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Job Strain as a Risk Factor for Leisure-Time Physical Inactivity: An Individual-Participant Meta-Analysis of Up to 170,000 Men and Women

The IPD-Work Consortium

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Unfavorable work characteristics, such as low job control and too high or too low job demands, have been suggested to increase the likelihood of physical inactivity during leisure time, but this has not been verified in large-scale studies. The authors combined individual-level data from 14 European cohort studies (baseline years from 1985–1988 to 2006–2008) to examine the association between unfavorable work characteristics and leisure-time physical inactivity in a total of 170,162 employees (50% women; mean age, 43.5 years). Of these employees, 56,735 were reexamined after 2–9 years. In cross-sectional analyses, the odds for physical inactivity were 26% higher (odds ratio = 1.26, 95% confidence interval: 1.15, 1.38) for employees with high-strain jobs (low control/high demands) and 21% higher (odds ratio = 1.21, 95% confidence interval: 1.11, 1.31) for those with passive jobs (low control/low demands) compared with employees in low-strain jobs (high control/low demands). In prospective analyses restricted to physically active participants, the odds of becoming physically inactive during follow-up were 21% and 20% higher for those with high-strain (odds ratio = 1.21, 95% confidence interval: 1.11, 1.32) and passive (odds ratio = 1.20, 95% confidence interval: 1.11, 1.30) jobs at baseline. These data suggest that unfavorable work characteristics may have a spillover effect on leisure-time physical activity.

cohort studies; exercise; physical activity; psychosocial factors; working population

Abbreviations: Belstress, the Belgian Job Stress Study I; CI, confidence interval; DWECS, Danish Work Environment Cohort Study; FPS, Finnish Public Sector Study; Gazel, the Gaz et Electricité Cohort Study; HeSSup, Health and Social Support Study; HNR, Heinz Nixdorf Recall Study; IPAW, Intervention Project on Absence and Well-being; IPD-Work, Individual-Participant-Data Meta-Analysis in Working Populations; OR, odds ratio; POLS, Permanent Onderzoek LeefSituatie; PUMA, Burnout, Motivation, and Job Satisfaction Study; SES, socioeconomic status; SLOSH, Swedish Longitudinal Occupational Survey of Health; WOLF N, Work, Lipids, and Fibrinogen Study Norrland; WOLF S, Work, Lipids, and Fibrinogen Study Stockholm.

Editor's note: *An invited commentary on this article appears on page 1090.*

Physical inactivity is associated with increased risk of premature death and morbidity due to chronic disease, including cardiovascular disease, type 2 diabetes, and some cancers (1–8). According to the World Health Organization, almost 2 million deaths per year worldwide are attributable to physical inactivity (9). Despite numerous public health campaigns to increase regular physical activity in populations, reductions in sedentary lifestyle have been relatively modest. In the United States, for example, the proportion of the population that reported no leisure-time physical activity has decreased only 3 percentage points during the last 10 years, from 28% in 1998 to 25% in 2008 (10). For this reason, there is a need for increased understanding of factors that influence participation in leisure-time physical activities.

It has been hypothesized that stressful jobs characterized by high psychological demands and low control (also known as high-strain jobs) result in fatigue and greater need for recovery, increasing the likelihood of leisure-time passivity and sedentary behavior (11, 12). Another hypothesis proposes that passive, unchallenging jobs with few demands and little control over work can lead to reduced self-efficacy, which in turn may result in more passive lifestyles (11, 12). To date, however, empirical evidence for both hypotheses remains limited. Studies from Finland, Japan, the United States, Canada, the United Kingdom, and Sweden have provided support for a link between job strain and physical inactivity (13–21), although in some studies the association was attenuated after adjustment for covariates (14, 16, 18). In the Whitehall II Study of British civil servants, participants working in passive jobs were particularly likely to be physically inactive during their leisure time (22). However, other studies have failed to observe an association between high strain or passive jobs and leisure-time physical activity (12, 23). Heterogeneity in the association has also been observed by sex, education, and ethnicity (14, 17–19, 21).

To better characterize the associations between high-strain or passive jobs and leisure-time physical inactivity, we pooled data from 14 independent European cohort studies including over 170,000 men and women. Our aim was to examine whether leisure-time physical inactivity is more common among employees working in high-strain or passive jobs compared with those in low-strain jobs. As a subset of the participating studies had repeat data on both physical activity and work characteristics, we were also able to examine the temporal order of the association, that is, whether work characteristics predict leisure-time physical activity at follow-up, or, alternatively, if physical activity predicts moving into a high strain or passive job over the follow-up period.

MATERIALS AND METHODS

This study is part of the Individual-Participant-Data Meta-Analysis in Working Populations (IPD-Work) Consortium of European cohort studies. Originally established during the annual Four Centers Meeting in London, November 8, 2008, the collaboration has been joined by new cohort studies since. The overall aim of the IPD-Work Consortium is to establish reliable estimates of the effects of psychosocial risk factors at work on chronic disease, mental health, disability, and mortality, based on acquisition and synthesis of extensive individual-level data from multiple published and unpublished studies.

Studies and participants

We pooled data from 14 prospective cohort studies based in 8 European countries: Belgium (the Belgian Job Stress Study I (Belstress)) (24, 25); Denmark (Danish Work Environment Cohort Study (DWECS) (26), Intervention Project on Absence and Well-being (IPAW) (27), Burnout, Motivation, and Job Satisfaction Study (PUMA) (28)); Finland (Finnish Public Sector Study (FPS) (29), Health and Social Support Study (HeSSup) (30), Still Working (31)); France (the Gaz et Electricité Cohort Study (Gazel) (32)); Germany (Heinz Nixdorf Recall Study (HNR) (33)); the Netherlands (Permanent Onderzoek LeefSituatie (POLS) (34)); Sweden (Swedish Longitudinal Occupational Survey of Health (SLOSH) (35, 36), Work, Lipids, and Fibrinogen Study Norrland (WOLF N) (37, 38) and Stockholm (WOLF S) (37, 39)); and the United Kingdom (Whitehall II Study) (40, 41). The years for the baseline data collection in the respective studies varied from 1985–1988 (Whitehall II) to 2006–2008 (SLOSH). Details of the design, recruitment, and ethical approval for the participating studies are presented in Web Appendix I available at http://aje.oxfordjournals.org/. Participants with complete data on leisure-time physical activity, the demand-control measures, sex, and age were included in the cross-sectional analyses in this study, which yielded an analytical sample of 85,132 employed men and 85,030 employed women. The prospective analyses were based on data from 56,735 participants.

Work characteristics

Work characteristics were defined by using the Demand-Control Model, first proposed by Karasek (42) and further developed and tested by Karasek and Theorell (11). A description of the self-administered multiitem measures of job demands and job control in each participating study has been provided elsewhere (43). Briefly, all questions in the job demands and job control scales had Likert-type response formats. Mean response scores for the job demands items and for the job control items were computed for each participant. We then used the study-specific median scores as cutpoints for high and low demands ("high demands" being defined as scores strictly above the study-specific median score) and high and low job control ("low control" being defined as scores strictly below the study-specific median score). Four categories of jobs were defined: 1) low-strain jobs (low demands, high control); 2) passive jobs (low demands, low control); 3) active jobs (high demands, high control); and 4) high-strain jobs (high demands, low control). We also evaluated the separate associations between job demands or job control and leisure-time physical inactivity using the study-specific quintiles for job demands and job control, respectively. Participants with missing data on more than half of the items for job demands or job control were excluded from the analysis ($n = 1{,}793$, 1% of the total population).

Leisure-time physical inactivity

Physical activity was measured by self-report in all studies. The questions used to assess leisure-time physical activity differed between studies. Some studies had only questions on sports activities and exercise, while for other studies information was also available for other types of leisure-time physical activities, such as walking and cycling. As our main aim was to evaluate the association between work characteristics and leisure-time physical inactivity, we constructed a measure of physical inactivity defined as no or very little moderate or vigorous leisure-time physical activity or exercise based on the best available information in each study. Examples of definitions of physical inactivity are "no weekly leisure-time physical activity," "no or very little exercise, only occasional walks," and "sport activities a few times per year or less." The definitions of leisure-time physical inactivity in all the studies included in the analyses are presented in Table 1.

Covariates

Sex and age were obtained from 1) either registers or self-reports during a medical examination (DWECS, FPS, Gazel, HNR, IPAW, PUMA, SLOSH, Still Working, WOLF N, and WOLF S) or 2) a questionnaire (Belstress, HeSSup, POLS, and Whitehall II). Age was treated as a continuous variable in the analyses. In addition, we included socioeconomic status (SES) as a covariate because SES may be related to both physical activity and psychosocial working conditions. SES was based on information on occupation obtained from register data (DWECS, FPS, Gazel, PUMA, and Still Working) or self-reports (Belstress, HNR, IPAW, POLS, SLOSH, WOLF N, WOLF S, Whitehall II). In HeSSup, SES was based on self-reported education. SES was classified as low, intermediate, or high. Self-employed participants and participants with missing data on SES were categorized as "others." We included smoking status as an additional covariate because smoking is considered to be the leading preventable cause of illness, disability, and premature death, and previous findings suggest that job strain is associated with current smoking (44). Smoking

Table 1. Definitions of Leisure-Time Physical Inactivity Among the IPD-Work Consortium of European Cohort Studies (Baseline Years From 1985–1988 to 2006–2008)

Study	Leisure-Time Physical Inactivity
Belstress	No weekly physical activity
DWECS	Almost completely physically passive or light physical activity for less than 2 hours/week (e.g., reading, television, cinema)
FPS	Less than 0.5 hour of each (brisk walking, jogging, or running) per week
Gazel	No sport activities
HeSSup	Less than 0.5 hour of each (brisk walking, jogging, or running) per week
HNR	Less than 0.5 hour of moderate or vigorous physical activity per week
IPAW	Almost completely physically passive or light physical activity for less than 2 hours per week (e.g., reading, television, cinema)
POLS	No exercise and less than 1 hour walking and less than 1 hour cycling for fun per week
PUMA	Almost completely physically passive or light physical activity for less than 2 hours per week (e.g., reading, television, cinema)
SLOSH	No or very little exercise, only occasional walks
Still Working	Sport activities less than a couple of times per month
Whitehall II	No moderate or vigorous exercise
WOLF N	No or very little exercise, only occasional walks
WOLF S	No or very little exercise, only occasional walks

Abbreviations: Belstress, the Belgian Job Stress Study I; DWECS, Danish Work Environment Cohort Study; FPS, Finnish Public Sector Study; Gazel, the Gaz et Electricité Cohort Study; HeSSup, Health and Social Support Study; HNR, Heinz Nixdorf Recall Study; IPAW, Intervention Project on Absence and Well-being; IPD-Work, individual-participant-data meta-analysis in working populations; POLS, Permanent Onderzoek LeefSituatie; PUMA, Burnout, Motivation, and Job Satisfaction Study; SLOSH, Swedish Longitudinal Occupational Survey of Health; WOLF N, Work, Lipids, and Fibrinogen Study Norrland; WOLF S, Work, Lipids, and Fibrinogen Study Stockholm.

status was self-reported in all studies and categorized as "never smoker," "former smoker," and "current smoker."

Statistical methods

Individual-level data were available for the following 10 studies: Belstress, FPS, Gazel, HeSSup, HNR, SLOSH, Still Working, Whitehall II, WOLF N, and WOLF S. Syntax and instructions for statistical analysis were provided for the investigators in the other studies (DWECS, IPAW, POLS, and PUMA), and they themselves calculated the study-specific results.

One- and two-stage meta-analyses of individual-participant data approaches were used (45–47). In the main cross-sectional analysis, we used 2-stage meta-analysis as we wanted to include all available cohort studies but had only aggregate data from 4 cohort studies (DWECS, IPAW, POLS, and PUMA). Stratified analyses were conducted by using 1-stage meta-analysis, excluding the 4 studies with only aggregate data.

In the 2-stage meta-analysis of the cross-sectional associations between work characteristics and physical inactivity, effect estimates and their standard errors were estimated by using logistic regression, separately for each study. The study-specific results were then pooled by random-effects meta-analysis (48). We calculated summary odds ratios and their 95% confidence intervals for individuals who were categorized as having passive, active, or high-strain jobs, comparing them with individuals with low-strain jobs. We adjusted the odds ratios for sex and age and for sex, age, SES, and smoking. Heterogeneity among study-specific estimates was assessed by using the I^2 statistic (49).

It has been argued that the prevalence ratio is more appropriate than the odds ratio when evaluating the cross-sectional association between 2 variables, as the odds ratio tends to inflate the association if the prevalence of the outcome is high (50, 51). Therefore, we ran additional 2-stage individual-level meta-analyses using log binomial regression to estimate the pooled prevalence ratios of leisure-time physical inactivity in relation to work characteristics in the 10 studies where we had direct access to individual data.

In the 1-stage meta-analysis, we pooled all available individual-level data into 1 data set. To examine the robustness of the cross-sectional associations between the work characteristics and physical inactivity, we conducted subgroup analyses separately for men and women; participants aged less than 50 years and those aged 50 years or older; participants from high, intermediate, low, and "other" SES groups; and never smokers, former smokers, and current smokers. We also evaluated the separate effect of job demands and job control on leisure-time physical inactivity, using study-specific quintiles to categorize job demands and job control in 1-stage meta-analyses.

In addition, we used 1-stage individual-level meta-analysis to examine prospective associations between work characteristics and leisure-time physical inactivity in the 6 cohort studies (Belstress, FPS, HeSSup, SLOSH, Whitehall II, and WOLF N; total $n = 56{,}735$) in which the work characteristics and physical activity measures had been repeated 2–9 years later and we had direct access to the data. In all studies, the same definition of work characteristics and physical activity was used at baseline and follow-up. These analyses were based on data from 56,735 participants. In the prospective analyses, we examined whether work characteristics at baseline predicted physical inactivity at follow-up in participants who were physically active at baseline, and if work characteristics at baseline predicted physical activity at follow-up in those who were inactive at baseline. To study potential reverse causality, we examined the association between physical inactivity at baseline and the likelihood of having a high-strain job versus having a low-strain, passive, or active job at follow-up among those in non-high-strain jobs at baseline. Corresponding analyses were undertaken to examine the odds of having a passive, active, or low-strain job at follow-up. In these analyses, we fitted a mixed-effects logistic regression model with study as the random effect and age, sex, SES, and smoking as covariates.

To study the effect of sample size on our findings, we ran sensitivity analysis taking 1% and 10% random samples from the pooled data set of 10 studies where we had access to individual data ($n = 132{,}704$).

Study-specific logistic regression models were fitted with PROC GENMOD in SAS, version 9, software (SAS Institute, Inc., Cary, North Carolina) (Belstress, DWECS, FPS, Gazel, HeSSuP, HNR, IPAW, PUMA, SLOSH, Still Working, Whitehall II, WOLF N and WOLF S) or SPSS, version 17, statistical software (SPSS, Inc., Chicago, Illinois) (POLS). Meta-analysis was conducted by using R, version 2.11, library Meta (R Foundation for Statistical Computing, Vienna, Austria). Study-specific log binomial regression models were also fitted with PROC GENMOD in SAS, version 9. One-stage meta-analyses were fitted with SAS, version 9, PROC GLIMMIX.

RESULTS

The characteristics of the study population are presented in Table 2. The mean age of the participants was 43.5 years, and 50% were women. The prevalence of leisure-time physical inactivity was 21% in the total sample, ranging from 7% in PUMA to 38% in Gazel. The proportion of participants with a high-strain job varied from 13% in the WOLF N study to 20% in SLOSH, while the prevalence of passive jobs ranged from 19% in DWECS to 34% in PUMA.

Cross-sectional analyses

The overall prevalence of physical inactivity was 18.6%, 23.5%, 18.9%, and 23.9% among those with low-strain, passive, active, and high-strain jobs, respectively. There was strong evidence in the pooled analyses that participants with high-strain (odds ratio (OR) adjusted for age and sex = 1.36, 95% confidence interval (CI): 1.25, 1.48) and passive (OR = 1.34, 95% CI: 1.23, 1.47) jobs were more likely to be physically inactive during leisure time, compared with those working in low-strain jobs (Figure 1). Further adjustment for SES and smoking attenuated these

Table 2. Study Population Characteristics Among the IPD-Work Consortium of European Cohort Studies (Baseline Years From 1985–1988 to 2006–2008)[a]

Study	Total No.	Age, years		Female		Work Characteristics, %				Physical Inactivity	
		Mean	Range	No.	%	Low Strain	Passive	Active	High Strain	No.	%
Belstress	20,397	45.4	33–61	4,775	23	26	24	31	19	4,527	22
DWECS	5,565	41.8	18–69	2,602	47	33	19	26	22	841	15
FPS	46,588	44.6	17–64	37,544	81	33	28	23	16	9,360	20
Gazel	10,628	50.3	43–58	2,897	27	32	20	33	14	4,001	38
HeSSup	16,339	39.6	20–54	9,079	56	30	27	26	18	3,601	22
HNR	1,829	53.4	45–73	747	41	33	30	25	12	226	12
IPAW	1,965	41.2	18–68	1,302	66	30	20	32	18	151	8
POLS	24,753	38.3	15–85	10,169	41	32	28	24	16	4,669	19
PUMA	1,806	42.6	18–69	1,486	82	33	34	18	15	130	7
SLOSH	10,853	47.6	19–68	5,848	54	28	25	27	20	2,072	19
Still Working	8,969	40.8	18–65	2,044	23	34	31	20	15	1,748	19
Whitehall II	10,133	44.4	34–56	3,315	33	24	33	29	14	1,652	16
WOLF N	4,686	44.1	19–65	779	17	32	24	31	13	1,254	27
WOLF S	5,651	41.5	19–70	2,443	43	25	33	26	16	1,321	23

Abbreviations: Belstress, the Belgian Job Stress Study I; DWECS, Danish Work Environment Cohort Study; FPS, Finnish Public Sector Study; Gazel, the Gaz et Electricité Cohort Study; HeSSup, Health and Social Support Study; HNR, Heinz Nixdorf Recall Study; IPAW, Intervention Project on Absence and Well-being; IPD-Work, individual-participant-data meta-analysis in working populations; POLS, Permanent Onderzoek LeefSituatie; PUMA, Burnout, Motivation, and Job Satisfaction Study; SLOSH, Swedish Longitudinal Occupational Survey of Health; WOLF N, Work, Lipids, and Fibrinogen Study Norrland; WOLF S, Work, Lipids, and Fibrinogen Study Stockholm.

[a] Participants with valid measures on work characteristics as defined by the Job Demand-Control Model, leisure-time physical activity, age, and sex.

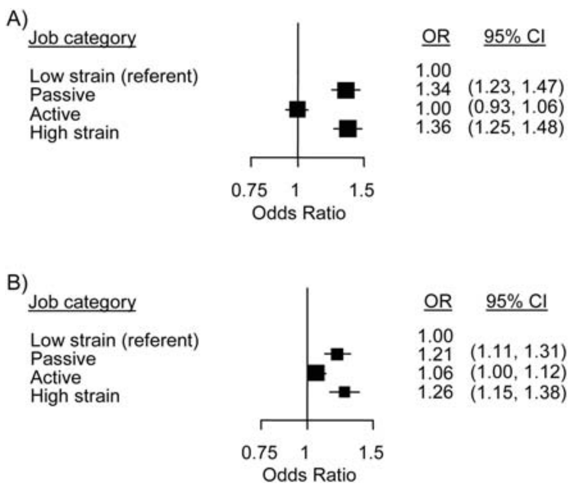

Figure 1. Pooled results from cross-sectional 2-stage meta-analysis from the IPD-Work Consortium of European cohort studies (baseline years from 1985–1988 to 2006–2008). Odds ratios for leisure-time physical inactivity by job category are defined according to the Demand-Control Model as low strain (low demands, high control), passive (low demands, low control), active (high demands, high control), and high strain (high demands, low control). A, adjusted for sex and age ($n = 170{,}162$); B, adjusted for sex, age, socioeconomic status, and smoking ($n = 163{,}242$). CI, confidence interval; IPD-Work, individual-participant-data meta-analysis in working populations; OR, odds ratio.

associations, but the odds ratios remained statistically significant (OR = 1.26, 95% CI: 1.15, 1.38 and OR = 1.21, 95% CI: 1.11, 1.31, respectively). There was some heterogeneity between the studies in the meta-analyses of high-strain and passive jobs, $I^2 = 77.5\%$ and 76.7%, respectively (the study-specific odds ratios are shown in Web Appendix II, Web Figure 1), supporting the use of a random-effects rather than a fixed-effect model. When the analysis was restricted to the 10 studies where we had direct access to the data, the sex-, age-, SES-, and smoking-adjusted odds ratios for leisure-time physical inactivity remained virtually the same as in the analysis including all 14 cohorts, with odds ratios of 1.26 (95% CI: 1.13, 1.40), 1.08 (95% CI: 1.01, 1.16), and 1.21 (95% CI: 1.10, 1.34), for the high-strain, active, and passive groups, respectively.

We repeated the 2-stage meta-analysis, estimating study-specific prevalence ratios using log binomial regression models and pooling them to give summary prevalence ratios across the 10 studies. These models yielded an age- and sex-adjusted summary prevalence ratio for leisure-time physical inactivity of 1.27 (95% CI: 1.18, 1.37) for high-strain jobs, 1.01 (95% CI: 0.95, 1.07) for active jobs, and 1.27 (95% CI: 1.17, 1.38) for passive jobs, compared with low-strain jobs. Additional adjustment for SES and smoking resulted in prevalence ratios of 1.18 (95% CI: 1.09, 1.28), 1.06 (95% CI: 1.00, 1.12), and 1.15 (95% CI: 1.07, 1.24), respectively.

Table 3. Cross-sectional Associations Between Work Characteristics[a] and Leisure-Time Physical Inactivity in Different Subgroups Among the IPD-Work Consortium of European Cohort Studies (Baseline Years From 1985–1988 to 2006–2008)

	No.	Leisure-Time Physical Inactivity, %	Odds Ratio[b]	95% CI
All (*n* = 132,704)				
Low strain	39,903	19	1	Referent
Passive	35,870	25	1.29	1.24, 1.33
Active	35,105	20	1.06	1.02, 1.10
High strain	21,826	25	1.32	1.27, 1.38
Stratified by sex				
Men (*n* = 65,043)				
Low strain	21,025	21	1	Referent
Passive	15,637	26	1.27	1.21, 1.34
Active	19,623	20	1.05	1.00, 1.11
High strain	8,758	27	1.36	1.28, 1.44
Women (*n* = 67,661)				
Low strain	18,878	18	1	Referent
Passive	20,233	24	1.27	1.21, 1.34
Active	15,482	19	1.08	1.02, 1.14
High strain	13,068	24	1.28	1.21, 1.35
Stratified by age				
Age <50 years (*n* = 86,650)				
Low strain	25,830	17	1	Referent
Passive	23,537	23	1.28	1.22, 1.34
Active	23,068	18	1.06	1.01, 1.11
High strain	14,215	23	1.30	1.23, 1.37
Age ≥50 years (*n* = 46,054)				
Low strain	14,073	22	1	Referent
Passive	12,333	28	1.28	1.20, 1.35
Active	12,037	23	1.05	0.99, 1.12
High strain	7,611	28	1.34	1.25, 1.43
Stratified by SES				
Low SES (*n* = 36,346)				
Low strain	8,483	24	1	Referent
Passive	15,267	28	1.23	1.15, 1.31
Active	4,675	24	1.05	0.96, 1.14
High strain	7,921	29	1.31	1.22, 1.41

Table continues

To study the robustness of the associations further, we conducted 1-stage meta-analyses stratified by sex, age, SES, and smoking. The pattern of higher odds ratios for physical inactivity among those with high-strain or passive jobs was observed across all the subgroups examined (Table 3).

When levels of job demands and job control were analyzed separately, a clear association between job control and physical inactivity was observed, with odds for physical inactivity increasing at lower levels of job control. The association between job demands and physical inactivity was weaker, and there was evidence of an association only in the highest quintile (Web Appendix II, Web Table 1; available at http://aje.oxfordjournals.org/).

Prospective analysis

In the prospective analysis based on data from 6 studies, we observed increased odds of becoming physically inactive at follow-up among those who at baseline had high-strain (OR = 1.21, 95% CI: 1.11, 1.32) or passive (OR = 1.20, 95% CI: 1.11, 1.30) jobs compared with those who had low-strain jobs (Table 4). This analysis was restricted to those who were physically active (i.e., it

Table 3. Continued

	No.	Leisure-Time Physical Inactivity, %	Odds Ratio[b]	95% CI
Medium SES (*n* = 63,530)				
Low strain	18,777	19	1	Referent
Passive	17,403	22	1.29	1.23, 1.36
Active	15,862	20	1.05	1.00, 1.11
High strain	11,488	23	1.33	1.26, 1.41
High SES (*n* = 30,026)				
Low strain	11,706	17	1	Referent
Passive	2,483	20	1.25	1.11, 1.40
Active	13,801	18	1.12	1.05, 1.20
High strain	2,036	20	1.31	1.16, 1.47
Other SES (*n* = 2,802)				
Low strain	937	19	1	Referent
Passive	717	26	1.36	1.07, 1.73
Active	767	23	1.20	0.95, 1.52
High strain	381	30	1.69	1.28, 2.23
Stratified by smoking				
Never smokers (*n* = 57,849)				
Low strain	17,285	17	1	Referent
Passive	15,124	22	1.34	1.27, 1.43
Active	15,970	18	1.11	1.05, 1.18
High strain	9,470	23	1.41	1.32, 1.50
Former smokers (*n* = 45,076)				
Low strain	14,359	18	1	Referent
Passive	11,910	22	1.22	1.15, 1.30
Active	11,996	18	1.02	0.95, 1.08
High strain	6,811	22	1.25	1.17, 1.35
Current smokers (*n* = 29,779)				
Low strain	8,259	26	1	Referent
Passive	8,836	32	1.29	1.20, 1.38
Active	7,139	26	1.04	0.97, 1.12
High strain	5,545	32	1.29	1.20, 1.40

Abbreviations: CI, confidence interval; IPD-Work, individual-participant-data meta-analysis in working populations; SES, socioeconomic status.

[a] Work characteristics defined according to the Demand-Control Model as low strain (low demands, high control), passive (low demands, low control), active (high demands, high control), and high strain (high demands, low control).

[b] Adjusted for age, sex, SES, and smoking. Study treated as random effect in the logistic model.

excluded the physically inactive) at baseline. In a further analysis—this time restricted to those who were physically inactive at baseline—we did not observe any clear association between work characteristics at baseline and becoming physically active at follow-up.

Our test of reverse causality showed physical inactivity at baseline to be associated with slightly increased odds of having a high-strain or passive job and with decreased odds of having an active or low-strain job at follow-up (Table 5).

Sensitivity analysis and effect of sample size

Many studies of job strain have been based on sample sizes of 1,000–3,000; very few include more than 10,000 participants. Figure 2 shows that it is not possible to observe the association between job strain and physical inactivity in a 1% random sample ($n = 1{,}327$) of the pooled data. However, this association becomes significant in the 10% random sample comprising over 10,000 participants

Table 4. Prospective Associations Between Work Characteristics[a] at Baseline and Leisure-Time Physical Activity or Inactivity at Follow-up Among the IPD-Work Consortium of European Cohort Studies (Baseline Years From 1985–1988 to 2006–2008)[b]

Baseline Population and Exposure at Baseline	No.	Odds Ratio[c]	95% CI	Cases at Follow-up	
				No.	%
Physical activity at baseline ($n = 45{,}927$)					
Low strain	14,551	1[d]	Referent	1,685	12
Passive	11,973	1.20[d]	1.11, 1.30	1,806	15
Active	12,334	1.07[d]	0.99, 1.15	1,483	12
High strain	7,059	1.21[d]	1.11, 1.32	1,049	15
Physical inactivity at baseline ($n = 10{,}808$)					
Low strain	2,861	1[e]	Referent	1,416	49
Passive	3,432	1.00[e]	0.90, 1.11	1,634	48
Active	2,545	1.10[e]	0.98, 1.22	1,315	52
High strain	1,970	0.98[e]	0.87, 1.10	946	48

Abbreviations: Belstress, the Belgian Job Stress Study I; CI, confidence interval; IPD-Work, individual-participant-data meta-analysis in working populations.

[a] Work characteristics defined according to the Demand-Control Model as low strain (low demands, high control), passive (low demands, low control), active (high demands, high control), and high strain (high demands, low control).

[b] Studies and follow-up times: Belstress (4–8 years), Finnish Public Sector Study (2–4 years), Health and Social Support Study (5 years), Swedish Longitudinal Occupational Survey of Health (2 years), Whitehall II Study (3–9 years), and Work, Lipids, and Fibrinogen Study Norrland (3–7 years).

[c] Adjusted for age, sex, socioeconomic status, and smoking.

[d] Outcome at follow-up: physical inactivity.

[e] Outcome at follow-up: physical activity.

($n = 13{,}270$). When repeating the random sampling procedure 5 times, it was observed that the estimated odds ratios vary substantially over the 5 different 1% samples. When using 10% samples, the estimates start to stabilize, but several estimates are still nonsignificant, as compared with the full sample size (Web Appendix II, Web Figures 2 and 3).

DISCUSSION

We found robust cross-sectional and prospective associations between unfavorable work characteristics and leisure-time physical inactivity, with 21%–26% higher odds for inactivity among participants working in high-strain and passive jobs compared with those with low-strain jobs. Prospective analyses showed that high-strain and passive jobs also predicted change from a physically active to an inactive lifestyle. We found some support for a bidirectional association, as leisure-time physical inactivity at baseline to some extent predicted change in work characteristics; for example, physically inactive employees were more likely to move into a high-strain or passive job compared with their physically active counterparts.

Individual-level meta-analysis of published and unpublished data, such as that used in the present study, is recognized as a strong study design as it reduces the possibility of publication bias that can limit the generalizability of evidence from single studies and literature-based meta-analyses (52). Our cross-sectional results are based on the largest data set to date on work characteristics ($n > 170{,}000$) and are in agreement with those of several previous studies. For example, an increased likelihood of low leisure-time physical activity among those with high strain and passive jobs compared with those in low-strain jobs was observed in 3,900 Swedish men (21) and 3,500 male white-collar workers in Canada (19), although no statistically significant associations were observed among women in these studies. Bennett et al. (17) found that people who reported job strain spent approximately 1 hour less in physical activities per week, compared with those who did not report job strain in a sample of 1,700 white individuals in Massachusetts. Furthermore, in a small study ($n = 241$) by Payne et al. (20), it was observed that employees reporting high strain did less exercise than employees in low-strain jobs (20). Choi et al. found that low-strain and active jobs were associated with a more physically active leisure-time compared with passive and high-strain jobs in 2,000 middle-aged American workers (18); Lallukka et al. (14) observed that a physically active leisure-time was more common in those with low strain and active jobs among 1,200 Finnish men and in those with low-strain jobs among the 5,000 Finnish women. However, in the latter 2 studies, the associations did not reach statistical significance at conventional levels in multivariable-adjusted models.

We observed similar odds ratios for physical inactivity in the high-strain and passive job groups. High-strain and passive jobs are both characterized by low control and, indeed, a subsidiary analysis revealed that the association between job control and leisure-time physical activity is much stronger than the association between job demands and physical activity. This is in agreement with some previous studies linking low control to a low level of physical activity (18, 53, 54), and it indicates that the association between work characteristics and leisure-time physical inactivity may be driven by the control dimension rather than by job demands. Our findings suggest that it makes little difference whether low control is combined with either high job demands (representing job strain) or low job demands (representing passive work).

Some earlier studies have failed to find an association between work characteristics and physical activity (12, 23). This inconsistency may be due to different definitions of physical activity but also to differences in the categorization of the psychosocial work characteristics. Furthermore, the smaller sample sizes in previous studies are likely to have introduced random error into the estimates, resulting in insufficient statistical power to detect relatively weak associations, such as those observed in the present meta-analysis (Figure 2; Web Appendix II).

Longitudinal data from 6 of the participating studies provided us with the opportunity to analyze temporal aspects

Table 5. Prospective Associations Between Leisure-Time Physical Activity or Inactivity at Baseline and Work Characteristics[a] at Follow-up Among the IPD-Work Consortium of European Cohort Studies (Baseline Years From 1985–1988 to 2006–2008)[b]

Baseline Population and Exposure at Baseline	No.	Odds Ratio[c]	95% CI	Cases at Follow-up	
				No.	%
All, except those with high-strain jobs at baseline ($n = 47,706$)					
Physical activity	38,868	1[d]	Referent	3,847	10
Physical inactivity	8,838	1.15[d]	1.07, 1.24	1,039	12
All, except those with active jobs at baseline ($n = 41,846$)					
Physical activity	33,583	1[e]	Referent	5,595	17
Physical inactivity	8,263	0.89[e]	0.83, 0.96	1,150	14
All, except those with passive jobs at baseline ($n = 41,330$)					
Physical activity	33,954	1[f]	Referent	4,763	14
Physical inactivity	7,376	1.12[f]	1.04, 1.20	1,196	16
All, except those with low-strain jobs at baseline ($n = 39,323$)					
Physical activity	31,376	1[g]	Referent	6,881	22
Physical inactivity	7,947	0.89[g]	0.84, 0.95	1,549	19

Abbreviations: Belstress, the Belgian Job Stress Study I; CI, confidence interval; IPD-Work, individual-participant-data meta-analysis in working populations.

[a] Work characteristics defined according to the Demand-Control Model as low strain (low demands, high control), passive (low demands, low control), active (high demands, high control), and high strain (high demands, low control).

[b] Studies and follow-up times: Belstress (4–8 years), Finnish Public Sector Study (2–4 years), Health and Social Support Study (5 years), Swedish Longitudinal Occupational Survey of Health (2 years), Whitehall II Study (3–9 years), and Work, Lipids, and Fibrinogen Study Norrland (3–7 years).

[c] Adjusted for age, sex, socioeconomic status, and smoking.

[d] Outcome at follow-up: high-strain job.

[e] Outcome at follow-up: active job.

[f] Outcome at follow-up: passive job.

[g] Outcome at follow-up: low-strain job.

of the link between work characteristics and leisure-time physical activity. This is in contrast to the vast majority of previous studies that have been based on cross-sectional data. Our main results support the idea that unfavorable work characteristics affect leisure-time physical activity. However, the association might be bidirectional because leisure-time physical inactivity also predicted, albeit weakly, adverse changes in work characteristics during follow-up. Certain personality traits may influence both participation in physical activity and the probability of having a job with more favorable characteristics. In a Finnish study, for example, it was observed that sustained involvement in physical activity in adolescence and young adult age was associated with reduced likelihood of reporting high strain jobs in early working life (15, 55), an association that was partly explained by personality traits (55).

This meta-analysis also has some limitations. First, data were based on multiexposure-multioutcome cohort studies that were not specifically designed to measure the impact of work characteristics on physical activity. Second, although we used a validated measure of work characteristics harmonized across all the studies (43), the number of items and the wording of measures varied somewhat between the studies included. This may be one source of the heterogeneity observed between studies and one which may lead to some over- or underestimation of the magnitude of the associations. Furthermore, leisure-time physical activity was self-reported in all the studies, and this may have given rise to a degree of misclassification. However, we believe it is reasonable to assume that these misclassifications were largely independent of the work characteristics and, thus, if they had any effect, would rather attenuate than inflate the associations investigated in our study. Third, we observed no differences in the association between work characteristics and leisure-time physical activity by sex, age, SES, smoking status, or time of the study, but further research is needed to examine whether issues not assessed in this meta-analysis, such as social relations, physically demanding work, or sedentary work, economic circumstances, cultural contexts, and length of exposure to work characteristics, might modify this association. Fourth, our data were obtained from studies conducted in Scandinavia, Continental Europe, and the United Kingdom; it is unclear whether these findings are generalizable to other countries and

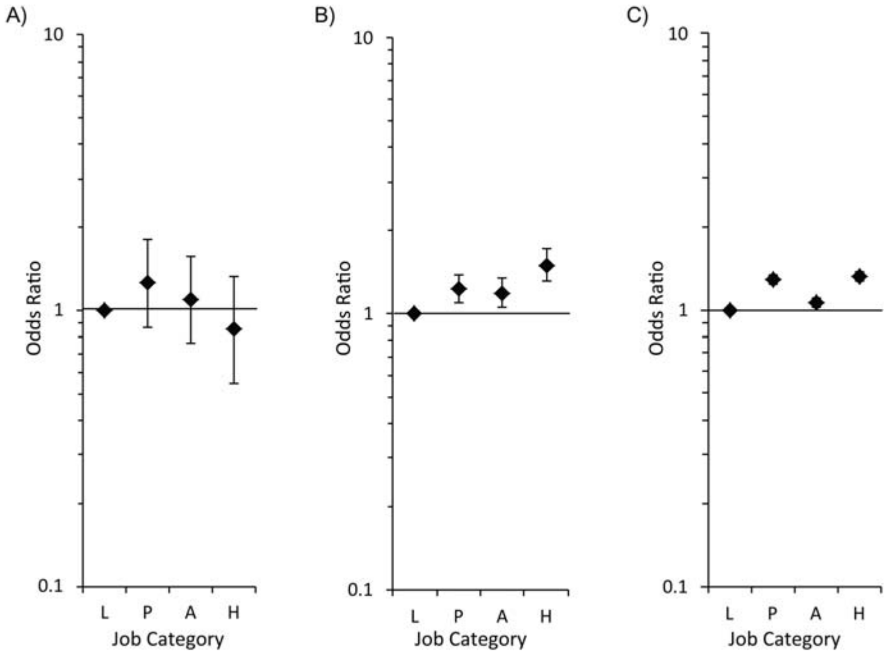

Figure 2. Estimated odds ratios and 95% confidence intervals for leisure-time physical inactivity in low-strain (L), passive (P), active (A), and high-strain (H) jobs based on different sample sizes from the IPD-Work Consortium of European cohort studies (baseline years from 1985–1988 to 2006–2008). Low-strain jobs are set as the referent category. The odds ratios are adjusted for sex, age, socioeconomic status, and smoking. A, 1% random sample ($n = 1{,}327$); B, 10% random sample ($n = 13{,}270$); C, total sample ($n = 132{,}704$). IPD-Work, individual-participant-data meta-analysis in working populations.

regions, such as Southern Europe, the United States, and Asia.

In conclusion, results from pooled data from over 170,000 participants in 14 European cohort studies provided consistent support for the hypothesis that unfavorable work characteristics have a spill-over effect on leisure-time physical activity. These results suggest that interventions to increase physical activity in the population may benefit from taking workplace factors into account.

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