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Describing the relationship between occupational and non-occupational physical activity using objective measurement

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ABSTRACT

Objective. Physical inactivity is a major health risk for working adults, yet the interplay between physical activity levels in work and non-work settings is not well understood. The association between occupational physical activity (OPA) and non-occupational physical activity (non-OPA), and associations by sex, were examined in a group of 233 working adults in the Minneapolis, MN metro area between 2010 and 2012.
Methods. Accelerometry-measured activity was split into OPA and non-OPA via participant-reported typical work start and end times. Regression models were used to estimate associations.
Results. Average weekly OPA was positively associated with non-OPA ($B = 0.18$, 95% CI: 0.08 to 0.28) and associations were stronger among women than men ($B_{interaction} = -0.39$, 95% CI: -0.61 to -0.17).
Conclusions. Results suggest that individuals with less physical activity during work also have less physical activity outside of work. Understanding the complexities of the OPA/non-OPA relationship will enable researchers to explore the underlying mechanisms.

Introduction

Approximately 65% of US adults are currently overweight or obese (Ogden and Carroll, 2010) and lack of physical activity is an often-recognized contributor. In tandem with population weight gain, estimated drops in occupational physical activity (OPA) equal 100 kcals per day over the past 50 years (Church et al., 2011). Working adults may compensate for this lack of OPA by increasing non-OPA. However, it is not clear whether OPA and non-OPA are related, and if so, the direction of the relationship (Autenrieth et al., 2011; Moore et al., 2012). The association between OPA and non-OPA is important to understand because physical activity in work and non-work settings contribute to overall physical activity level and thereby reduce health risk (Holtermann et al., 2012). Describing the complexities of this relationship will help researchers begin identifying the underlying mechanisms.

The association between occupational and non-occupational time has been studied as far back as 1965 (Rapoport and Rapoport, 1965). Since then, two primary theories have guided research in this area: spillover and compensation (Staines, 1980). Spillover is a positive association between activities done in and out of work, whereby doing physical activity during work makes one more likely to also do physical activity outside work. Compensation is a negative correlation between activities done in and out of work, suggesting that doing physical activity during work makes one less likely to do physical activity outside work. In both of these theories, physical activity during work influences physical activity level outside of work. Although this question has been studied for years, support for spillover or compensation has been mixed. This may be due to variability in types of measures used (e.g., self-reported questionnaires or logs) and activity type include in analyses (e.g., specific non-occupational activities like leisure-time activity or housework compared to all non-occupational activities).

Another reason for the inconsistent findings to-date could be the different populations studied. For example, differences have been observed by population sex. In a cohort of Brazilian adults, Del Duca et al. (2013) report that, for women, being physically active in leisure time clustered with being physically inactive in other domains. In men, however, physical inactivity during work clustered with inactivity in other domains (Del Duca et al., 2013). Similarly, Drygas et al. (2009) found that physical activity in leisure time was inversely associated with physical activity during work in a population-based study of adults in Poland. This pattern was slightly stronger in women than men (Drygas et al., 2009). Others found no association between non-OPA and OPA in men or women (Rombaldi et al., 2010). Importantly, all of these studies relied on self-reported measures of physical activity. The

Abbreviations: OPA, Occupational physical activity; MVPA, Moderate-to-vigorous physical activity; CV, Coefficient of variation

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validity and reliability of these self-report measures have been questioned (Kwak et al., 2011). Although a large body of literature on objectively-measured total physical activity exists, no studies have examined the relationship between OPA and non-OPA using objectively-measured activity.

In addition to relying on self-report measures, research thus far has only examined relationships using average activity levels (e.g., usual weekly OPA). If there is variability in a person's OPA from day to day, and OPA influences non-OPA, it might be expected that the association between OPA on a given day and non-OPA on that same day is stronger than the association between average OPA and average non-OPA. This temporality of activity is important in understanding the relationships between work and non-work activity. No studies have compared OPA and non-OPA within a given day. Sex differences have been observed in the clustering of activity domains (Del Duca et al., 2013; Drygas et al., 2009) therefore it may be expected that sex differences are also present in the day-to-day variability of OPA and non-OPA. One study found more heterogeneity in overall daily physical activity in men compared to women (Matthews et al., 2002), but little is known about sex differences in variability by domain. Differences in domain-specific variability by sex may also lead to differences in the association seen between these domains.

The longstanding debate over compensation and spillover is still interesting today as trends in OPA and non-OPA continue to shift. Examining the association between OPA and non-OPA objectively, examining usual weekly and within-day associations, and examining sex differences in these associations will contribute to the evaluation of the compensation and spillover theories. The purpose of this paper is to: 1) describe OPA and non-OPA in a group of working adults; 2) examine the association between usual OPA and non-OPA, as well as within-day OPA and non-OPA; and 3) examine whether these associations vary by sex.

Methods

Participants

Data include baseline measures from a randomized controlled trial evaluating the effect of lunch portion sizes on energy intake and body weight in a group of working adults in the Minneapolis, MN metro area between 2010 and 2012 (French et al., 2014). The study was approved by the University of Minnesota Institutional Review Board. Participants were recruited from a metropolitan medical complex in Minnesota that employs more than 2000 full-time employees from diverse backgrounds. Participants responded to a broad worksite recruitment campaign and were required to meet eligibility criteria. Men, minorities, and certain work departments were over-recruited and to ensure a diverse sample. Eligible, enrolled participants ($N = 233$) were between 18 and 60 years old, non-smokers, could speak and read in English, were not taking medications that affect appetite or weight, were able to pick up daily lunches at the cafeteria, had no food allergies, were not currently trying to lose weight, had not been diagnosed with an eating disorder, were not planning to move during the study, were not participating in other studies, were not pregnant or nursing, and completed all baseline measures. Additional details are available (French et al., 2014).

Anthropometrics and demographics

Anthropometrics were measured by trained study staff. Height and weight measurements were performed using a wall-mounted stadiometer and digital platform scale and BMI (kg/m^2) was calculated. Demographic characteristics, including age, sex, race, ethnicity, current job type, and household income, were collected via self-administered survey at the data collection site.

Physical Activity

Physical activity data were collected using GT1M accelerometers (ActiGraph LLC, Pensacola, FL) set to record data in 60-second epochs. Participants were asked to wear the monitors on an elastic belt around their waist for 7 consecutive days except while sleeping or during water activities (e.g. bathing or swimming). Accelerometers were downloaded and wear time was determined. Non-wear time was calculated as a 20-minute string of 0-counts allowing for 2 interruption intervals of up to 100 counts-per-minute. Participants not meeting 10 h of valid wear for 4 days (due to monitor failure or participant compliance) were asked to re-wear accelerometers up to 2 more times. Valid week days (10 h of wear on Monday–Friday) from all wears were included in these analyses. The decision to exclude non-OPA from on weekend days was made for two reasons. First, it was important to directly compare within-day results to average results, and second the patterns seen in non-OPA on weekend days were very similar to those seen on weekdays in this sample.

OPA and non-OPA

Participants were asked to report typical work day start and end times, which were used to create typical workday length in minutes. Daily accelerometry data were split into non-occupational wear time (minutes of wear prior to self-reported work start time and after work end time) and occupational wear time (minutes of wear time between self-reported work start and end times.) Wear time was categorized by self-reported start and end time. Non-occupational wear time included all activities done before or after work (e.g., transportation to and from work and leisure or household activities). Occupation wear time included lunch or other workday breaks. To calculate average weekly values and daily values for OPA and non-OPA, minutes of moderate-to-vigorous physical activity (MVPA) were calculated during occupational and non-occupational time using the cut points derived from the NHANES equations (Troiano et al., 2008). Data were summarized in two ways. First, separate daily total minutes of OPA and non-OPA were calculated for each day a participant wore the monitor, with up to 12 days per participant and no less than 3 days per participant. These daily variables were used to measure day-to-day variability in OPA and non-OPA as computed by the coefficient of variation and were also used in random coefficients regression analyses to look at within-day associations. Second, an average or usual weekly value of OPA and non-OPA was computed for each participant by averaging across all valid days of accelerometry wear. These average values were used in general linear regression models.

Statistical analyses

Means and standard deviations or frequencies are reported for all descriptive statistics as well as OPA and non-OPA. To describe the daily variability in OPA and non-OPA within a participant, a coefficient of variation (standard deviation divided by mean) was calculated. T-tests were used to determine differences in daily variability between men and women. Associations between usual OPA and usual non-OPA (averaged across the week) were assessed via general linear regression and R^2. General linear random coefficients models allowing for random intercepts and slopes were used to examine associations between OPA and non-OPA within a given day (up to 12 days per participant), allowing a random intercept and slope for each participant. Analyses were also conducted to examine sex as a potential effect modifier of the association between OPA and non-OPA. The models testing differences by sex were also adjusted for potential confounders including age, ethnicity, job type and BMI. Crude and age-adjusted models are presented. Analyses were run with and without outliers. Relationships remained the same when outliers were removed, therefore all values

Table 1
Baseline characteristics of participants in a study of working adults in the Minneapolis, MN metro area between 2010 and 2012.

	Male (n = 76)	Female (n = 153)	p-Value[a]
Age in years, *M(SD)*	41.4 (11.5)	43.2 (11.2)	0.2626
% non-Hispanic, White	68%	65%	0.6442
Job type			
% patient care (doctor, nurse, social worker, etc.)	38%	36%	0.0010
% executive/administrative (manager, etc.)	11%	11%	
% clerical, administrative support, or technician	26%	45%	
% service or labor (facilities maintenance, etc.)	13%	1%	
% other	13%	7%	
BMI[b] in kg/m^2, *M(SD)*	28.9 (4.6)	30.4 (7.1)	0.0464

[a] Results from two-sample t-test or chi-square for sex differences.
[b] BMI—Body mass index.

were retained. Analyses were conducted in Statistical Analysis System 9.2 (SAS Institute Inc., Cary, NC).

Results

Baseline demographic characteristics of enrolled participants by sex are provided in Table 1. Most participants were female (67%) and non-Hispanic, white (67%), with an average age of 42 years and average BMI of 29.9 kg/m^2. Women had higher BMI than did men ($p = 0.05$). There were also differences in job type by sex (chi-square $p < .01$). No other statistically significant sex differences were seen in demographic characteristics.

Table 2 presents descriptive information on accelerometry compliance, OPA and non-OPA. Workday wear time approximately equaled survey-reported workday length. On average, 6 h of wear time per day outside work was recorded. Both during work and outside work, participants accumulated less than 30 min of MVPA (mean OPA = 18.5 min, SD = 14.8 min; mean non-OPA = 15.1 min, SD = 11.4 min). Men accumulated more OPA than women ($p < .01$) and reported longer work days ($p = 0.02$), but did not have more wear time during work ($p = 0.21$). Men were also more active outside work ($p = 0.01$) with no significant sex differences in accelerometer wear time outside of work ($p = 0.60$). The average coefficient of variation (CV) for OPA and non-OPA was 62% (SD = 35%) and 64% (SD = 33%), respectively, suggesting high daily variability in physical activity levels both in an out of work. Women showed greater daily variability in OPA than did men ($p < 0.01$). No sex differences were seen in the daily variability of non-OPA ($p = 0.40$).

Results from crude general linear models comparing participants' average weekly OPA to average weekly non-OPA are shown in Fig. 1. A positive statistically significant association was observed between average OPA and non-OPA (B = 0.18, 95% CI: 0.08 to 0.28). Every additional 6 min of activity during the average work day was associated with an additional 1 min of activity outside of work. Although statistically significant, OPA only explained about 5% of the variability in non-OPA ($R^2 = 0.05$). Results from crude general linear random coefficients model allowing for random intercepts and slopes also showed a positive and statistically significant association between OPA and non-OPA (B = 0.12, 95% CI: 0.04 to 0.20). However, in this model, 7.2 min of OPA was associated with an additional 1 min of non-OPA. Results are compared in Fig. 2.

Sex was a statistically significant effect modifier of the crude association between average OPA and non-OPA. Average weekly OPA and average weekly non-OPA were positively associated in women, but among men there was almost no association ($B_{interaction} = -0.39$, 95% CI: -0.61 to −0.17, Fig. 3). This interaction remained statistically significant after adjusting for age, ethnicity, job type, and BMI ($B_{interaction} = -0.32$, 95% CI: −0.55 to −0.10). In the linear random coefficients model looking at within-day associations between OPA and non-OPA, no significant effect modification was seen by sex in either the crude ($B_{interaction} = 0.12$; 95% CI: −0. 04 to 0.29) or adjusted model ($B_{interaction} = 0.13$; 95% CI: −0. 04 to 0.30).

Discussion

This study described OPA and non-OPA in a sample of working adults, and makes several unique contributions to the research in this area. An objective measure was used, and both average and within-person associations between OPA and non-OPA were described. Consistent with the spillover theory that OPA positively influences non-OPA, upward associations were observed between usual activity during work and usual activity outside of work. This has important implications for practitioners, suggesting that intervening in one domain may have a positive impact in other domains. However, as hypothesized, if the spillover theory was correct and OPA causes non-OPA, an even stronger association might be expected when the within-day measure of OPA and non-OPA were examined. In this study however, a weaker but still statistically significant positive relationship was observed. Findings suggest that OPA on a given day does not have a strong impact on non-OPA on the same day. It is possible that the relationship between OPA and non-OPA is influenced by other variables: behavioral (e.g., self-efficacy), environmental (e.g., access to recreation facilities) or demographic (e.g., education) (Bauman et al., 2012). Identifying these mechanisms is an important next step in designing effective interventions. Finally, it is important to note that although compensation (a negative association) was not observed in this sample as a whole, there may be subsets of people for whom this type of relationship exists.

Table 2
Baseline levels of and variability in daily physical activity characteristics in a study of working adults in the Minneapolis, MN metro area between 2010 and 2012, *M(SD)*.

	Overall (N = 229)	Male (n = 76)	Female (n = 153)	p-Value[a]
Number of weekdays worn, days	4.7 (1.0)	4.8 (1.3)	4.6 (0.9)	0.3069
Workday length (self-reported), min	517.6 (56.5)	529.5 (76.5)	511.7 (42.6)	0.0238
Accelerometer wear time in work, min	487.6 (65.6)	495.2 (71.8)	483.8 (62.2)	0.2144
Accelerometer wear time out of work, min	382.8 (92.1)	387.3 (100.9)	380.6 (87.7)	0.6023
OPA[b], min	18.5 (14.8)	28.1 (18.2)	13.8 (9.9)	<.0001
Non-OPA[b], min	15.1 (11.4)	17.8 (11.9)	13.7 (11.0)	0.0110
Coefficient of variation for OPA	0.62 (0.35)	0.49 (0.31)	0.68 (0.36)	<.0001
Coefficient of variation for non-OPA	0.64 (0.33)	0.62 (0.35)	0.66 (0.31)	0.3969

[a] Results from two-sample t-test or chi-square for sex differences.
[b] OPA—Occupational physical activity.

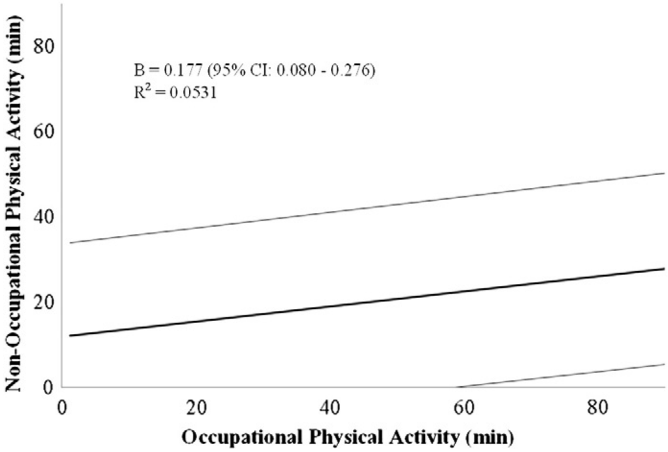

Fig. 1. Unadjusted relationship between occupational and non-occupational physical activity using general linear regression in a group of working adults in the Minneapolis, MN metro area between 2010 and 2012, N = 229.

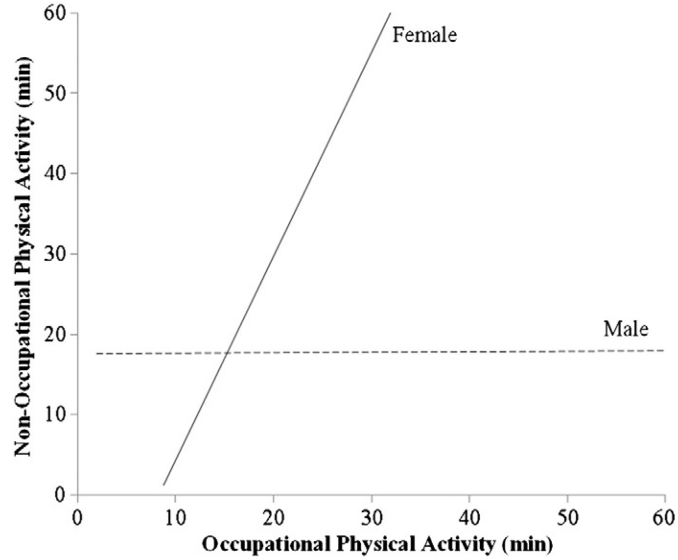

Fig. 3. Unadjusted effect modification of the relationship between occupational and non-occupational physical activity by sex for a group of working adults in the Minneapolis, MN metro area between 2010 and 2012, $B_{interaction} = -0.387$, 95% CI: −0.609 to −0.165.

Small sample size and lack of measurement of hypothesized relevant individual differences mentioned above preclude examination of this hypothesis, but could be explored in future studies.

The positive association between average or usual weekly OPA and usual weekly non-OPA was stronger in women compared with men. In previous literature, OPA was inversely associated with different activity domains for women and positively associated for men (Del Duca et al., 2013) while others found an inverse association for both men and women (Drygas et al., 2009). Differences in our findings may be due to the use of objective measurement or differing definitions of non-work domains between studies. The mechanisms behind the sex differences seen in these analyses could be due to the association between sex and the afore-mentioned variables. Although effect modification by sex remained after controlling for job type, age, etc., these differences could be explained by other behavioral or environmental factors not measured here. Future research should aim to determine the mechanisms behind these sex differences to inform the design of tailored intervention strategies. No sex differences were seen in the within-day associations suggesting that sex is more influential when looking at average OPA and non-OPA. These results highlight the need for further exploration of individual difference on OPA and non-OPA.

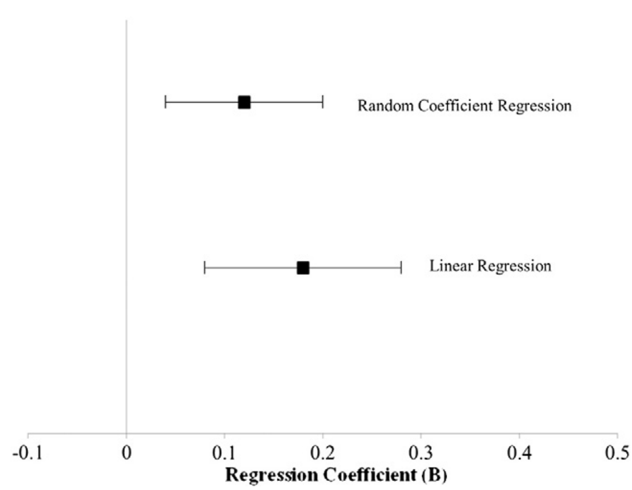

Fig. 2. Forest plot comparison of results from unadjusted general linear regression and general random coefficients regression, including point estimates and 95% confidence intervals for a group of working adults in the Minneapolis, MN metro area between 2010 and 2012.

The current study had a number of strengths and some limitations. This is the first study to explore objectively-measured OPA and non-OPA. Objective measurement allows for examination of physical activity without self-presentation bias or lack of validity of self-reporting for other reasons. Within-day measures provide another novel approach to examining OPA and non-OPA. Accelerometry compliance was high, reducing the potential for measurement bias. A limitation of the current analyses was the imprecise measures of work start and end time. Future studies could use objective measures of the workday or use new measurement technology to define activity domain by the location in which the activity was done. Use of new technology may allow researchers to provide detailed information about location of activity and the ability to separate activity to and from work (e.g., active transport or workday activity breaks). The current study was not able to separate these specific types of activities. Finally, as noted, only approximately 10% of all full-time employees were included in this study. It is possible that the results are not generalizable to a subset of the population. Examination of these associations in more representative populations could lead to a more nuanced understanding of the OPA/non-OPA relationship.

Conclusion

These findings suggest that (1) OPA and non-OPA are positively correlated, (2) average activity in and out of work are more closely associated than are daily levels, and (3) this association is particularly pronounced in women. Understanding the spillover and compensation theories related to work and non-work PA enable the design of more effective and focused physical activity interventions in community settings.

Conflict of interest statement

The authors declare that there are no conflicts of interest.

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