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Achieving 10,000 steps: A comparison of public transport users and drivers in a University setting

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ABSTRACT

Objective. To compare pedometer steps of university students who used public transport and private motor vehicles to travel to and or from The University of Western Australia (UWA).

Method. 103 undergraduate students in 2006 recruited by e-mail and snowballing wore a pedometer for five consecutive university days, and completed a travel and physical activity diary.

Results. Compared with private motor vehicle users, public transport users performed more daily steps (11443 vs. 10242 steps/day, $p=0.04$) After adjusting for gender, age group and average daily minutes of self-reported leisure-time physical activity, the odds of achieving 10,000 steps/day was higher in public transport users compared with private motor vehicle users (OR 3.55; 95% CI 1.34–9.38, $p=0.01$).

Conclusion. Walking associated with public transport use appeared to contribute to university students achieving higher levels of daily steps. Encouraging public transport use could help increase and maintain community physical activity levels.

Introduction

Many university students do not meet the recommended level of 30 min of moderate-intensity physical activity (PA) on most days, which is recommended to accrue health benefits (Huang et al., 2003). The challenge of balancing study, work, and social commitments may contribute to many students being insufficiently active (Salmon et al., 2003). Research suggests that using public transport could increase overall PA levels because most public transport trips begin and or end with walking (Besser and Dannenberg, 2005). Moreover, public transport use for many individuals may be habitual. Although Australian data are not available, US travel survey data suggests that approximately 49.0% of those using public transport over a two-month period did so at least once per week (National Center for Transit Research, 2005). This suggests that if public transport use is habitual, this could help maintain PA levels. Therefore, encouraging students to use public transport to and from university may be one strategy to increase PA participation and produce environmental benefits such as reduced pollution from car exhaust emissions (Tuomisto and Tainio, 2005).

Analyzing cross-sectional data from the US 2001 National Household Travel Survey (NHTS), Besser and Dannenberg (2005) found that 29% of public transport users accumulated 30 min or more of daily PA solely by walking to and from public transport. McCormack et al. (2003a) and others found that while self-reported frequency of incidental trips of less than 10 min was acceptable, recall of the duration of those trips achieved low reliability. Given that previous findings (Besser and Dannenberg, 2005) show that many trips associated with public transport use are short, it is possible that the time spent on these trips are not reliably recalled using self-report measures.

Pedometers provide an objective measure of PA (Hendelman et al., 2000), are useful for objectively recording walking behavior in free-living populations (Bassett et al., 1996) and have been used in previous population studies (McCormack et al., 2003b; Tudor-Locke and Myers, 2001). Studies have suggested that adults should walk at least “10,000 steps per day” to maintain optimum health (Hatano, 1993; Yamanouchi et al., 1995). However, a Western Australian study found that only 45.2% of the students achieved at least 10,000 steps/day (McCormack et al., 2003b). There appears to be few studies that compare objectively measured PA levels of users of public transport and private motor vehicles. However, a US study (Wener and Evans, 2007) compared pedometer steps of train and car commuters and found that train commuters walked an average of 30% more steps/day and were four times more likely to accumulate 10,000 steps/day than car commuters. Promoting walking to and from public transport may therefore increase PA levels, especially in those who do not meet the recommended levels of PA.

Therefore, the purpose of this study was to compare pedometer-determined PA levels of university students using public transport and private motor vehicles while controlling for participant characteristics

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and self-reported leisure-time physical activity (LTPA). In this study, public transport users were students who commute by bus, train or ferry to and from The University of Western Australia (UWA). We hypothesized that students who mainly used public transport to travel to and from the university would accumulate more pedometer steps compared with students whose main mode of travel was private motor vehicle.

Methods

Recruitment of study participants

This was a cross-sectional study that included a convenience sample of undergraduate students from UWA. The UWA main campus is geographically located adjacent to the Swan River, Perth, Western Australia. Approximately 10,900 full-time undergraduate students were enrolled at UWA at the time of this study (Semester 1, 2006).

Initially, the target population for the study were undergraduate students residing in suburbs within 4–8 km (i.e. 2.5–3.7 mi) from the UWA main campus. The boundary was chosen because previous UWA studies indicated that students residing within 4 km were more likely to walk or cycle to and or from the university, whereas students who resided further than 8 km were more likely to drive to and or from the university (Smith et al., 2004). Thus, a good mix of public transport users and private motor vehicle users was expected. To recruit respondents, an invitation was e-mailed to a cross-section of students ($n=1575$) residing in the 4–8 km boundary, with the permission granted by the UWA Institutional Research Unit. Undergraduate students commuting to UWA by either public transport or private motor vehicle were eligible to participate. Respondents who cycled to and from the university or to and from public transport were ineligible to participate. The boundary was subsequently removed due to recruitment difficulties as only 141 students responded to the recruitment e-mail with only 53 of these students eligible to participate in the study. A snowballing technique was then used to recruit additional respondents (i.e. recruits invited fellow undergraduates to participate in the study). To increase participation in the study, an incentive was offered (i.e. a one in four chance of winning an AUS $30 book voucher). Thus, using this recruitment method, 120 respondents met the eligibility criteria. The UWA Human Research Ethics Committee approved the study.

Data collection

The principle author met with respondents at a central campus location and provided them with information on the study. Students signed a consent form, provided information such as gender, age group, year of study, and employment status and received a survey package that contained a pedometer, pedometer instructions, a pedometer diary, and a travel and physical activity behavior diary.

Participants were asked to wear the pedometer during waking hours for five consecutive university days (i.e. Monday to Friday). Participants were asked to wear the pedometer at their hip, attached to their waist belt or clothing and above their knee. They were asked to remove the pedometer before retiring to bed and during any water activities such as bathing and swimming. Moreover, participants were informed not to reset their pedometer at any time. Participants were asked to record their daily steps in the pedometer diary and their travel and LTPA information in the travel and physical activity behavior diary before retiring to bed each night. Pedometer-determined PA was collected using the Yamax Digiwalker SW-700. This pedometer model is shown to be valid in adults (Crouter et al., 2003) and has been used previously in population-based surveys (McCormack et al., 2006). Prior to distributing pedometers, a step test was performed and one pedometer did not work.

Average minutes of LTPA on days attending university were determined from the physical activity behavior diary. Leisure-time physical activity was defined as "exercise, sports, recreation, or hobbies that are not associated with activities as part of one's regular job duties, household, or transportation" (US Department of Health and Human Services, 2006). Participants recorded the number of hours and minutes spent participating in LTPA in various activities (i.e. aerobics/step/dancing/circuit class, cycling for recreation or exercise, cycling for transport, gardening, golf, jogging/running, sailing, swimming/surfing, squash, tennis, table tennis, team sports, walking for exercise, walking for transport, weights) in the travel and physical activity behavior diary. Given the focus on travel-related PA (i.e. steps) in this study, LTPA was considered a covariate. LTPA was measured in average minutes of PA/day and was calculated by the total number of minutes of PA undertaken for days attending UWA divided by the number of days per week attending UWA. Walking for transport was excluded from the variable as this was the primary outcome measure of interest. Leisure-time physical activity was also categorised into three groups: 0–29 min /day b) 30–59 min /day and c) 60+ min/day to further examine the association between LTPA and average number of steps.

Statistical analyses

Average daily steps were dichotomized into less or more than 10,000 steps/day reflecting pedometer-determined step recommendations (Hatano, 1993; Tudor-Locke and Bassett, 2004). Because the focus of this study was on travel behavior, only steps counted on days respondents attended university were included (i.e. a range of 2 to 5 days). Missing data and outliers were screened. Respondents with pedometer steps greater than 30,000 steps/day were truncated at 30,000 ($n=6$). Main mode of transport to travel to and from UWA was the main independent variable. Main mode of transport was determined from the travel and physical activity behavior diary. A count of the number of times public transport and private motor vehicle was used to travel to and from UWA was determined. Main mode of transport was then categorized into 'public transport' and 'private motor vehicle'. One hundred and twelve respondents provided data. However, data from some respondents were excluded from the final analysis because they provided insufficient data ($n=2$) or could not be categorized into either public transport or private motor vehicle as their main mode of transport ($n=4$). Respondents with less than 2 days of pedometer data were further excluded ($n=3$). Respondents with two or more days of pedometer diary data were included in the analysis. Therefore, data were analyzed for 103 participants.

Univariate comparisons of average daily steps and minutes of LTPA between public transport users and private motor vehicle users were examined using independent t-tests. Comparisons of achievement of 10,000 steps between travel modes were conducted using Pearson's Chi-square. Average number of steps/day and achievement of 10,000 steps by gender, age group, year of study and employment status were calculated using cross-tabulations. Multivariate logistic regression was used to calculate odds ratios associated with achieving 10,000 steps/day by travel mode adjusting for gender, age, and LTPA. P-values less than 0.05 were considered statistically significant and the analysis was conducted using SPSS 14.0.

Table 1
Logistic odds ratio of achieving 10,000 steps per day adjusting for demographics and average minutes of daily leisure-time physical activity among university students[c]

Characteristic	$n=103$	Number achieving 10,000 steps/day	Odds ratio	95% CI lower	95% CI upper
Main mode of transport					
Private motor vehicle[a]	69	30	1.00		
Public transport[b]	34	21	3.55†	1.34	9.38
Gender					
Male	32	15	1.00		
Female	71	36	1.08	0.54	3.68
Age group					
16–20 years	57	29	1.00		
21 years and over	46	22	0.99	0.49	2.92
Average daily minutes of leisure-time physical activity					
0–29 min/day	63	22	1.00		
30–59 min/day	23	17	7.46†	2.32	23.94
60+ min/day	17	12	7.13†	2.00	25.40

†Statistically significant ($p<0.05$).
Note that overall, 51 of the 103 students achieved at least 10,000 steps/day.
[a] Students who mainly used private motor vehicles to commute to and or from The University of Western Australia (UWA).
[b] Students who mainly used public transport to commute to and or from UWA.
[c] UWA undergraduate students, Perth, Western Australia 2006.

Results

The sample included mainly women (72%) with more students aged between 16 and 20 years (56%). Age, gender, year of study and employment status were not associated with achieving 10,000 steps/day ($p>0.05$). Public transport users took more average daily steps than private motor vehicle users (11,443 ± 3761 vs. 10,242 ± 4098 steps, p ± 0.04). On average, private motor vehicle users participated in more daily minutes of LTPA than public transport users (34.4 ± 38.9 vs. 22.0 ± 24.3 min /day) but this was not statistically significant ($p=0.09$). LTPA data were negatively skewed as a result of respondents reporting zero activity ($n=7$ public transport and $n=16$ private motor vehicle users). Data transformation provided limited improvement to the distribution of LTPA data; hence the non-transformed data were included in the analysis. The odds of achieving at least 10,000 steps was approximately seven times higher in students participating in 30 min or more of daily LTPA, compared to those participating in less than 30 min of daily LTPA (Table 1). After adjusting for gender, age group and LTPA (Table 1), the odds of achieving 10,000 steps/day were almost four times higher in public transport users compared with private motor vehicle users (OR 3.55; 95% CI 1.34–9.38, $p=0.01$).

Discussion

This appears to be among one of the few published studies comparing objectively measured PA levels of public transport (bus, train or ferry) and private motor vehicle users. Previous research suggests that accumulating at least 10,000 daily steps confers health benefits (Hatano, 1993; Tudor-Locke and Bassett, 2004). We found that public transport use among university students appears to contribute to achieving 10,000 steps, independent of LTPA participation. Nevertheless, private motor vehicle users, on average, participated in more minutes of LTPA compared with public transport users. Drivers may find it more convenient to reach LTPA facilities (e.g. located en route between home and university) or that the convenience of private motor vehicle use results in more "free time" to undertake LTPA after commuting to and from university. Public transport users may compensate for additional time spent on travel-related PA by participating in less LTPA. Another explanation might be that public transport users consider transport-related PA as being sufficient and therefore another source of PA may not be required. Previous findings suggest that participation in recommended levels of LTPA – albeit vigorous-intensity – is negatively associated with walking for transport (McCormack and Giles-Corti, 2004). However, research should investigate whether participation in other types of PA, including moderate and vigorous-intensity LTPA, influences transport-related PA and vice versa.

As hypothesized, students using public transport accrued more steps compared with those using private motor vehicles. Tudor-Locke and others (Tudor-Locke et al., 2005) established steps per minute categorical cut-points that correspond to PA categories (MET levels). Their research determined that 3000 steps correspond to about 30 min of moderate-intensity PA, 1000 steps correspond to 10 min of PA and 100 steps equals 1 min of moderate-intensity PA. Applying these estimates to the current study, we found that students using public transport did an average of 1201 more steps than students who used private motor vehicles. This corresponds to an extra 12 min of activity each day although it is not clear from these findings that it may have been accumulated in one bout. Given that previous research has shown that accumulating several bouts of PA throughout the day, even as short as 8 to 10 min may contribute to health benefits (Jakicic et al., 1995), promoting public transport use could be one strategy to increase PA levels, particularly if people are encouraged to ensure they achieve at least a 10- min activity session. Besser and Dannenberg (2005) found that public transport users did an average of 24.3 min of travel-related PA/day (i.e. approximately 2400 steps), which is more than two-thirds of the daily amount of PA recommended in the current PA guidelines. However, the study used self-report measures of PA only. Moreover, Wener and Evans (2007) compared pedometer steps of public transport users and car users, and found that public transport users did 30% more steps than car users, however this study only compared train commuters with car users. Thus, the current study builds on existing research by using an objective method to measure PA as well as measuring PA for train, bus and ferry commuters.

Using public transport, may contribute to participation in more incidental PA (i.e. non-deliberate PA that is undertaken while performing other daily activities: McCormack et al., 2006). For public transport users, incidental PA may accumulate as they walk to and between public transport stops en route to work or in this case, university. Fewer opportunities for incidental activity are encountered en route to their destination for students who travel by private motor vehicle, even though they may walk from the car park to their class on arrival at University. Walking to and from public transport may help some individuals achieve sufficient levels of PA, particularly those who cannot or do not participate in other types of PA (Besser and Dannenberg, 2005). Given the challenge of maintaining PA behavior, further research should explore whether participation in transport-related PA helps maintain levels of PA.

Study limitations and strengths

This study involved a cross-sectional survey of a convenience sample of students, which are important limitations. Nevertheless, there are few similar studies and the results of this small study provide some indication that this topic is worth pursuing further. However, there were other limitations that future studies may like to redress. Many aspects of weather (e.g. temperature and rain) have been shown to affect the amount of steps/day undertaken by individuals (Chan et al., 2006). Data were mostly collected in winter (i.e. August and September), which, in 2006, had average temperatures between 44–68 °F and a total rainfall level of 230.4 mm. Hence, PA and travel behavior may not generalize to other seasons. Speculatively, fewer daylight hours and poor winter weather may have reduced the number of public transport users, public transport trips, and the amount of transport-related walking reported in this study. The influence of season on transport-related PA requires further investigation. Furthermore, the results of this study are only generalizable to university students. This study design could be replicated with other populations (e.g. children) and in different settings (e.g. workplaces). Participants' height and weight were not collected for this study and is therefore another limitation. However, other transportation studies have also omitted collecting height and weight status and where possible, this should be redressed in future research. Finally, the inclusion of non-normally distributed LTPA data in the regression analysis is a limitation. Although some caution should be used when interpreting these results, data transformation made little difference to the final model.

Although limitations are inherent in pedometer use (Tudor-Locke and Myers, 2001), pedometers provide an objective measure of PA and enable incidental PA to be captured (i.e. short walking trips), which are often difficult to measure using self-reported methods. Therefore, a strength of this study was the concurrent measurement of PA using both a self-report (i.e. a diary) and an objective (i.e. pedometer) measure of PA.

Conclusions

Public transport users appear more likely to achieve 10,000 steps/day compared with private motor vehicle users. Performing 10,000 steps/day contributes to achieving recommended levels of PA producing concomitant health benefits (Tudor-Locke and Bassett, 2004). Encouraging active transport appears to increase PA levels. Thus, public health professionals could contribute to transport policy debates by advocating for increased use of active transport modes with the potential of delivering environmental (i.e. reducing air pollution and road traffic congestion), mental and physical health benefits.

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References

Bassett, D.R., Ainsworth, B.E., Leggett, S.R., Mathien, C.A., Main, J.A., Hunter, D.C., 1996. Accuracy of five electronic pedometers for measuring distance walked. Med. Sci. Sports Exerc. 28, 1071–1077.

Besser, L.M., Dannenberg, A.L., 2005. Walking to public transit: steps to help meet physical activity recommendations. Am. J. Prev. Med. 29, 273–280.

Chan, C.B., Ryan, D.A.J., Tudor-Locke, C., 2006. Relationship between objective measures of physical activity and weather: a longitudinal study. Int. J. Behav. Nutr. Phys. Activ. 3.

Crouter, S.E., Schneider, P.L., Karabulut, M., Bassett, D.R., 2003. Validity of 10 electronic pedometers for measuring steps, distance and energy cost. Med. Sci. Sports Exerc. 35, 1455–1460.

Hatano, Y., 1993. Use of the pedometer for daily walking-exercise. ICHPER 29, 4–8.
Hendelman, D., Miller, K., Baggett, C., Debold, E., Freedson, P., 2000. Validity of accelerometry for the assessment of moderate-intensity physical activity in the field. Med. Sci. Sports Exerc. 32, 442–449.
Huang, T.T.K., Harris, K.J., Lee, R.E., Nazir, N., Born, W., Kaur, H., 2003. Assessing overweight, obesity, diet, and physical activity in college students. J. Am. Coll. Health. 52, 83–86.
Jakicic, J.M., Wing, R.R., Butler, B.A., Robertson, R.J., 1995. Prescribing exercise in multiple short bouts versus one continuous bout- effects on adherence, cardiorespiratory fitness, and weight-loss in overweight women. Int. J. Obes. 19, 893–901.
McCormack, G., Giles-Corti, B., 2004. Does participation in recommended levels of vigorous-intensity physical activity decrease participation in moderate-intensity physical activity? J. Phys. Activ. Health. 1, 45–55.
McCormack, G., Giles-Corti, B., Milligan, R., 2006. Demographic and individual correlates of achieving 10,000 steps/day: use of pedometers in a population-based study. Health Promot. J. Austr. 17, 43–47.
McCormack, G., Giles-Corti, B., Milligan, R., 2003a. The test-retest reliability of habitual incidental physical activity. Aust. NZ. J. Public Health. 27, 428–432.
McCormack, G., Milligan, R., Giles-Corti, B., Clarkson, J.P., 2003b. Physical Activity Levels of Western Australian Adults 2002: Results from the Adult Physical Activity Survey and Pedometer Study. Western Australian Government, Perth.
National Centre for Transit Research, 2005. Public Transit in America: Results from the 2001 National Household Travel Survey. Center for Urban Transportation Research. Tampa, University of Florida.
Salmon, J., Owen, N., Crawford, D., Bauman, A., Sallis, J.F., 2003. Physical activity and sedentary behavior: a population-based study of barriers, enjoyment, and preference. Health Psychology. 22, 178–188.
Smith, T., Giles-Corti, B., Pikora, T., Bulsara, M., Bull, F., Stark, K., Shilton, T., 2004. Commuting Habits and Potential for change- UWA Students. Physical Activity Research Group, School of Population Health and School of Human Movement and Exercise Science. The University of Western Australia, Perth.
Tudor-Locke, C., Bassett, D.R., 2004. How many steps/day are enough? Preliminary pedometer indices for public health. Sports Med. 34, 1–8.
Tudor-Locke, C.E., Myers, A.M., 2001. Methodological considerations for researchers and practitioners using pedometers to measure physical (ambulatory) activity. Res. Q. Exerc. Sport. 72, 1–12.
Tudor-Locke, C., Sisson, S.B., Collova, T., Lee, S.M., Swan, P.D., 2005. Pedometer-determined step count guidelines for classifying walking intensity in a young ostensibly healthy population. Can. J. Appl. Physiol. 30, 666–676.
Tuomisto, J.T., Tainio, M., 2005. An economic way of reducing health, environmental and other pressures of urban traffic: a decision analysis on trip aggregation. BioMed Central Public Health. 5, 123.
Wener, R.E., Evans, G.W., 2007. A morning stroll: levels of physical activity in car and mass transit commuting. Environ. Behav. 39 (1), 62–74.
Yamanouchi, K., Shinozaki, T., Chikada, K., Nishikawa, T., Ito, K., Shimizu, S., 1995. Daily walking combined with diet therapy is a useful means for obese NIDDM patients not only to reduce body weight but also to improve insulin sensitivity. Diabetes Care 18 (6), 775–778.