Associations between firefighters' physical activity across multiple shifts of wildfire suppression

Citation of the final article:

This is an Accepted Manuscript of an article published by Taylor & Francis in Ergonomics on 18 Jan 2016, available at:
https://www.tandfonline.com/doi/full/10.1080/00140139.2015.1107626

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Title: Associations between firefighters’ physical activity across multiple shifts of wildfire suppression.

Authors: Grace E. Vincent BSc (Hons)1,2*, Nicola D. Ridgers PhD1, Sally A. Ferguson PhD2,3, and Brad Aisbett PhD1,2

Affiliations:
1 Centre for Physical Activity and Nutrition Research, Deakin University, Burwood 3125, Australia
2 Bushfire Co-Operative Research Centre, East Melbourne 3002, Australia
3 Appleton Institute, Central Queensland University, Wayville 5034, Australia

Correspondence to:
*Grace Vincent
Centre for Physical Activity and Nutrition Research, Deakin University
221 Burwood Hwy, Burwood, VIC 3125, Australia
Tel: +61 4 780 165 26
Email: gvincent@deakin.edu.au
Keywords: Firefighting; Occupational Health; Actigraphy

Abstract
The aim of this study was to examine the associations between firefighters’ physical activity levels across consecutive shifts during a multi-day emergency wildfire and to determine whether sleep duration moderated these associations. Forty volunteer firefighters (31 males, 9 females) wore an activity monitor to concurrently measure physical activity and sleep duration. Sedentary time and time spent in light- (LPA), moderate- (MPA), and vigorous-intensity physical activity (VPA) during each shift were determined using monitor-specific cut points. During any given shift, every additional 60 min spent in LPA was associated with 7.2 min more LPA and 27.6 min MPA the following shift. There were no other significant positive or negative associations. No significant moderating effect of total sleep time was observed. Firefighters are able to maintain and/or increase their physical activity intensity between consecutive shifts. Further research is needed to understand firefighters pacing and energy conservation strategies during emergency wildfire deployments.

Practitioner Summary
To examine associations between firefighters’ physical activity levels across consecutive shifts during a multi-day emergency wildfire and determine whether sleep duration moderated these associations. Firefighters are able to maintain and/or increase their physical activity intensity between consecutive shifts. No significant moderating effect of total sleep time was observed.

Introduction
Wildfires can have a debilitating impact on communities worldwide through the loss of property, livestock, and human life (Hunter 2003, Schmuck et al. 2004, Hyde et al. 2008). In Australia, a workforce of 220,000 volunteer firefighters play a vital role in protecting the community from the threat of wildfire (McLennan and Birch 2005). During deployments, wildland firefighters are subjected to a myriad of stressors, such as long working hours (up to 16 h) and restricted sleep, often over consecutive days and under dangerous working conditions (Cater et al. 2007, Phillips et al. 2007, Aisbett et al. 2012). Globally, the frequency, duration, and severity of wildfires is predicted to escalate (Liu et al. 2010), which is likely to increase the cognitive and physical demands placed on wildland firefighting personnel. Therefore, understanding the impact of pertinent operational and environmental stressors on work behaviour is paramount in preserving firefighter health and safety.

Previous studies have examined the physiological (Cuddy et al. 2007, Rodríguez-Marroyo et al. 2012, Raines et al. 2013), environmental (Budd 2001, Cuddy et al. 2007), and musculoskeletal (Neesham-Smith et al. 2014) demands of wildland firefighting. However, few studies have examined physical activity levels during wildfire deployments, particularly using objective monitoring techniques. Wildland firefighting is described as predominately intermittent, sedentary to light-intensity physical work, punctuated with short periods of moderate- to vigorous-intensity physical activity (Heil 2002, Cuddy et al. 2007, Cuddy et al. 2011, Raines et al. 2012, Raines et al. 2013, Cuddy et al. 2015, Raines et al. 2015). However, the majority of studies evaluated firefighters’ physical activity during a single wildfire suppression shift, not between consecutive shifts. Of the studies examining multiple shifts, research has either used these data to describe average activity levels during wildfire suppressions shifts (Heil 2002, Cuddy et al. 2007) or reported differences in physical activity levels between shifts undertaken by salaried firefighters during planned burn operations (Raines et al., 2015) or wildfires (Cuddy et al. 2015). This provides insights into how the physical activity requirements may change between shifts, but does not examine how the amount of physical activity firefighters engage in during one shift subsequently affects their physical activity in the following shift. This information is integral for workforce planning, and health and safety management between shifts on
multi-day wildfire suppression deployments. For example, if firefighters are able to maintain physical activity levels between consecutive shifts, this may reduce the need to add more personnel to subsequent shifts. In turn, this may limit the number of firefighters exposed to environmental stressors and reduce the overall financial costs associated with wildfire operations.

Previously, hydration (Ruby et al. 2003), nutrition (Montain et al. 2008, Cuddy et al. 2011), and stress responses (Main et al. 2012) have been explored in relation to the influence they may have on firefighters’ activity patterns over multiple shifts. One under-investigated stressor is sleep duration between shifts (Aisbett et al. 2012, Vincent et al. 2015). Australia’s firefighting personnel are typically rostered to work a 12-h day or night shift, but can work shifts of up to 16 h for 3–5 consecutive days (Cater et al. 2007, Phillips et al. 2007), resulting in truncated sleep opportunities (Aisbett et al. 2012). The existing evidence surrounding firefighters’ sleep during multi-day wildfires is largely anecdotal, and the lack of robust objective measures of firefighters’ sleep is surprising given the considerable potential for sleep restriction. Subjectively, Australian and United States firefighters have reported obtaining 3–6 h of sleep per night (Gaskill and Ruby 2004, Cater et al. 2007). To the authors’ knowledge, only one industry report has assessed the relationship between accumulated sleep loss and physical activity during wildfire suppression (Gaskill and Ruby 2002). This report found that North American wildland firefighters’ total accumulated daily activity counts were moderately associated (ICC: 0.30) with firefighters’ sleep duration the night before (Gaskill and Ruby 2002). However, sleep in this report was subjectively determined, which can be inaccurate as individuals are often unaware of their time of sleep onset (Baker et al. 1999). In addition, while total daily activity counts were objectively measured using accelerometry, this study did not examine how physical activity was accumulated (i.e. time spent in different intensities), or evaluate physical activity patterns between consecutive shifts. Determining whether different sleep durations moderate associations of physical activity levels between shifts is important for both operations and wildland firefighters’ health and safety. For example, if firefighters who obtain more sleep are more active than those who obtain less sleep, this may have important implications for workforce productivity estimates.
Developing an understanding of firefighters’ physical activity patterns across multi-day deployments, and the factors that moderate them, is critical to ensure optimal operational effectiveness during a wildfire event. The aim of the current study was to examine associations between firefighters’ physical activity levels between consecutive shifts during a multi-day emergency wildfire. The secondary aim was to determine whether sleep duration moderated these associations. It was hypothesised that the more time firefighters spend at higher intensities of physical activity, the lower their subsequent physical activity levels will be during the following shift. Furthermore, it was hypothesised that sleep duration would moderate these associations.

**Materials and Methods**

*Recruitment and participants*

This study was advertised through fire agency crew leaders and Australasian Fire and Emergency Services Authorities Council communications officers. Interested participants contacted researchers directly, were given information sheets, and provided written informed consent. Ethical approval was obtained from the Deakin University Human Research Ethics Committee (2012-300).

Despite the prevalence of wildfires in Australia, the timing and location varies from season to season. Approximately 250 accredited volunteer firefighters were initially contacted to participate in the study, and 90 were subsequently recruited for a four-week period during the 2012/2013 or 2013/2014 Southern Australian fire season (November-February). From that group, 61 performed wildfire suppression duties. Of those, 43 completed all aspects of data collection, which included completing their sleep/work diaries and wearing the activity monitor for the entire data collection period. Three participants’ data were excluded from the analysis due to water damaged monitors, resulting in a final sample of 40 participants. Self-reported demographic data, obtained from a General Health Questionnaire (ACSM 2010), were collected prior to the study commencing (Table 1). Participants
self-reported their firefighting experience and height and weight measurements (used to calculate their body mass index). No relevant diagnosed medical and/or sleep disorders were reported.

Work diary

Firefighters completed a daily work diary, which required them to provide information about the timing of work during their rostered shift, as well as a brief description of their work duties (e.g., creating a fire break, extinguishing smoldering debris).

Physical activity

Participants were asked to wear an activity monitor (Actical MiniMitter/Respironics, Bend, OR) on their non-dominant wrist for the duration of the study. The activity monitor was used to concurrently and objectively measure physical activity and sleep duration. The Actical (28 × 27 × 10 mm, 17 g) device uses a piezo-electric omnidirectional accelerometer, which is sensitive to movements in all planes in the range of 0.5–3.0 Hz (John and Freedson 2012). Firefighters were instructed to remove the activity monitors during periods when contact with water was likely (e.g., whilst showering) and was set to sample in 1-min epochs.

Activity monitor data were downloaded using Actical software (Actical MiniMitter, software v. 3.10, Respironics, Bend, OR). This software uses validated location-specific algorithms that determines time spent in light- (LPA, ≥ 1.5–2.99 metabolic equivalent (MET)), moderate- (MPA, ≥ 3.0–5.99 METs), and vigorous- (VPA, ≥ 6 METs) intensity physical activity (Heil 2006). When the average activity counts for 3 consecutive minutes was less than 50 counts·min⁻¹, it was classified as Sedentary Time (SED) (Respironics, personal communication). The activity energy expenditure (AEE) values for each epoch were summed and multiplied by the subject’s weight. Total activity counts (C) per epoch were the sum of all counts generated in each minute of monitoring. Data were then reduced using a customized Microsoft Excel macro to determine physical activity intensities during work
shifts. Non-wear time during awake periods was defined as intervals with at least 60 min of
consecutive zeroes. In order for a shift to be included for analysis, firefighters had to wear the monitor
for 50% of the time in accordance with previous studies of activity patterns (Ridgers et al. 2012). All
shifts that were deemed to be valid were included in the analyses. It should be noted that the battery
life for the monitoring period and sleep measurement necessitated an activity monitor epoch length of
1-min. Therefore, VPA in the current study may have been underestimated as it is possible that
firefighters were performing bursts of high intensity activity for short durations (e.g. < 1 minute; Phillips, 2011).

Sleep assessment

Activity monitoring provides an objective, non-invasive, indirect assessment of sleep (Ancoli-Israel et
al., 2003) and has been validated against the gold standard, polysomnography, in both laboratory (De
Souza et al. 2003) and field settings (Signal et al. 2005). Given that multi-day wildfires often occur in
remote locations without access to electricity, polysomnography was considered an impractical
method to assess sleep in these environments as it requires an on-site sleep technician, set-up time,
and is relatively intrusive (Ancoli-Israel et al. 2003). Actical monitors have been comprehensively
validated to determine total sleep duration (Galland et al. 2012, Kosmadopoulos et al. 2012, Robillard
et al. 2012, Kosmadopoulos et al. 2014). Actical data were downloaded and processed using a
validated manufacturer propriety algorithm in the software (Actical v3.10) that generates a weighted
score for each 1-min epoch based on the amount of activity recorded during that epoch and the
surrounding 2 min (Kosmadopoulos et al. 2014). Epochs with scores below the specified sleep/wake
threshold are classified as sleep. In the current study, the default medium threshold of 40 counts per
epoch was employed to distinguish between sleep and wake states (Darwent et al. 2008). Sleep onset
was determined by a consecutive period of 10 min of immobility. The proprietary algorithm
retrospectively determined sleep offset from participant’s self-reported wake up time. The difference
between sleep onset and sleep offset results in the sleep duration. Total sleep time was defined as the
sleep duration obtained in the 24-h period from shift start time on the day in question, in accordance
with previous research (Ferguson et al. 2010, Ferguson et al. 2011). Participants’ sleep diaries were
cross-referenced with the activity monitors to determine total sleep time. This ensured the credibility of the self-reported measures, and minimised the possibility of incorrectly scoring periods of sedentary wakefulness (e.g., watching television) as sleep, or restless sleep as wake.

Statistical analyses

All statistical analyses were conducted using Stata 12.0 (StataCorp, Texas, USA). Descriptive statistics (mean ± standard deviation (SD)) were calculated for all measured variables. Multilevel analyses were conducted using generalized linear latent and mixed models (GLLAMM) (gllamm; version 2.3.20) (Rabe-Hesketh and Skrondal 2008). This modelling procedure has previously been employed in sleep (Van Dongen et al. 2003, Ingre et al. 2004, Vincent et al. 2015) and physical activity literature (Ridgers et al. 2014). GLLAMMs account for the serial correlation of data points over time, and are more suitable when analysing nested data that are not independent of each other (Molenberghs and Verbeke 2001).

The analyses utilised GLLAMM to examine the relationship between temporally adjacent values (pairs of shifts) of physical activity (e.g., LPA on shift $s$ with LPA on shift $s - 1$). In all models, the random structure considered random intercepts at the participant level. A two-level model was used in all these analyses; shift (level 1) and participant (level 2). All models were adjusted for age, sex, body mass index, firefighting experience, and actigraphy wear time, which were identified a priori as potential covariates. Wear time was included as a covariate as each individual had a unique shift start and end time. The potential moderating effect of sleep on observed associations was estimated by including appropriate interaction terms. The final parameter estimates are reported as $\beta$ coefficient ± 95% CI, $P$ value. Statistical significance was set at an alpha level of 0.05 and all data are presented as means ± SD.
Results

All forty participants (31 men, 9 women) met the physical activity data inclusion criteria and were included in the analyses. Descriptive data are presented in Table 1. There were no significant differences in demographic variables between firefighters that were included or excluded from the analyses (data not shown). A total of 126 pairs of consecutive shifts were included in the analysis and the average shift length was 11.0 ± 3.6 h. Firefighters’ average total sleep time between consecutive shifts during wildfire deployments was 6.1 ± 1.7 h.

The number of minutes and the proportion of time spent in each physical activity intensity across each shift is shown in Table 2. Firefighters, on average, engaged in physical activity of at least LPA for 87.7% of their shift.

The associations between the number of minutes spent in each physical activity intensity, the activity energy expenditure, and the total activity counts between pairs of shifts is shown in Table 3. Two significant associations were found between pairs of consecutive shifts. Every additional minute of LPA in a given shift was associated with 0.12 minutes more of LPA and 0.46 minutes more of MPA in the following shift. No other significant associations were observed between pairs of consecutive shifts. The interaction terms revealed no significant moderating effect of sleep duration on any associations.

Discussion

This study examined associations between time spent in various physical activity intensities during one shift and time spent in these intensities in the following shift during a multi-day wildfire using objective measures. Contrary to our hypotheses, the findings suggest that the more time firefighters
spent in LPA during one shift, the greater their LPA and MPA levels were during the following shift. Furthermore, sleep duration between shifts did not moderate firefighters’ physical activity levels.

Positive associations were found between time spent in LPA in one shift and LPA and MPA accumulated during the following shift. During any given shift, every additional 60 min spent in LPA was associated with 7.2 min more LPA and 27.6 min MPA in the following shift. This observation is consistent with ‘activity synergy’, whereby participation in one active behaviour has been observed to increase activity at other times (Goodman et al. 2011). A finding not consistent with ‘activity synergy’ is the positive association observed between LPA and SED, which while trending, did not reach statistical significance ($P=0.065$). It is possible that this is a spurious finding and further research is needed to explore the association between LPA and SED across shifts. There were no other significant positive or negative associations observed suggesting firefighters are able to maintain their physical activity from one shift to the next. While the type of data collected in the current study makes it difficult to determine the precise mechanisms, it is possible that firefighters self-pace their work efforts. Indeed, North American wildland firefighters accelerometry measured energy expenditure rarely exceeded 8 kcal.min$^{-1}$ and tended to oscillate between 4 and 6 kcal.min$^{-1}$ during a single wildfire suppression shift (Heil 2002). The author postulates that wildland firefighters may pace themselves as they have prior knowledge that their shift duration will last between 10–16 h (Heil 2002). Furthermore, self-pacing would allow firefighters to maintain physical activity engagement over multiple shifts during a wildfire deployment and may be reflective of energy conservation strategies. Firefighters’ physical activity requirements will likely change between shifts as each wildfire event is variable in duration, severity, terrain, smoke, and heat exposure. Overall, the current data suggest that firefighters are able to maintain and/or increase their work intensity between consecutive shifts despite variable environmental conditions. This is a positive finding for agencies in assisting with workforce productivity estimates as additional personnel may not be required if wildfire suppression activity levels can be maintained.
To date, research conducted across single or multiple shifts has been used to characterise average physical activity levels (Heil 2002, Cuddy et al. 2007, Raines et al. 2012, Raines et al. 2013, Cuddy et al. 2015). In the current study, 12%, 66%, and 22% of firefighting work was spent in SED, LPA, and MPA, respectively. A negligible 0.1% was spent in VPA. These findings are in contrast to previous Australian research where a larger proportion of time 50–62% was spent in SED, compared to light 32–43% and moderate 2–3% (Raines et al. 2012, Raines et al. 2013). This discrepancy could be explained by differences in monitor placement locations. Previous work has positioned the activity monitor on the xiphoid process (Raines et al. 2012, Raines et al. 2013) or jacket chest pocket (Heil 2002, Cuddy et al. 2007). The central location of devices in previous studies may be less sensitive to certain tasks performed during fire suppression, such as statically holding a fire hose to extinguish flames. Advancements in monitoring devices have resulted in smaller and more compact models, enabling physical activity to be measured at the wrist. Previous studies utilised central regions as earlier accelerometry models were too large to wear on the wrist, and thus had the potential to interfere with firefighters’ work. Given firefighting work often occurs in hot temperatures requiring firefighters to remove their jacket, monitor compliance may be improved by wrist worn devices. Furthermore, using one device to measure sleep and physical activity could accelerate the collection of valid physiological data while minimising cost and participant burden. More research is needed to establish firefighter physical activity levels during shifts using common monitor placement to ensure comparability between studies. Moreover, physical activity data, collected from descriptive field studies, are often used to develop laboratory research and/or simulations. Thus, it is important that the measurement of firefighters’ physical activity is accurate and consistent between studies and that monitor placement (and ensuing data analysis) are conducted using valid, reliable methods.

The current study is the first to examine moderating effects of sleep duration on physical activity intensities between consecutive shifts. Notably, in the current study, the observed average sleep duration (6.1 ± 1.7 h) was comparable to previous subjective reports (Gaskill and Ruby 2004, Cater et al. 2007) but significantly less than the current recommendations of 7–9 h for optimal cognitive
functioning (Bonnet and Arand 1995, Ferrara and De Gennaro 2001). Previous research has indicated that the impact of restricted sleep on physical activity is equivocal (Fullagar et al. 2014). The contradictory findings arise, at least in part, from confounding variables such as calorie restriction (Nindl et al. 2002) and the different physical work parameters (Opstad et al. 1978, Haslam 1984, Rodgers et al. 1995) utilised between studies. Recent work has suggested that in a controlled laboratory environment, a 4-h sleep opportunity did not impact firefighters’ performance on firefighting tasks compared to a control group who received an 8-h sleep opportunity (Vincent et al. 2015). However, sleep restricted firefighters were less physically active across a simulated shift, which was attributed to behavioural adaptations made during rest periods where passive rest (such as sitting still and lying down) was preferred over active rest activities (such as walking) (Vincent et al. 2015). The timing and duration of breaks were not recorded in the current study. Further interrogation of firefighters’ pacing and energy conservation strategies would enable fire agencies to understand the operational capabilities of firefighters, and inform policy on the frequency of rest breaks during deployments. It is also possible that the number of days of sleep restriction in the current study did not allow for observable adverse changes to firefighters’ physical activity. Therefore, experimental studies are needed to examine how firefighters respond to sleep restriction over prolonged periods (> 2 nights of sleep restriction), and under controlled conditions where the sleep restriction is more severe (< 4 h per night).

This study utilised a sample of 40 volunteer firefighters, resulting in the analysis of 126 pairs of shifts collected objectively during different wildfires (i.e. various durations, intensities etc.) across Southern Australia. The analyses used in the current study involved an advanced modelling procedure which accounted for individual-level covariates (age, sex, body mass index, wear time, firefighting experience). However, there are several limitations of this study that should be acknowledged. Collecting data during wildfire events is extremely difficult and presents unique challenges for researchers. These include, but are not limited to, briefing and fitting firefighters with monitors during an emergency event in a way that does not compromise the firefighters’ work or researcher safety.
Furthermore, wildland fires are unpredictable, therefore it is challenging to recruit firefighters for research purposes when there is no certainty of whether they will be called upon to attend a wildfire event. Thus, data collection for the current study took two years, which is comparable to other wildland firefighting research (Ruby et al. 2002, Rodríguez-Marroyo et al. 2012). While the sample of the current study is large relative to existing firefighting research, it is possible that the study is underpowered when examining the influence of potential moderators on physical activity. For example, it is possible that firefighters’ with varying years of experience may adopt different pacing strategies. Indeed, experience has been shown to alter pacing strategies in sporting contexts (Mauger et al. 2009, Green et al. 2010, Micklewright et al. 2010) and influence metabolic efficiency during manual handling tasks (Salvendy and Pilitsis 1974, Poole and Ross 1983) which may also have pacing implications. Future research, with much larger samples to accommodate a suite of moderators (e.g., age, sex, body mass index, fitness) could, accordingly, also explore relationships between worker experience and pacing across a whole shift or between shifts of wildfire suppression.

**Conclusion**

The findings from this study suggest that firefighters are able to maintain and/or increase their physical activity between consecutive shifts. Sleep duration did not moderate firefighters’ physical activity levels. Further research is needed to understand firefighters’ pacing and energy conservation strategies and how performance on certain work tasks may be affected during deployments especially under multi-stressor environmental conditions.

**Acknowledgements**

We would like to acknowledge the Bushfire Co-operative Research Centre for providing logistical support for this project. We would like to thank all the firefighters that generously volunteered their time to participate in this research. Dr. Nicola D Ridgers is supported by an Australian Research Council Discovery Early Career Researcher Award (DE120101173). We acknowledge Eoin O’Connell for the development of the customized Excel macro.
The authors’ have no conflicts of interest to declare.

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Phillips, M., Netto, K., Payne, W., Nichols, D., Lord, C., Brookesbank, N. & Aisbett, B., 2015. Frequency, intensity, time and type of tasks performed during wildfire suppression *Medical Sciences*, Accepted.


Table 1.

Self-reported demographics taken from answers on the General Health Questionnaire.

<table>
<thead>
<tr>
<th></th>
<th>Mean ± SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>39.4 ± 12.5</td>
<td>19–65</td>
</tr>
<tr>
<td>Body mass index (kg/m^2)(^a)</td>
<td>26.8 ± 4.7</td>
<td>20–38</td>
</tr>
<tr>
<td>Firefighting experience (years)</td>
<td>11.1 ± 11.0</td>
<td>0–48</td>
</tr>
<tr>
<td>Total multi-day deployments (number)</td>
<td>23 ± 34</td>
<td>0–150</td>
</tr>
<tr>
<td>Deployment sleep (hours)(^b)</td>
<td>5.9 ± 1.3</td>
<td>3–9</td>
</tr>
<tr>
<td>Normal sleep (hours)(^b)</td>
<td>7.5 ± 1.0</td>
<td>4–9</td>
</tr>
<tr>
<td>Sleep quality(^b,c)</td>
<td>2.4 ± 1.0</td>
<td>1–4</td>
</tr>
</tbody>
</table>

\(^a\) Calculated from self-reported height and weight measurements in the General Health Questionnaire (ACSM 2010).

\(^b\) On a ‘typical’ night

\(^c\) Sleep quality was assessed using a 5-point Likert Scale, where 1 = ‘very good’, 2 = ‘good’, 3 = ‘average’, 4 = ‘poor’, and 5 = ‘very poor’, as previously used by Paech et al. (2010).

Table 2. Average number of minutes and the proportion of time spent in each physical activity intensity per shift.

<table>
<thead>
<tr>
<th>Intensity (METs)</th>
<th>Number of minutes (± SD)</th>
<th>Proportion (%) (± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SED (≤ 1.5)</td>
<td>78 (79)</td>
<td>11.3 (10.5)</td>
</tr>
<tr>
<td>LPA (1.5–2.99)</td>
<td>453 (150)</td>
<td>65.6 (12.7)</td>
</tr>
<tr>
<td>MPA (3.0–5.99)</td>
<td>156 (99)</td>
<td>23.0 (13.9)</td>
</tr>
<tr>
<td>VPA (≥ 6.0)</td>
<td>1 (5)</td>
<td>0.1 (0.7)</td>
</tr>
</tbody>
</table>

SED, sedentary time; LPA, light intensity; MPA, moderate intensity; VPA, vigorous intensity.
Table 3. Associations between time (min) spent in different physical activity intensities, activity energy expenditure and total counts between pairs of shifts.

<table>
<thead>
<tr>
<th></th>
<th>b (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SED$<em>{S1}$ → SED$</em>{S2}$</td>
<td>-0.29 (–0.73 to 0.15)</td>
<td>0.203*</td>
</tr>
<tr>
<td>LPA$<em>{S1}$ → LPA$</em>{S2}$</td>
<td>0.12 (0.02 to 0.23)</td>
<td>0.025*</td>
</tr>
<tr>
<td>MPA$<em>{S1}$ → MPA$</em>{S2}$</td>
<td>-0.24 (–0.8 to 0.32)</td>
<td>0.407*</td>
</tr>
<tr>
<td>AEE$<em>{S1}$ → AEE$</em>{S2}$</td>
<td>-0.05 (–0.30 to 0.20)</td>
<td>0.708*</td>
</tr>
<tr>
<td>C$<em>{S1}$ → C$</em>{S2}$</td>
<td>-0.11 (–0.49 to 0.26)</td>
<td>0.557*</td>
</tr>
<tr>
<td>SED$<em>{S1}$ → LPA$</em>{S2}$</td>
<td>-0.08 (–0.17 to 0.01)</td>
<td>0.093*</td>
</tr>
<tr>
<td>SED$<em>{S1}$ → MPA$</em>{S2}$</td>
<td>-0.33 (–0.74 to 0.08)</td>
<td>0.116*</td>
</tr>
<tr>
<td>LPA$<em>{S1}$ → SED$</em>{S2}$</td>
<td>0.46 (–0.19 to 0.93)</td>
<td>0.060*</td>
</tr>
<tr>
<td>LPA$<em>{S1}$ → MPA$</em>{S2}$</td>
<td>0.46 (0.01 to 0.90)</td>
<td>0.048*</td>
</tr>
<tr>
<td>MPA$<em>{S1}$ → SED$</em>{S2}$</td>
<td>-0.08 (–0.64 to 0.48)</td>
<td>0.777*</td>
</tr>
<tr>
<td>MPA$<em>{S1}$ → LPA$</em>{S2}$</td>
<td>-0.03 (–0.15 to 0.09)</td>
<td>0.624*</td>
</tr>
</tbody>
</table>

Adjusted for age, sex, firefighting experience, wear time, and body mass index; SED, sedentary time; LPA, light intensity; MPA, moderate intensity; AEE, activity energy expenditure; C, total counts. *P<0.05.