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ORIGINAL ARTICLE

Measurement of Dog Walking Behaviour: Strengths and Weaknesses of Various Methods

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Abstract

Background: Physical activity promotion has become important in public health initiatives due to its overwhelming evidence in disease prevention; however, low participation rates prevail. Research between dog ownership and walking is relatively new, with primary evidence from self-report surveys. *Purpose:* The primary purpose of this study was to compare different physical activity (PA) measures: self-report, pedometry, accelerometry, and global positioning system (GPS) and to investigate self-report vs. direct measures of dog walking behaviour. *Methods:* Participants completed self-report; wore a pedometer, accelerometer, and GPS unit for four days. Results: Results indicate self-report both over and underestimates direct measures of PA. *Conclusion:* It is recommended that investigations of PA patterns and practices use direct measures such as GPS combined with accelerometry. **Health & Fitness Journal of Canada 2012;5(1):16-26.**

Keywords: self-report, accelerometry, pedometry, GPS, exercise

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Background

Physical activity (PA) promotion has become of paramount importance in public health initiatives due to its overwhelming evidence in disease prevention (Warburton et al., 2010); however, low participation rates prevail (Colley et al., 2011; USDHHS, 2004). Physical activity itself is a collection of various behaviours that may require targeted intervention (Rhodes et al., 2007a) and the most popular PA of choice is regular walking (Canadian Fitness and Lifestyle Research Institute, 2002; Ham et al., 2009). Walking has established health benefits (Brown et al., 2007; Manson et al., 2002; Manson et al., 1999; Pucher et al., 2010), so it stands to reason that promotion initiatives focused on increasing walking behaviour are needed.

Promotion interventions should be based on evidence of reliable correlates of PA behaviour (Courneya, 2004). To this end, research has demonstrated that walking is related to environmental characteristics (Owen et al., 2004), and personal intentions/motives (Rhodes et al., 2006; Rhodes et al., 2007b). An additional correlate of regular walking that has seen considerable attention recently is dog ownership (Brown and Rhodes, 2006; Coleman et al, 2008; Schofield et al., 2005; Cutt et al., 2007; Cutt et al., 2008; Salmon et al., 2010). Specifically, dog owners report more walking during leisure-time than non-owners (Brown and Rhodes, 2006; Oka and Shibata, 2009; Owen et al., 2004; Hoerster et al, 2011; Reeves et al., 2011), and have been observed to engage in more walking during leisure-time than non-owners (Temple et al., 2011). These findings have support across several different countries and appears to be within the small-medium effect size range when reading the extant research (Cohen, 1992).

Research between dog ownership and walking is in its relative infancy at present, with primary evidence from self-report surveys. While researchers do not advocate a practice of getting a dog merely to increase walking, interventions focused on dog-owners who currently do not walk their dogs, and Society for the Prevention of Cruelty to Animals (or similar) walking programs seem like a viable future for this line of research. Furthermore, continued measurement and monitoring of dog-walking behaviour seems important as we move to models that explain leisure-time walking behaviour. Thus, the accurate measurement of dog walking behaviour is important for these future initiatives.

Measuring dog walking behaviour has some obvious challenges. The quality of the walk in terms of PA intensity, duration and frequency may be more variable than those who walk without a dog. Frequent stops along the walk are inevitable and off-leash components of the walk with periods of standing are likely. Self-reports of walking behaviour may not be valid because they typically ask for “chunks” of behaviour or overall summaries and the stops and standing could be included in these assessments. The walk is also probably tied to the environmental context more than non dog owners who walk. Dog walkers are likely to seek parks or places where their animal can run. Thus, the issue of “where” the walk occurred may be even more important to understanding dog walking than regular walking behaviour. At this early phase of dog walking research, a better understanding of measurement issues and limitations with focused recommendations seems prudent.

Therefore, the purpose of this study was twofold: 1) to highlight and contrast four different forms of measurement for the purpose of dog walking behaviour: self-report, pedometry, accelerometry, and global positioning system (GPS), and 2) to compare self-report and direct measures of dog walking behaviour. It was hypothesized that GPS would offer the most comprehensive assessment of the walking experience, followed by accelerometers, and self-report would both overestimate and underestimate direct measures of dog walking behaviours.

Methods

Twenty (10 female, 10 male) adult (average age 48.1 yrs) dog owners from the Greater Victoria area were recruited to participate in the study. Dog owners were recruited from a list developed from a previous dog walking study; via an email sent to University of Victoria faculty and staff departmental email lists; and/or posters distributed throughout the Greater Victoria area. Participants were asked to wear a pedometer (Lifestyles Digi-walker SW-200) and accelerometer (Actigraph GT1M) all day and to wear a GPS unit (Garmin Forerunner 205) during all dog walks during a 4 day period. At the end of the 4 days, participants completed a questionnaire. The questionnaire included measures of demographics, neighbourhood environment, health information, past regular leisure time walking with and without their dog, and dog demographics (breed, age, size, gender, health status).

Using the validated Godin Leisure Time Exercise Questionnaire (GLTEQ) (Godin et al., 1986; Godin and Shephard, 1985; Shephard, 1997) participants were asked to recall their average dog walking and their total leisure time walking with and without their dog over the past 4 days (the same days that they wore the accelerometer and GPS watch). In this particular study, it made sense to have two very analogous measures for both leisure time walking and dog walking (Sudman and Bradburn, 1983). Therefore, leisure-time walking was requested in the same transparent way using the format of the GLTEQ. The GLTEQ contains three open-ended PA questions pertaining to the average frequency of mild, moderate, and strenuous physical activities (with examples of each) during free time during a typical week. The GLTEQ was also modified to include an open-ended assessment of average duration of physical activities and walking in minutes. Mild, moderate, and strenuous physical activities were changed to mild (slow walk), moderate (average pace), and strenuous (very brisk pace) walking and dog walking, respectively, for the walking measure and has been used previously (Rhodes et al., 2007b; Rhodes et al., 2009; Rhodes et al., 2006).

The Digi-Walker SW series pedometer has been previously validated (Schneider et al., 2004; Swartz et al., 2003) and accurately measures steps (Crouter et al., 2003; LeMasurier et al., 2004). Participants wore the Digi-Walker SW200 for 4 consecutive days from the time they rose in the morning until they went to bed in the evening. Step counts from the pedometer were recorded daily.

The Actigraph GT1M accelerometer has been shown to have good reliability in measuring both steps and counts (Silva et al., 2010) and is a more consistent measurement tool than previous Actigraphs (Rothney et al., 2008). Participants wore the Actigraph GT1M accelerometer for 4 consecutive days from the time they rose in the morning until they went to bed in the evening. Accelerometer data provided a daily step count as well as time spent in light, moderate, and vigorous activity.

The Garmin Forerunner 205 is a GPS-enabled personal trainer that allows one to chart pace, time, and distance travelled. Coutts and Duffield (2010) have shown that GPS devices have an acceptable level of accuracy for both peak speed and total distance. They caution, however, that the GPS devices should not be used interchangeably. Participants wore the same Garmin Forerunner 205 GPS unit during all dog walks over the 4 day period. GPS data provided distance, time, pace, weather temperature and wind speed, and location of walk (park, residential or a combination). Participants completed an activity log for each dog walk over the four days.

To compare self-report and direct accelerometry measures of dog walking behaviour the percent mean difference was calculated using the formula [(self-report mean – direct mean)/direct mean]*100 (Prince et al., 2008). For comparison of the four measurement methods, descriptive statistics were calculated for all variables measured, including mean, standard deviation and range.

Results

The majority of participants were Caucasian adults, with a college or university degree, and an annual income of $75,000 to $100,000 (Table 1).

Table 2 provides a descriptive of the various measures currently available to measure dog walking. As seen in Table 2, self-report and pedometers are inexpensive measurement tools that provide basic information. Information regarding time, intensity, and duration can be attained from self-report, while the pedometer can provide a step count for a specified period of time. The accelerometer is much more expensive than self-report and pedometers; however, it can provide more specific and detailed information including activity counts, energy expenditure, steps taken, activity intensity levels, and METs. The GPS unit is half the cost of the accelerometer and also provides specific and detailed information regarding location, speed, duration, and weather conditions during the dog walk.

Table 1: Participant Demographics.

	Mean (SD)
Humans	
Age (yrs)	47.8 (13.3)
Gender	10 female 10 male
Ethnicity	Caucasian
Education	College or University
Employment status	Paid full time
Income	$75,000 - $100,000
Height (cm)	171.7 (10.3)
Weight (kg)	73.8 (14.5)
BMI	0.25 (0.04)
Canines	
Age (yrs)	5.5 (3.2)
Gender	9 female 11 male
Weight (kg)	24.0 (15.9)

Table 3 compares self-reported walking with direct assessment of PA by accelerometry. The results indicate that participant's self-report significantly underestimated the total minutes spent with their dog by -26.9% ($r = 0.54$, $p > 0.05$). Self-report and the direct accelerometry measure of the time spent at a moderate to vigorous intensity with their dog differed by only 1% ($r = 0.41$, $p > 0.05$) indicating dispersion within the data. Self-report overestimated the overall time spent at a moderate to vigorous intensity with or without their dog by 60% ($r = -0.16$, $p > 0.05$).

Table 4 summarizes the GPS data and provides details such as time, pace, distance, speed, temperature, location, and number of pauses during the walks. Figures 1 and 2 are examples of the GPS and accelerometry output respectively.

Discussion

The aim of this study was to compare and contrast four forms of measurement for the purposes of dog walking behaviour and to investigate self-report vs. direct measures of dog walking behaviour. When comparing the four methods of measurement (see Table 2), GPS and accelerometry provided measures of intensity and duration of PA with GPS also providing an actual measure of the physical environment. Because dog walking is one of the more popular recreational activities in Western countries (Banks and Bryant, 2007), it is imperative for research purposes to be able to measure the intensity of PA to determine if this activity is contributing to improved health benefits to the participant. According to Brown et al. (2007) 60 minutes of moderate-intensity PA per week provides protective benefits for cardiovascular disease and diabetes. Walking and moderate-intensity PA have

Table 2: Comparison of four forms of measurement for the purposes of dog walking behaviour.

Feature	Self-report	Lifestyles SW200 pedometer	Actigraph GT1M accelerometer	Garmin Forerunner 205
Cost	minimal	$20	$300	$150
Dimensions (cm)		5.1 x 3.8 x 1.9	3.8 x 3.7 x 1.8	5.33 x 6.86 x 1.78
Weight (g)		21	27	77
Sensor mechanism		coiled spring-suspended lever arm	tri-axial acclerometer	GPS enabled
Capacity		99999 steps	16 MB	1000 laps 100 waypoints 50 routes
Battery Life		2 years	20 days - rechargeable	10 hours, rechargeable
Communication		digital counter display	USB cable	USB cable/ docking cradle
Software		n/a	Actilife	Garmin Connect
Calibration			Factory calibration	Factory calibration
Water Resistant		✓	✓	submersible to 1 m for up to 30 min
Step count		✓	✓	
Energy expenditure			✓	✓
Activity intensity levels	✓		✓	
METs			✓	✓
Weather conditions	✓			✓
Pace	✓			✓
Time	✓		✓	✓
Distance	✓			✓
Ease of use/feedback to layperson	✓	✓		✓

Table 3: Self-report in comparison to direct measures of dog walking behaviour.

	% Mean Difference	Pearson
Total minutes with dog	-26.9	0.54*
MVPA with dog	1.0	0.41
Total MVPA	59.6	-0.16

Note. MVPA = moderate to vigorous PA

Table 4: GPS dog walking results.

	Average	Min	Max
time (h:min:sec)	0:37:36	0:11:11	2:20:44
moving pace (min/km)	0:14:29	0:06:46	0:18:45
distance (km)	2.5	0.3	12.8
avg speed (kph)	4.3	1.0	8.9
max speed (kph)	8.4	5.0	14.0
temp (C)	10.7	-1.0	21.7
wind speed (kph)	11.4	1.3	27.2
park (%)	17.9		
sidewalk (%)	28.6		
combination parks/ sidewalks (%)	42.9		
unknown	10.7		
# pauses	0.77	0	6
duration of pauses (h:min:sec)	0:05:00	0:00:07	1:00:00

Figure 1: Sample GPS output from the Garmin Forerunner 205.

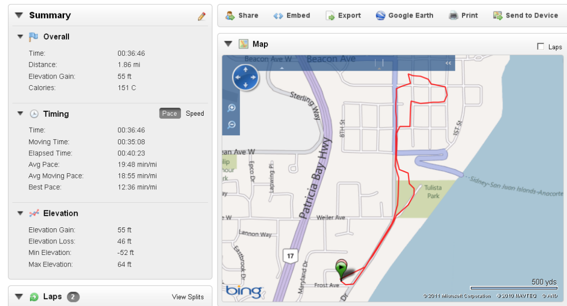
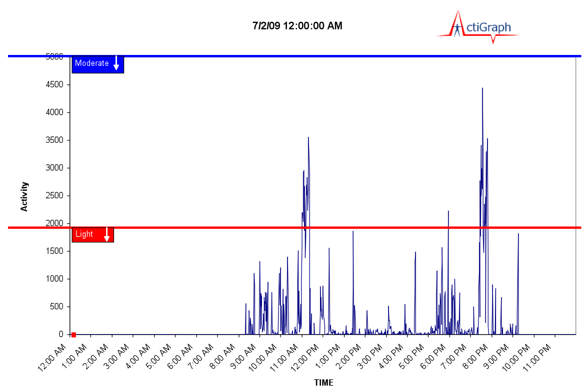


Figure 2: Sample GT1M accelerometer output.



been shown to be equally effective at providing risk reductions as the equivalent energy expenditure from more vigorous-intensity PA (Brown et al., 2007). This may explain why dog owners cite exercising through dog walking as one of the benefits of dog ownership (Duvall Antonacopoulos and Pychyl, 2010), in addition to a host of other social and psychological salutary advantages (Epping, 2011). The GPS provided information regarding the nature of the dog owner's walking behaviour, i.e., was the walk continuous or punctuated by sporadic or regular breaks. As seen in Table 4, this particular group of dog owners paused infrequently and for short durations. GPS also provided the speed of walking which can be interpreted as light, moderate or vigorous when compared to a compendium of PA. Accelerometry data may also indicate if the dog owner walked continuously or took breaks as can be seen by dips in the intensity at certain times during the walk (see Figure 2). By using a combination of GPS and accelerometry, researchers can see the nature of the walk (continuous or discontinuous walking) and actual location from the GPS data and the intensity or time at MVPA from the accelerometer.

Advantages of using accelerometry for dog walking research include ease of use, reliability, and accuracy (LeMasurier et al., 2004), however, use of accelerometry is reliant on self-report to identify when dog walks and/or PA took place. Newer accelerometer models, such as the ActiTrainer, have been developed to record heart rate (HR) as well as activity counts and vector magnitude, energy expenditure, steps taken, activity intensity levels, and subject position, providing another direct measure of activity intensity (Actigraph n.d.).

GPS units are attractive for dog walking research because they have the added feature of measuring the environment in which the dog walk actually takes place. Indeed, future research must consider the importance of the physical environment or 'place' on dog walking (Cutt et al., 2007) and improve our understanding of the relationship between PA behaviour and environmental attributes (Krenn et al., 2011). The added feature of knowing where dog owners are walking may contribute to smart growth urban planning decisions (Durand et al., 2011), and promoting dog walking as an intervention for increasing PA.

Disadvantages of the GPS unit may include the slow fix time, short battery life, and inability to use the device indoors. Fix time is the time required to gain a satellite fix once the unit is turned on. This can take as little as 35 seconds but can take longer. If participants do not wait for the fix to occur, data may be lost (Kerr et al., 2011). Battery life is limited, therefore, if participants go for several or extended walks, or forget to turn the unit off between walks, the battery may die causing a loss of data (Kerr et al., 2011). Data collection is limited to time spent outdoors and does not allow for measurement of the dog owners' daily activity (both indoors and out). It must be recognized that GPS technologies can also fail to record under heavy tree canopy and in dense urban areas (Rodriquez et al., 2005).

It is recommended that future studies using GPS use models that are able to produce a fast fix time (35 seconds), have a minimum 12 hour battery life, and have improved accuracy and sensitivity to provide accurate results at a minimum signal strength (Kerr et al., 2011). A GPS unit that is capable of measuring HR is recommended as a complement to using speed of walking to determine activity intensity. Ideally, the GPS unit would also include, or be worn with an accelerometer so that the time spent indoors would be measured. However, GPS is also reliant on self-report (Kerr et al.) to identify when dog walks and/or PA took place.

Based on the recognized limitations of self-report (Prince et al., 2008) it was hypothesized that self-reports compared to direct measures would be variable and that direct measures would provide a more comprehensive measure of dog walking behaviour compared to self-report. Self-report and the direct measure of the time spent at a moderate to vigorous intensity with their dog differed by only 1% with an insignificant correlation of 0.41, ($p > .05$). This indicates high dispersion within the data as the range for % mean difference was -100% to 212% for this sample. Our result supports those of Prince et al. (2008) that self-report both over and underestimates direct measures of PA. To rely on self-report alone is not recommended and the use of a direct measure is prudent. Since it has been shown that dog ownership facilitates walking behaviour (Temple et al., 2011; Brown and Rhodes, 2006; Thorpe et al., 2006); yet not all dog owners are meeting PA recommendations (Hoerster et al., 2011; Oka and Shibata, 2009), using a more accurate measure of walking intensity and duration is important for future research. Direct measures such as GPS and accelerometry may be used to obtain valid and reliable data as well as be motivational for the wearers to see their actual intensity, time and distance travelled.

A limitation of the study is the small, non-random sample. We recruited dog owners who were regular walkers (at least 4 times per week, for a minimum of 30 minutes at a moderate pace) to determine the walking patterns of dog owners in an urban setting. The small sample size may include outliers; however, the result does support the meta analysis by Prince et al. (2008).

Conclusion

In summary, this study supports the findings that self-report both over and underestimates direct measures of PA. Therefore it is recommended that for dog walking studies, and perhaps other investigations of PA patterns and practices, a direct measure such as GPS combined with accelerometry be utilized.

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Authors Qualifications

The authors' qualifications are: Holly Murray B.Sc., CSEP-CEP, Joan Wharf Higgins Ph.D, Viviene Temple Ph.D., Holly Tuokko Ph.D., Michelle Porter Ph.D., and Ryan E. Rhodes Ph.D.

References

Actigraph. (n.d.). Retrieved August 11, 2011, from http://www.theactigraph.com/

Banks, P. B. and Bryant J. V. (2007). Four-legged friend or foe? Dog walking displaces native birds from natural area. *Biology Letters, 3*, 611-13. http://dx.doi.org/10.1098/rsbl.2007.0374

Brown, S. G., and Rhodes, R. E. (2006). Relationships among dog ownership and leisure time walking amid Western Canadian adults. *American Journal of Preventive Medicine, 30*, 131-136. http://dx.doi.org/10.1016/j.amepre.2005.10.007

Brown, W. J., Burton, N. W., and Rowan, P. J. (2007). Updating the evidence on PA and health in women. *American Journal of Preventive Medicine, 33*, 404-411. http://dx.doi.org/10.1016/j.amepre.2007.07.029

Canadian Fitness and Lifestyle Research Institute. (2002). *2002 Physical Activity Monitor.* Retrieved August, 2004, from http://www.cflri.ca/cflri/pa/surveys/2002survey/2002survey.html

Cohen, J. (1992). A power primer. *Psychological Bulletin, 112*, 155-159. http://dx.doi.org/10.1037/0033-2909.112.1.155

Coleman, K. J., Rosenberg, D. E., Conway, T. L., Sallis, J., Saelens, B.E., Frank, L.D., and Cain, K. (2008). Physical activity, weight status, and neighborhood characteristics of dog walkers. *Preventive Medicine, 47*, 309-312. http://dx.doi.org/10.1016/j.ypmed.2008.05.007

Colley, R. C., Garriguet, D., Janssen, I., Craig, C. L., Clarke, J., and Tremblay, M. S. (2011). Physical activity of Canadian adults: Accelerometer results from the 2007 to 2009 Canadian health measures survey. *Health Reports, 22,* (21-28). http://www.statcan.gc.ca/pub/82-003-x/2011001/article/11396-eng.pdf

Courneya, K. S. (2004). Antecedent correlates and theories of exercise behaviour. In T. Morris & J. Summers (Eds.), *Sport Psychology: Theories, applications, and issues* (2nd ed., pp. 492-512). Sydney: John Wiley and Sons.

Coutts, A. J., and Duffield, R. (2010). Validity and reliability of GPS devices for measuring movement demands of team sports. *Journal of Science & Medicine in Sport, 13,* 133-135. http://dx.doi.org/10.1016/j.jsams.2008.09.015

Crouter, S. E., Schneider, P. L., Karabulut, M., and Bassett, D. R. (2003). Validity of 10 electronic pedometers for measuring steps, distance, and energy cost. *Medicine & Science in Sports & Exercise, 35,* 1455–1460. http://dx.doi.org/10.1249/01.MSS.0000078932.61440.A2

Cutt, H., Giles-Corti, B., Knuiman, M., and Burke, V. (2007). Dog ownership, health, and physical activity: A critical review of the literature. *Health & Place, 13*, 261-272. http://dx.doi.org/10.1016/j.healthplace.2006.01.003

Cutt, H. E., Knuiman, M. W., and Giles-Corti, B. (2008). Does getting a dog increase recreational walking? *International Journal of Behavioral Nutrition & Physical Activity, 5,* 17. http://dx.doi.org/10.1186/1479-5868-5-17

Durand, C. P., Andalib, M., Dunton, G. F., Wolch, J., and Pentz, M. A. 2011. A systematic review of built environment factors related to physical activity and obesity risk: implications for smart growth urban planning. *Obesity Reviews*, *12*(5), e173-182. http://dx.doi.org/10.1111/j.1467-789X.2010.00826.x.

Duvall Antonacopoulos, N.M. and Pychyll, T.A. (2010). An examination of the potential role of pet ownership, human social support and pet attachment in the psychological health of individuals living alone. *Anthrozoös, 23,* 37-54. http://dx.doi.org/10.2752/175303710X12627079939143

Epping, J.N. (2011). Dog ownership and dog walking to promote physical activity and health in patients. *Exercise is Medicine 10,* 224-227.

Godin, G., Jobin, J., and Bouillon, J. (1986). Assessment of leisure time exercise behavior by self-report: A concurrent validity study. *Canadian Journal of Public Health, 77*, 359–361.

Godin, G., and Shephard, R. J. (1985). A simple method to assess exercise behavior in the community. *Canadian Journal of Public Health, 10*, 141– 146.

Ham, S. A., Kruger, J., and Tudor-Locke, C. (2009). Participation by US adults in sports, exercise, and recreational physical activities. *Journal of Physical Activity & Health, 6*, 6-14.

Hoerster, K. D., Mayer, J. A., Sallis, J. F., Pizzi, N., Talley, S., Pichon, L. C., and Butler, D. A. (2011). Dog walking: Its association with physical activity guideline adherence and its correlates. *Preventive Medicine, 52*, 33-38. http://dx.doi.org/10.1016/j.ypmed.2010.10.011

Kerr, J., Duncan, S., and Schipperjin, J. (2011). Using global positioning systems in health research: A practical approach to data collection and processing. *American Journal of Preventive Medicine, 41*(5), 532-540. http://dx.doi.org/10.1016/j.amepre.2011.07.017

Krenn, P. J., Mag, D. I., Titze, S., Oja, P., Jones, A., and Ogilvie, D. (2011). Use of global positioning systems to study physical activity and the environment. *American Journal of Preventive Medicine, 41*(5), 508-515. http://dx.doi.org10.1016/j.amepre.2011.06.046

LeMasurier, G. C., Lee, S. M., and Tudor-Locke, C. (2004). Motion sensor accuracy under controlled and free-living conditions. *Medicine & Science in Sports & Exercise, 36*, 905–910. http://dx.doi.org/10.1249/01.MSS.0000126777.50188.73

Manson, J. E., Greenland, P., LaCroix, A. Z., Stefanick, M. L., Mouton, C. P., Oberman, A., Perri MG, Sheps DS, Pettinger MB, and Siscovick, D.S. (2002). Walking compared with vigorous exercise for the prevention of cardiovascular events in women. *New England Journal of Medicine, 347*, 716-724. http://www.nejm.org/doi/full/10.1056/NEJMoa021067

Manson, J. E., Hu, F. B., Rich-Edwards, J. W., Colditz, G. A., Stampfer, M. J., Willet, W. C., Speizer FE, and Hennekens, C.H. (1999). A prospective study of walking as compared with vigorous exercise in the prevention of coronary heart disease in women. *New England Journal of Medicine, 341*, 650-658. http://www.nejm.org/doi/full/10.1056/NEJM199908263410904

Oka, K., and Shibata, A. (2009). Dog ownership and health-related physical activity among Japanese adults. *Journal of Physical Activity & Health, 6*, 412-418.

Owen, N., Humpel, N., Leslie, E., Bauman, A., and Sallis, J. F. (2004). Understanding environmental influences on walking: Review and research agenda. *American Journal of Preventive Medicine, 27*, 67-76. http://dx.doi.org/10.1016/j.amepre.2004.03.006

Prince, S. A., Adamo, K. B., Hamel, M. E., Hardt, J., Connor Gorber, S., and Tremblay, M. (2008). A comparison of direct versus self-report measures for assessing physical activity in adults: A systematic review. *International Journal of Behavioral Nutrition & Physical Activity, 5*, 56. http://dx.doi.org/10.1186/1479-5868-5-56

Pucher, J., Buehler, R., Bassett, D. R., and Dannenberg, A. L. (2010). Walking and cycling to health: A comparative analysis of city, state, and international data. *American Journal of Public Health, 100*, 1986-1992. http://dx.doi.org/10.2105/AJPH.2009.189324

Reeves, M. J., Rafferty, A. P., Miller, C. E., and Lyon-Callo, S. K. (2011). The impact of dog walking on leisure-time physical activity: Results from a population-based survey of Michigan adults. *Journal of Physical Activity & Health, 8*, 436-444.

Rhodes, R. E., Blanchard, C. M., Courneya, K. S., and Plotnikoff, R. C. (2009). Identifying belief-based targets for the promotion of leisure-time walking. *Health Education & Behavior, 36*, 381-393. http://dx.doi.ogr10.1177/1090198107308376

Rhodes, R. E., Blanchard, C. M., and Matheson, D. H. (2007a). Motivational antecedent beliefs of endurance, strength, and flexibility activities. *Psychology, Health & Medicine, 12*, 148-162. http://dx.doi.org/10.1080/13548500600568290

Rhodes, R. E., Brown, S. G., and McIntyre, C. A. (2006). Integrating the perceived neighbourhood environment and the theory of planned behaviour when predicting walking in Canadian adult sample. *American Journal of Health Promotion, 21*, 110-118.

Rhodes, R. E., Courneya, K. S., Blanchard, C. M., and Plotnikoff, R. C. (2007b). Prediction of leisure-time walking: An integration of social cognitive, perceived environmental, and personality factors. *International Journal of Behavioral Nutrition & Physical Activity, 4*, 51. http://dx.doi.org/10.1186/1479-5868-4-51

Rodriguez, D. A., Brown, A. L., and Troped, P. J. (2005). Portable global positioning units to complement accelerometry-based physical activity monitors. *Medicine & Science in Sports & Exercise, 37*, S572–S581. http://dx.doi.org/10.1249/01.mss.0000185297.72328.ce

Rothney, M. P., Apker, G. A., Song, Y., and Chen, K. Y. (2008). Comparing the performance of three generations of Actigraph accelerometers. *Journal of Applied Physiology, 105,* 1091-1097. http://dx.doi.org/10.1152/japplphysiol.90641.2008

Salmon, J., Timperio, A., Chu, B., and Veitch, J. (2010). Dog ownership, dog walking, and children's and parents' physical activity. *Research Quarterly for Exercise & Sport, 81*, 264-271.

http://dx.doi.org/10.5641/027013610X13088573596023

Schneider, P. L., Crouter, S. E., and Bassett, D. R. (2004). Pedometer measures of free-living physical activity: Comparison of 13 models. *Medicine & Science in Sports & Exercise*, *36*, 331–335. http://dx.doi.org/10.1249/01.MSS.0000113486.60548.E9

Schofield, G., Mummery, K., and Steel, R. (2005). Dog ownership and human health-related physical activity: An epidemiological study. *Health Promotion Journal of Australia, 16,* 15-19.

Shephard, R. (1997). Godin leisure-time exercise questionnaire. *Medicine & Science in Sports & Exercise*, *29,* (suppl 6), S36–S38.

Silva, P., Mota, J., Esliger, D., and Welk, G. (2010). Technical reliability assessment of the Actigraph GT1M accelerometer. *Measurement in Physical Education & Exercise Science, 14,* 79-91.

Sudman, S., and Bradburn, N.M. (1983). *Asking questions* (2nd ed.). San Francisco, CA: Jossey-Bass.

Swartz, A. M., Bassett, D. R., Moore, J. B., Thompson, D. L., and Strath, S. J. (2003). Effects of body mass index on the accuracy of an electronic pedometer. *International Journal of Sports Medicine, 24,* 588-592. http://dx.doi.org/10.1055/s-2003-43272

Temple, V. A., Wharf-Higgins, J., and Rhodes, R. E. (2011). Unleashing physical activity: An observational study of park use, dog walking and physical activity. *Journal of Physical Activity & Health*, *8*, 766 -774. http://dx.doi.org/10.1177/1744629511422137

Thorpe, R. J. Jr., Simonsick, E. M., Brach, J. S., Ayonayon, H., Satterfield, S., Harris, T. B., Garcia M, & Kritchevsky, S.B. (2006). Dog ownership, walking behaviour, and maintained mobility in late life. *Journal of the American Geriatric Society, 54,* 1419-1424. http://dx.doi.org/10.1111/j.1532-5415.2006.00856.x

USDHHS. (2004). Surveillance Summaries. *Centers for Disease Control and Prevention Surveillance Summaries, 53*, SS-2.

Warburton, D. E. R., Charlesworth, S., Ivey, A., Nettlefold, L., and Bredin, S. S. D. (2010). A systematic review of the evidence for Canada's physical activity guidelines for adults. *International Journal of Behavioral Nutrition & Physical Activity, 7*, 39. http://dx.doi.org/10.1186/1479-5868-7-39