Day-to-Day Pattern of Work and Leisure Time Physical Behaviours: Are Low Socioeconomic Status Adults Couch Potatoes or Work Warriors?

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Research

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Abstract

Background

Most studies on day-to-day patterns of physical behaviours (i.e. physical activities and sedentary behaviour) are based on adult populations of high socioeconomic status (SES) and without differentiating between work and leisure time. Thus, we aimed to characterise the day-to-day leisure time physical behaviours patterns among low SES adults and investigate if a day of the week, workday, work duration, and work physical behaviours influence these leisure-time patterns.

Methods

This cross-sectional study included 1012 adults from typical low SES occupations (e.g. manufacturing, cleaning and transportation). The participants wore accelerometers for 1-7 days to measure daily physical behaviours during work and leisure time, expressed as 3-part time-use compositions consisting of time spent 1) sedentary, 2) standing or 3) being active (i.e. walking, running, stair climbing, or cycling). Multivariate multilevel log-ratio models were used to regress leisure time-use composition on day-of-week and the interaction between day-of-week and (1) type of day, (i.e., work/non-work), (3) work duration, and (4) work time-use composition. Models were adjusted for sex, age, BMI, and smoking-status.

Results

Over the course of a week, the workers were primarily sedentary during leisure time, while spending most work time standing or being active. Leisure time physical behaviours were associated with type of day ($p < 0.005$, more sedentary on workdays vs. non-workdays), day-of-week ($p < 0.005$, more sedentary on Friday, Saturday and Sunday), standing work ($p < 0.005$, more sedentary and less active leisure time on Sunday), active work ($p < 0.005$, less sedentary and more active leisure time on Sunday), and work duration ($p < 0.005$, less active leisure time on Friday).

Conclusions

Our findings suggest that while low SES adults' leisure time is mostly sedentary, their work time is predominantly standing or active. Leisure time was spent more sedentary on workdays compared to non-workdays, indicating that work factors influenced day-to-day leisure time behaviours. Accordingly, work physical behaviours and work duration were differently associated with leisure time physical behaviours. Our findings support the value of considering the influence of work factors when planning strategies aiming to increase health-enhancing leisure time activities among low SES adults.

Background

Leisure time physical behaviours (i.e. physical activities (PA) and sedentary behaviour) are well-known determinants of non-communicable diseases and mortality[1–4]. Worldwide efforts are made to increase PA[5, 6]. Nevertheless, current PA promoting interventions and policies seem to fail in reaching those in most need of health-enhancing leisure time PA: individuals of lower socioeconomic status (SES). Current data on global leisure time PA levels show a persistent, steadily widening SES gap, favouring high SES groups[7–9]. Clearly, there is an urgent need to strengthen PA promoting strategies to narrow this gap and thus, decrease inequalities in health.

One strategy to increase PA levels among low SES adults could be to recommend health enhancing physical activities on non-workdays days (during the week or weekends) with more energy and free time available than on workdays. This pattern of higher PA, e.g. during non-working weekends, than on workdays has been found among high SES adults[10–12] (termed “weekend warriors”). An opposite pattern, with more PA on weekdays than during the weekend has been found among low SES adults[13, 14]. However, none of the previous studies differentiated between work and leisure PA. As low SES adults are often in blue collar positions with high levels of PA as part of their job[15, 16], occupational PA is likely the driving factor for their high accumulation of PA on workdays.

Few studies assessing determinants of physical behaviour patterns over the week have primarily focused on individual factors, such as age[17], income[11] and education[13]. However, at best, individual-level factors explain 20–40% of the variance in PA levels[18]. Thus, research and policies on physical behaviours has increasingly adopted a broader approach which also considers environmental determinants, such as work factors[19, 20]. Understanding how work factors could affect daily leisure time physical behaviours is considered particularly important among low SES groups, as such factors are modifiable and amenable to change with interventions[21, 22]. Nevertheless, to our knowledge, no study has investigated how work factors, such as work physical behaviours and work duration, influence day-to-day leisure time physical behaviours. Such insight into domain-specific physical behaviours over the week and potentially modifiable determinants is needed to inform approaches aiming to increasing health-enhancing leisure time PA among low SES adults.

The aim of this study was to characterize the day-to-day pattern of work and leisure time physical behaviours among low SES adults. Moreover, we investigated the influence of day of the week and its interaction with type of day (i.e. workday vs. non-workday), work duration and work physical behaviours on day-to-day leisure time physical behaviours.

Methods

This cross-sectional study used baseline data from two Danish studies: the Danish PHysical ACTivity cohort with Objective measurements (DPhacto)[23] and the New Method for Objective Measurements of Physical Activity in Daily Living (NOMAD) study[24]. DPhacto and NOMAD were identical in data procedures and collection, which facilitated merging the data. Details of the studies have been described previously [23, 24].

The study population consisted of workers with low SES recruited from Danish workplaces within cleaning, transportation, manufacturing, construction, road maintenance, garbage disposal, assembly, mobile plant operator, and health care[23, 24]. Eligible workers were employed in one of the mentioned sectors for at least 20 h/week; between 18–65 years old; and had given voluntary consent to participate. Workers were excluded if they were pregnant, had fever on the day of data collection, or band-aid allergy.

The DPhacto and NOMAD studies were approved by the local Ethics Committee (file number H-2-2012-011 [23] and file number H-2-2011-047 [24], respectively). Both studies were conducted according to the Helsinki declaration and all data were anonymized in relation to individuals and workplaces.

Data Collection

Data were collected included questionnaires, health checks, and accelerometer-based measurements [23, 24]. Eligible workers were invited to complete a questionnaire and to participate in a health check, which consisted of anthropometric measurements and a physical health examination. Moreover, participants were asked to wear accelerometers for a minimum of two consecutive workdays and to complete a diary reporting time at work, time in bed at night and non-wear time.

Accelerometer Measurements of Physical Activity and Sedentary Behaviour

Physical activity at work and leisure time was assessed using data from one tri-axial ActiGraph GT3X + accelerometer (Actigraph, Pensacola, FL, USA). The accelerometer was fixed using double-sided adhesive tape (3 M, Hair-Set, St. Paul, MN, USA) and Fixomull (Fixomull BSN medical GmbH, Hamburg, Germany) and placed on the right thigh. Accelerometer data were downloaded using Actilife Software version 5.5 (Actigraph, Pensacola, FL, USA) [25] and analyzed using the custom-made MATLAB program Acti4 (The National Research Centre for the Working Environment, Copenhagen, Denmark) [26]. The Acti4 program has been shown to separate physical activity types with high sensitivity and specificity under semi-standardized[26] and non-standardized conditions[27]. Classification of physical behaviors using Acti4 has been described previously[26]. In brief, physical behaviors (i.e., cycling, stair climbing, running, walking, standing, sitting and lying) were classified based on an algorithm using angles from the accelerometers axis and standard deviation of mean acceleration[26].

Day of the week, daily work hours, leisure time and time-in-bed were defined from the participants' self-reported diary information. Only workers with at least one day of valid accelerometer measurements of work and leisure time periods were included. A valid day consisted of ≥ 4 h of accelerometer-derived work and leisure time or ≥ 75% of the individual's average work and leisure time. Leisure-time periods before work and time-in-bed were not considered in this study. Figure 1 show the flowchart of the study population. A total of 1200 eligible workers answered the questionnaire and/or participated in the physical health check. Of these workers, 37 were excluded due to being department leaders or students, were on holiday, pregnant or did not want to participate. Two-hundred workers were excluded from the study because they did not valid have leisure time accelerometer measurements on at least one weekday. Therefore, a total of 963 workers were included in the study.

(INSERT FIGURE 1 HERE)

Covariates

Sex and age of the workers were determined from each worker's unique Danish civil registration number. BMI (Body Mass Index) was calculated as weight (kg) divided by height (m) squared (kg/m^2). Information on smoking-status was obtained by the question: "Do you smoke" with four response categories: daily smoking, occasionally smoking, formerly smoked, and never smoked. The variable was dichotomized into smokers and non-smokers (including formerly smokers). Work duration was calculated as the log of total accelerometer-derived work time[28]. Information on shift work was assessed using the question: "At what time(s) of the day do you usually work in your main occupation?" with three response categories: fixed day work, night/varying work hours with night, and other. The variable was dichotomized into workers with and without fixed day work.

Statistical analysis

Time use of daily work and leisure time behaviours was treated as two compositions of activities performed within a 24-hour day. Work and leisure time were defined as a 3-part composition, consisting of time spent on sedentary (i.e. sitting or lying), standing and active (i.e. walking, running, stair climbing or cycling).

Compositional means were used to describe the day-to-day pattern of work and leisure time physical behaviours[29, 30]. They were obtained by computing the geometric mean of each individual behaviour of the respective compositions and then normalising (closing) these vectors of geometric means to workers' average daily work and leisure time (i.e. 450 min and 450 min, respectively). On non-workdays, the leisure time composition consisted of daily waking time, normalised to the workers' average daily time spent awake (i.e. 960 minutes).

Daily work and leisure time-use compositions were expressed using pivot isometric log-ratio (ilr) coordinates[31]. The first pivot-coordinate was calculated as the normalised log ratio of the first compositional part, relative to the geometric mean of the remaining parts within each of the work and leisure time compositions. The work and leisure time behaviours were sequentially rearranged to place each behaviour in the first position once, and the corresponding ilr-coordinate sets were then computed. In this way, the relative importance of each behaviour was sequentially represented in the first ilr-coordinate (ilr_1) of a set for subsequent statistical significance testing through regression analysis. A detailed description of how the pivot-coordinates were calculated is provided in Additional file 1.

Using the pivot-coordinates to express the leisure time-use composition as the outcome, we assessed associations with 1) day of the week, 2) type of day, (i.e. workday/non-workday), 3) work duration and 4) the work time-use composition (expressed as pivot-coordinates). The analysis was performed in multiple steps, using multivariate multilevel models. This way, the repeated measurements as well as multiple outcomes (i.e. the two pivot-coordinates to express the leisure time-use composition) for each worker were taken into account. In model 1, day of the week and an interaction between day of the week and type of day (reference = non-workday) were entered as a level-2 predictors. In model 2, the following level-

2 predictors were entered: work duration, the work time-use composition, and interaction terms between day of the week and work duration and the work time-use composition, respectively. Both models were adjusted by including the following level-2 predictors (reference in parenthesis for categorical variables): sex (men), smoking-status (smoker), BMI, and age. These covariates were chosen as potential confounders based on previous literature and theoretical assumptions concerning their possible influence on day-to-day pattern of leisure time and work physical behaviours and work duration[13, 17]. A detailed description of model development is provided in Additional file 1.

Model 1 was fitted three times. This was done to isolate the association with one of the leisure time behaviours with respect to the others in the first ilr-coordinate (denoted by ilr_1). Moreover, model 2 was fitted six times to investigate the association between each part of the leisure time and work compositions, respectively. Of note, only results of the association between the relative work time spent active and standing (as a proxies of physical work demands) and leisure time physical behaviours are shown. Missing data was not imputed. Results on the association between relative work time spent sedentary and leisure time spent sedentary, standing and active, respectively are shown in Additional file 2.

All analyses were performed in R version 1.1.3[32], using the *compositions*[33] and *MCMCglmm*[34] packages. We used the MCMCglmm package to conduct the multivariate multilevel analysis, following the guide provided by Baldwin et al[35], by which a Bayesian approach with uninformative priors were used. The assumptions of normality and homoscedasticity of the residuals were assessed for all models by visual inspection of residuals versus predicted values and quantile-quantile plots.

Sensitivity analysis

A sensitivity analysis was conducted in which only workers with at least two days of measurements were included (N = 831).

Results

Study population characteristics

Table 1 shows the basic characteristics of the study population. Mean age was 44.9 (SD = 10.0) years, mean BMI was 27.2 kg/m2 (SD = 4.9), 45% were women and the majority were working within manufacturing (59%).

Table 1
Characteristics of the study population (n = 963).

Variable	N (%)	Mean (SD)
Age (years)	963 (100)	44.9 (10.0)
BMI in kg/m^2	947 (98)	27.2 (4.9)
Aerobic capacity (mL O_2/min/kg)	718 (75)	32.0 (9.0)
Days with accelerometer measurements	963 (100)	4.1 (1.3)
Sex		
Men	528 (55)	
Women	435 (45)	
Smoking-status		
Smoker	319 (33)	
Non-smoker	644 (67)	
Missing	14 (< 1)	
Shift work		
Fixed day job	723 (75)	
Non-fixed day job	214 (22)	
Missing	26 (3)	
Working sector		
Cleaning	175 (18)	
Manufacturing	569 (59)	
Transportation	69 (7)	
Health Service	19 (2)	
Assemblers	33 (3)	
Construction	40 (4)	
Garbage Collectors	29 (3)	
Mobile Plant Operators	11 (1)	
Other[A]	20 (2)	

[A]*Includes general office clerks and other elementary workers.*

Day-to-day pattern in work and leisure time physical behaviours

Table 2 shows the compositional mean of day-to-day work and leisure time-use compositions on workdays and non-workdays. Throughout the week, the workers were predominantly sedentary during leisure time. On workdays, the workers showed a day-to-day increase in leisure time spent sedentary (Monday, 296 min/day, to Sunday, 332 min/day), while active leisure time decreased over the week (Monday, 42 min/day, to Sunday, 32 min/day). In contrast, active work time increased from Monday to Sunday (85 min/day on Monday, 110 min/day on Sunday). On non-workdays, no clear trend in physical behaviours over the course of the week was observed.

Table 2
Compositional means of leisure time and work physical behaviours on workdays and non-workdays.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Workday							
Work time behaviours (min/day)							
Sedentary	124	130	141	148	141	119	118
Standing	240	236	223	218	218	226	221
Active	85	83	86	84	91	106	110
Observations (N) [A]	154	332	457	544	388	77	47
Leisure time behaviours (min/day) [B]							
Sedentary	296	302	300	299	312	331	332
Standing	111	107	108	110	101	86	86
Active	42	41	42	41	37	33	32
Observations (N) [C]	184	362	498	569	423	103	58
Non-workday							
Physical behaviours (min/day)							
Sedentary	648	655	630	625	611	609	602
Standing	228	227	245	242	257	263	267
Active	84	78	86	93	91	88	91
Observations (N) [C]	47	43	76	102	100	380	343

[A] Workers with valid work accelerometer measurements. [B] Work time behaviours information only on workdays. [C] Workers with valid leisure time accelerometer measurements. Closure constant for leisure time composition was 450 minutes on workdays and 960 minutes on non-workdays based on the average accelerometer-derived time not in bed at night. Closure constant for work time composition was 450 minutes based on the average accelerometer-derived work time.

Results of multilevel models

Figure 2 shows the day-to-day mean ilr1, expressing relative leisure time spent sedentary, standing and active, respectively, on work and non-workdays. On workdays, significantly more leisure time was spent sedentary on Friday, Saturday and Sunday, compared to a Monday on non-workdays (Table 3, $\beta_{interaction}$ = 0.26, 95% CI= (0.07; 0.44), $\beta_{interaction}$ = 0.34, 95% CI= (0.13; 0.55), and $\beta_{interaction}$ = 0.27, 95% CI= (0.04;

0.46), respectively). Moreover, less leisure time was spent standing on Friday ($\beta_{interaction}$=-0.16, 95% CI= (-0.32; -0.02)) and Saturday ($\beta_{interaction}$ =-0.21, 95% CI= (-0.21; -0.07)), compared with a Monday on non-workdays.

(INSERT FIGURE 2 HERE)

Table 3
Association between day-to-day leisure time physical behaviours and weekday and workday.

	Outcome: Leisure composition pivot coordinates		
Predictors	**ilr_1(Sedentary)**	**ilr_1(Standing)**	**ilr_1(Active)**
	β (95% CI)	β (95% CI)	β (95% CI)
Weekday (Monday)			
Tuesday	-0.03 (-0.25 ; 0.15)	0.04 (-0.01 ; 0.18)	-0.02 (-0.18 ; 0.13)
Wednesday	-0.03 (-0.21 ; 0.16)	0.07 (-0.05 ; 0.19)	-0.03 (-0.16 ; 0.09)
Thursday	-0.09 (-0.26 ; 0.10)	0.03 (-0.08 ; 0.17)	0.05 (-0.07 ; 0.17)
Friday	-0.13 (-0.27 ; 0.03)	0.11 (-0.03 ; 0.24)	0.02 (-0.11 ; 0.14)
Saturday	-0.12 (-0.26 ; 0.04)	**0.11 (0.01 ; 0.22)**	0.01 (-0.11 ; 0.12)
Sunday	-0.13 (-0.28 ; 0.03)	**0.11 (0.01 ; 0.22)**	0.02 (-0.01 ; 0.12)
Workday (yes)	-0.07 (-0.22 ; 0.01)	0.02 (-0.11 ; 0.13)	0.05 (-0.08 ; 0.17)
Workday (yes)*weekday (Monday)			
Tuesday	0.07 (-0.11 ; 0.32)	-0.07 (-0.22 ; 0.09)	0.02 (-0.12 ; 0.11)
Wednesday	0.05 (-0.15 ; 0.26)	-0.08 (-0.21 ; 0.07)	0.02 (-0.14 ; 0.17)
Thursday	0.12 (-0.08 ; 0.28)	-0.04 (-0.18 ; 0.01)	-0.08 (-0.24 ; 0.05)
Friday	**0.26 (0.07 ; 0.44)**	**-0.16 (-0.32 ; -0.02)**	-0.10 (-0.25 ; 0.06)
Saturday	**0.34 (0.13 ; 0.55)**	**-0.21 (-0.34 ; -0.07)**	-0.14 (-0.29 ; 0.01)
Sunday	**0.27 (0.04 ; 0.46)**	-0.13 (-0.29 ; 0.02)	-0.14 (-0.28 ; 0.01)

*ilr_1 = first pivot coordinate, representing the relative importance of a leisure time physical behaviour (indicated in parenthesis) with respect to the others. Results based on multivariate multilevel models adjusted for sex, age, smoking-status and BMI. Total number of observations included = 3198. Bold indicates significant at $p < 0.05$. * indicates interaction term*

On most weekdays, we observed a trend of relative standing work to be positively associated with relative sedentary leisure time and negatively associated with relative active leisure time. However, the associations were only statistically significant on Tuesday (Table 4; $\beta_{interaction}$=-0.18, 95% CI= (-0.36; -0.02)) and Sunday ($\beta_{interaction}$ = 0.90, 95% CI= (0.19; 1.51) and $\beta_{interaction}$=-0.51, 95% CI= (-0.98; -0.05)). For relative active work time, we observed a contrasting trend, finding a negative association with relative sedentary leisure time and positive association with relative active leisure time throughout the week. These associations were only statistically significant on Tuesday (Table 5; $\beta_{interaction}$=-0.25, 95% CI= (-0.48; -0.03) and $\beta_{interaction}$ = 0.20, 95% CI= (0.01; 0.38)) and Sunday ($\beta_{interaction}$=-1.02, 95% CI= (-1.66; -0.38) and $\beta_{interaction}$ = 0.52, 95% CI= (0.11; 1.03)). On weekdays, work duration was negatively associated with relative active leisure time, yet only statistically significant on Friday (Table 5; $\beta_{interaction}$=-0.20, 95% CI= (-0.37; -0.02)).

Table 4
Association between day-to-day leisure time physical behaviours and relative standing work time and worktime.

	Outcome: Leisure composition pivot coordinates		
Predictors	**ilr_1(Sedentary)**	**ilr_1(Standing)**	**ilr_1(Active)**
	β (95% CI)	β (95% CI)	β (95% CI)
Weekday (Monday)			
Tuesday	-0.27 (-0.80; 0.28)	0.05 (-0.40; 0.52)	0.22 (-0.24; 0.64)
Wednesday	-0.34 (-0.86; 0.23)	0.01 (-0.41; 0.45)	0.37 (-0.004; 0.78)
Thursday	-0.44 (-0.97; 0.07)	0.17 (-0.21; 0.63)	0.30 (-0.13; 0.70)
Friday	-0.57 (-1.08; 0.05)	**0.24 (0.29; 0.71)**	0.37 (-0.20; 0.74)
Saturday	-0.21 (-1.04; 0.65)	0.29 (-0.28; 1.02)	-0.06 (-0.62; 0.68)
Sunday	-0.91 (-1.92; 0.17)	**0.78 (0.12; 1.65)**	0.19 (-0.64; 0.94)
Work ilr_1(Standing)	-0.12 (-0.30 ; 0.10)	**0.19 (0.03 ; 0.35)**	-0.07 (-0.21 ; 0.04)
Work ilr_1(Standing)*Weekday(Monday)			
Tuesday	0.19 (-0.01 ; 0.40)	**-0.18 (-0.36 ; -0.02)**	-0.004 (-0.16 ; 0.13)
Wednesday	0.10 (-0.13 ; 0.30)	-0.11 (-0.27 ; 0.09)	0.01 (-0.13 ; 0.18)
Thursday	0.10 (-0.10 ; 0.32)	-0.11 (-0.27 ; 0.07)	0.02 (-0.14 ; 0.14)
Friday	0.24 (0.00 ; 0.45)	-0.16 (-0.35 ; 0.03)	-0.09 (-0.22 ; 0.06)
Saturday	0.26 (-0.17 ; 0.66)	-0.09 (-0.52 ; 0.17)	-0.18 (-0.45 ; 0.03)
Sunday	**0.90 (0.19 ; 1.51)**	-0.44 (-0.96 ; 0.00)	**-0.51 (-0.98 ; -0.05)**
Worktime[A]	-0.03 (-0.29 ; 0.18)	-0.06 (-0.25 ; 0.11)	0.10 (-0.06 ; 0.25)
Worktime[A]*weekday (Monday)			
Tuesday	0.06 (-0.23 ; 0.35)	0.03 (-0.19 ; 0.23)	-0.09 (-0.27 ; 0.12)
Wednesday	0.13 (-0.11 ; 0.44)	0.04 (-0.20 ; 0.24)	-0.18 (-0.36 ; 0.00)
Thursday	0.18 (-0.11 ; 0.49)	-0.03 (-0.25 ; 0.18)	-0.16 (-0.35 ; 0.02)

*[A]Calculated as the log of total accelerometer-derived work time. ilr_1 = first pivot coordinate, representing the relative importance of a work or leisure time physical behaviour (indicated in parenthesis) with respect to the others Results based on multivariate multilevel models adjusted for sex, age, smoking-status and BMI. Total number of observations included = 1999. Bold indicates significant at $p < 0.05$, * indicates interaction term.*

	Outcome: Leisure composition pivot coordinates		
Friday	0.26 (-0.02 ; 0.52)	-0.08 (-0.32 ; 0.15)	-0.19 (-0.38 ; 0.00)
Saturday	0.16 (-0.20 ; 0.56)	-0.17 (-0.46 ; 0.09)	0.01 (-0.25 ; 0.34)
Sunday	0.28 (-0.20 ; 0.70)	-0.25 (-0.68 ; 0.08)	-0.01 (-0.46 ; 0.27)

*[A]Calculated as the log of total accelerometer-derived work time. ilr_1 = first pivot coordinate, representing the relative importance of a work or leisure time physical behaviour (indicated in parenthesis) with respect to the others Results based on multivariate multilevel models adjusted for sex, age, smoking-status and BMI. Total number of observations included = 1999. Bold indicates significant at $p < 0.05$, * indicates interaction term.*

Table 5
Association between day-to-day leisure time physical behaviours and relative active work time and worktime.

	Outcome: Leisure composition pivot coordinates		
Predictors	**ilr_1(Sedentary)**	**ilr_1(Standing)**	**ilr_1(Active)**
	β (95% CI)	β (95% CI)	β (95% CI)
Weekday (Monday)			
Tuesday	-0.28 (-0.76; 0.27)	0.08 (-0.36; 0.54)	0.18 (-0.24; 0.57)
Wednesday	-0.36 (-0.94; 0.09)	0.01 (-0.46; 0.43)	0.34 (-0.07; 0.72)
Thursday	-0.45 (-0.97; 0.02)	0.18 (-0.31; 0.60)	0.28 (-0.09; 0.70)
Friday	**-0.59 (-1.15; -0.13)**	0.25 (-0.19; 0.71)	0.32 (-0.14; 0.72)
Saturday	-0.24 (-0.10; 0.60)	0.26 (-0.30; 0.83)	-0.05 (-0.65; 0.62)
Sunday	-0.93 (-1.89; 0.21)	0.79 (-0.02; 1.57)	0.15 (-0.61; 1.11)
Work ilr_1(Standing)	0.15 (-0.06 ; 0.35)	**-0.21 (-0.37 ; -0.05)**	0.07 (-0.08 ; 0.23)
Work ilr_1(Standing)*Weekday (Monday)			
Tuesday	**-0.25 (-0.48 ; -0.03)**	**0.20 (0.01 ; 0.38)**	0.04 (-0.14 ; 0.23)
Wednesday	-0.10 (-0.31 ; 0.11)	0.12 (-0.06 ; 0.26)	-0.02 (-0.19 ; 0.14)
Thursday	-0.12 (-0.34 ; 0.09)	0.14 (0.00 ; 0.33)	-0.03 (-0.25 ; 0.12)
Friday	-0.21 (-0.46 ; 0.00)	0.16 (-0.02 ; 0.34)	0.05 (-0.12 ; 0.26)
Saturday	-0.29 (-0.73 ; 0.11)	0.01 (-0.30 ; 0.32)	0.26 (-0.07 ; 0.53)
Sunday	**-1.02 (-1.66 ; -0.38)**	0.51 (0.00 ; 0.93)	**0.52 (0.11 ; 1.03)**
Worktime[A]	-0.03 (-0.30 ; 0.18)	-0.06 (-0.26 ; 0.10)	0.10 (-0.03 ; 0.27)
Worktime[A]*Weekday (Monday)			
Tuesday	0.06 (-0.25 ; 0.37)	0.04 (-0.23 ; 0.24)	-0.10 (-0.27 ; 0.10)
Wednesday	0.14 (-0.14 ; 0.46)	0.04 (-0.18 ; 0.23)	-0.19 (-0.37 ; 0.02)
Thursday	0.19 (-0.08 ; 0.48)	-0.02 (-0.24 ; 0.18)	-0.16 (-0.32 ; 0.06)

*[A]Calculated as the log of total accelerometer-derived work time. ilr_1 = first pivot coordinate, representing the relative importance of a work or leisure time physical behaviour (indicated in parenthesis) with respect to the others Results based on multivariate multilevel models adjusted for sex, age, smoking-status and BMI. Total number of observations included = 1999. Bold indicates significant at $p < 0.05$, * indicates interaction term.*

Outcome: Leisure composition pivot coordinates			
Friday	0.27 (-0.04 ; 0.54)	-0.07 (-0.28 ; 0.12)	**-0.20 (-0.37 ; -0.02)**
Saturday	0.14 (-0.25 ; 0.55)	-0.16 (-0.44 ; 0.14)	0.02 (-0.23 ; 0.29)
Sunday	0.29 (-0.12 ; 0.88)	-0.25 (-0.66 ; 0.09)	-0.02 (-0.35 ; 0.34)

*[A]Calculated as the log of total accelerometer-derived work time. ilr_1 = first pivot coordinate, representing the relative importance of a work or leisure time physical behaviour (indicated in parenthesis) with respect to the others Results based on multivariate multilevel models adjusted for sex, age, smoking-status and BMI. Total number of observations included = 1999. Bold indicates significant at $p < 0.05$, * indicates interaction term.*

Sensitivity analysis

Results of sensitivity analysis among workers with at least two days of valid accelerometer data corresponded to those from the primary analyses.

Discussion

In this study, we investigated the day-to-day pattern of leisure time physical behaviours among blue-collar workers on workdays and non-workdays. Furthermore, we assessed the association between work factors (i.e. work physical behaviours and work duration) and day-to-day leisure time physical behaviours. The workers were primarily sedentary during leisure throughout the week on both workdays and non-workdays. Moreover, the workers were more sedentary at leisure during the weekend on workdays compared to non-workdays. Regarding the association between work factors and leisure time physical behaviours, standing work time was positively associated with sedentary leisure time and negatively associated with active leisure time. The opposite direction was found for the association between active work time and leisure time physical behaviours. Finally, work duration was negatively associated with active leisure time.

The overall finding of our study is that over the course of a week, low SES adults were predominantly sedentary during leisure, while most work time was spent standing or active. To our knowledge, this is the first study to investigate the domain-specific pattern of day-to-day physical behaviours among low SES adults. However, our results correspond to reviews finding leisure time PA to be less prevalent and work PA to be more prevalent among low SES adults compared to high SES adults[15, 36]. Moreover, accelerometer-based studies have consistently found low SES adults to be more active on workdays compared to non-workdays. One study found Swiss workers with manual jobs (e.g. craftsmen, machine operators and labourers) to be more active on workdays than non-workdays[37]. Another study reported adults with low educational level as less likely to be active during the weekend (i.e. non-workdays) and more likely to be active during the weekdays (i.e. workdays) compared to those with high educational level[13]. Finnish low-level occupational groups (e.g. cleaners, plumbers and construction workers) and Australian blue-collar workers have been found to be more sedentary and take less steps on weekends (i.e. non-workdays) compared to weekdays (i.e. workdays)[14, 38]. Taken together, these findings suggest that low SES adults derive the greatest proportion of day-to-day PA from work activities. Consequently, when only considering leisure time, low SES adults would appear to be “couch potatoes”. However, including work physical behaviours reveals that this population group might also be “work warriors”.

We further investigated whether the workers’ high amount of sedentary leisure time throughout the week was associated with work physical behaviours. Standing work time was associated with more sedentary and less active leisure time with the strongest associations observed on Sunday. This finding could be explained by the fact that standing for prolonged, uninterrupted periods increase blood pooling in the legs which can cause swelling, pain and muscle fatigue in the lower extremities[39, 40]. Consequently, workers with much standing work time could perceive to have an increased need to compensate with more sedentary time and less physical activities when coming home from work[41]. We have previously assessed the association between percentage work hours spent standing and percentage leisure time spent sedentary over consecutive workdays within the same population[42]. However, contrary to the present study, no relationship between occupational standing and sedentary leisure time was observed. One explanation for the discrepancy between the two studies could be that we did not consider the interdependency between work and leisure time physical behaviours as done in the current study. Counter to standing work time, active work was associated with less sedentary and more active leisure time, again with the strongest association observed on Sunday. This result is in line with one study finding a positive relationship between accelerometer-derived time spent on moderate-to-vigorous physical activity at work and leisure among 233 adults[43]. In contrast, another study based on accelerometer measurement from 112 adults found no difference in leisure physical activities between those with low and high work activity levels[44]. Thus, the relationship between work and leisure time physical behaviours among low SES adults remains unclear. We encourage future research on this topic based on technical measurements and considering the interdependency between time spent in daily behaviours.

We found work duration to be negatively associated with active leisure time on weekdays, with the strongest association on Friday, which suggests a trade-off between time spent at work and spent active during leisure time. According to economic theories of time allocation, free-time available for health-promoting leisure time activities is socially patterned, favouring higher SES individuals[16]. A plausible reason for this is that low SES typically have low control over work hours and lack financial resources to outsource domestic work (e.g. cooking, cleaning, and childcare)[45, 46]. Accordingly, “lack of time” has been reported as the primary barrier for leisure time physical activities among this population group[45, 47], which our result further supports. Thus, interventions and policies aiming to increase leisure time PA among low SES adults ought to consider how time-related constrains might act as a barrier.

Strengths and limitations

This study was based on technical measurements, which enabled accurate information on daily time spent in physical behaviours at work and during leisure time. Moreover, socioeconomic residual confounding was minimized given that the study population was similar in socioeconomic status (based on their occupation). Finally, the multivariate multilevel model that allowed for analysis which included the repeated measurements as well as multiple outcomes for each participant. The cross-sectional design of this study hinders causal inference. Most of the workers included in the NOMAD and DPhacto studies had the accelerometers mounted on Monday or Tuesday. Thus, it is possible that the workers behaved differently these days because they wore accelerometers. Moreover, participants with heavy physical work or a very active leisure time could have experienced issues with wearing the accelerometer, causing them to take off the devices at an earlier stage than less active participants. However, the sensitivity analysis excluding those with only one day of valid accelerometer data revealed results similar to that of the primary analysis. We did not have information about the context in which day-to-day physical behaviours were performed. Thus, we are unable to state if active leisure time spent was spent on health-promoting planned activities, such as sports, or spent on domestic work. An ideal approach for studying physical behaviours would be to combine the contextual information with technical measurements. Finally, we did not include time in bed at night in the analysis, which we encourage future studies on day-to-day patterns of daily physical behaviours to consider.

Conclusions

We found low SES adults to be primarily sedentary during leisure time, while work time was spent mostly standing or active. Thus, this group of adults could be characterised as ‘work warriors’. This highlights the need of differentiating between work and leisure time when assessing daily behavioural pattern among low SES adults. Work factors (i.e. standing and active work time and work duration) were differently associated with day-to-day leisure time physical behaviours. Accordingly, we recommend strategies for increasing health-enhancing leisure time PA among low SES adults to consider the potential influence of work physical behaviours and work-related time constrains.

Abbreviations

DPhacto
Danish PHysical ACTivity cohort with Objective measurements
NOMAD
New Method for Objective Measurements of Physical Activity in Daily Living
PA
physical activity
SES
socioeconomic status

Declarations

Ethics approval and consent to participate

The DPhacto and NOMAD studies were approved by the local Ethics Committee (file number H-2-2012-011(34) and file number H-2-2011-047 (35), respectively). The studies were conducted according to the Helsinki declaration and all data were anonymized in relation to individuals and workplaces.

Consent for publication

Not applicable.

Availability of data and materials

The datasets supporting the conclusions of this article are available at the Danish National Archives, https://www.sa.dk/en/k/about-us.

Competing interests

The authors declare that they have no competing interest.

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Authors' contributions

Charlotte Lund Rasmussen conceived the research idea of the study, conducted the analyses and was responsible for interpretation of the results and drafting the first draft of the manuscript. Dorothea Dumuid and Karel Hron advised on planning the study's analytic strategy. Andreas Holtermann and Marie Birk Jørgensen were principal investigators and responsible for the dataset used in this paper. All authors contributed to prepare the introduction and discussion sections, interpretation of the results, and have read and commented on the draft version and approved the final version of the entire manuscript.

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Figures

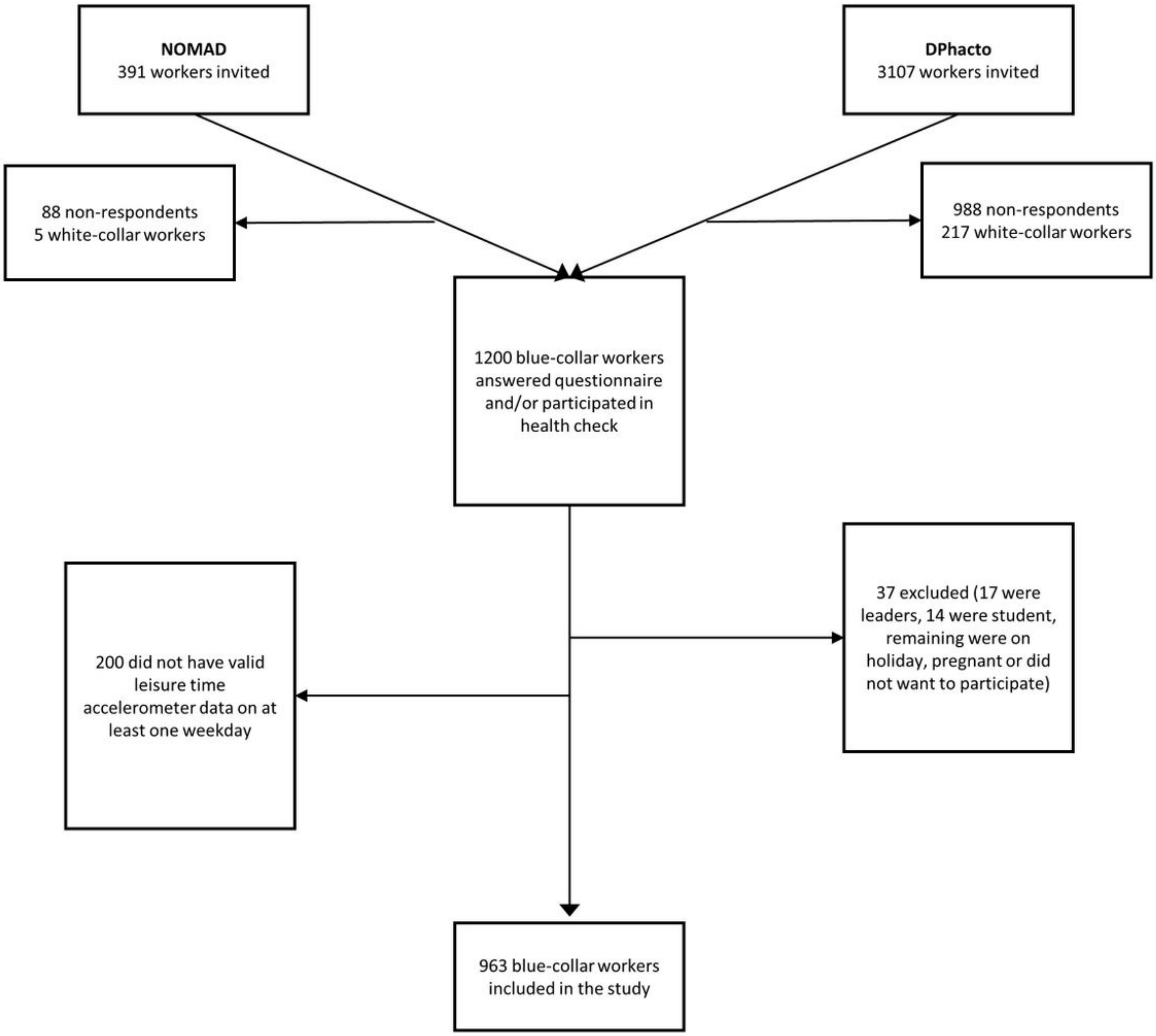

Figure 1

Flow chart of the study population.

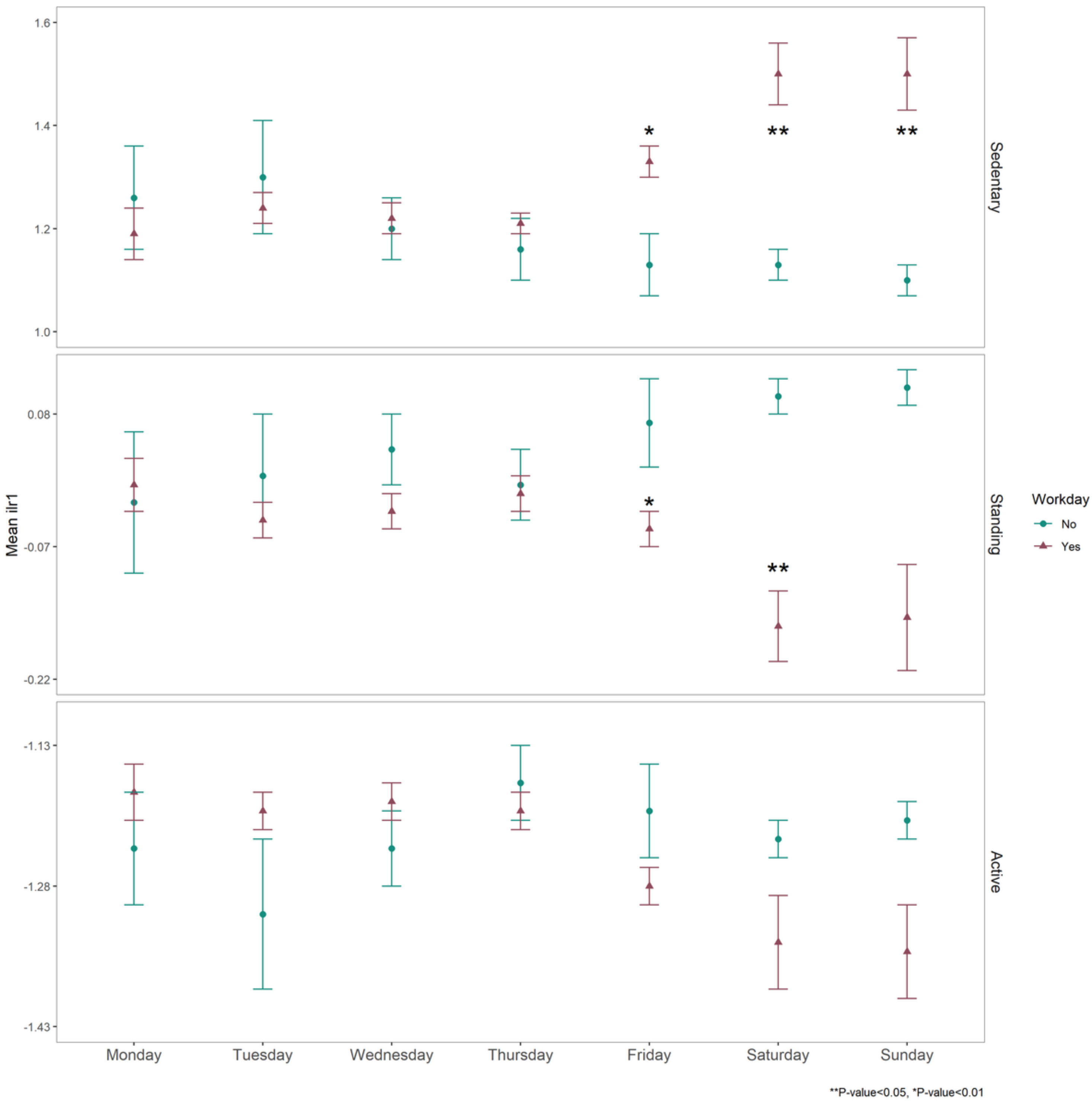

Figure 2

Mean ilr1, expressing relative leisure time spent sedentary, standing, and active on workdays and non-workdays. Points indicate the mean ilr1 and vertical lines represent ± standard deviation. Higher values of ilr1 means more leisure time spent on the specific behaviour with respect to the others. Significance based on a multilevel model, adjusted for sex, age, smoking-status. Monday and non-workday as reference. *P-value<0.05, **P-value<0.01.

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