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EFFECT OF WEATHER ON PHYSICAL ACTIVITY IN OLDER ADULTS

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EFFECT OF WEATHER ON PHYSICAL ACTIVITY IN OLDER ADULTS

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ABSTRACT

Hot, humid summer temperatures and cooler winter temperatures may negatively influence the daily physical activity (PA) levels of older adults. **Purpose:** to assess the effect of summer and winter weather variables on daily PA in older adults. **Methods:** two groups of community-dwelling older adults were recruited (summer: n=48, 77.4 ± 4.7yrs (71-89); 36 female; winter: n= 42, 76.4 ± 5.1yrs (70-86); 26 female). Waist-borne accelerometers were worn for 7-consecutive days and weather variables were linked to accelerometer PA values. **Results:** In the summer months (mean PA 207.5 ± 152.4 avg hr cts/min), PA significantly correlated to time of day, humidex, temperature, AQI and estimated VO_{2max}. In the winter months (mean PA 203.4 ± 234.3 avg hr cts/min), PA was correlated with temperature, windchill, month, snow accumulation, humidity and hour. **Conclusion:** weather conditions and fitness may have a significant impact on daily PA accumulation by older community-dwelling adults.

KEYWORDS: physical activity, weather, accelerometry, older adult.

CO-AUTHORSHIP

All experimental studies were conducted in the Aging and Physiological Assessment Laboratory at the University of Western Ontario and the Canadian Center for Activity and Aging, London, Ontario, Canada. All of the experimental work (study design, data collection, and data analysis) presented in the following thesis was performed by Caitlin Brandon. Dr. Gareth Jones (primary supervisor to Caitlin Brandon) provided input on study design and contributed editorial comments. Drs. Mark Speechley and Jason Gilliland contributed advisory discussion.

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LIST OF ABBREVIATIONS / DEFINITIONS

AQI	air quality index
avg hr cts/min	average hourly activity counts per minute
BMI	body mass index, kg/m^2
CCAA	Canadian Centre for Activity and Aging
cm	centimetre
count	unit of measure representing acceleration of body movement in a single plane
cts/min	activity counts per minute
Humidex	in °C; index measure of heat calculated using ambient temperature and percent humidity
$km \cdot h^{-1}$	kilometres per hour
MET	metabolic equivalent of energy expenditure required for 3.5 $ml \cdot kg^{-1} \cdot min^{-1}$ of work
mm	millimetre
PA	physical activity
Percent humidity	measure of the amount of water vapor in the air (at a specific temperature) compared to the maximum amount of water vapor air could hold at that temperature
Precipitation	rain in mm, snow in cm
Snow accumulation	inches or cm; measure of amount of snow accumulated on the ground
SWO	Southwestern Ontario
Temperature	degrees celsius (°C)
VO_{2max}	maximal oxygen uptake, $ml \cdot kg^{-1} \cdot min^{-1}$
Windchill	°C; index measure of cold calculated using ambient temperature and wind speed

CHAPTER 1

INTRODUCTION

A wealth of epidemiological evidence confirms that older adults who participate in daily physical activity (PA) and exercise may remain functionally independent and relatively healthy, despite having one or more age-associated chronic diseases (Pedersen & Saltin 2006). Current national initiatives and recommendations encourage older adults to remain independent and healthy by engaging in moderate to vigorous PA on most days of the week for 30-60 minutes in order to sustain health, fitness and ultimately functional independence (Health Canada 1999, Paterson et al. 2007). However, approximately 60 percent of Canadian adults 65 years and older do not meet weekly recommended PA requirements to remain healthy and independent (National Advisory Council on Aging [NACA], 2006). Therefore, researchers interested in PA adoption and maintenance have turned their attention to understanding the barriers older adults encounter when initiating and adhering to exercise and PA recommendations.

Recent research suggests that weather conditions and seasonality may influence PA participation (Humpel et al. 2002, Humpel et al. 2004, Sanderson et al. 2002, Thompson et al. 2002). Weather conditions, particularly extremely warm temperatures, are responsible for increased mortality (Diaz et al. 2002, O'Neil et al. 2005, Smoyer et al. 2000) and morbidity in older adults. Outdoor PA (e.g. walking, jogging, bicycling) is directly affected by changing weather conditions (Marsh et al. 2007, Pivarnik et al. 2003, Sims et al. 2007) and recent evidence suggests inclement weather conditions can reduce exercise class attendance (Tu et al. 2004). Nevertheless, older adults who are either well acclimatized or who do not experience such extreme seasonal shifts in temperature and weather conditions are more likely to remain physically active throughout the entire year (Hechler et al. 2004) while others may simply migrate to less extreme climates.

A recent review (Tucker and Gilliland 2007) found 37 studies examining the relationship between PA and weather or season, of which only one study was specifically focused on older adults (aged 50-82 years). There were nine studies reporting on children (pre-school – 12yr), four on adolescents (10 – 17yr), 20 primarily on adults (10yr and older) and two on postmenopausal women (49 – 72yr). These studies reported inclement weather to be a barrier to PA across all age groups and increased sedentary behaviour was greatest during the winter months as compared to the summer months (BRFSS Coordinators 1997, Pivarnik et al. 2003, Dannennberg et al. 1989). Most studies found that PA peaked during summer months, except in areas where summers were exceptionally hot and humid. For example, in the state of Texas, where average summer temperatures reach 29°C, PA declined significantly compared to PA levels accumulated during more moderate winter temperatures (Baranowski et al., 1993). Inevitably, these studies suggest PA is influenced by temperature, climate, and seasonality.

A recent investigation by Chan and colleagues (2006) examined the effect of weather on PA of adults living in the Canadian Maritimes. They found that temperature, rainfall and snowfall negatively influenced the total number of pedometer recorded ambulatory steps per day. Poor weather conditions were reported to be a barrier to the accumulation of daily PA in this population.

Togo and colleagues (2005) examined the influence of weather conditions on pedometer-measured ambulatory steps per day, over a 12-month period, in a sample of older adults living in a small coastal village in Japan. Precipitation (i.e. rainfall) was reported to be the primary weather condition to negatively influence PA accumulation in this population. However, a limitation of this investigation was that pedometers only account for ambulatory activity behaviour and are not considered a reliable measure of total PA accumulation (Crouter et al. 2005, Le Masurier & Tudor-Locke 2003). Lower-intensity household activities make a significant contribution to an older adult's accumulation of total daily PA (Dinger et al. 2004), thus more sensitive movement-monitoring devices, such as accelerometers, are considered to provide a more reliable record of total accumulated PA (Sirard et al. 2000). Currently there are no published investigations, to our knowledge, that have compared weather conditions with accelerometer-measured PA in older community-dwelling adults.

The weather conditions in Southwestern Ontario (SWO) are unique in that summer months are particularly hot and humid (average daytime summer temperature 23.4 °C; average daytime humidex 34.0 °C) and winter months can be quite cold (average daily temperature -4.0 °C; average windchill -13.3 °C) with significant monthly average snowfall accumulation of 31.0 cm (Environment Canada 2006, 2007). Regional-specific climate differences must be considered when examining the effect of ambient temperature, weather and seasonality on PA because individual differences will be related to one's ability to naturally acclimatize to the environment. For example, the PA response to a hot humid weather conditions by individuals living in SWO, may be different from the response exhibited by those who are already acclimatized to these temperatures, especially if they are typical the local region (Diaz et al. 2002, Hechler et al. 2004, O'Neil et al. 2005).

This thesis examines the influence of summer and winter temperatures and weather variables on the PA levels of community-dwelling older adults living in London, Ontario. PA was measured over 7-days using a waist-born accelerometer (Actigraph, GT1M). Body Mass Index (BMI) and estimated VO_{2max} were also examined to observe if higher fitness levels engendered older adults to have a more favourable response (continued PA participation) to changing weather conditions.

It was hypothesized the PA levels of older adults would be negatively affected by warmer summer temperatures and colder winter temperatures. It was also expected that fitter individuals would continue PA participation despite fluctuations in weather conditions, hot or cold. Therefore, higher levels of fitness may attenuate the potential influence of local climate conditions on the accumulation of daily PA by older adults.

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CHAPTER 2

METHODS

Participants were recruited from a membership list of registered participants (n=370) at the Canadian Center for Activity and Aging (CCAA) – a local exercise centre for older adults. Those older adults who were 70 years and older and who had completed a fitness appraisal within 12-months prior to study enrolment were eligible to participate. Advertisements informing CCAA members of an upcoming study were posted throughout the exercise center prior to randomization (Appendix I). A random numbers table was utilized to create a telephone call list from the CCAA's membership ID catalogue. A CCAA staff member contacted potential subjects using the randomly selected telephone numbers in sequence to recruit participant in the study. Upon verbal agreement, the staff member scheduled potential participants for a laboratory appointment.

There were two separate sampling periods (summer and winter) using two different groups of randomly-selected participants. The first summer sample (Chapter 3) was recruited during the month of May and participants completed the study between May 29 and August 9, 2006. The winter sample (Chapter 4) was recruited prior to February 2007. Participation in the previous summer sample was set as an exclusion criterion for the second group of randomly selected participants. These participants completed the study between February 8 and April 23, 2007. Health Research Ethics Review Board of the University of Western Ontario approved both summer and winter protocols (see Appendix II and III).

Information packages were mailed to each interested participant. This package provided an overview of the study and a brief explanation of what would be required should they consent to participate. The package also included a map giving directions to the laboratory and a notice of their scheduled appointment times.

At the initial laboratory visit the study requirements were reviewed and participants gave written consent (Appendix IV). They were then provided with an accelerometer, a waist band and instruction material for the week. This included an outline on how and when to wear the accelerometer as well as directions on how to record their PA in the logbook (Appendix V). Participants also completed a brief health questionnaire (Appendix VI), which asked the participant how they perceived their health and PA level in comparison to their peers and to themselves five years ago. The health questionnaire also asked general questions about education and socioeconomic status. Prior to the end of the appointment, accelerometer return-dates and times were set.

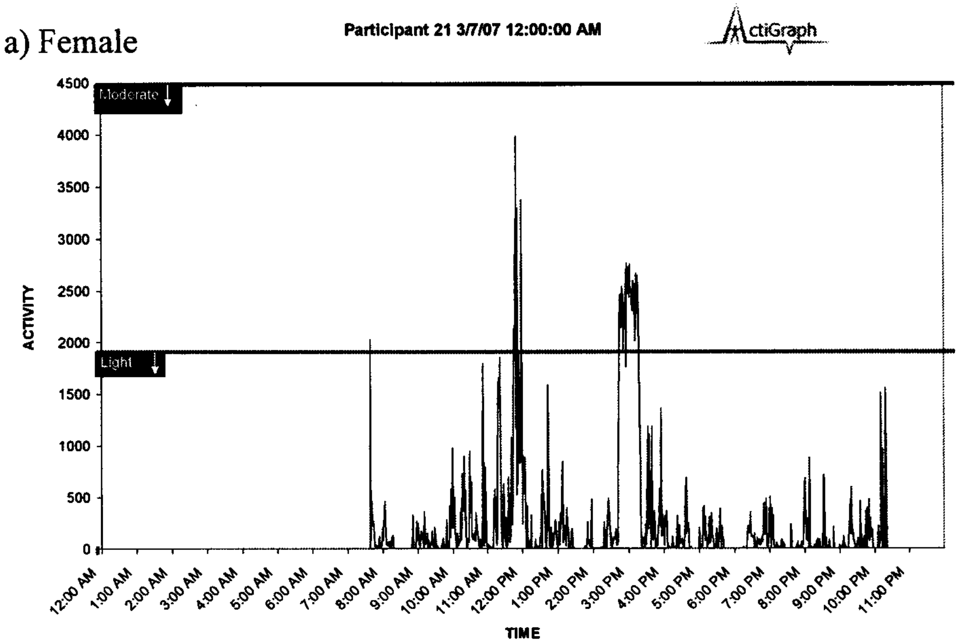
Study participants began wearing the accelerometer the morning following their first appointment. Participants put on the accelerometer each morning, while dressing, and verified by manual inspection that the accelerometer was in good working order. Subjects then removed the accelerometer in the evening, just prior to going to bed. Throughout the day they were also instructed to remove the accelerometer for any water-based activities including showering/bathing and swimming, as well as for any daytime naps. Participants completed a daily PA logbook which included information on when the accelerometer was put on and when it was taken off. They also indicated any significant PA events that they participated in during the day, including the following information: name of the activity, time of the day the activity began and ended, and a subjective estimate of the approximate intensity (easy, moderate or hard). The back-page of the logbook provided the participant with space to indicate any changes to his/her normal PA routine, such as being underactive or overactive, and the reason for this variation.

The accelerometer used in both investigations was the ActiGraph GT1M (ActiGraph GT1M, ActiGraph, Pensacola, FL.) The ActiGraph GT1M is a uniaxial piezoresistive accelerometer that uses a microprocessor with a 12-bit analog-to-digital converter that samples acceleration at a rate of 30 times per second (30 Hz). These data are then passed through a digital filter that limits the accelerometer to frequencies between 0.25 and 2.5Hz, the range appropriate to detect normal human movement from other types of movement (e.g. motorized vehicle). The filtered data is then summed over a defined sampling period referred to as an epoch. Accelerometer output is reported as "activity counts per minute" (cts/min). An example of a typical day's accelerometer output for a male and a female is presented in Figure 2.1, along with a description of the activities recorded in the PA logbooks. The spikes in cts/min correspond to activities such as exercise class, and mall walking, whereas periods of low cts/min are reflective of slower movements such as those accumulated while grocery shopping.

The ActiGraph was previously validated in adult populations. Melanson and Freedson (1995) reported that Actigraph accelerometer cts/min were well correlated (r = 0.80) with energy expenditure ($kcal \cdot min^{-1}$). In field-based validation studies using the Actigraph GT1M, cts/min were strongly correlated (r=0.90) with movement velocity (Nichols et al. 2000) and with estimated metabolic energy cost (METs) for daily activities (r=0.74; Tweedy and Trost, 2005). However, there are no published validation studies that have used an accelerometer with an older adult population (65^{+} years of age).

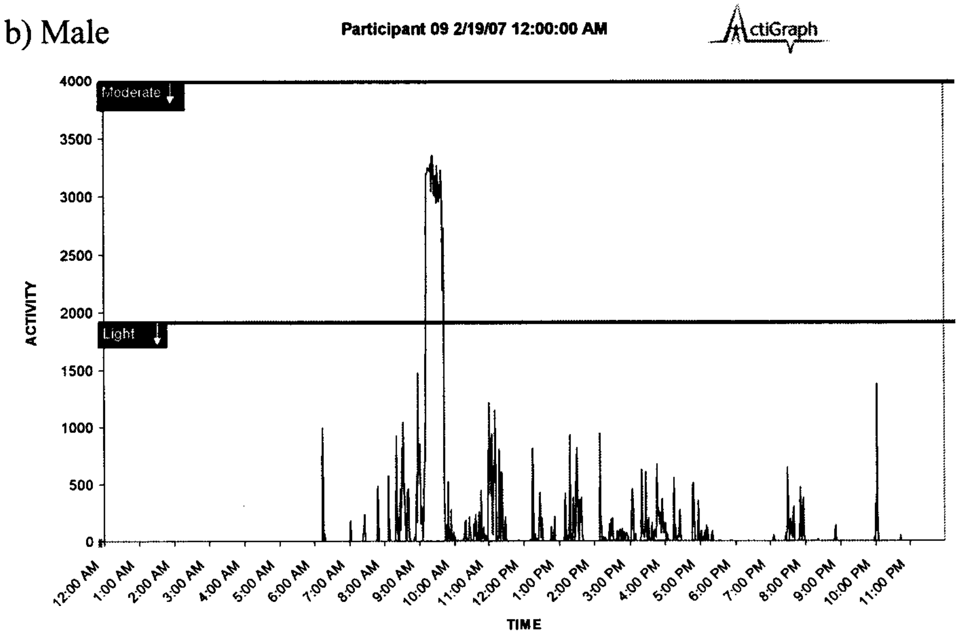
Figure 2.1 Graphical example of ActiGraph cts/min output, by sex, and description of corresponding activity recorded in PA logbook.

a) Female



12:00-11:59 AM	12:00-11:59 PM
7:40 accelerometer put on	2:45-3:15 mall walking
11:15-12:30 exercise class at CCAA	10:15 accelerometer removed

b) Male



12:00-11:59 AM	12:00-11:59 PM
7:00 accelerometer put on	3:30 grocery shopping
9:00-10:30 exercise class at CCAA	10:45 accelerometer removed

Accelerometers were chosen over other objective PA measuring devices, such as pedometers, because of their increased sensitivity to all movement (activities of daily living and exercise) that contributes to total daily PA. Pedometers measure predominantly ambulatory movements (e.g. walking), whereas accelerometers are sensitive to much lower intensity movements such as those performed as part of normal activities of daily living (Sirard et al. 2000). When looking at accelerometer values (vs. pedometer counts) it might be observed that individuals do little activity, corresponding with many low counts. However, pedometer-measured activity is typically summed over a period of time (e.g. 10 000 steps per day), whereas accelerometer counts produce an individual absolute value for every minute, including minutes when little movement is made. This should be taken into account when examining an individual's overall accelerometer data in that there are both high cts/min corresponding to the ambulatory movements a pedometer would register as well as low cts/min for smaller scale movements, which compose the majority of an individual's day (activities of daily living).

Each participant was sampled over a full seven-day period (five weekdays and two weekend days). Previous studies have revealed that seven days of monitoring gives between-day intra-class coefficients (ICC) of 0.70 and higher, whereas fewer days of monitoring give lower, unacceptable reliability coefficients (Trost et al. 2000). Older adult PA participation, specifically steps per day, also differs significantly between weekdays and weekend days (Tudor-Locke et al. 2002). This evidence mirrors the summary findings of the 2004 conference "Objective Monitoring of Physical Activity: Closing the Gaps in the Science of Accelerometry," which proposed a standard seven-day monitoring protocol should be used to observe weekend and weekday differences in PA across all age groups (Ward et al. 2005).

The accelerometer was worn around the waist using a nylon-elastic belt and positioned over the hip of the participant's dominant leg. Participants had the choice to wear the accelerometer above or underneath their clothing. The accelerometers were pre-programmed by study staff to begin collecting data at 12:01a.m. on the day subjects were to begin wearing the accelerometer. Epoch times were set at 1-minute intervals. Within 24-hours, post the 7-day PA assessment, the accelerometer and PA logbook were either collected by the investigator (CB) or the participant delivered both items to the laboratory. PA data were downloaded into standard spreadsheet software (Microsoft Office Excel 2003) and visually verified against the subject's PA logbook records. Hourly activity count averages (avg hr cts/min) were calculated from the minute-by-minute activity counts (cts/min) to better match the hourly reported weather variables (temperature, humidex or windchill, percent humidity, Air Quality Index) recorded by Environment Canada. In addition, unlike many published articles using accelerometers, the purpose of this study was not to identify individual energy expenditure or to study how many minutes a week participants spent above a certain PA threshold, both of which would require the use of minute-by-minute data. This study used two sample periods (summer and winter) to determine how overall hourly and daily physical activity fluctuated with different weather variables during the most extreme seasons. Once hourly averages were obtained for each subject, data were imported into SPSS 14.0 (SPSS Inc., Chicago, IL), along with hourly weather variables.

Because participants were instructed to remove the accelerometer at certain times (i.e. sleeping and water activities), not all monitored hours of the day contained valid activity data. There were often periods of time where the accelerometer registered "0" counts of activity because it was removed from the subject's body. These were therefore cleaned to improve the accuracy of overall hourly average activity cts/min by verifying subject PA logbooks to minute by minute accelerometer output. Periods of time during the day when a subject had removed the accelerometer were eliminated from the calculation of the hourly averages. This cleaned data were compared against the same weather variables as the original raw data. Overall average PA was determined by averaging each individual's hourly PA value across every hour there was at least one participant wearing an accelerometer. Therefore, each reported value in the analysis represented the average PA count achieved by either one or up-to 10 individuals (maximum of 10 subjects could be wearing the accelerometer at one time). This created a single value for every hour of the study period that was compared against the hourly weather variables. For weather variables that were only reported daily (i.e. precipitation), the same method was employed to create an average daily PA value for each day of the study period. Therefore, data were reported as average hourly activity cts/min and average daily activity cts/min to match hourly and daily Environment Canada weather records. Occasionally, there were data points that fell outside the sample distribution. These occurred because not every individual was wearing the accelerometer at the same time throughout the sampling period. Thus, the sole data point was included as it represented an average cts/min for that hour on that specific day. Utilizing more accelerometers so that a larger sample could be analyzed throughout the same sampling period would have helped reduce the occurrence of these occasional outliers.

All participants were annually screened by a physician in order to participate in the exercise programs. Therefore, data were not collected on specific co-morbidities as it was assumed they would not play a significant role in an individual's PA levels as these subjects were all exercising, functionally independent, and considered healthy older adults despite age-associated co-morbidity. Anthropometric measurements were taken during annual fitness appraisals (within 12 months prior to study enrollement). For this investigation, measures of height, weight and self-paced stepping were used.

Estimated VO_{2max} was calculated using the self-paced step test designed specifically for older adults. The test consists of stepping up and down two steps, each 20 cm in height, with the help of a railing or personal gait aid (if required). Individuals were to ascend and descend 20-times at a pace they considered "comfortable." Resting heart rate was taken from a seated position prior to commencement of the test; post-stepping heart rate was taken immediately following completion of the test; and the time it took to complete the 20-step cycles was also recorded during the test. VO_{2max} was estimated using the formula described by Petrella and colleagues (2001). The estimated VO_{2max} values were used as an estimate of the individual's cardiorespiratory fitness. All measurements were performed by trained personnel at the CCAA.

Conversion of cts/min to METs was considered and established conversion values can be found in Table 3.1. Corresponding MET values were derived from the conversion equation developed by Freedson and colleagues (1998) for the ActiGraph accelerometer (MET = 1.439008 + (0.000795 * cts·min^{-1}), $r^2 = 0.82$; SEE = ± 1.12 MET). The PA intensities associated with each category of MET (low: 1–3.99, moderate: 4.0– 4.49, moderately vigorous: 4.5–5.99, vigorous: 6.0+) were included and corresponded to those reported by Lee and Paffenbarger (2000).

Statistical analysis was performed using SPSS 14.0 (SPSS Inc., Chicago, IL). Pearson correlations were used to determine the relationship between average PA counts and the meteorological variables. Polynomial and linear regression analysis was used to observe the influence of temperature on PA. Multiple regression analysis was performed with PA as the dependent variable. All weather variables, as well as BMI and VO_{2max}, were included in the model. The final model was determined using only the significant variables after performing a backward stepwise regression.

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CHAPTER 3

RELATIONSHIP BETWEEN SUMMERTIME WEATHER AND ACCELEROMETRY RECORDED PHYSICAL ACTIVITY LEVELS OF OLDER COMMUNITY-DWELLING ADULTS

INTRODUCTION

A wealth of epidemiological evidence confirms that PA substantially reduces the impact of age-related morbidity and mortality in older adults (Pedersen and Saltin 2006). Current national initiatives and recommendations encourage older adults to remain independent and healthy by engaging in moderate to vigorous PA on most days of the week for 30-60 minutes in order to maintain health, fitness and ultimately functional independence (Health Canada 1999, Paterson et al. 2007). Yet, more than half of older Canadians currently do not meet these PA recommendations (NACA 2006).

Recent evidence suggests weather conditions and seasonality may influence PA participation of adults (Chan et al. 2006, Humpel et al. 2004, Merrill et al. 2005, Pivarnik et al. 2003, Sanderson et al. 2002, Thompson et al. 2002) and older adults (Togo et al. 2005, Tu et al. 2004, Yasunaga et al. 2008). Weather conditions and seasonality also impact health-related variables such as fracture risk (Bischoff-Ferrari et al. 2007, Mirchandani et al. 2005), food intake (Ma et al. 2006), blood cholesterol (Matthews et al. 2001) and asthma (Mancuso et al. 2006). However, no investigation to date has focused specifically on the influence of summertime temperatures on the daily PA participation levels of older adults (70+ years of age).

Annual summertime temperatures have increased gradually since 1948, with an overall warming trend of approximately 0.9°C (Environment Canada 2007). Extreme summertime temperatures are responsible for increased mortality in older adults (Diaz et al. 2002, O'Neil et al. 2005, Smoyer et al. 2000) especially in regions unaccustomed to extreme temperature fluctuations (Hechler et al. 2004). Generally, older adults find it difficult to regulate body temperature (Anderson et al. 1996, Nakamura et al. 1997, Potkanowicz et al. 2003, Scremin and Kenney 2004, Worfolk 1997) as a result of age-associated detuning of autonomic regulatory system (Collins et al. 1980). Autonomic detuning is responsible for decreased peripheral vasodilation in response to thermal stress (Richardson and Shephard 1991), reduced sweating (Foster et al. 1976) and a greater variance in control of core body temperature (Marion et al. 1989). Fitter individuals have more efficient thermoregulatory systems (Bittel et al. 1988, Ho et al. 1997) as a result of improved vascular tone (Westhoff et al. 2007) and improved autonomic cardiovascular functioning (Gulli et al. 2003), and are likely more capable of coping with rising ambient temperatures. To our knowledge no investigation has yet examined the influence of summer weather variables and fitness on PA participation in older adults.

The purpose of this study was to investigate the relationship between outdoor summer weather variables including ambient temperature, humidex, and air quality index on daily PA accumulation by healthy, community-dwelling, older adults. The secondary purpose was to examine the effect fitness (estimated VO_{2max}) may have on preserving normal PA accumulation despite the potential influence of higher ambient temperatures, greater humidity and poor air quality. We hypothesized that daily PA would be negatively influenced by rising daytime temperatures; however, fitter individuals would continue to be physically active despite warmer summer temperatures

MATERIALS & METHODS

Participants were randomly selected from a membership list (N=370) of a local, older adult, exercise centre. Inclusion criteria required participants to be 70+ years of age and regularly attending exercise classes. Participants were initially contacted by an exercise centre staff member who obtained verbal consent from volunteers to attend a baseline assessment. At this assessment, the study protocol was explained and written consent was obtained from those volunteers who chose to participate in the study. One hundred and nine individuals were contacted, of which 58 declined to attend an assessment session. Reasons for refusals included: ill or recovering from illness (n=18), uninterested in participating (n=12), too busy (n=11), away on holiday (n=11) or an ill spouse (n=4). Fifty-one randomly selected participants (37 females, 14 males) consented to participate. This study was approved by the Research Ethics Board of the University of Western Ontario (Appendix II).

The initial assessment took approximately 20 minutes and required participants to complete a personal health questionnaire, followed by instruction on how to use the accelerometer (ActiGraph GT1M; ActiGraph, Pensacola, FL.) and how to accurately complete a logbook to report significant daily PA events. The accelerometer, previously described in Chapter 2, recorded movement intensities over a one-minute epoch. These movements were summed to give a value of counts per minute (cts/min) which were later converted to MET values using the equation proposed by Freedson and colleagues (1998) (Table 3.1).

Each participant wore the ActiGraph GT1M accelerometer (3 cm x 4 cm x 1 cm; 27 grams) on their waist for one-week (seven-consecutive days) between 30 May and 9 August 2006. Accelerometer start times were pre-programmed by the investigator (CB). The accelerometer was worn only during waking hours, and participants were instructed to remove it when doing any water-based activities (e.g. bathing, swimming, etc.) and when sleeping, including daytime napping. Participants were instructed to wear the

Table 3.1. Conversion of accelerometer counts to metabolic equivalents (METs).

ActiGraph Activity Counts	MET*	Intensity†
0 – 3250	1 – 3.99	Light
3250 – 3850	4.0 – 4.49	Moderate
3850 – 5750	4.5 – 5.99	Moderately Vigorous
5750 – 9000	6.0 +	Vigorous

Activity Counts in counts per minute
MET = Metabolic Equivalent; 1MET is equivalent to a metabolic rate consuming 3.5 $mL \cdot kg^{-1} \cdot min^{-1}$ of oxygen per kilogram of body weight per minute (ACSM, 2006);
*Conversion equation from ActiGraph activity counts to MET established by Freedson and colleagues (1998);
†Intensity conversions established by Lee and Paffenbarger (2000).

accelerometer on the mid-axillary position, over their dominant leg (Ward et al. 2005). The accelerometer was attached to an elastic waist-band and could be worn over or under clothing. Since the accelerometer was not worn every minute over the seven-day assessment period, analysis was split between raw data (all data regardless of accelerometer removal) and cleaned data (removal of data when accelerometer was not worn, for example when bathing, sleeping and/or swimming). Raw data included "zero" counts which give an underestimation of true hourly average PA. Cleaned data consists of hourly PA averages calculated using only the minutes when participants were wearing the accelerometer (as determined by participant logbooks). Eliminating "zero" counts when the accelerometer was not worn improves the estimation of the true hourly, mean PA. Accelerometer cts/min were then averaged for each hour during the sampling period (agv hr cts/min) for comparison to the summer weather variables which were reported hourly (Environment Canada 2006).

Anthropometric and fitness measurements were recorded from fitness appraisal data collected by a qualified professional at the CCAA. Measurements of height and weight were recorded, and estimated VO_{2max} was determined using a submaximal aerobic step test for older adults (Petrella et al. 2001). Participants were later categorized for analysis based on estimated VO_{2max}, created by dividing the range of estimated VO_{2max} scores into three groups of equal size (tertiles). These tertiles separated participants into qualified groups based upon aerobic fitness level (poor, moderate, and high).

PA logbooks were used by participants to record significant PA events (i.e. attending exercise class, going for a walk, heavy gardening, etc.) as well as record the time they put on and took off the accelerometer (Appendix V). Participants returned the accelerometer along with the PA logbook at the follow-up assessment within 48 hours after the 7-day assessment period was completed. PA data were verified manually against the PA logbooks. Start and stop times were determined in reference to what was reported in the participant logbook. If participants failed to indicate a start and/or stop time then visual inspection of minute-by-minute accelerometer counts was used to determine start and finish points for the sampling day. This was done with a sense of confidence as the first spike of activity during the day was clearly evident in the accelerometer output.

Meteorological data were collected daily. This data were retrieved online from Environment Canada records measured at the London International Airport (Latitude 43° 2' N) (Environment Canada 2006). Recorded hourly variables included: ambient temperature, percent humidity, humidex and Air Quality Index (AQI).

Statistical analysis was performed using SPSS 14.0 (SPSS Inc., Chicago, IL). A polynomial regression of the second order was used to determine the relationship between PA levels (recorded between 07:00h and 19:00hr) and ambient daytime temperature. Polynomial regression was used over linear because the relationship between PA and temperature was curvilinear, and a linear model did not appropriately fit the data. Pearson correlations were performed to determine if a relationship existed between PA and all weather variables. Data were then cleaned to eliminate erroneous "zero" counts when participants were in fact not wearing the accelerometer. Correlation analysis was performed between PA and fitness level (estimated $VO_{2max.}$). Finally, multiple regression analysis was carried-out with PA as the dependent variable. All weather variables, as well as BMI and VO_{2max}, were included in the model. Only the significant variables established using backward stepwise regression analysis were used in the final model.

RESULTS

Fifty-one, older adults provided informed consent and began the study. Two subjects, both male, dropped-out midweek. One subject withdrew from the study as their spouse felt that they could not complete the PA logbook appropriately, while the other subject had to leave the country unexpectedly. There was one accelerometer malfunction where no data were collected (registered only zero counts for entire week). The remaining 48 subjects (36 female) wore the accelerometer for 7-consecutive days without malfunction. Table 3.3 describes the physical and health characteristics of the final subject sample. The mean scores for this sample group suggest that the majority of subjects were relatively non-obese and had satisfactory cardiorespiratory fitness for their age. However, the range of scores suggest that this was a heterogeneous sample as some subjects were considered obese (BMI $\geq$ 30 kg/m^2) (see Table 3.2) and unfit (estimated $VO_{2max} \leq 20$ ml·kg^{-1}·min^{-1}). However, recent evidence suggests that older adults with high BMI scores, above those considered 'healthy' in adults, have a lower relative risk of all cause mortality as a result of their weigh as compared to adult cohorts (Heiat et al. 2001). Accelerometers were worn an average 4410.5 ± 362.7 minutes of a possible 5040 minutes (87.5%). Two subjects forgot to wear the accelerometer accounting for 2 missed days. Missing data were not imputed.

Table 3.2 Health Risk Classification According to Body Mass Index (BMI)

Classification	BMI Category (kg/m2)	Risk of Health Problems	Summer Sample n=48
Underweight	<18.5	Increased	2.0%
Normal Weight	18.5 – 24.9	Least	33.3%
Overweight	25.0 – 29.9	Increased	47.9%
Obese			
Class I	30.0 – 34.9	High	14.6%
Class II	35.0 – 39.9	Very High	2.0%
Class III	>40.0	Extremely High	0.0%

Note: For persons 65 years and older the 'normal' range may begin slightly above BMI 18.5 and extend into the 'overweight' range. (World Health Organization 2000).

Table 3.3 describes the data assessed by the health questionnaire. Seventy percent of participants rated their own health as very good or better. Thirty-percent felt they were more active than others the same age. No participant described their memory to be worse than others the same age. Most (85 %) were married or widowed with a post-secondary education (74%) and were financially stable.

According to the MET correlates described in Table 3.1, subjects spent an average of 4380.0 ± 346.5 minutes accumulating 'light' PA, 13.5 ± 20.6 minutes achieving 'moderate' PA, 16.5 ± 44.5 minutes performing PA at 'moderately-vigorous', and only 0.5 ± 1.9 minutes of time spent at PA considered to be 'vigorous' (Freedson et al. 1998, Lee and Paffenbarger 2000). These values indicate that this group of older adults recorded an average of 30.5 min per week at an intensity equivalent to or higher than 4 METs (moderate to vigorous).

Table 3.3. Characteristics of summer sample subjects (n=48).

Characteristic	Value	Range	Characteristic	Value	Range
Age	77.4 ± 4.7	71 – 89	Self-perceived memory compared to 5 years ago (%)		
Weight (kg)	70.5 ± 12.0	43.5 – 103.0	Much better	2.0	
Height (m)	1.6 ± 8.3	1.5 – 1.9	Better	4.2	
Waist-hip ratio	.85 ± .09	.65 – 1.05	About the same	62.5	
Female	.81 ± .07	.65 – .97	Worse	31.3	
Male	.96 ± .06	.88 – 1.05	Number of subjects who reported a fall in the past 12-months.		25 %
BMI (kg/m^2)	26.2 ± 4.0	17.2 – 37.6	Average number of reported falls in last 12 months	0.4 ± 1.0	0 – 2
Estimated VO_{2max} ($ml \cdot kg^{-1} \cdot min^{-1}$)	30.0 ± 7.6	17.5 – 45.8	Average number requiring medical treatment	0.5 ± 0.5	0 – 1
Self-perceived health status (%)			Marital status (%)		
Excellent	16.7		Married	52.1	
Very good	54.2		Widowed	33.3	
Good	27.1		Divorced	4.2	
Fair	2.1		Single/Never married	10.4	
Self-perceived weekly activity level (%)			Highest level of education (%)		
Vigorously active 3x/week	64.6		Some elementary or high school	8.3	
Moderately active 3x/week	35.4		High school diploma	16.7	
Activity level compared to others the same age (%)			Some post-secondary	18.7	
Much more active	29.2		Post-secondary diploma	56.3	
About as active	56.3		Finances at the end of the month (%)		
Less active	14.6		Usually have money left over	81.3	
Memory compared to others the same age (%)			Just enough to make ends meet	16.7	
Much better	4.2		Refused response	2.0	
Better	39.6				
About the same	56.2				

kg = kilograms; m = meters; BMI = body mass index kg/m^2; VO_{2max} = a measure of cardiorespiratory fitness

PA cts/min were averaged for each individual for each hour they wore the accelerometer (avg hr cts/min). Polynomial regression of the second order revealed a curvilinear relationship between PA and temperature (r^2= .023; Figure 3.1). Mean PA avg hr cts/min values were 207.5 (range 13.4-614.6) when mean daytime temperature was <25°C. However, when ambient temperature rose above 25°C, mean PA declined by 15% (mean 176.8 avg hr cts/min; range 26.8-329.6). A similar curvilinear relationship was observed between PA and humidex, r^2= .043. Above 28°C, mean PA was 183.6 avg hr cts/min, with a narrower range of 53.4-227.5.

Pearson correlation coefficients were calculated to determine the relationship between PA and all of the separate weather variables, including; temperature, humidex, AQI, and percent humidity. All variables, except percent humidity, were correlated with PA (Table 3.4).

Table 3.5 presents raw and cleaned PA accelerometer data. Raw data includes hourly averages of PA counts including time when accelerometer was not worn. When raw data were cleaned the r^2 value improved from 0.023 to 0.040 (Figure 3.2). Most PA (62 %) was completed below temperatures of 25 °C for both raw and cleaned values. PA peaked at approximately 20°C and declined as temperatures continued to climb (Table 3.5, Figure 3.2). However, despite increasing temperatures, subjects did not completely eliminate PA, although PA was substantially reduced above ambient temperatures of 25°C.

Pearson correlation analysis revealed that age and VO_{2max} were ($p < 0.01$) associated with PA ($r = -0.35$; $r = 0.40$, respectively). All weather variables, age and estimated VO_{2max} were included in the final backwards stepwise regression model. The percent variance of each variable is presented in Table 3.6. A regression model was generated using significant variables: $PA=755.4+17.7VO_{2max}-Age-0.6\ VO_{2max}Temperature$ ($r^2 = 0.33$, $p<0.01$). Excluded variables included humidity and Air Quality Index, the latter of which was significant in the correlation analysis, but not in the regression analysis. Visual inspection of the histogram (Appendix VII), normal probability plot and scatterplot of the standardized residuals determined that this model met the assumptions of multiple regression (Kleinbaum et al. 1988). VO_{2max} x Temperature was significant, illustrating that the relationship between temperature and PA differs across the range of VO_{2max} values (17.5-45.8 ml·kg^{-1}·min^{-1}) (Figure 3.3). These findings suggest that older adults with higher estimated VO_{2max} remain more physically active despite warmer daytime temperatures.

Figure 3.1. Regression equation (raw PA).

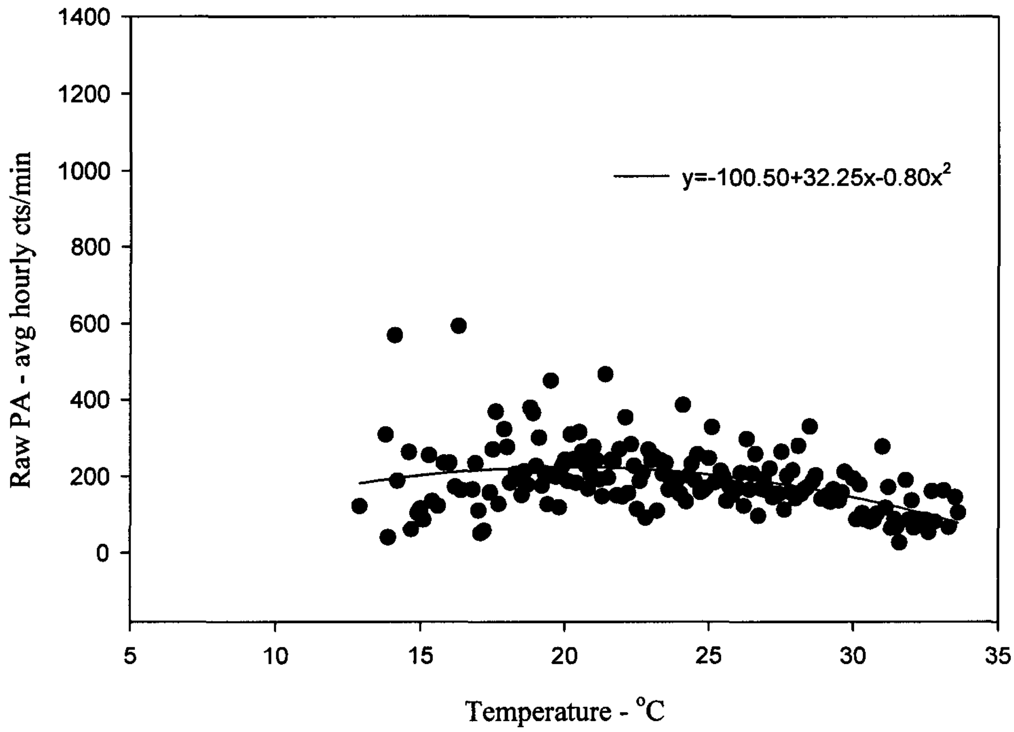


Table 3.4 Pearson correlations for total average PA 0700hr-1900hr.

Weather Variable	Correlation Coefficient	P-value
Time (hour of day)	-0.344	<0.01
Humidex (°C)	-0.198	<0.01
Temperature (°C)	-0.193	<0.01
Air Quality Index	-0.147	<0.01
Relative Humidity (%)	0.048	0.14

Table 3.5 Raw and cleaned PA 0700hr-1900hr vs. temperature.

Temperature	Mean PA* Raw	Percent Change from <20°C †	Mean PA* Cleaned	Percent Change from <20°C †
All (n=936)	195.1 ± 152.4		231.5 ± 182.7	
<20°C	208.1 ± 171.9		274.3 ± 234.3	
21-25°C	200.3 ± 161.0	↓4.0%	242.8 ± 186.3	↓11.5%
26-30°C	180.5 ± 110.1	↓13.3%	201.4 ± 133.9	↓26.8%
≥31°C	110.5 ± 79.3	↓46.9%	141.1 ± 99.8	↓48.6%
Humidex 28°C	183.6 ± 133.8		209.8 ± 154.8	

PA = physical activity
*Units displayed as hourly average counts/minute ± standard deviation (sd)
†Percent change in average hourly counts/minute of PA: -[(new temp range avg PA/temp range avg PA <20°C)x100] + 1

Figure 3.2. Regression equation (cleaned PA).

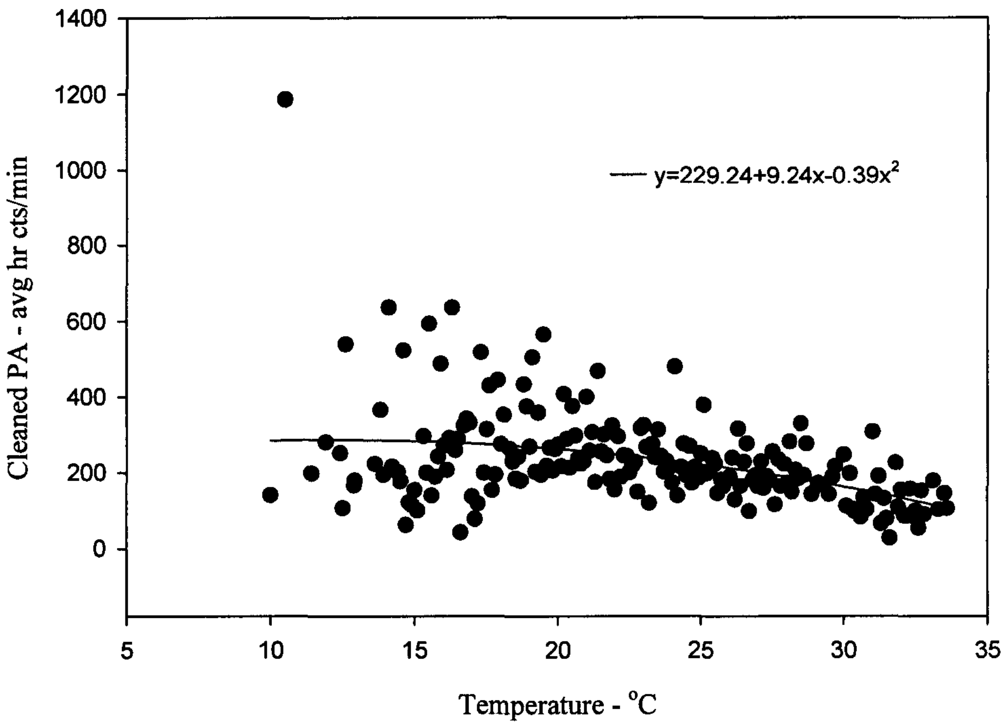
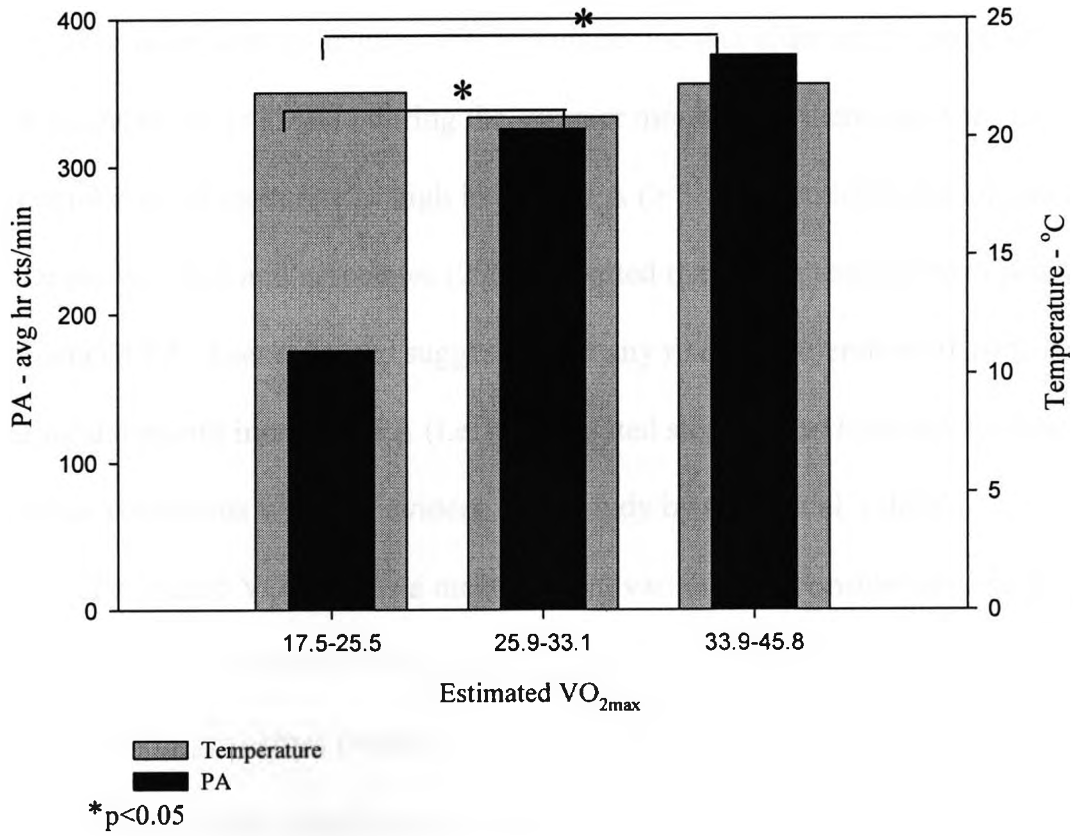


Table 3.6 Percent variance explained by selected variables.

Variable	β*	SE†	Variance explained (%)
Estimated VO_2max	0.399	2.419	15.9
Age	-0.352	3.438	12.4
Humidex	-0.198	2.044	3.9
BMI	-0.195	4.257	3.8
Temperature	-0.193	1.395	3.7
AQI	-0.147	0.641	2.2
Percent Humidity	0.048	0.236	0.2

*β = probability of failing to reject hypothesis when it is false
†SE = standard error; BMI = body mass index (kg/m^2); AQI = air quality index

Figure 3.3. Average cleaned PA and temperature across estimated VO_{2max} subgroups.



DISCUSSION

This study found a curvilinear relationship between temperature and PA as well as humidex and PA. PA was negatively correlated with temperature, humidex and AQI. Cleaned PA data provided a better estimation of hourly PA (cts/min) and a stronger relationship to changing ambient temperatures. The PA levels of fitter individuals, those with estimated VO_{2max} within the 2nd and 3rd tertiles, were significantly higher than those recording in the lowest VO_{2max} tertile, despite rising ambient daytime temperatures.

These results suggest that ambient daytime temperatures significantly affected the daily PA levels of this group of older adults. These results were similar to the curvilinear relationship reported by Togo and colleagues (2005) where PA (i.e. pedometer steps/day) declined as daytime temperatures increased. Tu and colleagues (2004) reported similar findings in that exercise class attendance significantly dropped when humidex rose above 32°C. Yasunaga and colleagues (2008) commented that older adults primarily accumulate low intensity PA (<3MET) during the summer months and there was very little accumulation of moderate to high intensity PA (> 3MET) during these summer months. Alternately, Chan and associates (2006) reported that rising temperatures positively influenced PA. These authors suggested that any rise in temperature of 10°C or more during the month increased PA (i.e. accumulated steps/day). However, hot and humid weather conditions were not evident in the study by Chan et al. (2006).

Estimated VO_{2max} was a measurement variable not considered in previous weather vs. PA studies. The results of this study suggest that participants who had higher estimated VO_{2max} values (within the second and third tertile) were found to be more active despite higher temperatures (above 25°C). The PA completed by those in the 3rd tertile (VO_{2max} 33.9-45 ml $\cdot$ kg^{-1} $\cdot$ min^{-1}) was not significantly higher than that completed in the 2nd tertile (VO_{2max} 25.9-33.1 ml · kg^{-1} · min^{-1}). Higher levels of fitness may facilitate PA participation in warmer temperatures because it may aid with thermogenic efficiency through an improved vasodilatory response (Ho et al. 1997), thus allowing fitter individuals to adapt more readily to outdoor ambient temperatures. Also, those individuals who have maintained their fitness for many years may simply continue their exercise routine despite increased ambient temperatures or they look for other exercise opportunities, likely indoor activities (i.e. exercise club, mall walking), while those who are less fit may be more apt to remain inactive during warmer daytime temperatures.

Certain limitations of the study must be considered. The study sample was randomly selected from a membership list of exercising older adults and all study participants were actively exercising 2 or 3 times per week. As such, this sample population may participate in more vigorous PA than other samples of older adults, despite weather conditions. Any observed differences in PA due to weather seen in this sample population would likely be magnified in the general population as a result of greater variance in overall physical fitness and accessibility to exercise facilities other than outdoor walking.

Due to the availability of accelerometers, a maximum of 10 participants were able to wear the accelerometer at any given time, therefore not all participants wore the accelerometer during the same week. As a result all participants were not subject to the same range of weather conditions during the sampling period, and direct comparison between individual participants was not possible. Nevertheless, each subject wore the accelerometer for 7-days, allowing for collection of PA across various days of the week (i.e. weekdays, weekends), thus generating a better representation of an individual's overall activity level, even on days when they did not have an exercise class. The 7-day assessment period also provided the opportunity to experience a greater range of weather conditions.

Physical activity may have been underestimated when subjects engaged in water-based activities as this could not be measured with the accelerometer. Swimming was the most common water-based PA, with a total of 7 subjects indicating they swam between 1 to 8 times during the assessment period for an average 54.6 minutes.

Using the Freedson (1998) conversion equation to change cts/min into MET values likely provides an underestimation of overall energy expenditure for this population as the conversion equation was originally developed with a sample of younger adults. Underestimation was observed using data from this sample group of exercising older adults who achieved average hourly PA values that did not exceeded the corresponding MET value for "light" activity (see Table 3.1), despite the fact that the study population was comprised of participants who exercised two-three times per week. Paterson and colleagues (2007), reported that PA at an intensity of 3-4 MET is considered to be of moderate-vigorous intensity for older adults. Thus the observed MET values in the current investigation suggest that these older adults were meeting recommended levels for energy expenditure.

There were three potential limitations for assessing vigorous PA in this investigation. First, the older subjects may have selectively performed more vigorous (>4.5 METS) PA during cooler times of the day (before 0700hr or after 1900hr) to avoid the heat and thus outside the period monitored for this investigation. Secondly, PA that required primarily upper-body movement, for example weight-training performed during each exercise class, was likely not recorded by the waist-born accelerometer because it could not provided an accurate measure of upper-body activity (Montoye et al. 1996, Welk 2005). Finally, the accumulation of vigorous activity was likely lost in the calculation of avg hr cts/min. Visual inspection of the data confirms that the majority of exercise bouts lasted less than 30 minutes. Therefore, 30 minutes of vigorous activity would be averaged against 30 minutes of light activity, thus effectively masking the contribution of vigorous activity to the avg hr cts/min.

It is crucial that older adults remain active and exercise regularly in order to remain functionally independent. Alternatives to outdoor activities are important for this population to consider if they plan to continue regular exercise during warmer weather. The influence of weather and temperature should be considered with regard to daily PA reported during summer months. Fitter older adults may tolerate hotter daytime temperatures or they simply may chose to consider exercise alternatives done indoors. Vigorous activity is advised to engender fitness and maintain existing functional capacity of older adults (Paterson et al. 2007), and doing PA indoors – in a climate-controlled environment – is a plausible solution. Health promotion efforts should focus on accumulating more moderate-vigorous PA participation in this age-group (Craig et al. 2007). Thirty-minutes of moderate-vigorous PA per day is required to maintain health and functional independence in older adults (Paterson et al., 2007).

Research addressing regional and climate-specific research is required to account for factors of acclimatization (Curriero et al. 2002, Hechler et al. 2004, O'Neil et al. 2005). Future investigations should consider evaluating the influence of wintertime weather on PA participation by older adults. The use of multiple accelerometers (i.e.

upper body and lower body) may provide a better estimation of total PA, as waist-borne accelerometers do not accurately record upper-body movements (e.g. weight-lifting exercises). Measurement time periods of less than one hour may give future studies a better estimation of vigorous activity, as older adults tend to participate in PA at this level for shorter bouts than one hour. Finally, an assessment of the role of the aging thermoregulatory system and its role in PA tolerance is warranted considering the biological link between the body's ability to maintain thermal homeostasis and the unavoidable consequence of heat production during vigorous PA.

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CHAPTER 4
EFFECT OF WINTER WEATHER ON PHYSICAL ACTIVITY LEVELS OF OLDER EXERCISING ADULTS

INTRODUCTION

Weather and its impact on the PA of older adults has become a topic of increasing interest to researchers (Chan et al. 2006, Togo et al. 2005, Tucker and Gilliland 2007). In Canada, one half to two thirds of all people are inactive throughout the year (Merchant et al., 2007). Seasonality studies in both Canada (Merchant et al. 2007) and the US (Matthews et al. 2001, Pivarnik et al. 2003) show that winter is the most sedentary season of the year across all age-groups. Recent research considering the impact of weather and seasonality on PA has employed the use of questionnaires (Humpel et al. 2004, King et al. 2000, Ma et al. 2006, Matthews et al. 2001, Merrill et al. 2005, Pivarnik et al. 2003, Salmon et al. 2003, Stetson et al. 2005, Wilcox et al. 2000) or pedometers (Chan et al, 2006, Togo et al, 2005, Yasunaga et al. 2008) to assess PA levels. However, accelerometer assessment of PA is arguably a more accurate estimation of overall PA.

Waist-born accelerometers are most effective at recording lower extremity movement, specifically lower intensity movements often required to complete most activities of daily living (ADL) (Bassett et al. 2000). Movement associated with ADL account for much of the PA reported by older adults. However, most PA questionnaires and pedometers do not accurately report PA accumulated by slower movements (Washburn 2000, Welk 2005).

Current research suggests PA of older adults decreases during colder, more inclement seasons (Togo et al. 2005, Yasunaga et al. 2008). Precipitation (i.e. rainfall or snowfall) and colder temperatures negatively affect daily accumulation of PA (Chan et al. 2006) and exercise class participation by adults (Tu et al. 2004). Research investigating barriers and facilitators to PA and exercise in adult populations has identified weather as an influential factor affecting participation in vigorous activity (Humpel et al 2002, Merrill et al 2005, Pivarnik at al 2003, Sanderson et al, 2002, Thompson et al, 2002). However, no investigation has yet examined the specific impact of winter weather conditions on the overall PA levels in older, community-dwelling, adults.

This study aimed to examine the impact of winter weather on the PA levels of older adults, 70 years and older, who were community-dwelling and regular exercisers. We hypothesized that as temperature decreased and snowfall accumulation increased average PA would decline.

MATERIALS AND METHODS

The membership list (N=370) from a local older adult exercise centre was randomly sampled for potential research subjects. Inclusion criteria required participants to be 70+ years of age and regularly attending exercise classes. Exclusion criteria included being involved in a previous and similar investigation (Chapter 3). A random numbers table was employed against eligible participant identification numbers. An exercise centre staff member initially contacted eligible participants by telephone. Those who verbally consented were scheduled for a baseline assessment.

One hundred-and-one individuals were contacted, of which 51 declined to attend an assessment session. Reasons for refusal included: too busy (n=12), ill or recovering from illness (n=11), leaving for a trip during the study period (n= 5), not interested in being involved in the study (n=8), unable to be contacted (n=7), too busy caring for an ill family member (n=3), acknowledged that they did not like to participating in research studies (n=2), already involved in another research study (n=1), or had no means of transportation (n=1). Fifty individuals (33 females, 17 males) consented to participate and entered the study. This study was approved by the Health Sciences Research Ethics Board of the University of Western Ontario (Appendix III).

During the baseline laboratory assessment, willing participants provided written consent, completed a short health questionnaire (Appendix VI), and were given instructions on how to wear the accelerometer (ActiGraph GT1M, ActiGraph, Pensacola, FL.) and how to accurately complete the PA logbook during the seven-day assessment period. Specifications of the ActiGraph GT1M can be found in Ch 3. Epoch times were preprogrammed and set at one-minute, yielding accelerometer output in cts/min for every minute over the seven-day monitoring period.

The ActiGraph GT1M accelerometer (3 cm x 4 cm x 1 cm; 27 grams) was worn by consenting participants on a nylon band around their waist for seven-consecutive days. Subjects wore the accelerometer during waking hours only and were asked to remove it when doing any water-based activities (e.g. bathing, swimming, etc). Accelerometers were worn over the participant's dominant leg, in the mid-axillary position.

Individual PA logbooks were used by participants to report significant PA events (e.g. attending exercise class, going for a walk, cross-country skiing, etc.) as well as the time they put on and took off the accelerometer (i.e. in the morning, for naps or water-based activities, and at night). Accelerometer recorded PA data were later verified manually against participant PA logbooks. If the participant failed to indicate in the PA logbook when they put on or took off the accelerometer a start or stop time was determined by visual inspection of minute-by-minute accelerometer counts.

Participants' anthropometric measurements were collected from fitness appraisal data assessed by qualified personnel. For the purpose of this study, fitness appraisal information included measurements of height, weight and estimated VO_{2max}. An estimate of VO_{2max} was determined using a submaximal aerobic step test for older adults (Petrella et al., 2001). Accelerometer outputs were also converted to energy expenditure (MET).

Hourly and daily weather data were collected for the study period from Environment Canada records measured at the London International Airport (Latitude 43° 2' N) (Environment Canada, 2007). Recorded hourly weather variables included: ambient temperature, percent humidity, windchill and Air Quality Index (AQI). Daily recorded variables included rain, snow, total precipitation (mm) and the amount of snow accumulation (cm).

All statistical analysis was performed using SPSS 14.0 (SPSS Inc., Chicago, IL). Data were cleaned to eliminate periods of time where the accelerometer was not worn (i.e. sleeping, bathing, etc.) from hourly PA calculations. Cleaned data were the cts/min of activity which was computed into hourly PA averages using only the minutes when participants were wearing the accelerometer (as determined by participant PA logbooks). Average daily cts/min were also calculated and compared to daily weather variables (precipitation and snow accumulation). Data was cleaned to eliminate "zero" counts that occurred when the accelerometer was not worn. Data cleaning improves the estimation of the true, mean, hourly PA. Linear regression was used to determine the relationship between PA recorded between the hours of 7:00a.m. and 7:00p.m. (0700hr-1900hr) and hourly ambient temperatures. Correlation analysis was performed to determine if relationships existed between PA and reported hourly (temperature, windchill, humidity, AQI, time) and daily (snow accumulation) weather variables. Multiple regression analysis was performed with PA as the dependent variable and all winter weather variables were included in the model. The final model was determined using only the significant variables, after performing a backward stepwise regression.

RESULTS

The final analysis was conducted using accelerometer data from 42 subjects. During the study there were eight accelerometer malfunctions; six battery interruptions, and two errors resulting in corrupted files. For these individuals, data were only collected for four-days or less. Subject characteristics and results from the baseline health questionnaire are presented in Table 4.1.

Subjects wore the accelerometer for an average 4470.7 ± 312.4 minutes of a possible 5040 min between the hours of 0700 and 1900 over seven consecutive days. Subjects spent an average of 4436.8 ± 298.8, 13.7 ± 17.8, 19.3 ± 39.4, 1.0 ± 4.5 min doing "light", "moderate", "moderately-vigorous", and "vigorous" activity, respectively. On average, subjects spent only 34.0 min a week performing PA of four METs or higher.

Overall, the mean daytime avg hr cts/min was 203.4 ± 234.3. PA. Accelerometer (cts/min) and was positively related to outdoor temperature (Figure 4.1a). Similarly, PA and windchill temperature were positively related (Figure 4.1b). PA increased with each sequential month (February, March, April) (Figure 4.1c). Snow accumulation ranged from zero cm to 19 cm. PA was inversely related to snow accumulation and there was a trend toward less vigorous activity being performed as snow accumulation increased (Figure 4.1d). As percent humidity rose, average temperature decreased, and the observed range of PA recordings narrowed by 35 percent (from 4.8-2656.3 to 0.0-1717.4 avg hr cts/min)(Figure 4.1e). Hour of the day was strongly correlated with PA, and the most vigorous average hourly cts/min were recorded in the morning (prior to 12p.m.) and decreased steadily throughout the day until 7:00 p.m. (Figure 4.1f). Estimated VO_{2max} was not significantly correlated with PA during the winter (r=0.28, p=0.08).

Backwards stepwise regression was performed and included all variables significant in correlation analysis. Only variables which remained significant following regression remained in the final model. These variables included: temperature, percent humidity and hour of the day. The equation *PA = 604.6 - 20.5Time + 5.2Temperature - 2.0Humidity* (r^2=0.15, p<0.01) was generated. Visual inspection of the histogram (Appendix VIII) and normal probability plot of the standardized residuals was done to determine whether the model met the assumptions of multiple regression. Inspection of the scatterplot to determine variance homoscedasticity revealed that there are some mild departures from homogeneity (Kleinbaum et al. 1988). In the future, these departures should be investigated further.

DISCUSSION

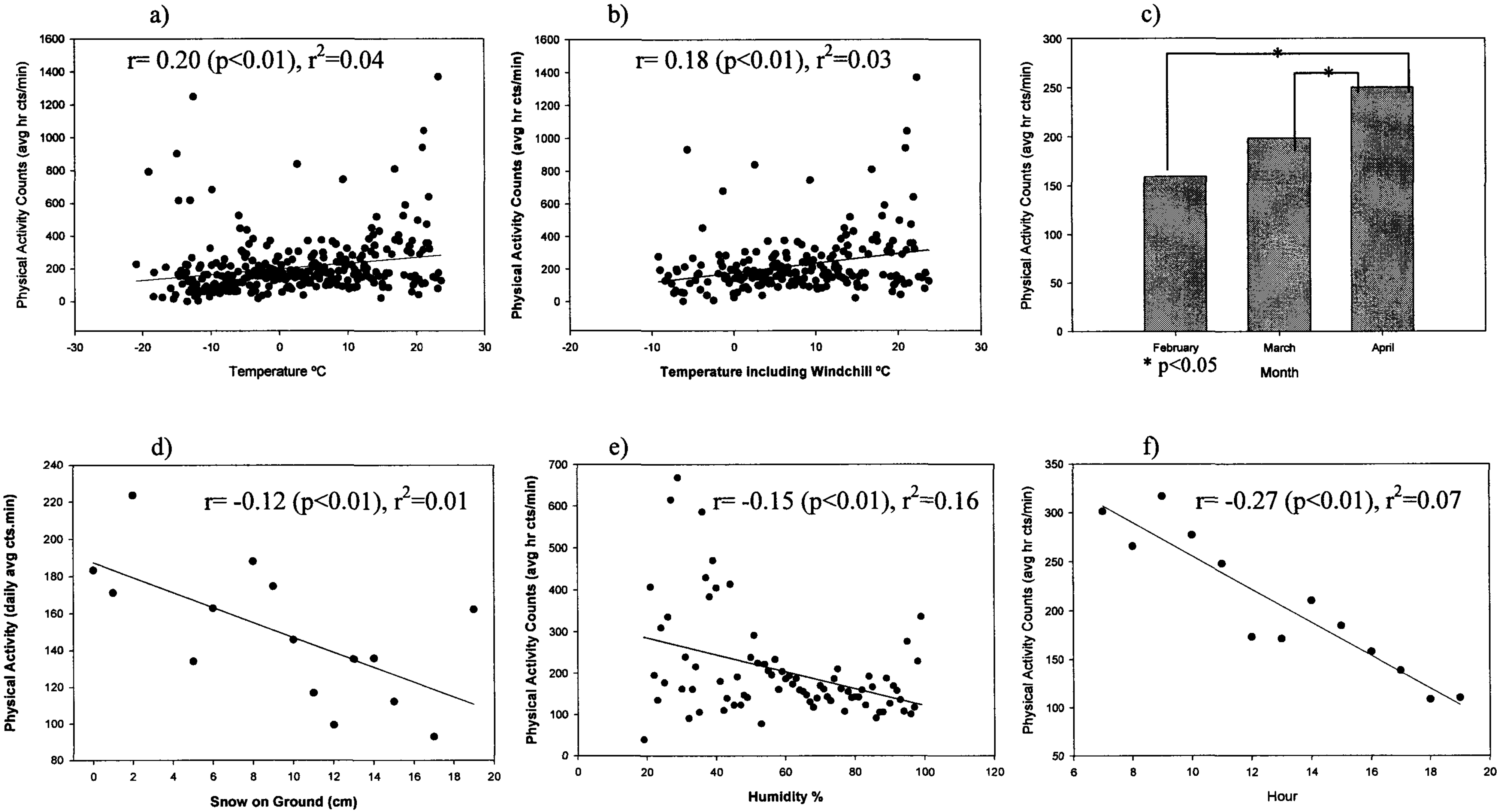
PA was positively associated with increasing temperature and with seasonality change from winter to spring months (February – April) (Figure 4.1a,c). These results were expected considering the existing evidence indicating that PA levels are often higher during spring months compared to winter months (Chan et al. 2006, Hechler et al. 2004, Matthews at al. 2001). An even stronger relationship was observed when windchill was included with temperature (Figure 4.1b), which might suggest that older adults are influenced more by the *"feels like"* aspect of temperature, than ambient temperature itself. Also congruent with the results reported by Chan and colleagues (2006), PA was negatively associated with the amount of snow accumulation (Figure 4.1d). In an older adult population, driving in inclement winter weather is sometimes avoided (Finlayson

Table 4.1. Characteristics of winter sample subjects (n=42).

Characteristic	Value	Range	Characteristic	Value	Range
Age	76.4 ± 5.1	70 – 86	Self-perceived memory compared to 5 years ago (%)		
Weight (kg)	71.8 ± 15.7	45.0 – 115.0	Much better	2.4	
Height (m)	1.6 ± 1.0	1.5 – 1.9	About the same	57.1	
Waist-hip ratio	0.86 ± 0.09	0.73 – 1.15	Worse	38.1	
Female	0.81 ± 0.05	0.73 – 0.90	Much worse	2.4	
Male	0.95 ± 0.08	0.82 – 1.15	Number of subjects who reported a fall in the past 12-months.		38 %
BMI (kg/m^2)	26.2 ± 4.4	18.3 – 39.3	Average number of falls in last 12 months	0.8 ± 1.4	0 – 5
Estimated VO_{2max} ($ml \cdot kg^{-1} \cdot min^{-1}$)	31.5 ± 8.9	16.9 – 52.0	Number requiring doctor visit (mean)	0.1 ± 0.25	0 – 1
Self-perceived health status (%)			Marital status (%)		
Excellent	21.4		Married	57.1	
Very good	42.9		Widowed	33.3	
Good	31.0		Divorced	7.1	
Fair	4.8		Single/Never married	2.4	
Self-perceived weekly activity level (%)			Highest level of education (%)		
Vigorously active 3x/week	81.0		Some elementary or high school	9.5	
Moderately active 3x/week	19.0		High school diploma	7.1	
Activity level compared to others the same age (%)			Some post-secondary	9.5	
Much more active	19.0		Post-secondary diploma	73.8	
About as active	59.5		Finances at the end of the month (%)		
Less active	14.3		Usually have money left over	90.5	
Much less active	7.1		Just enough to make ends meet	7.1	
Memory compared to others the same age (%)			Refused response	2.4	
Much better	4.8				
Better	31.0				
About the same	57.1				
Worse	7.1				

kg = kilograms; m = meters; BMI = body mass index kg/m^2; Estimated VO_{2max} = a measure of cardiorespiratory fitness

Figure 4.1. Physical activity vs. temperature, windchill, month, snow accumulation, percent humidity and hour of the day.



and Kaufert 2002), which may account for lower PA levels on days with substantial snowfall accumulation.

The results found in this study when comparing PA to percent humidity (Figure 4.1e) were different from those reported by Togo and colleagues (2005) who found a positive relationship between pedometer recorded steps per day and percent humidity. This difference may be explained by the observed variations in weather conditions experienced between different climactic regions. The current study took place during the winter months, whereas Togo and colleagues recorded PA over an entire year, in a rural costal community that experienced different seasonal temperatures than those recorded in the current investigation. The association between PA and hour of the day (Figure 4.1f) was not a variable of interest in other similar investigations; however, the strong correlation reported between PA and time of day in this study suggests older adults may prefer to do more vigorous activities (e.g. exercise) earlier in the day and spend more time relaxing in the afternoon and evening. The participants from this study attended regular exercise classes, which were offered at various times during the day. However, the majority of individuals participated in the morning exercise classes (n=32).

VO_{2max} was not significantly correlated with PA during the winter, suggesting fitness was not as influential in determining if these older adults participated in PA. Additionally, PA may be predominantly performed indoors during the winter and improved fitness would likely have less of a thermoregulatory benefit in environmentally controlled conditions.

Daily avg hr cts/min were similar to those found by Washburn and Ficker (1999) who reported daily avg cts/min of 206 in an older adult sample (mean age 72 years).

However, these were slightly higher than the daily average 168 cts/min reported by Dinger et al (2004) who recorded PA only between 9a.m. and 9p.m. The daily avg hr cts/min recorded in the present study indicate that these older adults had similar PA levels to those reported elsewhere, although they participated in regular exercise two-three times per week. This might suggest that the older adults in the current study did less total PA but likely had higher levels of intense PA (i.e. exercise class participation) as compared to other investigations.

There are several limitations with this current study. The sample population utilized in this investigation may be considered a unique study-group, as all participants were of higher socio-economic status, in good general health, and participated in weekly (two-three times per week) exercise classes. As such, the impact of winter weather conditions on PA accumulation, although significant, may not be indicative of what might be observed in a more representative population (i.e. less active, greater morbidity) of older adults.

Sampling was limited to a maximum of 10 subjects at one time because only 10 accelerometers were available, thus not all participants wore the accelerometer during the same week. This resulted in participants being exposed to different weather conditions across the sampling period.

The exercise classes included a strength training component that utilized weight machines whereby the participant pushed or pulled weights from a seated position. This vigorous activity was likely not registered by the accelerometer because waist-born accelerometers do not accurately detect upper body motion (Montoye et al. 1996, Welk 2005). This would contribute to an underestimation of recorded PA (avg hr cts/min) accumulated during the exercise class. The aerobic (ambulatory) component of the exercise class registered as vigorous activity on the accelerometer; however, the strength training component, although of vigorous intensity, was not recorded by the accelerometer. Therefore the aerobic and strength training components performed in the exercise class effectively cancelled each other out when the cts/min were averaged over the hour.

Future research should consider year-long seasonal evaluation of older adults' PA. Togo and colleagues (2005) completed a 12-month evaluation using pedometers to measure daily steps/day in relation to weather, however, the climate in costal Japan was quite different from that experienced in London, Ontario. Conducting a similar study using accelerometers would allow for more accurate comparison of results and would provide data for each participant on all possible climatic conditions for a given region.

It is imperative that calibration studies with the ActiGraph be completed in order to create age-specific cts/min-MET conversion equations. This has already been suggested following a 2004 symposium: Objective Monitoring of Physical Activity – Closing the Gap in the Science of Accelerometry and summarized by Ward and colleagues (2005). They suggest it is necessary to determine calibration equations for an older adult population, whose activity level may span from sedentary to vigorous.

The use of multiple accelerometers located on different body sites (i.e. on the wrist) may be a consideration allowing for a more detailed understanding of daily PA levels, specifically non-ambulatory movements of the upper extremity that may be performed while seated (e.g. exercise weight-machines). However, research by Swartz and colleagues (2000) suggest that the small amount of added information gained is overshadowed by the expense of the accelerometer and the added time to analyze additional data.

Despite the considerable snowfall experienced in London, Ontario, research in regions of Canada which frequently receive in excess of 20 cm of snow accumulation throughout the winter season should be considered for investigation. Older adults living in regions with larger snowfall accumulations may face even greater movement challenges, such as poor driving and/or transportation conditions (e.g. walking, bus), which may translate into the accumulation of lower levels of PA as compared those recorded from this current investigation's sample population. Further research using other regions throughout the country may improve our understanding of the PA habits of older adult Canadian's during the winter months.

This investigation suggests older adults may require alternatives to outdoor PA during the winter months. PA is crucial for the maintenance of health and independence (Paterson et al. 2007). With impending transition of the baby-boomer cohort, a notably sedentary group (Leveille et al. 2005), into older adulthood it is imperative that health practitioners endeavour to find means to increase and maintain PA regardless of climate.

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CHAPTER 5

GENERAL DISCUSSION AND CONCLUSIONS

A growing body of research is being established on the influence of weather conditions and seasonality upon PA levels of people across all age groups (Chan et al. 2006, Hechler et al. 2004, Ma et al. 2006, Matthews et al. 2001, Merchant et al. 2007, Merrill et al. 2005, Pivarnik et al. 2003, Togo et al. 2005, Tucker and Gilliland 2007). With increasing ease and cost effectiveness of objective PA monitoring equipment, such as accelerometers, it has become possible to measure daily PA in the field with some degree of accuracy (Freedson and Miller 2000). Unfortunately, little research in this area has targeted older adults. Previous research has indicated the need for region-specific research in this area as climate varies greatly throughout the world (Tucker and Gilliland 2007). In a country such as Canada, which covers such expansive land mass, multiple within country studies may be warranted because of the diversity of weather conditions. The current thesis project aimed to identify the effect of summer and winter weather variables on the PA levels of older adults in London, Ontario.

The results of these studies indicated that certain aspects of both summer and winter weather affect PA levels of older, exercising, community-dwelling adults. Temperature was found to influence PA during the summertime (negative relationship) and during the winter months (positive relationship). Data from the summer study also indicated a relationship between temperature and estimated VO_{2max}, suggesting that fitter older adults remain more active in warm weather than do their less fit counterparts. This was, however, not the case during the winter study. The majority of PA in the winter was done indoors (namely at the CCAA exercise classes), compared to the summer when many individuals also walked outdoors for exercise. Fitness (estimated VO_{2max}) has less of an influence on PA because individuals exercised in a climate controlled environment (indoors) and thus any fitness engendered benefit to thermoregulation was not as important as it was during the summer months. Overall, the average hourly cts/min of PA was low, corresponding to current adult accelerometer calibration MET conversions of "light" activity (Freedson et al. 1998). This was an unexpected result in both the summer and winter study, considering subjects regularly attended exercise class.

Minute-by-minute assessment of accelerometer data were analyzed on an individual basis and classified according to Freedson's cut points (Freedson et al. 1998) (see Table 3.1). This analysis revealed that individuals spent an average of only 30 minutes a week in PA considered to be of a "moderate intensity". All subjects, however, participated in exercise class two or three times per week, and therefore should have accumulated more minutes per week at more moderate-high intensity PA. The results of this current study suggest that Freedson and colleagues' (1998) prediction equation employed with the ActiGraph may not be appropriate for use with older adults. Likely older adults reach higher intensity PA at lower MET levels (i.e. 4-6 MET) than those proposed by Freedson et al. (1998). Therefore, creating age-specific PA intensity cut points would be a logical progression for future research.

BMI was likely not a significant factor as subjects were from a generally healthy, non-obese, exercising older adult population. Future research should consider examining the same parameters in a non-exercising, more generalizable population, where higher BMI values may impact PA levels to a greater degree. Weather variables may be more or less significantly related to PA in a less fit older adult population as there may be more variation in health indices, modes of transportation (aside from personal vehicles), and accessibility to exercise facilities which could be more affected by weather.

Challenges experienced throughout this investigation included: adherence to study protocols (i.e. remembering to wear the accelerometer and full completion of the logbook) and the low daily average PA counts, that resulted from averaging the data across 60 minute epochs (due to the averaging process). Both methodological conditions would likely be exacerbated in a general older adult population. When studying an aging population, issues of cognitive abilities must be considered. Alzheimer's disease and other related dementias may make completion of the weekly logbook and adherence to accelerometer wearing less reliable (i.e. putting accelerometer on as soon as you get up in the morning and only removing it just before bed and for water based activities) (Cotrell et al. 2006). A baseline questionnaire completed during subjects' first laboratory appointment was used to alert study staff to any potential cognitive issues. However, there was only one individual who indicated any memory problems over the previous five years, and they subsequently dropped out of the study mid-week and were not included in analysis.

The exclusion criteria used in the winter study was employed for two reasons. To keep participant-learning similar between both studies, new participants were recruited to eliminate any possibility that those who had experience using the accelerometers would perform differently the second time around. Secondly, it was expected that solicitation of the same subjects from the summer project would result in lower enrolment, as many subjects may have declined to participate a second time.

Future research should consider the use of accelerometers with built-in geographic information systems (GIS) and heart rate monitors. This will allow for a more detailed account of weather conditions experienced by individuals as well as provide information to more easily determine energy expenditure and PA intensity. Research needs to include a more general older adult population and be conducted across a whole year rather than individual seasons. Future research investigations should consider ensuring all study subjects participate during the same time frame. Individual thermoregulation system functioning should also be considered, as this may play a role in activity tolerance in extreme hot or cold temperatures. The body's thermoregulation system is responsible for vasodilatation in heat and vasoconstriction during cold, as well as sweat gland activity in an effort to keep the body thermoneutral (McArdle et al. 2001). The role of exercise and maintained PA in the preservation of aging thermoregulatory systems should also be considered.

Conversion of cts/min to MET revealed that study participants spent little time doing activity that would be considered moderate or vigorous. Future studies should consider including a measure of perceived exertion, as older adults may subjectively feel they are participating in activity at more vigorous intensities than are objectively being captured by PA monitoring devices such as accelerometers.

This research highlights the importance of considering weather and climate when doing population based PA studies. Many national surveys are completed at different times of the year and ask about activity levels within the past week or month (NACA 2006). Surveys conducted during winter months, when individuals are more sedentary, may give an inaccurate representation (i.e. underestimate) annual PA. Older adults are a vulnerable population who may have limited access to indoor exercise facilities (Belza et al. 2004, Stewart et al. 2006). The information presented in the paper emphasizes the continued need to offer indoor alternatives for exercise. In this aged population, in-home alternatives to within-community activities may be of particular benefit in winter months when snow may be a deterrent to going outdoors or in summer months when remaining indoors in air conditioning is suggested. When a population is more physically active, its members are healthier, more independent and the less of a burden to the health care system.

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Western

APPENDIX I
Recruitment Advertisement

NOTICE - Invitation to Participate in a Research Project

If you are a registered participant in exercise programs at the Canadian Centre for Activity and Aging (CCAA) and 70 years of age or older, you may receive a telephone call from a CCAA staff member about a research project. We are taking a random sample of CCAA members aged 70 or older, so your name may or may not be selected. Participation in this study is voluntary.

The purpose of the phone call will be to:

1. briefly describe the study
2. if you are interested in participating, ensure we have your correct mailing address
3. schedule two appointments
    a. an in-person meeting at Elborn College (University of Western Ontario) lasting a maximum of one hour (parking paid)
    b. a brief (15-20 minute) telephone interview approximately eight days after the in-person meeting.

The study involves asking people to wear a small lightweight device (about half the size of a deck of cards) on their waist for seven days. The device, an accelerometry-based activity monitor, measures movements of your body caused by walking, standing up, sitting down, etc. The telephone interview will consist of a questionnaire about physical activities such as housekeeping, walking, swimming, etc, and a questionnaire about the neighbourhood in which you live. The monitor will be picked up from you at your convenience. We will use this information along with weather data to see how winter weather affects physical activity.

Dr. Gareth Jones, PhD., Dr. Mark Speechley, Ph.D., and Dr. Jason Gilliland, Ph.D., are the study investigators; Caitlin Brandon and Kristian Larsen are master's students working on the project.

APPENDIX II
Ethics Approval Letter (Summer sample)

Western

Office of Research Ethics

The University of Western Ontario
Room 00045 Dental Sciences Building, London, ON, Canada N6A 5C1
Telephone: (519) 661-3036 Fax: (519) 850-2466 Email: ethics@uwo.ca
Website: www.uwo.ca/research/ethics

Use of Human Subjects - Ethics Approval Notice

Principal Investigator: Dr. M. Speechley
Review Number: 12307E **Revision Number:**
Protocol Title: Validation of a physical activity questionnaire for community-dwelling older adults
Department and Institution: Epidemiology & Biostatistics, University of Western Ontario
Sponsor: Ontario Neurotrauma Foundation Mentor-Student Award in Injury Prevention
Ethics Approval Date: April 28, 2006 **Expiry Date:** December 31, 2006
Documents Reviewed and Approved: UWO Protocol, Letter of Information & Consent
Documents Received for Information:

This is to notify you that The University of Western Ontario Research Ethics Board for Health Sciences Research Involving Human Subjects (HSREB) which is organized and operates according to the Tri-Council Policy Statement and the Health Canada/ICH Good Clinical Practice Practices: Consolidated Guidelines; and the applicable laws and regulations of Ontario has reviewed and granted expedited approval to the above named research study on the approval date noted above. The membership of this REB also complies with the membership requirements for REB's as defined in Division 5 of the Food and Drug Regulations.

This approval shall remain valid until the expiry date noted above assuming timely and acceptable responses to the HSREB's periodic requests for surveillance and monitoring information. If you require an updated approval notice prior to that time you must request it using the UWO Updated Approval Request Form.

During the course of the research, no deviations from, or changes to, the protocol or consent form may be initiated without prior written approval from the HSREB except when necessary to eliminate immediate hazards to the subject or when the change(s) involve only logistical or administrative aspects of the study (e.g. change of monitor, telephone number). Expedited review of minor change(s) in ongoing studies will be considered. Subjects must receive a copy of the signed information/consent documentation.

Investigators must promptly also report to the HSREB:
a) changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;
b) all adverse and unexpected experiences or events that are both serious and unexpected;
c) new information that may adversely affect the safety of the subjects or the conduct of the study.

If these changes/adverse events require a change to the information/consent documentation, and/or recruitment advertisement, the newly revised information/consent documentation, and/or advertisement, must be submitted to this office for approval.

Members of the HSREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the HSREB.

Chair of HSREB: Dr. John W. McDonald
Deputy Chair: Susan Hoddinott

Ethics Officer to Contact for Further Information		
☒ Karen Kueneman	☐ Janice Sutherland	☐ Jennifer McEwen

This is an official document. Please retain the original in your files.

cc: ORE File
LJ-RI
Faxed: Y / N

LAWSON HEALTH RESEARCH INSTITUTE

CLINICAL RESEARCH IMPACT COMMITTEE

RESEARCH OFFICE REVIEW NO.: R-06-207

PROJECT TITLE: Validation of a physical activity questionnaire for community-dwelling older adults

PRINCIPAL INVESTIGATOR: Dr. M Speechley

DATE OF REVIEW BY CRIC: May 19, 2006

HEALTH SCIENCES REB #: 12307E

Please be advised that the above project was reviewed by the Clinical Research Impac Committee and the project:

Was Approved

PLEASE INFORM THE APPROPRIATE NURSING UNITS, LABORATORIES, ETC. BEFORE STARTING THIS PROTOCOL. THE RESEARCH OFFICE NUMBER MUST BE USED WHEN COMMUNICATING WITH THESE AREAS.

Dr. Joseph J. Gilbert
Chairman
Clinical Research Impact Committee

All future correspondence concerning this study should include the Research Office Review Number and should be directed to Sherry Paiva, Room C210, Nurses Residence, South Street Campus.

APPENDIX III
Ethics Approval Letter (Winter sample)

Western

Office of Research Ethics

The University of Western Ontario
Room 00045 Dental Sciences Building, London, ON, Canada N6A 5C1
Telephone: (519) 661-3036 Fax: (519) 850-2466 Email: ethics@uwo.ca
Website: www.uwo.ca/research/ethics

Use of Human Subjects - Ethics Approval Notice

Principal Investigator: Dr. G.R. Jones
Review Number: **12869E** **Review Date:** December 6, 2006 **Revision Number:**
Protocol Title: Effect of winter climate on community-dwelling older adults
Department and Institution: Occupational Therapy, University of Western Ontario
Sponsor:
Ethics Approval Date: December 7, 2006 **Expiry Date:** August 31, 2007
Documents Reviewed and Approved: UWO Protocol, Letter of Information and Consent
Documents Received for Information:

This is to notify you that The University of Western Ontario Research Ethics Board for Health Sciences Research Involving Human Subjects (HSREB) which is organized and operates according to the Tri-Council Policy Statement and the Health Canada/ICH Good Clinical Practice Practices: Consolidated Guidelines; and the applicable laws and regulations of Ontario has reviewed and granted expedited approval to the above named research study on the approval date noted above. The membership of this REB also complies with the membership requirements for REB's as defined in Division 5 of the Food and Drug Regulations.

This approval shall remain valid until the expiry date noted above assuming timely and acceptable responses to the HSREB's periodic requests for surveillance and monitoring information. If you require an updated approval notice prior to that time you must request it using the UWO Updated Approval Request Form.

During the course of the research, no deviations from, or changes to, the protocol or consent form may be initiated without prior written approval from the HSREB except when necessary to eliminate immediate hazards to the subject or when the change(s) involve only logistical or administrative aspects of the study (e.g. change of monitor, telephone number). Expedited review of minor change(s) in ongoing studies will be considered. Subjects must receive a copy of the signed information/consent documentation.

Investigators must promptly also report to the HSREB:

a) changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;

b) all adverse and unexpected experiences or events that are both serious and unexpected;

c) new information that may adversely affect the safety of the subjects or the conduct of the study.

If these changes/adverse events require a change to the information/consent documentation, and/or recruitment advertisement, the newly revised information/consent documentation, and/or advertisement, must be submitted to this *office for approval.*

Members of the HSREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the HSREB.

Chair of HSREB: Dr. John W. McDonald

Deputy Chair: Susan Hoddinott

Ethics Officer to Contact for Further Information		
☑ Denise Grafton (dgrafton@uwo.ca)	☐ Janice Sutherland (jsutherl@uwo.ca)	☐ Jennifer McEwen (jmcewen4@uwo.ca)

cc: ORE File

This is an official document. Please retain the original in your files.

UWO HSREB Ethics Approval
2006-10-01 (HS-EXP) 12869E Page 1 of 1

APPENDIX IV
Letter of Consent

INFORMATION/CONSENT DOCUMENT

Effect of Climate on the Physical Activity of Community-Dwelling Older Adults

Dear <Name of Potential Participant>:

This research is directed by **Dr. Gareth Jones, Dr. Mark Speechley, and Dr. Jason Gilliland** of the **University of Western Ontario** and the **Canadian Centre for Activity and Aging**. This letter contains research study. It is important for you to understand why the study is being conducted and what it will involve. Please take the time to read this carefully and feel free to ask questions if anything is unclear or there are words or phrases you do not understand.

What is the purpose of this study?

The purpose of this study is to see how climate affects physical activity participation of older adults. This includes activities you would do around your home, for recreation and for conditioning (for example to strengthen your muscles). We have participants wear a small device to measure all activities that you do in a typical week as well as complete two questionnaires that ask questions about the activities you do. After completing this study, we hope to have an accurate and quantitative measure of physical activity patterns so that we can determine if a relationship exists between daily physical activity and daytime ambient temperature and weather conditions.

Why have you been contacted?

You have been selected at random, that is, by a method of chance, from a list of all participants enrolled in exercise programs at the Canadian Centre for Activity and Aging (CCAA) who are 70 years of age or older. We have selected 50 older adults in total to be contacted to participate in this study.

What is involved if you choose to participate?

The study will require you to meet with one of our study staff members at Elborn College in the Aging and Physiological Assessment Laboratory (located at the University of Western Ontario) for a maximum of one hour. You will be able to park just outside this accessible building and your parking will be paid for. You will be asked to fill out a short questionnaire, which consists of questions about you and your health. Following this, you will be given a small device (about half the size of a deck of cards) to wear on your waist for the following seven days and an activity logbook. The device, an accelerometry-based activity monitor, measures movements of your body as you go about your normal daily activities. We will explain how to use this device, what to record in the logbook, answer any questions you might have and provide you with some written instructions to take home with you. Completing the logbook would take approximately 5 minutes of your time each day for the seven-day period.

Approximately eight days after your first appointment you will be telephoned by one of our study staff members to complete a physical activity questionnaire and neighbourhood walkability questionnaire. This telephone interview will ask questions about the activities you did in the past week, such as housekeeping, walking and gardening as well as some questions about the neighbourhood in which you live. You will be asked not to consult your activity logbook during this interview. The interview will only take about 20 minutes. On this same day, the activity monitor and logbook will be picked up from you at your convenience.

In order to better describe people in our study, we ask for your permission to access your records kept at the CCAA. Specifically, we would like to access your information collected as part of your most recent fitness appraisal and stress test.

What are the risks and discomforts to you if you participate?

While wearing the activity monitor it is possible that the elastic band it is attached to could cause chafing (particularly if you wear it under your clothes rather than over top). Although unlikely, please stop wearing the activity monitor if any discomfort such as this occurs and inform study staff. Other than this potential for physical discomfort, there are no other known risks to your participation in this study.

What are the benefits to you if you participate?

You may benefit by increasing your daily physical activity as a result of the study, however, there is no guarantee that you will benefit because you are already active since you attend a regular exercise program.

Voluntary Participation

Participation in this study is voluntary. You may refuse to participate, refuse to answer any questions or withdraw from the study at any time with no effect on your future participation in exercise programs at the CCAA. The decision to participate, or not participate, is solely up to you. You may withdraw at any point in the study; however, any information collected up to that point may still be used in the study. If you are participating in another study at this time, please inform those study investigators right away to determine if it is appropriate for you to participate in this study.

Privacy & Confidentiality

Your confidentiality will be respected. If the results of the study are published, your name will not be used. Your information will be locked in a cabinet in a secure office of which only investigators and research staff are granted access. Once we have completed the study we will destroy all documents that contain any of your personal information (for example your name or address) and within five years of our study completion, we will destroy all remaining study documents including hard copies of your information (for example questionnaires) and electronic data. Representatives of The University of Western Ontario Health Sciences Research Ethics Board may contact you or require access to your study-related records to monitor the conduct of the research.

Other pertinent information

If you would like to receive a copy of the overall results of this study please inform a study staff member at your first appointment. You do not waive any legal rights by signing the consent form. You will be given a copy of this information/consent document once it has been signed. If, during the course of this study, new information becomes available that may relate to your willingness to continue to participate, this information will be provided to you by the investigator.

If you have any questions or concerns regarding this study, please contact **Dr. Gareth Jones, Ph.D., School of Occupational Therapy, University of Western Ontario, or Caitlin Brandon, M.Sc. Cand., Health & Rehabilitation Sciences, University of Western Ontario.**

If you have any questions about the conduct of the study, or your rights as a research participant you may contact the Director of the Office of Research Ethics (519) 661-3036, email ethics@uwo.ca.

Thank you for taking the time to read this document.
Sincerely,

Gareth Jones, Ph.D.

Caitlin Brandon, M.Sc. Candidate

Mark Speechley, Ph.D.

Jason Gilliland, Ph.D.

Kristian Larsen, M.A. Candidate

CONSENT:

Project Title: **Effect of Climate on the Physical Activity of**

Community-Dwelling Older Adults

Study Investigators: **Dr. Gareth Jones, Dr. Mark Speechley,**
Dr. Jason Gilliland
The University of Western Ontario &
The Canadian Centre for Activity and Aging

I have read the Information/Consent document, have had the nature of the study explained to me and I agree to participate. All questions have been answered to my satisfaction.

Participant:

Signature ______________________

Name (*Printed*) ____________________

Date ________________________

Person Explaining Informed Consent:

Signature ______________________

Name (*Printed*) ____________________

Date ________________________

APPENDIX V
Physical Activity Logbook

Activity Logbook - Monitoring of your Daily Physical Activity

ID#________________ Start Date: ______________ End Date: __________________

Over the next 7-consecutive days please report any physical activity that you would consider significant such as attending an exercise class, going for a walk, doing heavy outdoor work, recreational activities, and any seasonal activities, etc. Indicate the approximate time you started and ended the activity and indicate the intensity of the activity as easy (E), moderate (M), or hard (H). Additionally, please write down what type of activity (e.g. light housework, shopping, preparing lunch, watching TV, walking, etc.) you were doing at these three specific times: (1)______________, (2)________________, (3)______________. Finally, please indicate for each day the time you put the monitor on and anytime you took the monitor off.

	SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
AM							
PM							
After 6PM							

Report any irregularities to your typical physical activity pattern this week compared to last week or last month. For example you may not have felt well one day and decided to rest at home rather than work outside or attend exercise class.

Sunday: ____

____

____

Monday: ____

____

____

Tuesday: ____

____

____

Wednesday: ____

____

____

Thursday: ____

____

____

Friday: ____

____

____

Saturday: ____

____

____

You are scheduled to have this activity logbook and the activity monitor returned to Elborn College or picked up from your place of residence on _______________. If you have any questions please contact Caitlin Brandon. Thank you for your time.

APPENDIX VI
Baseline Questionnaire

Baseline Questionnaire - Effect of Climate on Physical Activity

The purpose of this questionnaire is to gather information that can be used to describe people participating in our research study. Your name will not be used in any presentation of our results.

The first part of this questionnaire asks you about your: general health, overall level of physical activity, memory and any falls you may have experienced. By health, we mean not only the absence of disease or injury but also physical, mental and social well-being. Please answer all of the questions to the best of your ability – there are no right or wrong answers!

For the following 5 questions, please mark one answer only:

1. In general, how would you **rate your health?** Would you say it is...

☐ Excellent

☐ Very Good

☐ Good

☐ Fair

☐ Poor

2. From the following list, what best describes **your activity level**?

☐ Vigorously active for at least 30 minutes, 3 times per week (examples include: exercise program, brisk walking, tai chi and swimming)

☐ Moderately active at least 3 times per week (examples include: gardening, walking and housework)

☐ Seldom active, preferring more sedentary activities (examples include: reading, playing cards and watching television)

3. Compared to **other people your own age**, do you think you are:

☐ Much more active

☐ More active

☐ About as active

☐ Less active

☐ Much less active

4. Compared to **other people your own age**, do you think your memory is:

☐ Much better

☐ Better

☐ About the same

☐ Worse

☐ Much worse

5. Compared **to yourself 5 years ago**, do you think that your memory is:

☐ Much better

☐ Better

☐ About the same

☐ Worse

☐ Much worse

For the next 2 questions, please record your best estimate.

6. **How many times have you fallen** in the **past year**? By 'falling' we mean coming to rest unintentionally on the floor or ground.

Number of Falls in Past 12 months: ___________________

7. How many of those falls resulted in an **injury** that required you to see a **doctor**?

Number of Fall-related injuries in Past 12 months: ____________

Please answer the following 3 general questions about yourself by marking one answer only for each question. Remember that your responses are entirely confidential.

8. What is your **marital status**?

☐ Married

☐ Living common-law

☐ Widowed

☐ Separated

☐ Divorced

☐ Single, never married

9. What is the **highest level of education** that you have ever attained?

☐ Some elementary or high school

☐ High school diploma

☐ Some post-secondary education

☐ Post-secondary degree, certificate or diploma

10. In general, how do your **finances** usually work out at the end of the month? Do you find that you:

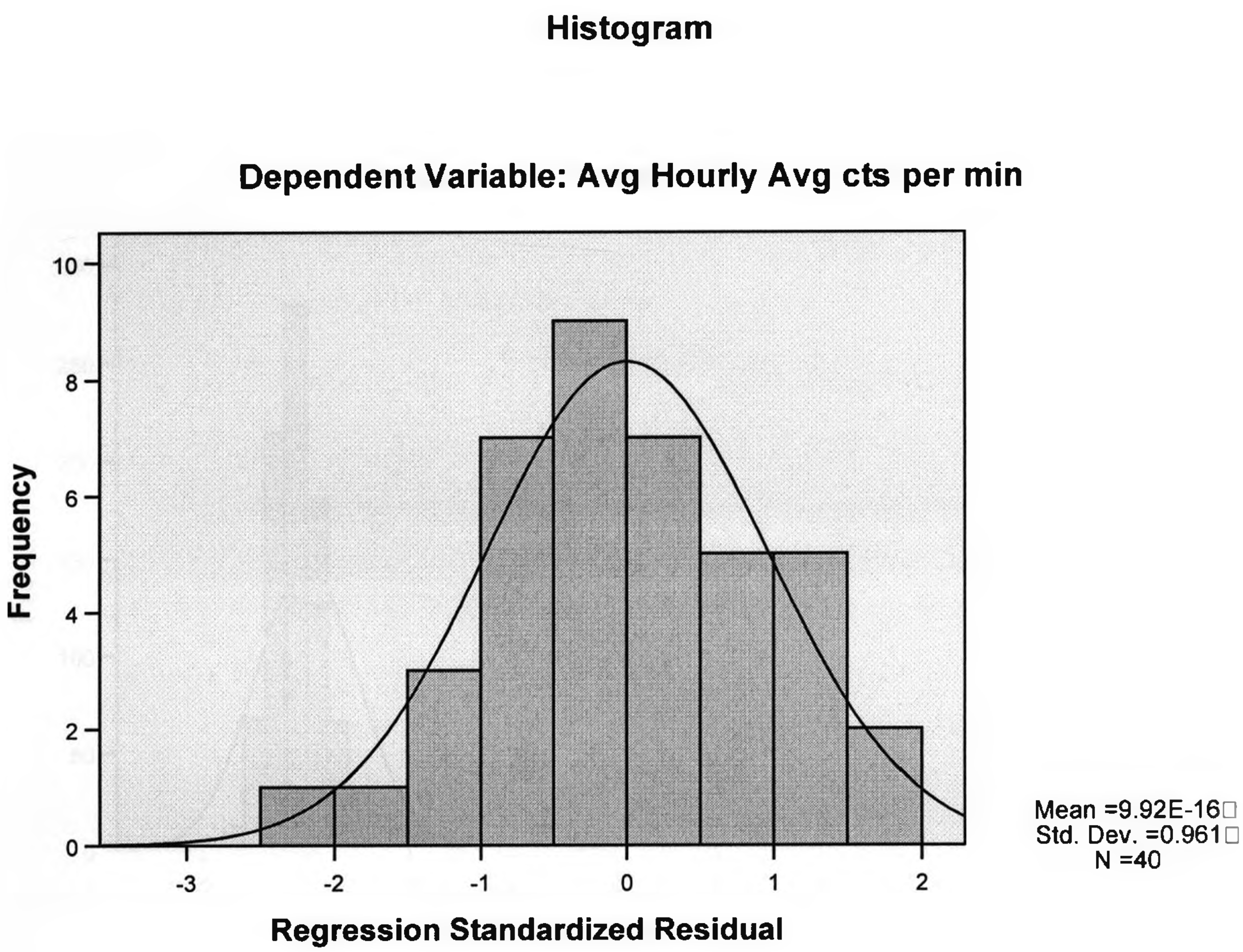
☐ Usually end up with some money left over

☐ Have just enough to make ends meet

☐ Do not have enough money to make ends meet

Thank you for completing this questionnaire!

APPENDIX VII
Histogram of Regression Standardized Residuals (Summer sample)



APPENDIX VIII

Histogram of Regression Standardized Residuals (Winter sample)