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The descriptive epidemiology of standing activity during free-living in 5,412 middle aged adults: the 1970 British Cohort Study

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Data are publicly available: https://ukdataservice.ac.uk/

Summary box

What is already known on this subject?

- Standing is often classified as light intensity physical activity, with potential health benefits compared to sitting.
- Free-living standing is rarely captured owing to measurement difficulties.
- We measured free-living standing behaviour at a population level using a unique postural allocation device

What does this study add?

- Adults spent nearly a third of the day in activities involving standing.
- Key characteristics such as obesity, health, occupation, were associated with standing times.
- Standing merits attention as health-related posture and may represent a potential target for public health intervention.

Abstract

Background: Standing is often classified as light intensity physical activity, with potential health benefits compared to sitting. Standing is, however, rarely captured as an independent activity. To better understand free-living standing behaviour at a population level we incorporated a gold standard postural allocation technique into a national cohort study.

Methods: Participants (n=5,412, aged 46.8 ± 0.7 yrs) from the 1970 British Cohort study were fitted with a water-proofed thigh mounted accelerometer device (activPAL3 micro) worn 24 hrs continuously over 7 days (90.7% provided at least 3 full days). We examined the correlates of free-living standing during waking hours.

Results: Total daily standing time averaged 4.6±1.5 hr/d, accounting for 29% of waking hours, which was largely (98.7%) accumulated in bouts lasting less than 30 min. In mutually adjusted models, male sex, obesity, diabetes, professional occupation, poor self-rated health, and disability were associated with lower device measured standing times.

Conclusion: Middle aged people in Britain spent a surprisingly large proportion of the day in activities involving standing. Standing merits attention as health-related posture and may represent a potential target for public health intervention.

Key words: Standing; Physical activity; Lifestyle; Population Cohort; Wearable

Introduction

Standing is a posture classified as “stationary activity” (1) where the body is held upright with the legs in a relatively static position. Activities involving standing are generally classified as light intensity, although in some instances, e.g., painting/decorating, may achieve energy expenditure values approaching moderate intensity (2). Cardiometabolic health benefits (3) as well as harms (4) have been ascribed to light intensity physical activity. The potential public health benefits of substituting sedentary behaviour with standing were present in some randomised trials (5-7) although the evidence as a whole is inconsistent (8). Indeed, beneficial observations reported may be due to related postural transitions (from interrupting sitting with repeated short bouts of standing) rather than from the posture of standing per se.

In order to translate epidemiological evidence into successful interventions there is a need to better understand how light intensity activity such as standing is accrued during daily living. At present we lack these data as light intensity activities often form part of everyday life that are difficult to accurately capture through self report (9). To the best of our knowledge there are no large scale population data on device measured standing. Existing accelerometry studies have largely analysed data using a threshold-based approach which is useful for distinguishing between activity intensities but cannot precisely differentiate between postures often leading to misclassification of low-intensity non-sedentary behaviours such as standing (10). In order to better understand free-living standing behaviour at a population level we incorporated a gold standard postural allocation device into a national cohort study. The aim was to describe population characteristics of standing activity. Based on previous literature around sedentary behaviour (11) we hypothesised associations between standing and various sociodemographic variables including sex, education, socio-occupational group, health status, obesity, smoking.

Methods

Design and participants

The 1970 British Cohort Study (BCS70) recruited participants born in a single week of 1970 from England, Scotland and Wales (12). The age 46 survey was a home visit conducted in 2016-18, and comprised of 50 minutes of interviews (both face-to-face computer-assisted-personal-interview and computer-assisted-self-completion-interview) with a further 50 minutes of biomedical assessments performed by trained nurses (12). Participants provided informed consent and the study received full ethical approval from NRES Committee South East Coast - Brighton & Sussex (Ref 15/LO/1446).

Standing behaviour measurement

The study used a thigh-mounted accelerometer device (activPAL3 micro; PAL Technologies Ltd., Glasgow, UK), as previously described (13), that uses derived information about thigh inclination and acceleration to estimate body posture (i.e., sitting/lying and upright) and transition between these postures, stepping, and stepping speed (cadence). We utilised a previously adopted wear protocol (14); Devices were programmed to sample at the default frequency of 20 Hz. The device was waterproofed (heat sealed (P200-C heat sealer [Packer, Essex, UK]) within Layflat plastic tubing) and fitted by a trained nurse on the midline anterior aspect of the upper thigh as recommended by the manufacturer. Participants were requested to wear the device continuously for 7 days, including sleeping, bathing, swimming, and all physical activities. If the device fell off or was removed before the stated end date re-attachment was discouraged. Devices were returned via post. Data were processed using freely available software that has been previously validated (15). The software uses an algorithm to isolate valid waking wear data from sleep or prolonged non-wear, summarized elsewhere (15). We used a step cadence threshold ≥ 100 in order to derive moderate – vigorous intensity physical activity [MVPA] (16). The first partial day was removed and subsequent days were defined from midnight – midnight. Participants were included if they recorded at least one valid day during the monitoring period, defined as at least 10 hrs of waking wear time.

Lifestyle and health measures

Participants provided information on smoking habits (never; ex-smoker; current), self-rated health (excellent; very good; good; fair; poor), disability - using The European Statistics of Income and Living Condition (EU SILC) classification - (none; some extent; severely hampered), education (none; GCSE/A-level/diploma; degree), social occupational group (Professional; Intermediate; Lower supervisory/technical; Semi-routine/ routine; Long term unemployed; Non-classified), occupational activity (standing; sitting; heavy manual), and domestic activity including food preparation, cooking, washing (hours per week). Nurses measured height and weight for the calculation of body mass index (BMI), which was categorised as under weight (BMI <18.5 kg/m^2), normal weight (BMI 18.5<25 kg/m^2), overweight (25<30 kg/m^2), obese (30-35 kg/m^2), morbidly obese (≥35 kg/m^2). Participants provided information on physician diagnosed diabetes and undiagnosed cases were identified through glycated haemoglobin (Hba1C > 48 mmol/mol) measured from a blood sample provided at the biomedical assessment (12).

Statistical analyses

The distribution of activPAL variables were examined for normality. The activity data represents mean hours per day averaged over the number of days the device was worn. Average daily standing time was categorised into tertiles (low: <3.8hr/day; medium: 3.8-5.0 hr/day; and high: >5 hr/day) and examined in relation to sociodemographic and lifestyle variables. After confirmation of assumptions of normality, Generalised linear models were used to examine associations between standing time (continuous dependent variable) and sociodemographic / lifestyle variables, adjusting for month of wear and waking hours wear time.

Results

A total of 6,562 (88% of those invited) cohort members consented to participate in the activPAL study. After removal of participants with unusable activPAL data (n=1114) [nurse unable to initiate (n=102); lost in post (n=591); unable to download (n=421)], and missing covariates (n=36) the analytic sample comprised 5,412 participants (52.5% female). Participants declining to wear the device were more likely to be male, smokers, report poorer health, and have higher BMI, as previously described (17). There was high adherence to the wear protocol, 90.7% of the sample recorded at least 3 full days of device wear, 79.6% recorded 6 full days of wear, and 65.5% wore the device for the full 7 days.

Total daily standing time averaged 4.6±1.5 hr/d, accounting for 29% of waking hours, which was largely (98.7%) accumulated in bouts lasting less than 30 min. Standing was similar on weekdays (4.7±2.0 hr/d) compared to weekends (4.5±1.9 hr/d). Greater daily standing was accumulated in women, smokers, non-degree educated, non-professional occupations, non-obese, and those with better health (Table 1). Higher standing time was also characterised by standing occupations and domestic activity (food preparation, cooking, washing), although commuting by public transport was linked to lower standing (Table 1). In correlations, standing was inversely associated with sitting time (r= -0.74) and positively with MVPA (r= 0.12).

In unadjusted models standing time was associated (main effect, $p<0.05$) with all variables of interest. In mutually adjusted models, sex, obesity, diabetes, occupational group, self-rated health, and disability remained associated with device measured standing times (Table 2). In particular, professional occupations recorded 1.14 (1.0, 1.28) hr/d less standing than lower supervisory/

technical workers; cohort members reporting poor self rated health recorded 0.48 (0.22, 0.75) hr/d less standing than those with excellent health; morbidly obese recorded 0.43 (0.18, 0.65) hr/d less standing than normal weight. In sensitivity analyses that excluded participants with less than 4 days wear results were not materially different (online Table S1).

Discussion

We aimed to better understand free-living standing behaviour in middle aged adults at a population level using a novel postural allocation device. Standing accounted for nearly of third of total waking hours, which is consistent with recent data suggesting light activity is the main driver of physical activity energy expenditure (18). Light intensity activities are thought to be accrued during daily living and our data suggested greater standing in participants with standing occupations and undertaking more domestic activities. Cohort members with poorer health and higher levels of adiposity accrued less daily standing although from the present cross-sectional design it is difficult to ascertain if health was a consequence or cause of standing behaviour. However, differences in standing time between normal weight and obese equated to nearly 3hrs/week, which reflects significant disparities in energy expenditure.

There was a strong inverse correlation between sitting and standing in the present study. Some controlled trials have suggested cardiometabolic health benefits of substituting sitting with standing (5,6) although others have not (19). Epidemiological data have also shown associations between standing and greater risk of heart disease in blue collar workers (4). The epidemiological evidence linking sedentary behaviour with adverse health outcomes (20) may not be purely driven by sitting time, but instead the balance between transitions from sitting and standing. It is important to make this distinction as the benefits may be accrued from contraction of large muscle groups when moving between postures outweighing harmful effect of single static posture.

The main strengths of this study are the nationally representative sample, the use of a novel postural allocation device to better capture standing, and high adherence to the wear protocol with little data loss. Some data have suggested a minimum of 4 wear days are needed to achieve acceptable degree of repeatability (21), although the study was conducted on a sample of 68 middle aged women and thus difficult to draw comparison with our large scale general population cohort. Exclusion of participants with less than 4 days wear did not influence our results. Our wear protocol minimised the problems of non-wear as participants were requested not to re-attach their device if removed prematurely. As is the case in most population studies, respondents that did not consent to wear a device tended to be less educated and report poorer health that may have introduced bias. Our study was conducted on middle aged (largely working) adults, before the onset of functional decline, thus may not be representative of the wider population.

In conclusion, standing merits attention as health-related posture and may represent a potential target for public health intervention.

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Table 1. Descriptive characteristics in relation to daily standing time (n=5,412)

	Low (<3.8 hr/d)	**Medium (3.8-5.0 hr/d)**	**High (>5 hr/d)**
N	1805	1806	1801
Men (%)	53.3	46.6	42.8
Smokers (%)	13.0	11.9	15.1
Degree educated (%)	26.8	25.5	18.6
Professional social occupational group (%)	23.7	16.6	9.3
Poor self-rated health (%)	6.6	3.3	1.8
Disability (%)	8.0	4.2	2.5
Obese (% ≥ 30 kg/m^2)	33.1	29.6	30.6
Physician diagnosed diabetes (%)	5.0	2.7	3.1
Device sitting time (hr/d)	10.8 ±1.5	9.3 ±1.3	7.6 ±1.6
Device stepping (activity) time (hr/d)	1.6± 0.6	2.1± 0.7	2.3± 0.7
Standing accumulated in bouts >30min (hr/d)*	0 (0 – 1.0)	0 (0 – 2.0)	0 (0 – 4.6)
Device moderate-vigorous physical activity (min/d)	45± 26	53± 26	55± 25
Device wear days	6.1± 1.7	6.3± 1.4	6.1± 1.6
Standing occupation (%)	8.1	14.1	23.1
Use of public transport to commute	14.3	12.5	9.6
Domestic activity (% >10hr/wk)	10.7	18.4	21.8

* data presented as the median and range

Table 2. Regression of sociodemographic and lifestyle factors on device measured standing

Variable	N	B (95% CI)*
Sex: Male	2572	Ref
Female	2840	0.41 (0.33, 0.49)
Education (Ref :None)	1423	Ref
GCSE/A-level/diploma	2487	0.01 (-0.08, 0.10)
Degree	1502	-0.10 (-0.21, 0.01)
Social occupational group		
Professional (Ref)	894	Ref
Intermediate	2228	0.32 (0.21, 0.43)
Lower supervisory/technical	870	1.14 (1.0, 1.28)
Semi-routine/ routine	721	0.91 (0.77, 1.06)
Long term unemployed	75	-0.10 (-0.43, 0.24)
Non-classified	624	0.47 (0.31, 0.62)
Smoking (Ref: Never)	2682	Ref
Ex-smoker	1768	-0.03 (-0.12, 0.06)
Current	962	0.06 (-0.05, 0.17)
Self-rated health (Ref: Excellent)	1030	Ref
Very good	2019	0.10 (-0.02, 0.22)
Good	1497	0.09 (-0.03, 0.22)
Fair	649	0.03 (-0.13, 0.19)
Poor	217	-0.48 (-0.75, -0.22)
Disability (Ref: none)	4571	Ref
Some extent	571	0.05 (-0.10, 0.18)
Severely hampered	270	-0.48 (-0.71, -0.26)
Body mass index (Ref: normal 18.5<25)	1580	Ref
Underweight (<18.5)	121	-0.17 (-0.45, 0.09)
Overweight (BMI 25<30)	2043	-0.19 (-0.28, -0.09)
Obese (BMI 30<35)	1504	-0.19 (-0.28, -0.07)
Morbidly obese (BMI ≥ 35)	164	-0.43 (-0.65, -0.18)
Diabetes (Ref: no)	5217	Ref
Yes	195	-0.22 (-0.43, 0.00)

*(B) Coefficients are mutually adjusted for all variables, plus month of data collection and waking hours wear time