11)	632	33.7	162 (135–189)	−12 (−24 to 0)
	Very tired	42	2.6	168 (126–211)	10 (−24 to 44)	217	11.6	166 (137–195)	−8 (−27 to 10)

Lsmeans: least square means; yrs: years. Significant differences from reference (Not tired) are marked in bold.

Table III. Amount of high-intensity physical activity during leisure (minutes per week) among workers with sedentary and physical work, respectively.

Age group	Fatigue after work	*N*	%	Sedentary work		*N*	%	Physical work	
				Lsmeans (95% CI)	Diff.			Lsmeans (95% CI)	Diff.
All	Not tired	3965	84.1	140 (114–166)		3259	61.1	153 (127–178)	
	Somewhat tired	660	14.0	120 (92–147)	**−20 (−33 to −7)**	1554	29.1	134 (109–160)	**−19 (−29 to −8)**
	Very tired	92	2.0	132 (91–172)	−8 (−42 to 25)	522	9.8	113 (86–140)	**−40 (−56 to −23)**
< 50 yrs	Not tired	2645	86.2	159 (119–200)		2233	64.5	165 (125–206)	
	Somewhat tired	372	12.1	133 (90–177)	**−26 (−44 to −8)**	922	26.7	149 (109–189)	**−16 (−31 to −2)**
	Very tired	50	1.6	161 (97–225)	1 (−51 to 54)	305	8.8	115 (72–158)	**−50 (−74 to −27)**
≥50 yrs	Not tired	1320	80.0	113 (79–147)		1026	54.7	116 (81–151)	
	Somewhat tired	288	17.5	99 (63–135)	−14 (−32 to 4)	632	33.7	95 (60–130)	**−21 (−36 to −6)**
	Very tired	42	2.6	101 (49–153)	−12 (−54 to 30)	217	11.6	90 (53–127)	**−26 (−49 to −3)**

Lsmeans: least square means; yrs: years. Significant differences from reference (Not tired) are marked in bold.

≥50 years reporting 'Very tired' after work, the level of high-intensity leisure-time physical activity was also lower compared with those reporting 'Not tired', with a difference of −26 min per week (95% CI −49 to −3).

Discussion

The main finding of the present study is that the duration of high-intensity leisure-time physical activity gradually decreases with increased work-related fatigue in workers with physically demanding jobs. Furthermore, the level of high-intensity leisure-time physical activity is lower among older workers (≥50 years) compared with younger workers (<50 years).

Low-intensity leisure-time physical activity

In contrast to our hypothesis, there was no important association between work-related fatigue and the level of low-intensity leisure-time physical activity in workers with physically demanding jobs. We only observed an association between work-related fatigue and the level of low-intensity leisure-time physical activity among all workers with physically demanding jobs reporting 'Somewhat tired' after work (Table II). Previous studies have reported no health effect of low-intensity physical activity intervention on, for example, sickness absence in women with physically demanding jobs [27,28]. Furthermore, Calatayud et al. (2015) did not observe any association between the amount of low-intensity leisure-time physical activity and work ability among workers with physically demanding jobs [18]. Thus, according to our results and previous studies, work-related fatigue does not seem to influence the level of low-intensity physical activity during leisure. Because low-intensity physical activity can also have health benefits, workers that are too fatigued to perform high-intensity physical exercise after work may still benefit from, for example, walking. These results could be used to guide public

health recommendations for different working groups in society.

High-intensity leisure-time physical activity

Associations between work-related fatigue and high-intensity physical activity were only reported among sedentary workers being 'Somewhat tired'. Thus, sedentary workers feeling 'Very tired' after work were equally physically active as those not being tired. It can be speculated that those being very tired may use high-intensity physical activity in leisure-time to cope with a stressful job. In fact, high-intensity resistance training has shown beneficial effects on maximal muscle strength and muscular fatigue resistance in female office workers with trapezius myalgia, having lower strength capacity than their healthy colleagues [29]. Resistance training hence preserves beneficial effects on sedentary workers. Workplaces may therefore benefit from allowing workers to perform physical activity during working hours.

In line with our hypothesis, the present study shows that fatigue after a working day is associated with less high-intensity physical activity during leisure, especially among workers with physically demanding jobs. The present study elaborates on previous findings that workers with physically demanding jobs experience a higher level of work-related fatigue than sedentary workers [9–11]. Physically demanding jobs require higher physical capacity to manage work demands and are a risk factor for musculoskeletal disorders, premature exit from the labour market and increased sickness absence in older age [14,15]. Moreover, an association has previously been reported between increased duration of high-intensity leisure-time physical activity and work ability [18]. However, as implied by the present and previous findings, workers with physically demanding jobs may not have the necessary energy to perform high-intensity physical activity after work due to experienced fatigue [9–11]. This may lead to an unfortunate vicious circle, because especially workers with physical jobs need to maintain high physical fitness to manage work demands and attenuate fatigue, prevent injuries and illness, obtain increased work ability and hence prolong working life. Engaging in high-intensity physical activity has demonstrated beneficial effects on general health and even attenuate age-related declines in aerobic capacity [15]. Besides providing positive effects on general health, physical activity may also prevent diseases [1–4]. Furthermore, high-intensity physical activity has demonstrated positive effects on preventing work-related fatigue [5,6]. All of the above-mentioned factors state the importance of engaging in high-intensity physical activity for improving or maintaining general health, work ability and quality of life [30]. According to the mean duration of high-intensity leisure-time physical activity in the present study (Table III), all sub-groups on average conform to the American College of Sports Medicine's recommended activity level of ≥75 min per week of vigorous-intensity physical activity [1]. However, adults who are unwilling or unable to perform the recommended amount of physical activity may still benefit from participating in lower amounts of physical activity [1]. The health benefits elicited from physical activity increase in a dose–response fashion [1], underscoring the importance of participating in physical activity at a level one can manage. Hence, workplaces should provide opportunities for workers with physically demanding jobs to engage in high-intensity physical activity for obtaining general health and preventing diseases and work-related fatigue, for example, through workplace health promotion programmes.

High-intensity physical activity can be conducted as aerobic exercise and resistance training. Numerous physiological adaptations occur when performing (high-intensity) aerobic exercise, which enhance aerobic capacity [15]. Increasing aerobic capacity may lower the relative physical exertion during work, which may prevent work-related fatigue, injuries and sickness absence [15]. Furthermore, engaging in aerobic physical activity can attenuate age-related declines in aerobic capacity [15]. However, some decline in aerobic capacity with ageing seems inevitable, e.g. decreased maximal heart rate and peak rate of ventilation, which appears unaffected by training [15].

High-intensity resistance training increases muscular strength and mechanical muscle performance by increasing muscle size and neural drive [31]. Improving muscular strength will likely lighten work tasks, because the work will be performed at a lower relative strain. Previous studies have failed to demonstrate improvements on physical exertion through aerobic exercise [32,33], whereas resistance training appears to provide improvements in physical capacity and muscular fatigue resistance in workers [34,35]. Furthermore, performing as little as 20–30 min per week of workplace resistance training for 10 weeks has been shown to lower physical exertion during patient handling among nurses with physically demanding jobs [36]. In addition, performing heavy-resistance strength training until failure resulted in improved strength gains and time to fatigue (i.e. time until force decreased below 50% of maximum force) among workers with physically demanding jobs [34]. Ten weeks of strength training also improved muscle peak force during 100

consecutive maximal voluntary contractions of shoulder elevation in women with trapezius myalgia, indicating an improved muscular endurance [29]. Increased muscular strength and improved muscular fatigue resistance elicited from resistance training therefore seems highly relevant for workers with physical jobs to prevent or delay fatigue development during work and thereby sustain higher force production. Additionally, increased muscle strength and improved muscular fatigue resistance could attenuate the experience of work-related fatigue and may thereby prevent work-related injuries, premature exit from the labour market and deterioration of work ability. Moreover, resistance training can function as a countermeasure for age-related impairment on physical capacity [15,17]. Performing resistance training seems to elicit important beneficial effects by increasing muscle cross-sectional area and neuromuscular function resulting in increased muscle performance, even in very old individuals (>80 years) [17].

Thus, compelling evidence exists that high-intensity leisure-time physical activity, performed as aerobic and/or resistance exercise, can attenuate age-related decline in physical capacity, which may improve work capacity and prevent work-related fatigue [5,6,15,34]. Importantly, the same type of high-intensity physical activity can be offered through workplace health promotion programmes and thereby reach target groups that would otherwise perform this type of activity during leisure.

Leisure-time physical activity related to age

The population in Western societies is ageing and the retirement age is gradually increasing in many countries, which results in an increased proportion of older workers. With increased age, mechanical muscle performance declines due to age-related loss of spinal motor neurons and reduction in muscle fibre number and muscle fibre size resulting in reduced functional capacity during everyday tasks [17]. In spite of reduced physical capacity in increased age, work demands may remain the same [15]. This could lead to increased work-related fatigue and eventually affect work ability and consequently lead to work-related injury, sickness absence and premature exit from the labour market; especially in workers with physically demanding jobs [15]. In the present study, we observed lower levels of high-intensity leisure-time physical activity in older workers and an association between the duration of high-intensity physical activity and work-related fatigue. Moreover, Figure 1 illustrates a decrease in high-intensity physical activity with age among both sedentary and physical workers. Therefore, taking the increasingly older working population into account, which typically is less physically active [25], maintaining a physically active life style seems vital for sustaining work ability and preventing work-related injury and sickness absence [15]. The workplace may be the optimal setting to provide health promotion of high-intensity physical activity for older workers also.

Strengths and limitations

The present study contains both strengths and limitations. The self-reported data on the level of leisure-time physical activity may be less accurate than if the participants wore an accelerometer to register their activity level [37]. People tend to either over- or underestimate low-intensity activity level in questionnaires, whereas high-intensity activity is more valid [37]. This may have influenced our results on the association between work-related fatigue and low-intensity activity during leisure. In spite of reported differences of, for example, only 6 min per week in low-intensity leisure-time physical activity between older and younger workers, although statistically significant, the result should be carefully interpreted. It is a limitation of the study that the workers reported their activity level by self-reports. Rough categories of the duration of physical activity were converted to a linear time scale. Thus, the estimation method could be less accurate in revealing small differences in physical activity between groups, whereas the results with small (i.e. <10 min per week) between-groups differences should be interpreted with caution. Future studies may incorporate technical and more objective measurements to detect the activity level more precisely. Conversely, self-reported questionnaires are relatively low cost in comparison with the amount of data generated. The large population of 10,427 general Danish workers in the present study is a strength, where we stratified the workers by work type (sedentary and physical) and age (older and younger). Moreover, as a strength of this study, the analyses were controlled for a number of control variables such as age, psychosocial work factors, alcohol intake, BMI and smoking status. A limitation is, however, that only approximately 53% of the invited workers responded to the questionnaire, which could have introduced selection bias. A previous non-response analysis showed a higher response rate for more educated job groups, whereas a subsequent robustness analysis revealed that this influenced the rating of their working environment only to a minor extent [38,39]. Because the present analyses were controlled for a number of potential confounders, selection bias does not seem to have influenced the present results

to any relevant extent. Furthermore, in cross-sectional studies like ours, associations may not be causal, e.g. fatigue may lead to less activity during leisure, but less activity during leisure may also indirectly lead to higher levels of fatigue, i.e. our results may also reflect a vicious circle of a bi-directional association between fatigue and leisure-time physical activity. Specifically, workers performing less leisure-time physical activity may have a lower physical capacity, which may lead to increased fatigue, which again may lead to decreased leisure-time physical activity. Another limitation of the present study is that all the information was collected from self-reports, and the results could therefore be influenced by common method variance [40]. Nevertheless, the most critical source is that the predictor and outcome score is reported from the same person [40]. This may influence the data, since the answers may reflect the person's mood, socioeconomic status, disease status, etc. To reduce the influence of common method variance in studies, temporal, proximal, psychological or methodological separation of measurements may be introduced [40]. However, our self-reported data originates from one large questionnaire sent to approximately 20,000 workers, which complicates the use of these separations, e.g. temporal separation with time lag between measurement of independent and dependent variable. Also, proximal or methodological separation of the conditions and circumstances could not be different when answering questions regarding the independent and dependent variables. The questionnaire comprised a large variety of questions making it difficult for the worker to identify the main context of the questionnaire. However, by emphasizing the importance of separating the measurement, DWECS has attempted to organize the questionnaire in such a way as to receive as accurate and valid replies as possible.

Conclusions

The amount of high-intensity leisure-time physical activity decreases gradually with increased work-related fatigue in workers with physically demanding jobs. Additionally, older workers perform lower levels of high-intensity physical activity than their younger counterparts.

Perspectives

Workplaces could potentially consider initiatives to allow workers with physically demanding jobs and older workers to engage in physical exercise during working hours to prevent work-related fatigue. However, future studies should repeat the results in a follow-up setting with a more accurate measure to estimate the amount of leisure-time physical activity and its association with work-related fatigue. If the results are validated in prospective studies using an objective measure of physical activity, future studies should investigate how to increase high-intensity physical activity among workers with physically demanding jobs and among older workers. Using the workplace as the setting could provide a fruitful opportunity to reach this goal.

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