Summer to Winter Variability in the Step Counts of Normal Weight and Overweight Adults Living in the UK

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Background: This study investigated whether pedometer-determined activity varies between summer and winter in normal-weight and overweight adults. Methods: Forty-five normal-weight (58% female, age = 39.1 ± 12.4 years, BMI = 22.2 ± 2.1 kg/m²) and 51 overweight (49% female, age = 42.1 ± 12.5 years, BMI = 29.3 ± 4.5 kg/m²) participants completed a within-subject biseasonal pedometer study. All participants completed 2 4-week monitoring periods; 1 period in the summer and 1 period the following winter. Changes in step counts across seasons were calculated and compared for the 2 BMI groups. Results: Both BMI groups reported significant summer to winter reductions in step counts, with the magnitude of change being significantly greater in the normal-weight group (–1737 ± 2201 versus –781 ± 1673 steps/day, \( P = .02 \)). Winter step counts did not differ significantly between the 2 groups (9250 ± 2845 versus 8974 ± 2709 steps/day, \( P = .63 \)), whereas the normal-weight group reported a significantly higher mean daily step count in the summer (10986 ± 2858 versus 9755 ± 2874 steps/day, \( P = .04 \)). Conclusion: Both normal-weight and overweight individuals experienced a reduction in step counts between summer and winter; however, normal-weight individuals appear more susceptible to winter decreases in ambulatory activity, with the greatest seasonal change occurring on Sundays. Effective physical activity policies should be seasonally tailored to provide opportunities to encourage individuals to be more active during the winter, particularly on weekends.

Keywords: seasonality, pedometer, Sunday, body mass index, ambulatory activity

Physical activity levels tend to fluctuate according to season, being characteristically highest during the summer and lowest during the winter. This seasonal pattern has been well defined in large scale self-report studies conducted in both the USA\(^1-^4\) and UK\(^5\). Self-report measures of physical activity can however lack validity in that individuals often exhibit an inability to accurately assess low intensity activities, such as walking behavior.\(^3\) Walking is reportedly the most prevalent form of physical activity in both US\(^7\) and UK adults,\(^8\) yet it is commonly underestimated through questionnaires.\(^8-^{11}\) By not capturing walking or ambulatory behavior adequately, self-report studies may lack the sensitivity needed to detect actual seasonal physical activity patterns.

Pedometers are increasingly being used as a surveillance tool to objectively assess free-living ambulatory activity as they provide an accurate and reliable measure of walking behavior by counting the number of steps taken per day. Limited data currently exists however to describe seasonal changes in the step counts of free-living adults.\(^12\) Due to the increasing public health burden of obesity,\(^13\) and other diseases related to physical inactivity,\(^14\) it is essential to understand activity behaviors of different populations to aid in the development of appropriate public health initiatives.

Differences in pedometer-determined activity levels have been previously reported between different body mass index (BMI) groups\(^15-^{19}\) with normal weight individuals (BMI < 25 kg/m\(^2\)) characteristically reporting higher step counts than their overweight (BMI 25 to 29.9 kg/m\(^2\)) and obese (BMI ≥ 30 kg/m\(^2\))\(^20\) counterparts. In addition, differences in activity patterns over the different days of the week have been reported between normal weight and overweight adults.\(^15,^{16}\) It is currently unknown however whether normal weight and overweight individuals exhibit similar or discrete seasonal activity patterns. A clearer understanding of activity patterns of normal weight and overweight individuals could potentially identify risky behaviors that could be targeted in the design of obesity prevention programs. The aim of the current study therefore was to investigate whether pedometer-determined activity varies between summer and winter in normal weight and overweight adults living in the UK.

Methods

Design

A within-subjects repeated-measures design was employed, which consisted of 2 methodologically identical data collection periods. The first period of data
collection took place during the summer of 2005 (data collected during this time period have been reported elsewhere\(^{15}\)) and the second took place 6 months later during the winter of 2006. This paper details the findings from those participants completing both the summer and winter monitoring frames.

**Participants**

Participants were recruited during the summer of 2005 from 2 different counties in the United Kingdom—Leicestershire (n = 70) and Cornwall (n = 52)—through advertisements placed in local media. Male and female adult participants were recruited using a sampling frame that was developed to achieve an equal spread of individuals across the age range of 18 to 65 years. The sampling frame also ensured that, at the study outset, an equal number of participants were classified as either normal weight (BMI < 25 kg/m\(^2\)) or overweight (BMI \(\geq\) 25 kg/m\(^2\)), to reflect the 2001 prevalence of overweight in UK adults.\(^{21}\)

Upon completion of the summer monitoring frame participants were asked if they would be willing to repeat the procedure the following winter. Eight participants indicated that they would not be available during the designated winter testing period, and the remaining 114 participants consented and were approached the following autumn via e-mail or telephone. Five participants did not respond to this invitation, while 10 met the winter study exclusion criteria which encompassed any nonseasonal lifestyle change made since completion of the summer study which may affect physical activity levels [reasons for exclusion were: a change in job (n = 2), moving house during the study period (n = 2), moved house resulting in changes to commuting behavior (n = 1), divorced and changed leisure time physical activity (n = 1), sustained an injury which influenced walking behavior (n = 2), and moved away from the area (n = 2)]. Ninety-nine participants started the winter monitoring period.

Participants reported being in good general health and none had any physical illnesses or disabilities that might affect their normal daily routine. The study received ethical approval from the Loughborough University Ethical Advisory Committee. Participants were informed about the purpose of the study, they received written and oral information about the study protocol and provided written informed consent.

**Measurements of Body Weight and Composition**

At the beginning of the study, height was measured without shoes using a wall-mounted stadiometer (Seca UK, Model: 206, Birmingham, Warwickshire, UK). Body weight and percentage body fat were measured using a Tanita Body Composition Analyzer (Tanita UK Ltd, Model: BC-418 MA, Middlesex, UK) that measures body fat using 8-point bioimpedance analysis. Percent body fat measured using the Tanita BC-418 has been shown to correlate highly with the reference measure of dual-energy X-ray absorptiometry (DXA).\(^{22}\) As impedance fluctuates with the distribution of body fluid, to improve accuracy, participants were required to urinate before the measurement of percentage body fat was taken. BMI was calculated as kg/m\(^2\). Measurements of body weight, BMI, and percentage body fat were taken at the beginning of the summer and winter monitoring frames.

**Pedometer-Determined Activity**

Participants were issued with the same SW-200 pedometer (New Lifestyles, Inc., Lees Summit, MO) during both monitoring periods. This pedometer has been shown to accurately detect steps taken in both free-living conditions\(^{23}\) and under controlled laboratory conditions using normal weight,\(^{24–26}\) overweight, and obese\(^{27}\) individuals. The same protocol was employed during both seasons. Participants were instructed to wear the pedometer throughout waking hours for a period of 4 weeks, only removing it when either bathing, showering or swimming. The appropriate position to wear the pedometer, on the waist band in-line with the midline of the thigh, was shown to participants at the outset. Pedometer accuracy was confirmed with each participant upon issue by means of a 20 step test (acceptance criteria: plus/minus 2 steps). Each night before going to bed participants recorded the number of steps displayed in an activity log provided. Participants also recorded whether they had gone for a walk that day, along with any participation in sports and/or recreational physical activities. The pedometer was then reset ready for the following day.

All participants were encouraged not to make any changes to their typical daily routine of work and leisure activity. Upon finishing each monitoring period participants completed a brief poststudy questionnaire inquiring whether they had suffered from any ill health or made any changes to their normal routine, diet, or general activity levels during the study period.

**Meteorological Information Associated With Each Monitoring Frame**

Seasonal changes in physical activity are thought to be mediated through changes in the environment, with ambient temperature, daylight hours, and precipitation considered most influential.\(^{2,28}\) Data summarizing the mean, minimum, and maximum temperature (°C), sunshine hours, and rainfall volume (mm) were therefore collected retrospectively from the Met Office that corresponded to the summer 2005 and winter 2006 monitoring periods.

**Statistical Analyses**

Statistical analyses were conducted using SPSS for Windows version 16. To ensure the participants completing both monitoring frames did not differ to those completing the summer period only, the 2 groups were compared in terms of mean summer step counts, presummer study
BMI, and gender distribution using independent samples \( t \) tests and Chi-squared statistics.

Summer and winter mean daily step counts were calculated over each 4-week monitoring frame for the normal weight (BMI < 25 kg/m\(^2\)) and overweight (BMI \( \geq 25 \) kg/m\(^2\)) participants. To test for an overall effect of season, and for an interaction between seasonal change in steps and weight status, a 2-way mixed ANOVA was conducted with season (summer and winter mean steps) as the within-subjects factor and weight status as the between subjects factor (normal weight versus overweight). Effect sizes of the differences in step counts between subjects factor (normal weight versus overweight). Effect sizes of the differences in step counts between subjects were calculated.\(^{29}\)

For the normal weight and overweight participants the percent change in step counts between seasons was calculated by dividing the mean seasonal change in steps (winter minus summer) by mean daily step counts reported in the summer, multiplied by 100. For each group mean step counts reported on each specific day of the week were calculated for each season by averaging the 4 step count values available for each day. Using these data a repeated-measures ANOVA with Bonferroni corrected post hoc comparisons were applied to test whether mean step counts differed between days within each season. Mean step counts reported on each day of the week were compared between seasons (eg, summer mean Monday steps versus winter mean Monday steps etc.) using multiple paired sample \( t \) tests, with a Bonferroni correction applied. Day-specific seasonal changes in steps were also calculated (eg, winter mean Monday steps minus summer mean Monday steps). The measurements of body weight, percent body fat, and BMI were compared between seasons using paired-samples \( t \) tests. Statistical significance was set at \( P < .05 \).

**Follow-Up Study**

A subsample of participants from the main study (normal weight: \( n = 17 \); overweight: \( n = 11 \)) agreed to participate in a follow-up study conducted during the summer of 2006. The aim of this follow-up study was to confirm any seasonal changes observed during the main study and to establish any possible ordering effects that might have been influenced by pedometer reactivity. The protocol followed was exactly the same as that outlined for the previous 2 monitoring frames, and the same exclusion criteria applied to the winter study were also applied to this follow-up. All participants included in this sub-study remained healthy throughout according to poststudy questionnaire results. Participants who completed the follow-up were compared with those who did not take part in this additional study using independent samples \( t \) tests. Mean daily step counts taken by this subsample of normal weight and overweight participants, during each of the 3 monitoring frames, were compared using a repeated-measures ANOVA, with Bonferroni corrected comparisons applied in the event of a significant seasonal effect.

## Results

### Meteorological Information

Meteorological data recorded by the Met Office for Cornwall and Leicestershire, along with the national average for England, during the monitoring periods (summer 2005, winter 2006, summer 2006) are shown in Table 1. Due to the relatively small size of the country, large differences in climate between regions do not exist. Large climate-related differences in activity between our participants recruited from Cornwall and Leicestershire were therefore not observed and no significant differences in mean daily step counts were found between participants from each location in either season (Summer: Leicestershire sample = 10837 ± 3119 steps/day versus Cornwall sample = 10056 ± 2966 steps/day, \( P = .213 \); Winter: Leicestershire sample = 9729 ± 2685 steps/day versus Cornwall sample = 8709 ± 3027 steps/day, \( P = .09 \)).

### Participants

Of the 99 participants who started the winter monitoring period, 3 were lost at follow-up. Ninety-six participants (78.6% of those used in the analysis of the summer monitoring period) therefore completed both the summer and winter monitoring frames. Participants who completed only the summer section of the study did not differ significantly to those who completed both the winter and summer sections with respect to; summer mean daily step count, presummer study BMI or gender proportion (\( P > .05 \), data not shown).

Forty-five normal weight and 51 overweight participants completed the 2 monitoring periods. Demographic characteristics of the normal weight and overweight groups are shown in Table 2, along with a summary of the seasonal activity data reported by participants in each group. Participants provided 5324 person-days of pedometer data, of a possible 5376 (99% compliance). There were no significant differences between the normal weight and overweight participants in terms of the number of days the pedometer was worn during each season (Summer: normal weight = 27.6 ± 0.7 days versus overweight = 27.8 ± 0.6 days, \( P = .10 \); Winter: normal weight = 27.7 ± 0.7 days versus overweight = 27.7 ± 0.7 days, \( P = .66 \)). Furthermore, the number of days in which the pedometer was worn did not differ significantly between the 2 seasons for either participant group (\( P > .05 \)). All participants remained in good health during the summer and winter monitoring periods and no changes to daily routine or lifestyle were reported.

The normal weight participants exhibited no significant changes in body weight and BMI between the summer and winter monitoring periods, however a significant increase in percentage body fat was observed in the winter in this group (\( t = 2.4, P < .02 \) (Table 2). In comparison, significant increases in body weight, BMI, and percentage body fat were observed between the
### Table 1  A Summary of the Mean Temperature, Sunshine Hours, and Rainfall Volume Recorded in Cornwall and Leicestershire, Along With the National Average for England, by the Met Office During Summer 2005, Winter 2006, and Summer 2006

<table>
<thead>
<tr>
<th>Location</th>
<th>Temperature (°C)</th>
<th>Sunshine hours</th>
<th>Rainfall volume (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>Cornwall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summer 2005</td>
<td>15.6</td>
<td>11.4</td>
<td>19.9</td>
</tr>
<tr>
<td>Winter 2006</td>
<td>4.4</td>
<td>1.6</td>
<td>7.2</td>
</tr>
<tr>
<td>Summer 2006 (follow-up)</td>
<td>16.5</td>
<td>12.0</td>
<td>21.1</td>
</tr>
<tr>
<td>Leicestershire</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summer 2005</td>
<td>15.9</td>
<td>11.1</td>
<td>20.7</td>
</tr>
<tr>
<td>Winter 2006</td>
<td>3.8</td>
<td>1.1</td>
<td>6.6</td>
</tr>
<tr>
<td>Summer 2006 (follow-up)</td>
<td>17.2</td>
<td>12.0</td>
<td>22.4</td>
</tr>
<tr>
<td>England</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summer 2005</td>
<td>15.9</td>
<td>11.2</td>
<td>20.5</td>
</tr>
<tr>
<td>Winter 2006</td>
<td>4.0</td>
<td>1.2</td>
<td>6.8</td>
</tr>
<tr>
<td>Summer 2006 (follow-up)</td>
<td>17.0</td>
<td>12.0</td>
<td>22.0</td>
</tr>
</tbody>
</table>

summer and winter monitoring periods in the overweight group (all $P < .05$) (Table 2).

**Differences in Summer and Winter Step Counts**

Results of the 2-way mixed ANOVA revealed a significant overall effect of season, with both groups exhibiting significant reductions in mean step counts between summer and winter ($F = 40.3, P < .001$, effect size = 0.55). Normal weight participants showed a consistent summer to winter reduction in mean step counts on every day of the week (Table 3), with this group reporting an overall mean winter reduction in ambulatory activity of 1736 steps/day (effect size = 0.62). The overweight group reported an overall mean winter reduction in ambulatory activity of 781 steps/day (effect size = 0.43). A significant interaction effect of BMI group was observed, with the normal weight group exhibiting a significantly larger winter reduction in mean daily step counts in comparison with the overweight group ($F = 5.8, P = .02$, effect size = 0.24) (Figure 1). The normal weight participants exhibited on average a 15.4% reduction in step counts in the winter in comparison with a 6.9% reduction in steps seen in the overweight group ($t = 2.49, P = .02$, effect size = 0.25). During the summer monitoring period, the normal weight participants reported a significantly higher mean daily step count than the overweight group ($t = 2.1, P = .04$, effect size = 0.21), however no statistically significant differences in mean step counts were observed between the 2 BMI groups during the winter monitoring period ($t = 0.49, P > .05$) (Figure 1).

**Day-of-the-Week Variations in Step Counts**

No significant variations in step counts were observed in the normal weight group over the different days of the week during the summer monitoring period ($F = 2.1, P > .05$) (Table 3). A significant day-of-the-week effect was observed in this group however during the winter monitoring frame ($F = 4.4, P < .001$), with step counts reported on a Sunday being significantly lower than those reported on all other days (all $P < .002$). In the overweight group a significant day-of-the-week effect was observed during both seasons (summer: $F = 4.2, P < .001$; winter: $F = 3.8, P < .001$), with step counts reported on a Sunday being significantly lower than those reported on all other days of the week during summer and winter (all $P < .002$) (Table 3).

**Follow-Up Study**

Participants who completed the follow-up study (normal weight: $n = 17$, overweight: $n = 11$) did not differ significantly from the remainder of the sample with regards to summer 2005 and winter 2006 mean daily step counts (all $P > .05$, data not shown). Significant differences in mean daily step counts were observed across the 3 seasons in the normal weight participants (summer 2005 = 11213 ± 2399 steps/day, winter 2006 = 9554 ± 2952 steps/day, summer 2006 = 11085 ± 3222 steps/day, $F = 9.98, P < .001$), with post hoc analyses revealing that step counts reported in the winter of 2006 were significantly lower than those reported during both summers (2005
Table 2  Demographic Characteristics of the Normal Weight and overweight Participants Along With Each Group’s Mean Daily Step Counts, Minutes Reported Walking, and Minutes Reported Engaged in Sports and/or Recreational Physical Activities During Summer 2005 and Winter 2006 Monitoring Framesa

<table>
<thead>
<tr>
<th></th>
<th>Normal weight participants (n = 45)</th>
<th>Overweight participants (n = 51)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Summer mean (SD)</td>
<td>Winter mean (SD)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>39.1 (12.4)</td>
<td>42.1 (12.5)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>168.8 (10.5)</td>
<td>169.5 (9.7)</td>
</tr>
<tr>
<td>Percent female</td>
<td>58%</td>
<td>49%</td>
</tr>
<tr>
<td>Percent from Cornwall</td>
<td>40%</td>
<td>51%</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>63.3 (9.0)</td>
<td>83.8 (11.5)</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>22.2 (2.1)</td>
<td>29.3 (4.6)</td>
</tr>
<tr>
<td>Percent body fat</td>
<td>20.5 (9.0)</td>
<td>32.0 (9.5)</td>
</tr>
<tr>
<td>Overall seasonal mean steps/day</td>
<td>10986 (2858)</td>
<td>8975 (2874)</td>
</tr>
<tr>
<td>Median (IQR) minutes reported walking/daya</td>
<td>18.7 (7.3, 30.8)</td>
<td>12.1 (3.2, 22.0)</td>
</tr>
<tr>
<td>Median (IQR) minutes reported in other activities/dayb</td>
<td>7.7 (0.5, 21.3)</td>
<td>4.3 (0.8, 17.1)</td>
</tr>
</tbody>
</table>

a Data are mean (SD) values unless otherwise stated.
b Due to skewed data, the median and interquartile ranges are reported for the self-reported time spent walking, and time engaged in other recreational physical activities data. Within group seasonal differences in time spent walking and time engaged in other activities were compared using the Wilcoxon Signed Ranks Test.
Table 3  Mean (SD) Daily Step Counts Reported on Each Day of the Week by the Normal Weight and Overweight Participants During Summer 2005 and Winter 2006 Monitoring Frames

<table>
<thead>
<tr>
<th></th>
<th>Normal weight participants (n = 45)</th>
<th>Overweight participants (n = 51)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Summer mean (SD)</td>
<td>Winter mean (SD)</td>
</tr>
<tr>
<td>Monday</td>
<td>10524 (3412)</td>
<td>9006 (3249)</td>
</tr>
<tr>
<td>Tuesday</td>
<td>11176 (3481)</td>
<td>9666 (3465)</td>
</tr>
<tr>
<td>Wednesday</td>
<td>11026 (3547)</td>
<td>9716 (3705)</td>
</tr>
<tr>
<td>Thursday</td>
<td>10929 (3555)</td>
<td>9138 (3443)</td>
</tr>
<tr>
<td>Friday</td>
<td>11177 (3197)</td>
<td>9495 (3029)</td>
</tr>
<tr>
<td>Saturday</td>
<td>11733 (3714)</td>
<td>9901 (4447)</td>
</tr>
<tr>
<td>Sunday</td>
<td>10327 (3526)</td>
<td>7824 (3143)</td>
</tr>
<tr>
<td>Within group/season differences</td>
<td>$P &gt; .05$</td>
<td>$P &lt; .001^*$</td>
</tr>
</tbody>
</table>

* Within group differences, mean daily step counts reported on a Sunday were significantly lower than those reported on all other days of the week by the normal weight group during the winter, and by the overweight group during both summer and winter.
No significant overall effect of season was observed in the follow-up sample of overweight participants (summer 2005 = 9245 ± 2271 steps/day; winter 2006 = 8260 ± 2289 steps/day; summer 2006 = 8701 ± 2052 steps/day; \( F = 1.92, P = .172 \)).

**Discussion**

The aim of this study was to determine whether pedometer-determined activity varies between summer and winter in normal weight and overweight adults. Reductions in ambulatory activity were observed in both BMI groups in the winter monitoring period, and this was accompanied by significant increases in percentage body fat measured in the winter relative to the summer in both groups. The magnitude of seasonal change in activity was greater in the normal weight participants studied suggesting that normal weight individuals are more prone to seasonal fluctuations in ambulatory activity. The changes in ambulatory activity observed in the current study reflect changes in ambient temperature and sunshine hours measured in the UK at the time of each monitoring frame, supporting previous evidence suggesting that seasonal changes in physical activity are mediated through changes in the environment, particularly the weather.

The observed changes in ambulatory activity are consistent with seasonal changes in activity reported in questionnaire-based surveys of physical activity, accelerometer-determined physical activity, and pedometer-determined activity, whereby a sample of adults living in the US reported winter reductions in step counts. This paper is the first of its kind however to distinguish between normal weight and overweight adults, living in the UK, when describing seasonal patterns in ambulatory activity.

The findings from the follow-up sample of normal weight participants studied in the summer of 2006 showed that this group of participants increased their activity levels, relative to the winter monitoring period, the following summer. No significant differences in step counts recorded between the 2 summer monitoring periods (2005 and 2006) were observed in this group demonstrating that these normal weight individuals reattained their increased activity levels the following summer. While this follow-up sample did not differ significantly from the rest of the sample in terms of summer 2005 and winter 2006 step counts, it is not possible to determine whether the same pattern was observed in the normal weight participants who did not complete the follow-up study. Indeed, seasonal changes in activity could have
potential health consequences if such individuals do not reattain their activity levels the following summer. While a winter reduction in mean daily step counts was observed, in comparison with the 2 summer monitoring periods, in the follow-up sample of overweight participants the magnitude of seasonal change was not statistically significant supporting the observation made from the whole sample of overweight participants that overweight individuals appear to be less susceptible to seasonal changes in activity. Encouraging overweight individuals to make the most of the summer weather by increasing their activity levels to the level observed among the normal weight participants during this season could be an effective starting point for strategies aimed at reducing the prevalence of obesity in the UK.

While the normal weight participants showed a consistent summer to winter reduction in mean step counts on every day of the week, the greatest seasonal change in steps appeared to occur on Sundays for this group. The mean reduction in steps between the summer and winter monitoring period on Sunday was 2503 steps/day. It was evident that the normal weight group maintained their activity levels throughout the week during the summer, as no day-of-the-week effects occurred during this monitoring frame. However, during the winter period step counts were significantly lower for this group on a Sunday in comparison with all other days. As the majority of participants who completed this study worked Monday through to Friday occupation would be likely to greatly influence steps on these days, and it is likely that the step counts reported on Saturdays and Sundays are reflective of general lifestyle and leisure-time activities. Public health messages and the provision of suitable in-door facilities that encourage activity on a Sunday during the winter months could potentially reduce the magnitude of seasonal changes in activity observed in the normal weight participants surveyed. The development of such facilities and public health messages may also be effective in encouraging overweight individuals to increase their activity levels on a Sunday, given the decreases in activity that were also seen in this group on this particular day of the week across both seasons.

In addition to highlighting differences in seasonal activity between normal weight and overweight adults, the findings of the current study also have methodological implications in that data collection restricted to 1 season may either overestimate or underestimate year round habitual ambulatory activity, particularly in normal weight adults. For example, in the summer monitoring period 60% of the normal weight group reported mean daily step counts above the recommended 10,000 steps/day, this figure fell to 36% in the winter monitoring period. The proportion of overweight participants achieving at least 10,000 steps/day during the summer and winter monitoring periods were 43% and 35% respectively. Similar to the findings of Tudor-Locke et al., we observe that to obtain a nonbiased reflection of general day-to-day step count levels, pedometer studies should either be conducted throughout different time points over the year, or restricted to spring or fall to avoid the summer peaks and winter troughs in activity reported herein.

A limitation of the current study is the fact that only seasonal summaries of meteorological data were available, and thus it was not possible to statistically assess any relationships between step counts and the climate. Future studies should overcome this by recording daily weather conditions concurrently with step count data. Another limitation is the fact that data were collected from a self-selected sample. The current findings should therefore be confirmed in a random sample of adults, recruited from a number of regions throughout the UK. Furthermore, the size of the follow-up sample assessed in the summer of 2006 was relatively small in comparison with the sample size of the main study which potentially led to a lack of statistical power to detect differences between the seasons in the overweight group. A further limitation, common to pedometers, is the fact that they do not measure physical activity using only upper body movements, neither do they measure activity associated with cycling or swimming. Results from this study should therefore be interpreted in context with the study aim; to assess seasonal variation in ambulatory activity.

Despite these limitations, this study was the first of its kind to describe seasonal patterns in ambulatory activity, measured objectively, in a sample of normal weight and overweight adults living in the UK. Given daily step counts measured in normal weight, overweight, and obese adults living in the UK, and in other European countries tend to be higher by approximately 3000 to 4000 steps/day, than those observed in US adults, it is important to understand habitual activity levels and patterns in different populations to aid in the formulation of appropriate, population-specific, public health messages. Furthermore, given the diverse global climate, and as seasonal changes in physical activity are thought to be partly mediated through changes in the weather, it is likely that seasonal patterns in ambulatory activity may vary between countries, and more regionally specific studies are necessary if we are to understand global patterns in activity. A strength of our study is the 4-week monitoring frame applied in both seasons which increases the likelihood that we have captured participants habitual activity and any reactivity effects, a potential validity threat to short-term pedometer studies have been minimized.

In conclusion, step counts in the sample of UK adults surveyed decreased significantly in the winter compared with the summer, with the normal weight participants appearing more susceptible to winter decreases in ambulatory activity. Public health messages that encourage overweight adults to take advantage of the warmer weather during the summer months by increasing their activity levels during this season could be an effective starting point for strategies aimed at reducing the prevalence of obesity in the UK. Effective physical activity policies should be seasonally tailored to provide opportunities to encourage individuals to be more active during the winter. For example, encouraging physical activity through indoor activities, particularly on a Sunday, could...
potentially reduce the magnitude of seasonal changes seen in normal weight adults, and may also help to encourage overweight adults to increase their activity levels on this particularly in-active day of the week.

References