Pedometer-Determined Physical Activity Levels of Adolescents: Differences by Age, Sex, Time of Week, and Transportation Mode to School

Maea Hohepa, Grant Schofield, Gregory S. Kolt, Robert Scragg, and Nick Garrett

Background: Few studies have examined high school students’ physical activity habits using objective measures. The purpose of this study was to describe pedometer-determined habitual physical activity levels of youth. Methods: 236 high school students (age 12–18 years) wore sealed pedometers for 5 consecutive days. Data were analyzed using generalizing estimating equations. Results: Mean steps/d (± SE) differed significantly by sex (males, 10,849 ± 381; females, 9652 ± 289), age (junior students [years 9–11], 11,079 ± 330; senior students [years 12 and 13], 9422 ± 334), time of week (weekday, 12,259 ± 287; weekend day, 8241 ± 329), and mode of transportation to and from school (walkers, 13,308 ± 483; car transit users, 10,986 ± 435). Only 14.5% of students achieved at least 10,000 steps on every day during the monitoring period. Conclusion: Daily step counts differed substantially by age, sex, time of week, and transportation mode to school.

Keywords: step counts, descriptive, adolescent, commuting

Increasing physical activity among youth is a priority in many countries, including New Zealand. Around the globe, knowledge about youth physical activity behaviors is based predominantly on survey-derived data, a measurement method associated with well-described limitations. In comparison, few studies have examined the physical activity habits of high school students using objective measures.

One objective measure becoming more popular in physical activity research is pedometry. Pedometers are small digital devices typically worn on the waist that measure step counts as a result of vertical body displacement (eg, hip acceleration). Pedometers provide an unobtrusive and inexpensive method for objectively assessing total physical activity in research and health-promotion settings. Depending on
brand, pedometers have high accuracy in counting steps and provide a valid option for assessing physical activity among children and adults.9-11

Since the conception of the pedometer, cut points for assessing pedometer-determined physical activity have emerged. The well-known criterion of 10,000 steps per day is frequently used in public health–promotion initiatives and by private health-promotion organizations. For ostensibly healthy adults, 10,000 steps per day indicates an active lifestyle,12 which roughly equates to the 30-minutes-per-day physical activity message.13,14 Only recently have preliminary guidelines specific to the child population emerged. Body mass index–referenced standards for children age 6 to 12 years suggest 15,000 steps per day for boys and 12,000 steps per day for girls.15 Based on a descriptive study of 711 children (age 6–12 years), Vincent and Pangrazi16 recommended 11,000 steps per day for girls and 13,000 steps per day for boys. Although youth age 6 to 17 years are recommended to accumulate at least 11,000 steps on at least 5 days per week as part of the Presidential Active Lifestyle Award,17 this criterion is largely arbitrary. A health-based threshold for assessing step values specific to the adolescent population has yet to be established.

Average daily step-count values by sex and age are commonly reported in youth studies. Pedometer evidence has consistently shown that males are more active than females, with aggregated daily step count values ranging between 10,000 and 13,700 for males and 8400 and 11,300 for females.5-8,18,19 In addition, a trend toward reduced activity with age is typically observed,5,8,20 with steps counts peaking at age 12.8 years for females and 14.3 years for males.8

Researchers, however, have yet to examine the number of young people meeting any step-based criteria. An obvious limitation of conducting such an examination is the absence of a criterion-based step threshold specific to the age range represented during the high school years. The 10,000-step threshold, which is reflective of being considered active during adulthood,12 however, provides a conservative criterion for the youth population considering the commonly reported decline in physical activity during adolescence. For this reason, the proportion of students achieving at least 10,000 steps per day is examined in the current study.

In addition to determining overall activity, identifying key periods of low physical activity is crucial in directing future health-promotion efforts. A convenient way to delineate these periods for youth is by dividing the week into school days (weekdays) and weekend days. Based on the limited evidence, some studies of high school students show significantly higher activity counts21,22 and step counts23 on weekdays, whereas other studies show lower step counts (significance not stated) on weekdays8 or no significant differences between time periods when physical activity is assessed by heart-rate monitoring.24 The equivocal research findings in this area indicate that further investigation is warranted.

Irrespective of time of week, youth can accumulate health-related physical activity within a number of contexts. One physical activity context receiving increased research attention is transport-related physical activity. Although increasing the prevalence of active transportation among young people is recommended,25 especially walking to and from school, the importance of active transportation to daily physical activity levels of high school students has rarely been examined. A recent study found that students (13–14 years) who walked to and from school achieved 25.9 more minutes of moderate-to-vigorous physical activity (as assessed by accelerometry) than did their peers who traveled by car, bus, or train to and from school.26
Although several studies have examined youth physical activity with objective measures (eg, using pedometry), several limitations with the methodology employed are apparent. First, previous research has included only those participants who had complete step data for a predefined number of days (typically a minimum of 4 days). Although this process is not a limitation for studies on children that typically report low exclusion levels, it might potentially bias the sample, and subsequently, the results of studies noting high exclusion levels (>30% exclusion level), which is apparent in studies of adolescents. Second, although longitudinal data are usually collected, step-count data are frequently averaged before analysis, which substantially reduces the number of observations per participant to 1 and reduces the potential statistical power. Third, some previous statistical analyses have been applied to daily step-count averages in which the number of monitoring days might differ between participants (eg, some participants have complete step data for 4 days, whereas other participants have complete data for 5 days or 6 days). The common statistical analyses applied to these averages will not account for within-subject variation or differences in variance of step counts when the number of monitoring days varies between participants. To address the just-mentioned limitations, the data in our study have been analyzed using generalizing estimating equations (GEE).

The aims of the current study, therefore, were twofold. First, our aim was to examine daily step counts and make comparisons by age, sex, time of week, and transportation mode. Second, we aimed to determine the percentage of youth who meet the 10,000-steps-per-day criterion by sex and age.

**Methods**

This study is linked with a larger study known as the Obesity Prevention in Communities (OPIC) project, an ecological-based obesity prevention initiative focusing on high school students that is being conducted across 4 countries (Australia, New Zealand, Fiji, and Tonga). In New Zealand, the intervention is targeting youth attending schools with a low socioeconomic rating within a predefined suburb in South Auckland, New Zealand. Based on reducing school burden, 3 of the intervention schools were approached to participate in this pedometer study.

**Sample**

Data were collected from a convenience sample of students attending 1 of 3 high schools within Manukau City, Auckland. All schools were of low socioeconomic status with a decile rating of 1 or 2. The decile rating is a proxy for socioeconomic status ranging from 1 (most deprived) to 10 (least deprived). From the 3 schools, 20 classes in total were approached to participate in this study, with the number of classes approached per school relative to the number of students attending each school. A total of 348 students agreed to participate.

Only participants age 12 to 18 years were included for analysis. Through using GEE analysis, which is a standard statistical method often used in situations in which there is missing longitudinal data, all participants who had a least 1 weekday of pedometer data were considered for inclusion in the analysis. The inclusion of data with only 1 or 2 data points overcomes the potential sample bias that could
occur if such data were excluded. All step values collected on days with reported compliance (ie, not detaching the pedometer for more than 1 waking hour per day) were included. Dealing with outliers among the youth population has received little attention. In line with a recent study on children, daily step counts between 1000 and 30,000 were included.

For GEE analysis, participants were excluded if they (1) were outside the age criteria (n = 4, 1.1%), (2) had provided no age data (n = 9, 2.6%), (3) had no weekday data (n = 4, 1.1%), (4) had no pedometer data (n = 51, 14.7%), (5) did not comply with pedometer instructions (n = 37, 10.6%), or (6) had all their pedometer data points below 1000 steps or greater than 30,000 steps (n = 7, 2.0%). In total, 112 participants (32.2%) were excluded, leaving a final sample of 236 participants with 844 usable data points. The exclusion of 32% of the participants is similar to another pedometer-based study of high school students that used more stringent inclusion criteria and reported an exclusion percentage of 39%. Chi square analysis revealed no significant sex or age-group differences between the included and excluded participants.

Of the 236 participants (mean age = 15.3 ± 1.6 years), female (59.7%) and junior (year 9, 10, and 11 students, 58.5%) students composed a larger proportion of the sample than did their male and senior (year 12 and 13 students) peers, respectively. Ethical approval was gained from the Auckland University of Technology Ethics Committee. Informed consent to participate was obtained from the principals of each school, all participants, and parents for students below 16 years of age.

**Measures**

*Pedometer.* The NL-2000 pedometer (New-Lifestyles Inc) was used because it displays high accuracy (within ±3% of actual step taken) and intramodel reliability and has the memory capacity to store 7 consecutive days of data. A check of functionality and reliability of each pedometer was conducted before the start of the study with a step-count test. All pedometers were found to be within the acceptable ±3% margin of error. Before the reuse of each pedometer, the pedometer’s clock was checked to ensure the 1-day epoch covered the 24-hour time period from midnight to midnight.

*Questionnaire.* Mode of transport to and from school was collected by questionnaire. Participants were asked to indicate how they traveled to and from school on each of the previous 3 school days by choosing 1 of 4 response options (car, bus, walk, and bike). For analysis purposes, students were categorized into 1 of 5 groups: car only (traveled to and from school by car), bus one way (traveled by bus to or from school but did not walk), bus only (traveled to and from school by bus), walk one way (traveled to or from school by walking), and walk only (traveled to and from school by walking).

**Data Collection**

Data were collected during the Southern hemisphere spring season (between late August and early November) in 2005. Before data collection, all students were informed about the study and the required consent forms, and information sheets were distributed to each participant and collected once completed. On the first
monitoring day, participants received a sealed pedometer and instructions regarding pedometer attachment. Participants were asked to wear the pedometer from the time they woke up in the morning until bedtime the same day, every day for 7 days. Only during water-based activities (e.g., swimming, showering) and competition contact sport were the participants instructed to detach and reattach their pedometer directly before and after the activity, respectively. On the final monitoring day, participants returned their pedometers and completed a short questionnaire (to gain information on their main mode of transportation to and from school) and a compliance form (requesting information on how many hours they did not wear the pedometer on each of the previous 5 days). Noncompliance with the pedometer instructions was operationalized as individuals detaching the pedometer for more than 1 hour during their wake time, a protocol used in previous studies.6 Data collected on monitoring days 2 through 6 were included in the analyzes because pedometer distribution and collection took place on monitoring days 1 and 7; these days, therefore, did not represent complete data. As a result, 5 full days of complete pedometer data could be potentially collected per participant.

**Data Analysis**

The data were analyzed using the GEE procedure with repeated measures and an unstructured correlation matrix. GEE was chosen because (1) the variation in step counts for each potential collection period (1–5 days) is taken into account, thereby allowing inclusion of participants who wore the pedometer for a minimum of 1 day and, in turn, maximizing participant retention and sample size; (2) it maximizes statistical power of the study design by analyzing all data points rather than averaged step counts; and (3) it takes into consideration the covariance structure of the repeated data points, which are likely to be correlated.

Data were analyzed using Statistical Analysis System (SAS) version 9.1 (SAS Institute Inc, Cary, NC, USA), with corrections for any design effects arising from the sampling method employed. Through the GENMOD procedure in SAS, GEE estimated daily step counts and standard errors according to age group, sex, time of week, and engagement levels in active transportation with respective P values. For each GEE model, all potential main effects (age, sex, time of week), as well as all possible 2-way and 3-way interactions were initially entered into the model and examined for significance. Using a stepwise process, only those interactions and main effects that were significant (P < .05) were included in the final GEE model.

When determining the proportion of days students were reaching 10,000 steps, only those students with at least 3 days of pedometer data were included for the analysis (n = 193). The following method was used to determine the percentage of days each student achieved the 10,000-step criterion: (the number of days meeting the recommended guidelines/total number of usable days monitored) × 100. Each participant was then categorized into 1 of 4 groups: never (did not achieve 10,000 steps on any day for which they have complete data), sometimes (achieved 10,000 steps at least once but on less than half of the days for which they had complete data), often (achieved 10,000 steps on at least half, but not all, of the days for which they had complete data), and always (achieved 10,000 steps on all days for which they had complete data).
The reasons for choosing the 10,000-step threshold are as follows. First, in a population in which physical activity substantially declines during the high school years, the 10,000-steps-per-day threshold, which is reflective of being active for adults, can be considered a conservative level that most young people should try to achieve. Second, 10,000 steps per day provides a middle ground between step thresholds that consider adults to be somewhat active (7500–9999 steps per day)\(^\text{12}\) and preliminary thresholds for children (12,000–15,000 steps per day).\(^\text{15}\) Third, although determining the proportion of students achieving this criterion does not represent the percentage considered active, nor does it correspond to a magic number in which health benefits appear for any population group, it does provide a benchmark to monitor physical activity trends of high school students. Future research, however, needs to establish best practice step cut points for the adolescent population that are based on a health criterion and that are in line with recent time-based guidelines.\(^\text{30}\)

### Results

**Daily Step Counts**

Table 1 shows the results from the GEE analyses used to estimate daily step counts while adjusting for clustering by school. Daily step counts differed by sex, age group, and time of week. Table 1 shows, after adjusting for all factors, that males accumulated nearly 1100 more daily steps than their female peers, junior students accrued over 1600 more steps daily than their senior peers, and higher daily step counts were achieved on weekdays than on weekend days. In addition, a significant age-group by time-of-week interaction emerged. A larger

<table>
<thead>
<tr>
<th>Variable and grouping</th>
<th>Estimated daily steps ± SE(^\text{a})</th>
<th>(P) value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td>.01</td>
</tr>
<tr>
<td>female</td>
<td>9652 ± 289</td>
<td></td>
</tr>
<tr>
<td>male</td>
<td>10,849 ± 381</td>
<td></td>
</tr>
<tr>
<td><strong>Age group</strong></td>
<td></td>
<td>.0004</td>
</tr>
<tr>
<td>junior</td>
<td>11,079 ± 330</td>
<td></td>
</tr>
<tr>
<td>senior</td>
<td>9422 ± 334</td>
<td></td>
</tr>
<tr>
<td><strong>Time of week</strong></td>
<td></td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>weekday</td>
<td>12,259 ± 287</td>
<td></td>
</tr>
<tr>
<td>weekend</td>
<td>8241 ± 329</td>
<td></td>
</tr>
<tr>
<td><strong>Time of week by age group</strong></td>
<td></td>
<td>.01</td>
</tr>
<tr>
<td>weekday junior</td>
<td>13,575 ± 401</td>
<td></td>
</tr>
<tr>
<td>weekend junior</td>
<td>8583 ± 420</td>
<td></td>
</tr>
<tr>
<td>weekday senior</td>
<td>10,944 ± 374</td>
<td></td>
</tr>
<tr>
<td>weekend senior</td>
<td>7900 ± 470</td>
<td></td>
</tr>
</tbody>
</table>

\(^\text{a}\) SE corrected for cluster effect by school.
A reduction in step counts from weekdays to weekend days was observed for the junior school students than for their senior counterparts. Although there was a significant step-count deferential between age groups on weekdays, this was not the case for weekend activity.

**Engagement in Active Transportation**

From the sample of 236 participants, 230 had completed questions on transportation to and from school and were, therefore, included for analysis. Daily step counts were limited to the school days only. Results from the GEE procedure examining daily step counts by level of engagement in active transportation to and from school on weekdays are shown in Table 2. After adjusting for age, sex, and the school effect, the final GEE model revealed significant differences in accrued steps between those using different transportation modes \((P = .006)\). Compared with the car only reference group, the walk only group accumulated over 2300 more steps, and the walk one way group accrued over 1700 extra steps daily.

The proportion of students using the different modes of transportation by school is presented in Table 3. Substantial differences in transportation patterns between the 3 participating schools are apparent. Most students in school 2 (56.7%) walked to and from school, whereas a smaller proportion of students undertook this behavior at school 1 (38.9%). Only 7% of students at school 3 traveled to and from school by car.

### Table 2  Estimated Weekday Daily Step Counts (± Standard Error) According to Mode of Transportation Adjusted by Age and Sex (n = 230)

<table>
<thead>
<tr>
<th>Mode of travel</th>
<th>Estimated daily steps ± SE(^a)</th>
<th>(P) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car only</td>
<td>10,986 ± 435</td>
<td>Referent</td>
</tr>
<tr>
<td>Bus one way</td>
<td>12,462 ± 825</td>
<td>.08</td>
</tr>
<tr>
<td>Bus only</td>
<td>12,397 ± 675</td>
<td>.06</td>
</tr>
<tr>
<td>Walk one way</td>
<td>12,741 ± 453</td>
<td>.002</td>
</tr>
<tr>
<td>Walk only</td>
<td>13,308 ± 483</td>
<td>.0002</td>
</tr>
</tbody>
</table>

\(^a\) SE corrected for cluster effect by school.

### Table 3  Percentage of Students (n = 230) Participating in Each Transport Mode by School

<table>
<thead>
<tr>
<th>Mode of travel</th>
<th>Total (%)</th>
<th>School 1 (%)</th>
<th>School 2 (%)</th>
<th>School 3 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car only</td>
<td>34.1</td>
<td>30.7</td>
<td>14.9</td>
<td>67.3</td>
</tr>
<tr>
<td>Bus one way</td>
<td>4.3</td>
<td>3.6</td>
<td>2.8</td>
<td>8.0</td>
</tr>
<tr>
<td>Bus only</td>
<td>4.5</td>
<td>4.0</td>
<td>3.6</td>
<td>7.1</td>
</tr>
<tr>
<td>Walk one way</td>
<td>20.1</td>
<td>22.8</td>
<td>22.0</td>
<td>10.6</td>
</tr>
<tr>
<td>Walk only</td>
<td>37.0</td>
<td>38.9</td>
<td>56.7</td>
<td>7.0</td>
</tr>
</tbody>
</table>
Achievement of the 10,000-Steps-Per-Day Criterion

Of the 236 participants, 193 had at least 3 days of pedometer data and were included in this analysis. As shown in Table 4, participants were categorized into 1 of 4 groups depending on the percentage of total days monitored that they achieved the 10,000-step criterion. Few students met the 10,000-step criterion on each day for which they had complete data (ie, the always group), although a substantial proportion (49.7%) did achieve 10,000 steps on at least half (but not all) the days for which they had complete data. Depending on sex and age, between 7.0% and 14.1% of students never met the 10,000-steps-per-day criterion.

Table 4 Percentage of Students (n = 193) Who Meet the 10,000 Step Criterion

<table>
<thead>
<tr>
<th>Grouping</th>
<th>Never&lt;sup&gt;a&lt;/sup&gt; (%)</th>
<th>Sometimes&lt;sup&gt;b&lt;/sup&gt; (%)</th>
<th>Often&lt;sup&gt;c&lt;/sup&gt; (%)</th>
<th>Always&lt;sup&gt;d&lt;/sup&gt; (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>11.4</td>
<td>24.4</td>
<td>49.7</td>
<td>14.5</td>
</tr>
<tr>
<td>Female</td>
<td>13.9</td>
<td>27.0</td>
<td>49.2</td>
<td>9.8</td>
</tr>
<tr>
<td>Male</td>
<td>7.0</td>
<td>19.7</td>
<td>50.7</td>
<td>22.5</td>
</tr>
<tr>
<td>Juniors</td>
<td>9.6</td>
<td>15.7</td>
<td>54.8</td>
<td>20.0</td>
</tr>
<tr>
<td>Seniors</td>
<td>14.1</td>
<td>37.2</td>
<td>42.3</td>
<td>6.4</td>
</tr>
</tbody>
</table>

<sup>a</sup> Did not achieve 10,000 steps on any day for which they had complete data.

<sup>b</sup> Achieved at least 10,000 steps at least once but on less than half of the days for which they had complete data.

<sup>c</sup> Achieved at least 10,000 steps on at least half of the days but not on every day for which they had complete data.

<sup>d</sup> Achieved at least 10,000 steps on all days for which they had complete data.

Discussion

Three key findings which were congruent with previous studies emerged. First, total step counts were comparable to those of earlier pedometer-based studies on youth;<sup>3-8,18</sup> however, the daily steps observed among New Zealand youth fall in the lower end of the step-count spectrum, indicating that youth in this study might be less active than many of their non-New Zealand peers. Second, in support of research showing a sex difference in physical activity, higher physical activity levels were observed in males than in females. Third, a drop in step counts by age group was observed, with junior students accumulating 1657 more steps per day than their senior counterparts. In addition, the accumulated steps were substantially lower than the mean weekdays (boys, 16,133 ± 3864; girls, 14,124 ± 3286) and weekend (boys, 12,702 ± 5048; girls, 11,158 ± 4309) step counts reported in a large sample of New Zealand primary school students.<sup>31</sup>

In support of findings reported by Trost et al<sup>21</sup> and Klasson-Heggebo et al,<sup>22</sup> our data also demonstrates lower physical activity levels on weekend days than on weekdays. Developing out-of-school strategies, therefore, might maximize potential gain in physical activity health promotion for all age groups. This, however, does not preclude the importance of school-day physical activity strategies, especially for seniors, who demonstrate significantly lower levels of physical activity on school
days than their junior peers. A possible contributor to the school-day differential in daily step counts is participation in physical education class. Although physical education is available at each year level during the high school years, physical education is a compulsory subject only for students in years 9 and 10, which in turn might contribute to the higher step counts noticed among the junior age group. Furthermore, strategies targeting habitual activity on school days might be more easily implemented than those targeted at weekend physical activity.

Promoting active transportation as a school-related strategy is further supported by our study, because students walking to and/or from school accrued significantly greater steps than car transit users, a finding reported by previous research using accelerometry. The proportion of students walking to school differed substantially between schools. Because school 3 is an integrated Christian school, students are likely to travel from beyond the local school area to attend. This might explain, in part, the substantially higher car user level (and lower level of walking) for students at school 3. Strategies targeting active transportation, therefore, might be a key strategy for some but not all schools, which highlights the need for school-specific strategy development.

A main finding of this study was the proportion of students meeting the physical activity step-based criterion of 10,000 steps daily. Few students, especially females and senior students, achieved 10,000 steps on all days for which each student had available data. Considering the substantial decline in physical activity during adolescence, it is likely that the current youth population will fail to reach the 10,000-step criterion as they enter young adulthood. Although other studies, through the use of accelerometers or questionnaires, have examined the proportion of young people considered active (ie, that is achieving time-based guidelines), making direct comparisons with the findings noted in this article is difficult for 2 reasons. First, the 10,000-step criterion is not specific to youth and might not correctly classify a teenager as active or not. Second, previous research on both adult- and child-population groups has found difficulty in defining a step threshold that accurately identifies those who meet currently recommended time-based physical activity guidelines. The aim of this study, therefore, was not to examine the proportion of students deemed active, but the proportion reaching 10,000 steps daily, a conservative criterion that should be achieved by young people considering the continuous subsidence of physical activity during the adolescent years.

The findings of the current study must be viewed in light of the following limitations. Although pedometers provide an objective tool to measure physical activity, thereby overcoming the subjective limitations inherent in self-report methods, pedometers are not designed to measure intensity of activity or nonambulatory (eg, swimming) or isometric physical activities. One consequence, therefore, is that we are unable to examine the percentage of students meeting the current moderate-to-vigorous physical activity recommendations. Duration and intensity of physical activity participation can be captured through use of accelerometry; however, pedometers provide a less expensive and, therefore, more plausible alternative for gathering objective physical activity data among youth. An advantage of the NL-2000 pedometer (New-Lifestyles Inc) used in this study is that it has an internal clock and data storage capacity to store total step counts at 1-day epoch intervals for a total of 7 days. The pedometer could not, however, provide smaller
epoch intervals, which limits the ability to capture step counts during certain segments of the day without increasing participant or researcher burden.

Because the larger OPIC project purposefully recruited students of low socioeconomic status, the resultant sample for this study (because of size and convenience sampling from the OPIC school sample) is not representative of the New Zealand youth population. In comparison to the high school population of New Zealand, a slightly higher proportion of the sample in this study was female (50% versus 58.5%, respectively). Although ethnicity was not collected from participants, the schools included in this study have a large proportion of Maori and Pacific Island students, 2 key groups that the OPIC project is targeting. At each school, between 67% and 92% of students identified being Maori or Pacific, whereas the ethnic composition for the New Zealand child population (<15 years old) is 7.6% Pacific Island, 24.5% Maori, 62.4% European, and 5.0% Asian. Although convenience sampling is not the gold standard, the sample size and sampling methods we employed are in line with published studies assessing children and youth physical activity using pedometers. Although the generalizability of the findings to the New Zealand youth is limited, they are the first published data available on high school students in New Zealand and need to be confirmed through a study using a larger representative sample.

Another limitation is that a large proportion of participants (32.2%) and data points (51.2%) were excluded from the final GEE analysis. Several reasons are likely for the loss of participants and data. Although the use of pedometers that have a memory capacity reduces the participant and researcher burden of recording daily step counts, it also eliminates the potential prompt that daily recording might provide to the participant to wear the pedometer. In addition, conducting research within a high school environment is substantially different than in an elementary school situation. In elementary school, students generally have the same teacher each day, which standardizes pedometer distribution and allows the teacher to provide consistent reminders to wear the pedometer daily. This, however, is not always possible within the high school setting.

Also, it has been suggested that 8 days of monitoring is associated with a reliable estimate of physical activity among adolescents using accelerometers. This length of monitoring might not always be practical or attainable and might not be directly transferable as an accurate monitoring frame for assessing physical activity using pedometry. Because of the compliance issues with this population group, the GEE-analysis approach was used to maximize the sample size while accounting for the variation in the number of complete data-collection days obtained between participants, which allowed participants with at least 1 weekday of data to be included for analysis. As a result, any potential bias that might have occurred as a result of analyzing only participants with complete data was minimized. When examining the proportion of students achieving the 10,000-step criterion, only those with a minimum of 3 days of data were included for the analysis. Although this monitoring frame might not represent habitual physical activity, it is similar to the monitoring frames used in previous research.

In summary, the current study is the first published study to provide insight into objectively determined physical activity levels and subjectively examined transportation patterns of high school students in New Zealand. Although a large proportion of students do not achieve at least 10,000 steps daily, increasing the level
of student engagement in active transportation, a habitual activity that could be incorporated into the daily routine of students, could assist students in achieving part of their daily activity dose. Strategies that are implemented, however, need to meet the needs of students at specific schools because, at least in our study, substantial differences in active commuting patterns were noticed between schools. Future exploration of objectively determined activity behaviors using a larger sample size is needed, as well as examination of potential correlates of activity among New Zealand high school students. Also, considering the substantially lower levels of physical activity on weekend days, examination of competing sedentary behaviors should be investigated.

Acknowledgments

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References


