



An examination of compensation effects in accelerometer-measured occupational and non-occupational physical activity

Jennifer L. Gay^{a,*}, David M. Buchner^b, Jessalyn Smith^c, Chunla He^d

^a Department of Health Promotion & Behavior, University of Georgia, Athens, GA, USA

^b Department of Kinesiology and Community Health, University of Illinois at Urbana-Champaign, Champaign, IL, USA

^c Data Recognition Corporation, Maple Grove, MN, USA

^d Department of Epidemiology & Biostatistics, University of Georgia, Athens, GA, USA

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ABSTRACT

Self-report data suggests a large proportion of total physical activity (PA) occurs at work. However, adults with higher levels of occupational PA may compensate by engaging in less non-occupational PA. The study aims were to 1) estimate the intensity, volume, and duration of PA in American adults that occurs at work, and 2) determine if those more active at work are less active outside of work. A cross-sectional sample of full-time employed adults ($N = 510$) was recruited from Georgia city and county governments in 2013–2015. Participants wore an Actigraph GT3X + accelerometer for two weeks. In 2016, for 442 participants with complete data including work schedules and self-reported job titles, accelerometer wear minutes were classified as either occupational or non-occupational, and as sedentary, LPA (light-intensity PA), or MVPA (moderate-to-vigorous intensity PA). The proportion of daily PA that occurred during work was 41.2% for total PA, 41.0% for LPA, and 39.5% for MVPA. Higher levels of occupational LPA were associated with lower levels of non-occupational LPA ($r = -0.38, P < 0.0001$). However, higher levels of occupational MVPA were associated with higher levels of non-occupational MVPA ($r = 0.17, P < 0.0001$). These associations remained significant in a MANOVA adjusting for labor sector and other covariates. On average, employed adults get more LPA and MVPA outside of work. Adults who do more occupational MVPA do not compensate by doing less non-occupational MVPA. In contrast, adults who do more occupational LPA do compensate by doing less non-occupational LPA. Evaluations of interventions to reduce sedentary behavior should be designed to detect compensation effects.

1. Introduction

Occupational physical activity has declined steadily over the past half century in the United States (Brownson et al., 2005; Church et al., 2011; Ng and Popkin, 2012). Even so, an analysis of time-use data showed that as of 2009, occupational activity accounted for the majority of physical activity energy expenditure in adults (Ng and Popkin, 2012). Limited data suggest adults have not compensated for declining levels of occupational activity by substantially increasing non-occupational activity (Brownson et al., 2005; Ng and Popkin, 2012).

The relationship between changes in occupational and non-occupational activity is unclear. In some studies, there appears to be a dose-response relationship whereby the amount of physical activity increases in a stair-step fashion as occupational activity increases (Gay and Buchner, 2014; Marshall et al., 2007). That is, adults who are more active at work engage in more physical activity during free time. However, some evidence suggests the opposite—a compensation or

substitution effect occurs where employees who engage in greater amounts of activity during work are more sedentary outside of work (Matthews et al., 2001; Salmon et al., 2000). Further, there are limitations to the existing evidence on compensation effects in the use of self-reported data and lack of domain (i.e., work versus non-work) analyses. The use of self-reported physical activity data is prevalent in studies of occupational activity (Burton and Turrell, 2000; Macera et al., 2005; Marshall et al., 2007; Matthews et al., 2001; Ng and Popkin, 2012; Salmon et al., 2000). There is a lack of confirmatory data from wearable devices to support the findings in studies using self-report. In existing studies that measure physical activity with accelerometry, work activity has not been separated from other domains (Gay and Buchner, 2014; Wolin and Bennett, 2008).

To fill this research gap, the present study measured levels of both occupational and non-occupational activity using accelerometers in adults employed full-time. There were three study aims: (1) To estimate the volume (accelerometer counts/day) and minutes/day of light-

* Corresponding author at: Department of Health Promotion & Behavior, University of Georgia, 100 Foster Road, 251E Wright Hall, Athens, GA 30602, USA.
E-mail address: jlgay@uga.edu (J.L. Gay).

intensity physical activity (LPA) and moderate-to-vigorous physical activity (MVPA) occurring during work (occupational) versus outside of work (non-occupational). (2) To determine if the relative amounts of occupation and non-occupational activity varied by type of occupation (labor sector). And (3) to determine if adults who are more active at work are less active outside of work. We hypothesized that workers in more active jobs (e.g., construction) would engage in greater amounts of non-occupational physical activity.

2. Materials and methods

2.1. Study sample

The reporting of this study conforms to the STROBE statement (von Elm et al., 2008). City or county governments in the state of Georgia were invited to participate in a cross-sectional study at an annual meeting of commissioners. Data collection began in July 2013, was completed in November 2015, and included nine counties. Two larger sites provided proportions of racial/ethnic groups and male/female for their worksites. Within those two sites, significantly more women participated relative to the government workforce ($P < 0.05$), but there was no significant difference in race/ethnicity. To calculate the population-level US Census-based labor sector proportions, participating government offices were asked to provide a list of all job titles and the number of employees in each job title. The study used a quota sampling framework to approximate representation by labor sector. In the present study the aim was to match the percentage of study participants (total $n = 510$) in a specific labor sector to the population percentage of employees in that sector. These data are provided in Supplemental Table 1. The study was approved by the Institutional Review Boards at the University of Georgia and University of Illinois Urbana-Champaign.

Table 1
Participant ($N = 445$) demographic characteristics and physical activity behavior.

Variable	N	% ^a
Sex		
Male	151	34.0
Female	294	66.0
Race/Ethnicity ^b		
White	272	62.1
Black/African-American	129	29.5
Other	37	8.5
Weight Status (BMI)		
Underweight	7	1.6
Normal	86	19.3
Overweight	145	32.6
Obese	27	46.5

	M	SD	Range
Age, yrs	43.08	10.56	19–68
Body Mass Index (BMI; kg/m ²)	30.80	7.11	17.99–69.16
Body Fat (%)	35.29	10.25	9.50–62.90
Waist Circumference (cm)	96.07	15.48	45.34–150.11
Hip Circumference (cm)	111.26	14.74	77.47–185.17
Waist-to-Hip Ratio	0.86	0.08	0.42–1.10
Mean Daily Minutes, Counts of PA			
Occupational LPA Minutes	118.69	61.60	7.89–354.75
Occupational MVPA Minutes	8.74	9.39	0.00–52.78
Non-Occupational LPA Minutes	166.34	58.23	8.50–396.00
Non-Occupational MVPA Minutes	12.74	10.87	0.00–73.00
Occupational LPA Counts	70,917	45,060	5197–290,795
Occupational MVPA Counts	25,204	29,296	0–168,805
Non-Occupational LPA Counts	94,743	38,296	3724–303,090
Non-Occupational MVPA Counts	42,401	42,494	0–295,450

^a Proportions for demographic variables may not total 100 due to rounding.

^b Seven participants did not self-report race or ethnicity.

Full-time employees (≥ 30 h/week) were recruited via email and in-person meetings. Study participants provided written informed consent, took a brief survey (including health history, job content, and demographic items), had their anthropometric measurements taken, and were given an accelerometer to wear for two weeks. Participants self-reported their job title at time of enrollment. Job titles were matched with the 2010 occupational census codes (United States Census Bureau, 2015) to determine industry and occupation groups. Job titles were coded separately by two study team members, with any discrepancies resolved through consensus.

Herein, a one-word label is used to describe labor sectors. Supplemental Table 1 provides the full labor sector label along with example job titles. This table also provides a comparison of the percentage of participants relative to the employee population by labor sector (i.e., an assessment of the quota sampling framework). The proportion of participants from the Service labor sector was substantially lower than the population proportion. Employees from the Service sector, such as law enforcement, were more difficult to recruit because of their wide array of work schedules, and ability or level of comfort wearing the accelerometer with their equipment belts. And for this sector (unlike others), it was necessary to do a large amount of recruitment using email rather than in-person meetings. Two labor sectors were over-represented apparently due to a higher interest level of participants: 1) Management and 2) Community Service.

Analyses included 445 participants with job title, anthropometric, and physical activity data. Participants were excluded from data analyses for the following reasons: insufficient accelerometer wear time (defined as < 10 h/day and < 4 days; $n = 35$), missing work schedule ($n = 15$), declining to wear the accelerometer ($n = 8$), errors with the accelerometer device ($n = 4$), and three devices that were not returned.

2.2. Measures

2.2.1. Anthropometric measures

Anthropometric measures including body weight, height, waist and hip circumference, and body fat percentage were assessed using standard protocols for body positioning (Lohman et al., 1988). Two assessments were taken for each measure. If the two assessments varied significantly, a third measure was taken. The mean of the two assessments was used or the median when three assessments were needed (Lohman et al., 1988).

2.2.2. Physical activity

Objective measurements of (PA) were obtained using a triaxial accelerometer (Actigraph GT3X+, The ActiGraph, Pensacola, FL). The participants were asked to wear the accelerometer on their hip during all waking hours except when bathing or engaging in water activities. They wore the device for 14 days to assess PA behaviors during and outside of work time. They were also asked to fill out a log that indicated the time they wore the device each day along with their work schedule and exercise activity. If logs were not returned work schedules were imputed based on self-report of normal work schedule from the participant or human resources (e.g., Monday through Friday, 8 am to 5 pm). For 15 participants (10 protective services, 2 community service, 2 maintenance, 1 construction) work schedules could not be imputed due to non-traditional work hours. These participants were not included in the analyses.

2.2.2.1. Physical activity data reduction. Raw data from the y-axis of the accelerometer were processed using the NHANES physical activity monitor SAS code (National Cancer Institute, 2016). Data were summarized into one-minute epochs. Wear time was determined using the Troiano et al. (2008) definition of non-wear = 60 + minutes of consecutive zeroes. Mean daily wear time was 14.85 h (± 2.20 h). With this definition, participants with sufficient wear time (at least 10 h on at least 4 days/week) 86.7% of participants wore the

accelerometer enough to be included in the analyses. The Troiano et al. (2008) cut points were used to assign intensity thresholds for the activity count data, where LPA is defined as 100–2019 counts per minute, and MVPA is defined as with > 2020 counts per minute. Participant log data were merged with accelerometer data, and the SAS codes were adapted to classify each epoch as either a work or non-work minute. Variables were summarized into mean daily values for minutes and intensity counts for total, occupational, and non-occupational PA.

2.3. Statistical analysis

Descriptive statistics for demographic characteristics, anthropometric measures, minutes of wear time and work time, as well as occupational PA and non-occupational PA variables were calculated. For Aims 1 and 2, the mean daily minutes and intensity counts for PA, by domain and labor sector, were calculated. The proportion of mean daily PA minutes and intensity counts from work were calculated for the total sample and by labor sector.

Aim 3 addressed the issue of a compensation effect: do participants who accumulate more activity in their jobs compensate by doing less activity outside of work? The initial evaluation of compensation was examined through Pearson correlation tests among total, occupational, and non-occupational PA variables (in minutes). Second, partial correlation coefficients adjusting for age, sex, race/ethnicity, and labor sector were calculated (in minutes and counts). Finally, as there was variation in PA variables by labor sector, a multivariate analysis of covariance (MANCOVA) was then conducted to examine whether there was a compensation effect adjusting for labor sector, wear time, age, sex, and race/ethnicity. Post-hoc contrasts were conducted for labor sector. All analyses were conducted in SAS version 9.4 (Cary, NC) *P*-values < 0.05 were considered statistically significant for all analyses.

3. Results

The sample (*n* = 445) was approximately two-thirds female, 62.1% white, 79.1% overweight or obese, and had a mean age of 43.1 years. Participants wore the accelerometer on average 14.85 ± 2.20 h per day, and reported an average of 6.05 ± 1.90 h of work per day. Additional sample characteristics are provided in Table 1.

Table 2 presents the proportion of total activity minutes and counts that the sample participated in during occupational activities. Overall participants accumulated 41.2% of their PA minutes and 40.2% of their activity counts during work time. Within labor sectors, Management and Office derived the lowest amounts of activity from occupation, whereas Maintenance had 51.1% of minutes and 48.6% of activity counts from work. The proportion of minutes and counts from work

were similar between LPA and MVPA. Mean daily minutes and intensity counts of PA by domain and labor sector are shown in Supplemental Tables 2 and 3.

Pearson correlation coefficients for all activity variables are provided in Table 3. All activity variables were significantly associated with each other. Interestingly, as total occupational activity and occupational LPA increased, non-occupational activity decreased at all intensities. Specifically, more occupational LPA was associated with less non-occupational LPA (*r* = -0.34, *P* < 0.0001). However, more occupational MVPA was associated with more non-occupational MVPA (*r* = 0.26, *P* < 0.0001).

Partial correlation coefficients for LPA, MVPA, and total PA by domain are shown in Table 4. Results are provided for associations in minutes and accelerometer counts as a measure of PA volume. These coefficients can be interpreted to mean that (1) as occupational LPA increases, LPA outside of work decreases, but (2) as occupational MVPA increases, MVPA outside of work also increases, after adjusting for labor sector, race/ethnicity, age, sex and wear time. The associations were significant for both minutes and accelerometer counts.

The MANCOVA results also identified significant differences in PA levels by sector (Supplementary Table 4). Construction had greater total, light-intensity, and moderate-to-vigorous intensity non-occupational PA compared with other labor sectors.

4. Discussion

The results suggest that, on average, employed adults get more physical activity (both LPA and MVPA) outside of work than at work. Adults were more active outside of work, whether level of physical activity was assessed using minutes/day or counts/day. In the current study, occupational physical activity is not providing the majority of total physical activity minutes (41.2%) or counts (40.2%). This is in contrast with Ng and Popkin's time use data, where approximately 55.8% of MET-hours per week was derived from occupation (Ng and Popkin, 2012). There was only modest variation by labor sector, where occupational tasks accounted for 36.4% to 51.1% of total physical activity, with Maintenance workers most similar to time use data.

There was a compensation effect for light-intensity physical activity. Workers who performed more light-intensity activity during work hours were less active outside of their jobs. This is an important finding. Interventions to decrease sedentary time at work focus primarily on increasing light-intensity activity. If increasing light-intensity activity during work time could decrease activity outside of work, then these interventions may have a net negative impact on total physical activity. This is similar to the findings in Mansoubi et al. (2016) where the use of a sit-to-stand workstation increased step counts and light-intensity activity during work time, but significantly reduced light-intensity

Table 2
Proportion of mean daily activity in minutes and intensity counts from work by labor sector.

	Minutes from Work			Intensity Counts from Work		
	% Total PA	% Light PA	% MVPA	% Total PA	% Light PA	% MVPA
Total Sample (<i>N</i> = 445)	41.2	41.0	39.5	40.2	41.1	39.0
Computer (<i>n</i> = 25)	43.4	43.3	45.3	43.4	44.0	44.6
Construction (<i>n</i> = 18)	41.2	41.2	40.6	45.3	42.2	39.9
Community Service (<i>n</i> = 69)	41.2	41.1	39.7	40.1	41.1	39.2
Healthcare (<i>n</i> = 44)	45.5	45.3	42.6	43.1	45.1	42.1
Maintenance (<i>n</i> = 14)	51.1	49.6	49.7	48.6	50.8	48.5
Management (<i>n</i> = 77)	36.4	36.2	34.9	35.5	36.1	34.4
Office (<i>n</i> = 75)	39.1	39.1	33.3	36.4	38.1	32.9
Service (<i>n</i> = 109)	42.5	41.9	42.9	42.1	42.8	42.1
Production (<i>n</i> = 14)	43.3	43.0	40.8	41.3	43.5	39.8

Note: Computer = Computer, Engineering, and Science; Construction = Construction and Extraction; Community Service = Education, Legal, Community Service, Arts, and Media; Healthcare = Healthcare Practitioners and Technical; Maintenance = Healthcare Practitioners and Technical; Management = Management, Business, Financial; Office = Office and Administrative Support; Production = Production, Transportation and Material Moving.

Table 3
Pearson correlation coefficients among physical activity variables (in mean daily minutes).

	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Total PA	–								
2. Light PA	0.98 ^d	–							
3. MVPA	0.51 ^d	0.34 ^d	–						
4. Total Occupational PA	0.61 ^d	0.60 ^d	0.32 ^d	–					
5. Occupational Light PA	0.59 ^d	0.60 ^d	0.23 ^d	0.99 ^d	–				
6. Occupational MVPA	0.46 ^d	0.33 ^d	0.77 ^d	0.61 ^d	0.51 ^d	–			
7. Total Non-Occupational PA	0.55 ^d	0.53 ^d	0.27 ^d	–0.31 ^d	–0.33 ^d	–0.08 ^c	–		
8. Non-Occupational Light PA	0.53 ^d	0.54 ^d	0.14 ^b	–0.33 ^d	–0.34 ^d	–0.14 ^b	0.99 ^d	–	
9. Non-Occupational MVPA	0.29 ^d	0.15 ^b	0.80 ^d	–0.06	–0.11 ^a	0.26 ^d	0.47 ^d	0.32 ^d	–

^a $P < 0.05$.
^b $P < 0.01$.
^c $P < 0.001$.
^d $P < 0.0001$.

Table 4
Partial correlation coefficients between occupational and non-occupational activity variables.

Minutes	Non-Occupational Light PA	Non-Occupational MVPA	Total Non-Occupational PA
Occupational Light PA	–0.38 ^d	–0.14 ^b	–0.38 ^d
Occupational MVPA	–0.21 ^d	0.17 ^d	–0.17 ^c
Total Occupational PA	–0.38 ^d	–0.11 ^a	–0.38 ^d
Counts	Non-Occupational Light PA	Non-Occupational MVPA	Total Non-Occupational PA
Occupational Light PA	–0.22 ^d	–0.10	–0.19 ^d
Occupational MVPA	–0.13 ^b	0.18 ^d	0.04
Total Occupational PA	–0.20 ^d	0.02	–0.11 ^a

Correlations are adjusted for labor sector, age, sex, and race/ethnicity.

^a $P < 0.05$.
^b $P < 0.01$.
^c $P < 0.001$.
^d $P < 0.0001$.

activity outside of work. Minimizing the compensation effect for light-intensity activity may have long-term health implications as light-intensity activity is inversely related to glucose (Thorp et al., 2014) and insulin (Yates et al., 2015).

In contrast, there was no evidence of a substitution or compensation effect for MVPA, as more MVPA at work correlated with more MVPA outside of work. Indeed, workers who engaged in greater amounts of occupational MVPA also had the highest amounts of MVPA outside of work. One explanation for this finding is that workers who are employed in active occupations have higher levels of fitness, either because of the occupational activity or self-selection, or both (Lakdawalla and Philipson, 2007). If so, higher fitness facilitates MVPA outside of work, as MVPA is not perceived to require as much effort. Another explanation is that engaging in small amounts of MVPA throughout the workday does not generate the same amount of fatigue as increasing light-intensity activity (e.g., through standing workstations). Programs designed to increase physical activity during work may consider focusing on shorter bouts of MVPA, such as taking the stairs, rather than increasing light-intensity activity. Though only modest amounts of MVPA may be feasible per hour (e.g. 1–3 min), the total MVPA in 40 h week is substantial (40–120 min). Further the results suggest the increase in occupational MVPA would be amplified by a modest increase in MVPA outside of work.

This study has several strengths, including population-based sampling, use of objective measurements of physical activity analyzed with standard protocols, and a good adherence to a longer accelerometer wear time (two weeks) compared to most accelerometer studies. The study has several limitations. First, the sample sizes within some labor sectors were small. Hence, in Table 2, the precision of estimates of “minutes” and “intensity counts” varies by sector. Second, labor sector

definitions include a variety of specific jobs, so that there may be substantial variation in activity levels among people in the same labor sector. For example, managers on construction sites are classified as Construction and Extraction rather than Management. This makes sense from an occupational classification perspective, but managers may not be as active as the employees they supervise. Third, work schedules were missing in a non-random fashion—mainly for some protective service and firefighting occupations. As the service industry was the largest labor sector within our participating city/county governments, including those participants would have improved the representativeness of estimates for this sector. Additionally, time spent commuting or type of transportation, which were not measured, may influence activity levels outside of work. Finally, the study did not include several labor sectors that are not employed by city/county governments. Future research should collect objective physical activity data on these sectors, though it is challenging to get a representative sample of all workers in a geographic area due to the large number of organizations that must participate in the research study. In general, more research is needed to assess the causal relationships between occupational and non-occupational activity and whether compensation effects commonly occur.

The results suggest that, on average, employed adults get more activity (both LPA and MVPA) outside of work than at work. If confirmed by other studies using objective measures of physical activity, the finding means the steady decline in occupational physical activity over the past half century is more dramatic than previously recognized. The results also showed that adults who do more occupational MVPA do not commonly compensate by doing less non-occupational MVPA. In contrast, adults who do more occupational LPA do compensate by doing less non-occupational LPA. These findings have two major implications.

First, the effects of relatively small but feasible interventions to increase occupational MVPA may be amplified by concomitant increases in non-occupational MVPA. Second, evaluations of interventions to reduce sedentary behavior should be designed to detect compensation effects.

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Conflict of interests

The authors declare that they have no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <http://dx.doi.org/10.1016/j.pmedr.2017.07.013>.

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