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Seasonality in physical activity: Should this be a concern in all settings?

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ABSTRACT

This study examines the relationship between weather conditions and overall and domain-specific physical activity in adults living in a city with a temperate, stable climate. Objective and self-reported physical activity levels were measured in 1754 adults participating in RESIDE, a longitudinal study undertaken in Perth, Australia. Steps per week and self-reported minutes of domain-specific physical activity were compared with date-stamped weather data. Weather conditions were relatively constant across all seasons, showing little impact on physical activity behaviour. Variation in weather conditions had modest explanatory power (<6%) for predicting overall and domain-specific physical activity engagement in this sample. Weather variations observed in this study were of insufficient magnitude to impact on physical activity levels. This has implications for study designs and exploration of other factors associated with physical activity in these settings.

1. Introduction

Despite well-known benefits from adequate physical activity engagement, self-report data demonstrate that approximately 50% of adults in developed countries are insufficiently active to confer health benefits (Centres for Disease Control and Prevention, 2005; Department of Health, Physical Activity, Health Improvement and Promotion, 2004), and studies using objective measures suggest this figure may be higher (Hagstromer et al., 2007; Troiano et al., 2008). Targeting specific domains of activity, such as leisure-time or transportation, may assist with overcoming the low prevalence of activity. It has been recognised, however, that there are demographic, psychosocial, and environmental differences in physical activity participation across these domains and for diverse populations (Humpel et al., 2002; Salmon et al., 2000; Salmon et al., 2003; Sternfeld et al., 1999). Inclement weather is one environmental factor that has been shown to impact negatively on physical activity participation in adults (Chan et al., 2007; Humpel et al., 2004a; Togo et al., 2005; Uitenbroek, 1993) and children (Duncan et al., 2008; Brodersen et al., 2005). Indeed, a recent review of the international literature identified that weather conditions influenced physical activity participation in 73% ($n=27$) of the studies investigated (Tucker and Gilliand, 2007), with up to 51% of variance explained in physical activity during summer months for Greek-Cypriot children (Loucaides et al., 2004).

There are differences in the magnitude of this relationship across populations; self-report data indicate that those who are habitually active (Humpel et al., 2004a) or who enjoy being active (Salmon et al., 2003) are least likely to report weather as a barrier to engage in physical activity, irrespective of purpose. Of the studies that have used objective measures of physical activity engagement and weather conditions, increases in temperature were positively associated with the behaviour, while rainfall was negatively related with physical activity engagement (Chan et al., 2007; Togo et al., 2005; Duncan et al., 2008). These studies were conducted in New Zealand (Duncan et al., 2008), Canada (Chan et al., 2007), and Japan (Togo et al., 2005) where there can be substantial variations in weather conditions within the year.

Although internationally weather is often cited as a major barrier for being physically active (Tucker and Gilliand, 2007; Trost et al., 2002), to our knowledge the impact of fluctuating weather patterns on habitual and domain-specific physical activities in a predominantly stable, temperate meteorological environment (for example Perth, Australia and some US and European cities) has not been investigated. It is unknown if smaller variations in weather conditions indeed impact on physical activity patterns within a largely stable climate in the first instance, and whether these associations differ for engagement in overall,

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leisure-time, transport-related, and moderate and vigorous intensity physical activity participation, or by physical activity classification. Gaining insight into these relationships is important for informing future social, behavioural, and infrastructural interventions that seek to promote domain-specific physical activity or target specific populations. Furthermore, in longitudinal studies or evaluations of physical activity interventions, it is recommended that study designs adjust for potential confounders, such as weather variations, to enable conclusions to be drawn independent of external factors beyond the control of the study (Tucker and Gilliand, 2007). These techniques, however, may become less relevant in cities with temperate climates and further investigation is required.

Accordingly, the aim of this study was to characterise the effects of weather conditions in Perth, Australia, on objectively measured overall, and self-reported leisure-time, transport-related, and moderate and vigorous intensity physical activity engagement for adult participants within the context of the RESIDential Environments (**RESIDE**) study.

2. Methods

2.1. Design and sample

RESIDE is a longitudinal project examining the impact of urban design on physical activity engagement, and is a quasi-experimental five-year study examining people who commissioned the building new homes ($n=1813$) and moved into 74 new housing developments in Perth, Western Australia. Detailed information regarding recruitment methodology, data collection procedures, and participant characteristics have been reported elsewhere (Giles-Corti et al., 2008). In brief, those who had commissioned the building of a home and were planning to move into a house within the selected neighbourhood developments were contacted by the Water Corporation (the state water supply agency) and invited to participate. Participants were recruited between September 2003 and March 2005. One adult per household was randomly selected using the next birthday methodology. Eligibility requirements included being: proficient in the English language, aged ≥ 18 years, intending to be domiciled in their new house by December 2005, and willing to complete a questionnaire and wear a pedometer at three time points across four years. Participants received information about the study and provided written consent prior to completing the baseline questionnaire. The Human Research Ethics Committee at The University of Western Australia approved the study protocol. Baseline data are only examined here.

2.2. Measures

2.2.1. Socio-demographic factors

Participant socio-demographic characteristics were assessed using standard survey items to measure sex, age, country of birth, marital status, education attainment, working status, household income, children in the household, and vehicle access.

2.2.2. Physical activity measures

Overall and domain-specific physical activity was measured using the Neighbourhood Physical Activity Questionnaire (**NPAQ**). The NPAQ measures self-reported usual weekly duration and frequency of transportation and recreational walking and cycling, and moderate and vigorous intensity physical activity (excluding walking and cycling) undertaken within (i.e., a 15 min walk from home) and outside of the neighbourhood. The NPAQ has sound reliability with an Intra-class Correlation range of 0.55–0.96 (Giles-Corti et al., 2006). The NPAQ has not undergone validity testing.

For this study, participants' total minutes per usual week of transport-related, moderate-intensity recreational, and moderate and vigorous intensity physical activity were examined. Following existing procedures, reported minutes per week of all walking, cycling, and moderate and vigorous intensity activity were truncated at 1680 min for each participant to adjust for over-reporting, and have previously been reported in Australian national physical activity surveys (Australian Institute of Health and Welfare, 2003; Armstrong et al., 2000). Self-reported minutes spent engaged in vigorous intensity activity were weighted by two before being included in the moderate and vigorous physical activity category (Armstrong et al., 2000). Participants were further classified into being sufficiently or insufficiently active for health benefits based on accumulating 150 min of at least moderate intensity physical activity for all purposes across five or more sessions during the usual week.

To overcome some of the recognised limitations of self-reported physical activity (e.g., recall bias, social desirability, misinterpretation) participants also wore a Yamax Digiwalker hip-mounted pedometer (SW-200-024) for seven days at the time of NPAQ completion. Participants logged daily steps at the end of each day and did not reset the device during the monitoring period. Participants also recorded the number of days the unit was worn, and these logs provided an objective measure of weekly physical activity accumulated for all purposes (Tudor-Locke et al., 2008). It is possible that pedometer counts were overestimated due to reactivity as conflicting information exists for higher step counts when participants' self-recording daily pedometer values. Matevey et al. (2006) identified no reactivity for adults reporting pedometer step counts over a one week period. Conversely, Clemes and Parker (2009) showed significant daily mean differences over seven days between unsealed pedometers (9176 ± 3299 steps) and unsealed pedometers with daily logging of steps ($9635 \pm 2{,}709$) when compared with sealed pedometer counts (8832 ± 2845). Data were checked for extreme values in order to overcome potential reactivity; daily counts <1000 steps were removed and counts $>30{,}000$ were truncated to 30,000 steps (Tudor-Locke et al., 2008). No adjustments were made for activities undertaken or periods when the pedometer was removed as this information could not be derived accurately from the compliance log, and the overall weekly steps accumulated were used in the analysis.

2.2.3. Weather variables

Daily weather data for the study period were accessed from the Australian Bureau of Meteorology, and sampled from the Perth Metropolitan airport (site number: 9021). Variables measured across a 24 h period included: maximum ambient temperature (degrees Celsius (°C)), mean ambient temperature (°C), precipitation (rainfall; millimetres (mm)), and duration of bright sunlight (hours). First, weather data were compared with the southern hemisphere seasons, being spring (September–November), summer (December–February), autumn (March–May), and winter (June–August). Second, daily weather data were matched to the date participants wore the pedometers. Mean values of the four weather variables were derived for each participant, thereby providing individualised weather exposure data for the pedometer-wearing period.

2.3. Statistical analysis

A stepwise regression was initially conducted to identify demographic factors significantly associated with total weekly step counts. Weather variable data were not normally distributed; therefore