



Research Institute
Healthy Active Living and Obesity Research

Institut de recherche
Recherche sur les saines habitudes de vie et l'obésité

ACCEL+ Version 1.0 User Guide

Actical Accelerometer Data Analysis Support Tool:
Harmonizing with the Canadian Health Measures Survey

Prepared By:

Rachel Colley, PhD

Healthy Active Living and Obesity Research Group
Children's Hospital of Eastern Ontario Research Institute
Ottawa, Ontario

November 2012

DISCLAIMER: This program is provided as a resource only and users are responsible for the results obtained using this product.

Executive Summary

In January 2011, Statistics Canada published two papers from the Canadian Health Measures Survey (CHMS) which profiled the physical activity levels of Canadian adults and children, measured by accelerometer [1,2]. These publications were preceded by publications relating to quality control, data reduction and analytical procedures for these data [3-5].

Despite detailed methodology in the physical activity papers [1,2], a background paper on data reduction and analytical procedures [3], several methodological papers on physical activity intensity cut-points [4-8], and a data user guide [9], there is still a gap in the information available to researchers who want to analyze their own Actical data in a way that is harmonized with the CHMS. The purpose of Accel+ is to provide the annotated SAS code required to convert raw count and step data from the Actical accelerometer into physical activity and sedentary behaviour derived variables. Intermediate knowledge of SAS is recommended.

Suggested Citation

Colley RC. *Actical Accelerometer Data Analysis Support Tool: Harmonizing with the Canadian Health Measures Survey (Accel +)*. Available at: www.halloresearch.ca/accel. Accessed: [Enter Date].

Acknowledgements

The following individuals contributed to this project:

Didier Garriguet, Health Analysis Division, Statistics Canada

Glenn Glover, System Engineering Division, Statistics Canada

Elyse Labonte, Statistical Information Systems Division, Statistics Canada

Janine Clarke, Health Statistics Division, Statistics Canada

Table of Contents

	Page Number
Executive Summary, Suggested Citation and Acknowledgements	2
List of Tables, Figures, Acronyms	4
The Canadian Health Measures Survey	5
Objective Measurement of Physical Activity in the Canadian Health Measures Survey	5
Accelerometer Data Reduction Decisions	6
Harmonization in Analysis	7
The SAS Code Files	8
Input and Output Files	8
Variable Dictionary	9
Getting Set Up	11
Critical Analytical Steps	11
Special Considerations for Assessing the Physical Activity Guidelines	13
References	15

List of Tables and Figures

	Page Number
Table 1: Summary table of physical activity intensity cut-points used in Cycle 1 of the CHMS.	7
Table 2: Summary of input and output files.	8
Table 3: Names and descriptions of variables by code file not including temporary variable names.	9
Table 4: Steps requiring user input in the analysis process.	11
Figure 1: Summary of analytical steps for accelerometry data analysis.	8

Acronyms

CHMS – Canadian Health Measures Survey

CPM – Counts per Minute

MVPA – Moderate-to-Vigorous Physical Activity

VPA – Vigorous Physical Activity

MPA – Moderate Physical Activity

LPA – Light Physical Activity

Background

The Canadian Health Measures Survey

The Canadian Health Measures Survey (CHMS) is a nationally representative survey that covers the Canadian population living in private households. Cycle 1 was collected at 15 sites on 6-79 year olds between March 2007 and February 2009. Details of the survey design, sampling and ethical considerations are available elsewhere [10-12]. Residents of Indian Reserves or Crown lands, institutions and certain remote regions, and full-time members of the Canadian Forces are excluded. Approximately 96% of Canadians are represented. The survey involved an interview in the participant's household and a visit to a mobile examination centre where they underwent a series of physical measurements. Ethics approval to conduct the survey was obtained from Health Canada's Research Ethics Board [10]. Informed written consent was obtained from all respondents. Participation was voluntary; respondents could opt out of any part of the survey at any time.

Objective Measurement of Physical Activity in the Canadian Health Measures Survey

Measurement Procedures

Upon completion of the mobile examination centre visit, ambulatory participants were asked to wear an Actical accelerometer (Phillips – Respironics, Oregon, USA) over their right hip on an elasticized belt for 7 days. The monitors were initialized to start collecting data at the first occurrence of midnight following the clinic appointment. Participants were asked to wear the device during their waking hours. All data were blind to participants while they were wearing the device. The monitors were returned to Statistics Canada in a prepaid envelope, where the data were downloaded and the monitor was checked using a custom-built calibrator to determine if it was still within the manufacturer's calibration specifications [3].

Measurement Device

The Actical (dimensions: 2.8 x 2.7 x 1.0 centimetres; weight: 17 grams) is designed to measure and record time-stamped acceleration in all directions, providing an indication of the intensity of physical activity. The digitized values are summed over a user-specified interval of either 15, 30

or 60 seconds. All data in cycles 1 and 2 were collected in 60-sec epochs, therefore the units of the raw data were counts per minute (cpm). Accelerometer signals are also translated into steps accumulated per minute. The Actical has been validated to measure physical activity in adults [7] and children [6,8] and step counts in adults and children [13]. A new daily step count target was recently published for children and youth [14] and for preschool-aged children [15].

Accelerometer Data Reduction Decisions

There are several data reduction decisions that are embedded within the Accel+ code. Users should note that alterations to these data reduction steps can markedly affect the derived variables. Researchers using Accel+ with their own data are encouraged to gain a solid understanding of the implications of changing these data reduction steps and outline the steps clearly in their own methods documentation. The critical data reduction steps are listed below with the specification used in cycle 1 of the CHMS [1,2].

- Epoch Length: The data in cycle 1 and 2 of the CHMS were collected in 60-sec epochs.
- Wear Time: Wear time was determined by subtracting nonwear time from 24 hours. Nonwear time was defined as at least 60 consecutive minutes of zero counts, with allowance for 2 minutes of counts between 0 and 100.
- Valid Day: A valid day was defined as having 10 or more hours of wear time.
- Intensity Cut-Points: The cut-points used in the cycle 1 papers [1,2] are summarized in Table 1.

Table 1: Summary table of physical activity intensity cut-points used in Cycle 1 of the CHMS.

Intensity	Metabolic Equivalents (METs)	Example	Accelerometer Count Range (cpm): Adults (20-79 years)	Accelerometer Count Range (cpm): Children and Youth (6-19 years)
Sedentary	1 to less than 2	Car travel, sitting, reclining, standing	Less than 100 [5]	Less than 100 [5]
Light	2 to less than 3	Walking less than 3.2 km/h, light household cleaning, cooking, light play	100 to less than 1,535 [4,5]	100 to less than 1,500 [5,8]
Moderate	3 to less than 6	Walking more than 3.2 km/h, bicycling for pleasure, aerobics	1,535 to less than 3,962 [4]	1,500 to less than 6,500 [8]
Vigorous	6 or more	Jogging, running, competitive team sport participation	3,962 or more [4]	6,500 or more [8]

Harmonization in Analysis

The National Health and Nutrition Examinations Survey (NHANES) started collecting accelerometer data in 2003-2004 using the Actigraph accelerometer (Actigraph, Pensacola, FL). The National Cancer Institute posted the SAS code online to assist researchers working with the 2003-2004 NHANES accelerometry file (http://riskfactor.cancer.gov/tools/nhanes_pam/) [16]. This SAS code was the basis of the first accelerometer results published from the NHANES survey [17]. The SAS code was written for the Actigraph accelerometer, therefore the primary goal of the current project was to build upon that work to create a similar resource for researchers working with Actical data. The portions of the code which are consistent with the NCI code include the derivation of wear time and the calculation of time spent in moderate and vigorous activity (both non-bout and activity accumulated in bouts).

Data Reduction & Analysis

The SAS Code Files

The figure below depicts the 4 separate code files that are available in Accel+.

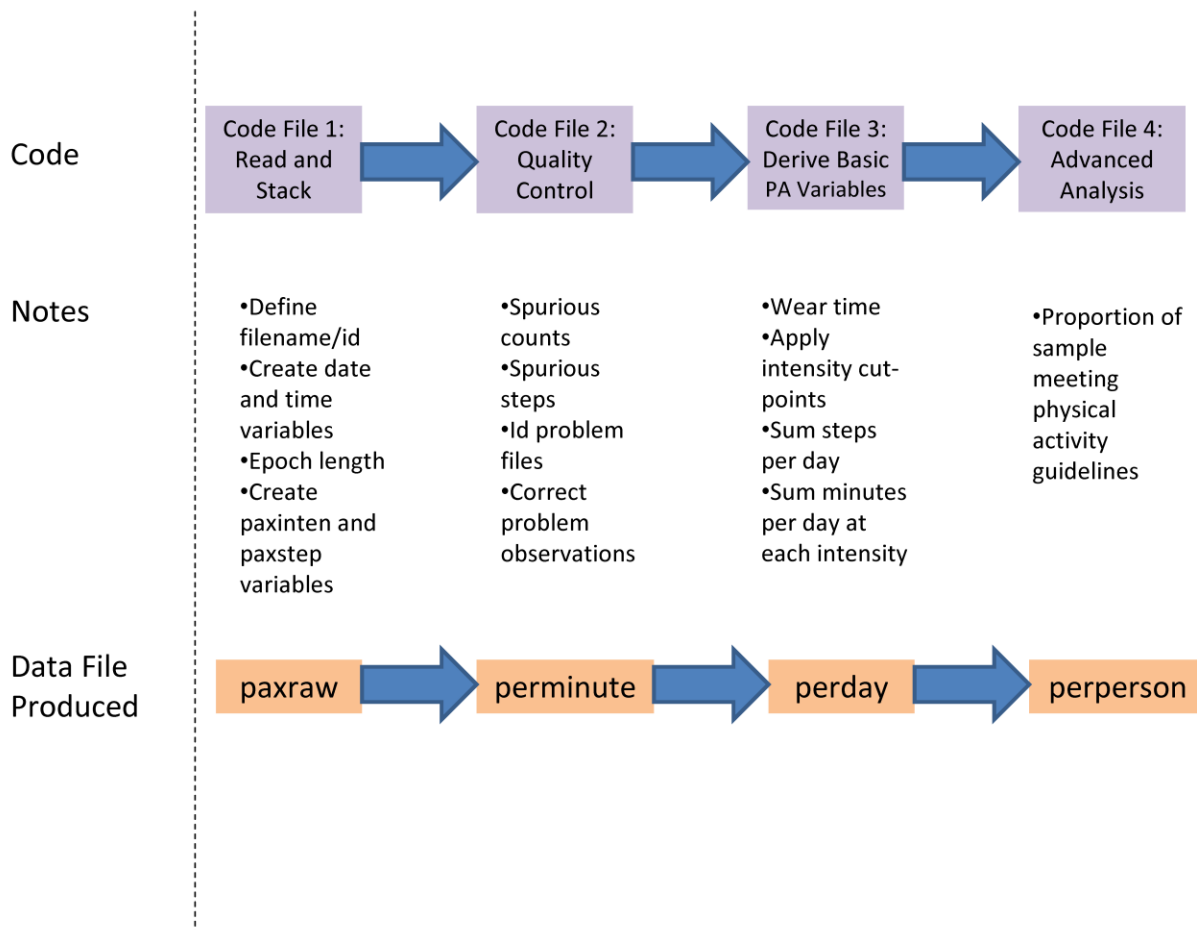


Figure 1: Summary of analytical steps for accelerometry data analysis.

Input and Output Files

Table 2: Summary of input and output files.

	Input File(s)	Output File
Code File 1	Multiple raw .awc files	paxraw
Code File 2	paxraw	perminute
Code File 3	perminute	perday
Code File 4	perday	perperson

Variable Dictionary

Table 3: Names and descriptions of variables by code file, not including temporary variables.

Code File	Variable Name	Variable Description
Code File 1	seqn	Respondent identification number
	am_identify_no	Respondent identification number that was entered during Actical initialization process
	am_strt_date	Start date that was entered during Actical initialization process
	date	New SAS date variable created from am_strt_date
	am_strt_time	Start date that was entered during Actical initialization process
	am_epoch	Epoch length that was entered during Actical initialization process (1, 2 or 4)
	am_serial_no	Actical serial number
	paxn	Observation number (i.e., 1 through 10,080 in a 7-day file with epoch set at 60-sec)
	paxinten	Accelerometer count value
	paxstep	Accelerometer step value
	day	Sequential day (1-7)
	paxhour	Hour of day (0-23)
	paxminut	Minute of hour (0-59)
	paxday	Day of the week (i.e., Sunday (1) through Saturday (7))
Code File 2	clinicid	Renamed “seqn”
	amcount	Renamed “paxinten”
	amstep	Renamed “paxstep”
	dayworn	Renamed “day”
	hour	Renamed “paxhour”
	minute	Renamed “paxminut”
	dayofweek_worn	Renamed “paxday”
	obsn	Renamed “paxn”
	wear_hr	Wear time (hours)
Code File 3	ltthresh	Light threshold
	modthresh	Moderate threshold
	vigthresh	Vigorous threshold

	tot_dur_sed1	Total sedentary time including all minutes (not including wear time zeros)
	tot_dur_lt1	Total LPA including all minutes
	tot_dur_m1	Total MPA including all minutes
	tot_dur_v1	Total VPA including all minutes
	tot_dur_mv1	Total MVPA including all minutes
	tot_dur_m	Total MPA (10-min bouts)
	tot_dur_v	Total VPA (10-min bouts)
	tot_dur_mv	Total MVPA (10-min bouts)
	newsed	Total sedentary time including wear time zeros plus any observations between 0 and 99 cpm
Code File 4	wear_hr_avg	Average number of wear hours on valid days
	tot_cnt_wr_avg	Average total counts on valid days
	tot_dur_mv_avg	Average minutes of MVPA (10-min bouts) on valid days
	tot_dur_m_avg	Average minutes of MPA (10-min bouts) on valid days
	tot_dur_v_avg	Average minutes of VPA (10-min bouts) on valid days
	tot_dur_mv1_avg	Average minutes of MVPA on valid days
	tot_dur_m1_avg	Average minutes of MPA on valid days
	tot_dur_v1_avg	Average minutes of VPA on valid days
	tot_dur_lt1_avg	Average minutes of LPA on valid days
	newsed_avg	Average minutes of sedentary time on valid days
	amstep_avg	Average steps on valid days
	valdays	Number of valid days
	n_active	Number of active days according to daily criteria
	week_criteria	Follows the weekly guideline criteria
	prob_day_criteria	Probability of adherence to the daily guideline criteria
	step_criteria	Follows the step count criteria

Getting Set Up

Before analyzing your accelerometry data, there are a few simple steps that will prevent errors in the analysis and allow for easier trouble-shooting later on. Save all of your raw .AWC files in a single folder and create an input data set name for it to be entered into your SAS code where indicated in Code File 1. Ensure that all your files are named using numerical values only and that the number of digits in the id name is consistent. Create an output folder and specify the path within the code where indicated.

Critical Analytical Steps

The 4 code files are relatively simple to use with the exception of a few critical steps that must be addressed by the user. Default values are in place; however, you are likely going to change many of these depending on your population (e.g., children vs. adults). The critical steps listed in Table 4 should be carefully reviewed and considered prior to running the code. More detail is available within the code files themselves about each these steps. These steps are all located at the start of each Code File. After the critical steps are complete, you will see the following text:

```
"/***IMPORTANT!!! FROM THIS POINT FORWARD, YOU SHOULD NOT NEED TO CHANGE ANY CODE*****/"
```

Table 4: Steps requiring user input in the analysis process.

Code File	Critical Step Number	Description
Code Step 1	1.1	Tell SAS where your raw data are stored and where you want your output files to go <pre>%let pi_path1 = A:\Insert path here to your raw AWC files; %let po_path1 = B:\Insert path here for your output; %let po_path2 = B:\Insert path here for your output\Reports;</pre>
	1.2	Set file identification length. The default is set at “4”. Adjust this number to fit with the length of your file identification numbers (e.g., if your ID numbers are 3 digits, change the “4” to a “3”).
Code Step 2	2.1	Tell SAS where you want your output files to go. This is likely the same as what you specified in Code File 1.
	2.2	Spurious thresholds are set at 20,000 cpm for accelerometer counts and 253

		steps·min ⁻¹ for step counts. They can be changed at this step if you wish.
	2.3	<p>The wear time interruption period used in the CHMS was 60 minutes and this is consistent with the way the 2003-2004 NHANES data were analyzed [16,17]. If you wish to change this (might be desired in younger age groups), a single number needs to be altered.</p> <p>The wear time criteria is set to 10 hours per day. If you want to change this, this needs to be altered here and again in Code File 4 (see Step 4.2).</p>
Code Step 3	3.1	Tell SAS where you want your output to go.
	3.2	This is where you can specific physical activity intensity cut-points. The defaults are set for children [8].
	3.3	Specify where you want to have your summary perday dataset output to an Excel spreadsheet and what you want to call it.
Code Step 4	4.1	Specify whether you are analyzing adult or child/youth data. The choice will tailor the output so that you get the results for the appropriate physical activity guideline.
	4.2	Tell SAS where you want your output to go.
	4.3	Be default, a valid day is set to 10 hours per day. This is a repeat check of step 2.3.
	4.4	Specify the criteria for the assessment of physical activity guidelines. For adults, the code assesses whether people accumulate the equivalent of 150 minutes a week of MVPA accumulated in bouts. Adjustment is made for people with less than 7 days of data. For children and youth, the code assesses the probability of adherence to accumulating at least 60 minutes on at least 6 days per week. See the “Special Considerations for Assessing the Physical Activity Guidelines” on page 13.
	4.5	Specify step count criteria. By default, it uses 12,000 steps per day on average [14]. This should be changed to 10,000 if you are working with adults or 6,000 if you are working with preschool-aged children [15].
	4.6	Specify where you want to have your summary perperson dataset output to an Excel spreadsheet and what you want to call it.

Special Considerations for Assessing the Physical Activity Guidelines

Code Step 4 provides SAS code to assess adherence to the current physical activity guidelines. There are some important considerations to understand about how this is done.

Adults (18-64 years):

Guideline: To achieve health benefits, adults aged 18-64 years should accumulate at least 150 minutes of moderate- to vigorous-intensity aerobic physical activity per week, in bouts of 10 minutes or more.

The challenge with assessing the adult guideline is that many respondents, if not most, will not have 7 valid days of data. This makes it therefore inappropriate to do a simple sum of minutes of MVPA as the number of days available will vary between people. The SAS code provided uses the average MVPA per valid day and determines if this is greater than or equal to 150 minutes divided by 7 days (21.43 minutes). In other words, we have converted the weekly target into a daily target to allow for the reality that we will often have respondents with less than 7 days of data.

Children (5-11 years) and Youth (12-17 years):

Guideline: For health benefits, children aged 5-11 years and youth aged 12-17 years should accumulate at least 60 minutes of moderate- to vigorous-intensity physical activity daily.

Similar to in adults, assessing the child/youth guideline is challenging because of the occurrence of files that do not have 7 valid days of data. Further, assessing “daily” adherence to something is very difficult because even if a child accumulates 60 minutes of MVPA on 7/7 days, it does not necessarily mean they will do so every single week. This challenge was overcome in both the NHANES [17] and CHMS [2] publications. A Bayesian approach was used to incorporate information from all individuals with 4 or more valid days. An individual’s probability of being active at least 6 days out of 7 days was estimated using a Beta distribution for its observed combination of active and wear days. The estimated population prevalence was derived as the weighted average of these individual probabilities [2,17].

The SAS code provided takes this same approach which may or may not be appropriate for every analysis. This approach works well for estimating population level adherence (the average probability becomes the proportion of the population who is meeting the guideline); however, may not be as appropriate with a small sample size where you want to know on a "yes/no" basis whether your respondents achieved the guideline or not. An individual probability is really telling you that a given individual has a x% likelihood of accumulating at least 60 minutes of MVPA on at least 6 days out of 7. In a smaller study where you have good compliance, it may be more useful to look at the perday file (output of Code Step 3) as you will be able to see how many days an individual accumulated greater than or equal to 60 minutes of MVPA.

References

1. Colley RC, Garriguet D, Janssen I, Craig CL, Clarke J, Tremblay MS. Physical activity of Canadian adults: Accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Reports* 2011, 22(1):1-14.
2. Colley RC, Garriguet D, Janssen I, Craig CL, Clarke J, Tremblay MS. Physical activity of Canadian children and youth: Accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Reports* 2011, 22(1):15-23.
3. Colley RC, Gorber SC, Tremblay MS. Quality control and data reduction procedures for accelerometry-derived measures of physical activity. *Health Reports* 2010, 21(1):63-69.
4. Colley RC, Tremblay MS. Moderate and vigorous physical activity intensity cutpoints for the Actical accelerometer. *Journal of Sports Sciences* 2011, 29(8): 783-789.
5. Wong S, Colley RC, Connor Gorber S, Tremblay MS. Actical accelerometer sedentary activity thresholds for adults. *Journal of Physical Activity and Health*. 2011, 8:587-591.
6. Evenson K, Catellier D, Gill K, Ondrak KS, McMurray RG. Calibration of two objective measures of physical activity for children. *Journal of Sports Sciences*. 2008, 26:1557–1565.
7. Heil DP. Predicting activity energy expenditure using the Actical activity monitor. *Research Quarterly for Exercise and Sport* 2006, 77: 64-80.
8. Puyau MR, Adolph AL, Vohra FA, Zakeri I, Butte NF. Prediction of activity energy expenditure using accelerometers in children. *Medicine and Science in Sports and Exercise* 2004, 36(9):1625-1631.
9. Statistics Canada. Canadian Health Measures Survey (CHMS) Data User Guide: Cycle 1, 2010. Available at: http://www.statcan.gc.ca/imdb-bmdi/document/5071_D2_T1_V1-eng.pdf. Accessed July 4, 2011.

10. Day B, Langlois R, Tremblay MS, Knoppers B-M. Canadian Health Measures Survey: Ethical, legal and social issues. *Health Reports* (Statistics Canada, Catalogue 82-003) 2007, 18:37-51.
11. Giroux S. Canadian Health Measures Survey: Sampling strategy overview. *Health Reports* (Statistics Canada, Catalogue 82-003). 2007, 18(Suppl):31-36.
12. Tremblay MS, Wolfson M, Connor Gorber S. Canadian Health Measures Survey: background, rationale and overview. *Health Reports* (Catalogue 82-003) 2007; 18(Suppl):7-20.
13. Esliger DW, Probert A, Connor Gorber S, Bryan S, Laviolette M, Tremblay M.S. Validity of the Actical accelerometer step-count function. *Medicine and Science in Sports and Exercise* 2007, 39:1200-1204.
14. Colley RC, Janssen I, Tremblay MS. Daily step target to measure adherence to physical activity guidelines in children. *Medicine and Science in Sports and Exercise* 2012, 44(5):977-982.
15. Gabel L, Proudfoot NA, Obeid J, Macdonald MJ, Bray SR, Cairney J, Timmons BW. Step count targets corresponding to new physical activity guidelines for the early years. *Medicine and Science in Sports and Exercise* 2012, Oct 2 [Epub ahead of print].
16. National Cancer Institute. SAS Programs for Analyzing NHANES 2003-2004 Accelerometer Data. Available at: http://riskfactor.cancer.gov/tools/nhanes_pam/. Accessed: November 1, 2012.
17. Troiano R, Berrigan D, Dodd K, Masse LC, Tilert T, McDowell M. Physical activity in the United States measured by accelerometer. *Medicine and Science in Sports and Exercise* 2008, 40(1):181-188.