ACTIVE LIVING RESEARCH ACCELEROMETER PROCESSING WORKSHOP

DETAILS OF PROGRAMS TO PROCESS ACCELEROMETER DATA

SOFTWARE NAME	MeterPlus
Summary	
Features/ Benefits	Batch processing, age-specific scoring (based on different cut-points for each age), flexible output, quick screen for valid wearing time in list format
Functions	Screens for valid wearing time, produces summary values of time spent in different activity intensities by the hour, day and total. Codes data for valid and not valid wearing time. Summarizes bouts and EE (version 4).
Strengths/weaknesses	Strengths: User interface to screen raw data files for valid wearing time, batch processing, age-specific scoring, flexibility in cut-points, flexibility in identifying non-wearing time, flexible output. Version 4 will have time filters, EE and bouts. Weaknesses: Limited epoch lengths, data must be manually checked for meter malfunction.
Costs	To be determined
Training/Manual availability	Yes/Yes
Devices used with/compatible with	Actigraph GT1M, 256, 7164
Last update date	2/7/08 (version 3); 9/1/08 (expected date for version 4)
Contact person and details	Kelli Cain (kcain@projects.sdsu.edu)
Filtering	
Epoch options	30, 60 (version 3); 10, 30, 60 (version 4)
How is data viewed such as when screening for valid wearing time?	In a list format with date, valid hours (user-defined), and Valid day (yes or no). Raw data can be viewed by clicking on date.
How is invalid data handled (exported, coded as invalid, imputations?)	Program can identify strings of zeros (user-defined) and code in output. Valid days coded in output based on user-defined criteria.
Outlier filters	No, but could create activity category for high values and exclude this way.
Equations used	EE: Freedson, Work Energy Theorem, or combination (version 4)
Count cut off options (fixed, multiple simultaneously, age?)	No limit on number of categories created. Cut-points can be changed. Can store multiple profiles for age-specific scoring or different intensity thresholds. Multiple profiles can be applied in same batch.
Is batch processing supported	Yes, no limit.
Other filter options (e.g. time of day)	Option to filter out times of day (version 4). User defines up to 50 periods of time per file.
Output Options	
Fields/variables exported	Can parse file name into variables, file name, unit serial number, date and day of week, hourly, daily and sum in each category, total valid days, valid hours, valid hours in valid

	days, counts. Option to include only valid days or both valid and invalid days (separate sets of variables). EE and bout output (version 4).
Option to filter output	Yes, user can select hourly, daily or summary with option for valid days only. User chooses to include EE and bouts (version 4) and can refine output by using time filters (version 4).
Output format (CSV, Tabs, SPSS, SAS)	CSV and syntax to import into SPSS.
Activity bouts, EE?	Bouts (version 4): User-defined bout length, threshold & tolerance. Output is number of bouts (hourly, daily, sum), epochs in bouts (hourly, daily, sum), start and end times, average length (daily, sum). EE (version 4): User chooses one of 3 equations. User has option to link to weight file. Output is daily and total, by activity category, mean and peak.
Other	
Programming language, operating system	Stand-alone Windows application (programmed in C# using .net framework)
Study uses to date	Neighborhood Quality of Life Study (Adult and Senior), Neighborhood Impact on Kids Project, PACE studies – used to screen and analyze data.

SOFTWARE NAME	
Summary	
Features/ Benefits	For Actigraph files Batch processing (100's files at once)Uses raw data files when possible (fewer intermediate processing steps) Easy to modify cut-pts and prediction equations and re-score all data records Includes automated checks for common technical problems
Functions	
Strengths/weaknesses	
Costs	SAS License
Training/Manual availability	No
Devices used with/compatible with	Actigraph, RT3, activPAL
Last update date	Continuously updating
Contact person and details	charles.matthews@vanderbilt.edu
Filtering	
Epoch options	Adjustable (eg, 10, 30, 60 s)?
How is data viewed such as when screening for valid wearing time?	We use the NHANES algorithm to estimate wearing time, and use time values to identify valid days.
How is invalid data handled (exported, coded as invalid, imputations?)	Excluded
Outlier filters	Yes

Equations used	Freedson, Crouter, Swartz
Count cut off options (fixed, multiple simultaneously, age?)	Multiple cut-points for sedentary, light, moderate, and vigorous activity.
Is batch processing supported	Yes
Other filter options (e.g. time of day)	Not currently in use, but this could easily be added to the code.
Output Options	
Fields/variables exported	Date, wearing time, qualify control info, avg count per day, expenditure estimate, duration data by intensity (as above), steps, bout information (number bouts of specific lengths for various intensities
Option to filter output	Yes
Output format (CSV, Tabs, SPSS, SAS)	SAS, but could go to CSV, Excel, or Access easily
Activity bouts, EE?	Yes, yes
Other	
Programming language, operating system	SAS / Windows

1. **C.E. Matthews**, Hebert, J.R., Freedson, P.S., Stanek, E.J., Ockene, I.S., Merriam, P. Comparison of physical activity assessment methods in the Seasonal Variation of Blood Cholesterol Levels Study. Medicine & Science in Sports & Exercise 32(5): 976-984, 2000.

2. **C. E. Matthews**, P. S. Freedson, E. J. Stanek, III, J. R. Hebert, P. A. Merriam, M. C. Rosal, I. S. Ockene. Seasonal Variation of Household, Occupational, and Leisure-time Physical Activity: Longitudinal Analyses from the Seasonal Variation of Cholesterol Study. American Journal of Epidemiology. 153(2): 172-183, 2001.

3. **Matthews, C. E.**, B. E. Ainsworth, R. W. Thompson, and D. J. Bassett. Sources of variance in daily physical activity levels as measured by an accelerometer. Medicine & Science in Sports & Exercise. 34:1376-1381, 2002.

4. S. A. Adams, **C. E. Matthews**, C. G. Moore, J. E. Cunningham, J. Fulton, J. R. Hebert. The Effect of Social Desirability and Social Approval on Self-Reports of Physical Activity. American Journal of Epidemiology. 161(4): 389-398, 2005.

5. **C. E. Matthews**, B. E. Ainsworth, C. L. Hanby, R. R. Pate, C. Addy, P. S. Freedson, D. A. Jones, C. A. Macera, Development and Testing of a Short Physical Activity Recall Questionnaire. Medicine and Science in Sports & Exercise 37:986-994, 2005.

6. **C. E. Matthews,** S. Wilcox, C. L. Hanby, C. Der Ananian, S. P. Heiney, T. Gebretsadik., A. Shintani. Evaluation of a 12-week Home-based Walking Intervention for Breast Cancer Survivors. Supportive Care in Cancer. 15: 203-11, 2007.

7. **C. E. Matthews**, K. Y. Chen, P. S. Freedson, M. S. Buchowski, B. Beech, R. R. Pate, R. P. Troiano. Amount of Time Spent in Sedentary Behaviors – United States 2003-2004. American Journal of Epidemiology (in press); 2008.

SOFTWARE NAME	Spatial activity data processor
Summary	
Features/ Benefits	Shareware. Java code (runs in PCs and Macs with windows). Flexible. Merges accelerometer and GPS data. Automatic calculation of whether participant(s) meet PA standards.
Functions	Accelerometer epoch automatically detected. GPS epoch input.
Strengths/weaknesses	
Costs	Free
Training/Manual availability	No
Devices used with/compatible with	Tested only with Actigraph model 7164 and Foretrex 201 GPS units
Last update date	Expected march 10, 08
Contact person and details	Daniel Rodriguez, danrod@unc.edu
Filtering	
Epoch options	Yes
How is data viewed such as when screening for valid wearing time?	Wearing time assumed to be determined outside of program. Wearing time data can be exported as text file to software of choice (access, excel, SAS) and determined for re-running software.
How is invalid data handled (exported, coded as invalid, imputations?)	Coded as invalid. No imputations possible
Outlier filters	Yes
Equations used	No
Count cut off options (fixed, multiple simultaneously, age?)	Multiple, varying by day type (weekend, weekday)
Is batch processing supported	Yes
Other filter options (e.g. time of day)	n/a Can be filtered subsequently in other software (Access, Excel, SAS, etc.)
Output Options	
Fields/variables exported	Various output files. For each participant: a) meet vs. not meet PA weekly standards, MPA mins, VPA mins, MPA mins in bouts, VPA min in bouts by week. B) same as a) but by day. c) Compliance (valid days) output by day of week. d) Individual bouts of MPA and VPA , with GPS data if appropriate
Option to filter output	
Output format (CSV, Tabs, SPSS, SAS)	ASCII tab delimited
Activity bouts, EE?	Yes
Other	
Programming language, operating system	Java.
Study uses to date	Montgomery County walking Study (http://www.planning.unc.edu/ALR/) and TAAG2 study

Karolinska Institutet
Department of Biosciences and Nutrition
Unit for Preventive Nutrition
www.prevnut.ki.se

SOFTWARE NAME	PrevNut accelerometer software
Summary	
Features/ Benefits	This program was developed in the late 90´s, based upon the knowledge at that time. It is a simple program that does not allow any flexibility.
Functions	Summaries counts per hour or day, minutes in three different levels of intensities, continues time spent on one intensity, number of continues periods, total recorded time per day
Strengths/weaknesses	+ make it possible to get at least some basic variables - not flexible, not user friendly
Costs	-
Training/Manual availability	-
Devices used with/compatible with	MTI Actigraph (CSA)
Last update date	2004
Contact person and details	Maria Hagströmer, Patrick Bergman @ki.se
Filtering	
Epoch options	no
How is data viewed such as when screening for valid wearing time?	Include subjects if >x (can be manually set) minutes/day
How is invalid data handled (exported, coded as invalid, imputations?)	Excluded
Outlier filters	No, that is done manually prior to analysis
Equations used	Flexible, possible to use either
Count cut off options (fixed, multiple simultaneously, age?)	fixed
Is batch processing supported	yes
Other filter options (e.g. time of day)	no
Output Options	
Fields/variables exported	See above (total counts, time in 3 intensities etc)
Option to filter output	
Output format (CSV, Tabs, SPSS, SAS)	Microsoft Access
Activity bouts, EE?	Yes, can calculate time continues time (but does not allow for drops)
Other	
Programming language, operating system	Microsoft Access

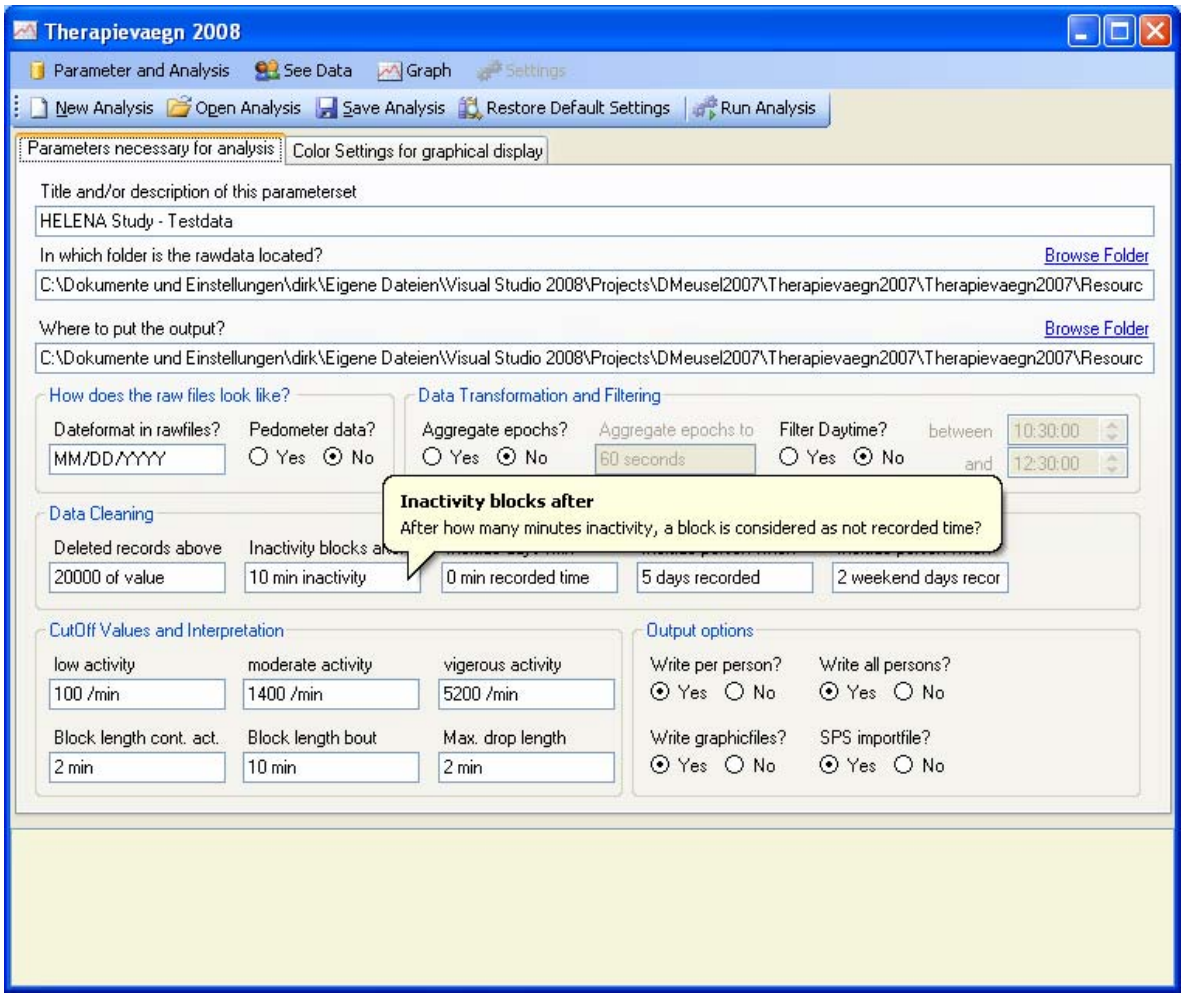
Study uses to date	Swedish studies such as method development, validation studies, EYHS (in Sweden), the ABC study etc
Citations	Yngve et al 2007 (MSSE) Hagströmer et al 2007 (MSSE) Ruiz et al 2006 and 2007 Hurtig-Wennlof et al 2005-2006 etc

Development

We have (as a part of the EU-funded, ALPHA project) started the development of a new more flexible program. This is not ready for use yet. But it will be able to analyse different epochs, use parts of the day etc.

It is based on a literature review and tries to settle a European consensus. It has an graphic component, allows summaries to be exported to Excel and SPSS, has several filtering options and allows for several cut-off value profiles to be used for analyzing various studies repeatedly.

Please find below an example of how will appear



SOFTWARE NAME	MAHUffe
Summary	
Features/ Benefits	Batch analysis Able to enter a variety of thresholds/parameters Produces hourly, daily and overall summary files and can also output 60 second epoch values
Functions	Produces summary files of hourly, daily and summary values of time spent in different intensity thresholds and also total count, count per minute and bout values Can exclude unworn data and determine valid days
Strengths/weaknesses	Strengths: Batch analysis, can enter varying intensity thresholds, exclude continuous zeros, summarize bouts, copes with various epoch lengths, summarizes over different time periods Weaknesses: Unable to summarize by weekday and weekend day or to exclude pre-determined hours from the summary (however this is possible through MS Access)
Costs	Freely available at www.mrc-epid.cam.ac.uk
Training/Manual availability	Manual/Standard operating procedure available
Devices used with/compatible with	Actigraph GT1M and Model 7164
Last update date	28th August 2007
Contact person and details	Dr Ulf Ekelund ulf.ekelund@mrc-epid.cam.ac.uk
Filtering	
Epoch options	5, 10, 15, 20, 30, 60 and 120 seconds
How is data viewed such as when screening for valid wearing time?	Individual files can be graphically viewed or summarized in Excel on a group basis. Valid wear time can be automatically screened by excluding varying numbers of continuous zeros and setting limits for valid days *a priori*.
How is invalid data handled (exported, coded as invalid, imputations?)	Options can be entered for determining valid data, varying amounts 'invalid' data can be excluded based on continuous zeros. Summary excludes data coded as missing from the calculation of cpm but it is included in sedentary time in the output.
Outlier filters	There is only an outlier filter for low numbers of counts, high outliers need to be screened manually from summary data or graphically on individual data
Equations used	Intensity threshold values can be entered by the user. PAEE can be estimated using Freedson equation. Inbuilt option to convert counts and frequency into acceleration units (G) which enables comparison between brands of monitors
Count cut off options (fixed, multiple simultaneously, age?)	Intensity threshold values can be entered by the user for sedentary, light, moderate, vigorous and very vigorous intensity activity
Is batch processing supported	Yes, up to 100 files of 10 days of data in 60 second epochs can be simultaneously processed
Other filter options (e.g. time of day)	Can be trimmed after a specified amount of continuous zeros

	at the end of a file.
Output Options	
Fields/variables exported	Number of valid days, minutes spent sedentary, active, light, moderate, vigorous, very vigorous, bouts, total counts, counts/min, valid time, steps, acceleration, optional: energy expenditure and METs
Option to filter output	Only valid days are summarized in the summary output, all data is exported in the minute-by-minute output
Output format (CSV, Tabs, SPSS, SAS)	Excel for summary files and CSV for minute by minute output
Activity bouts, EE?	The numbers of bouts are displayed in the daily and hourly summaries, the intensity of the bout can be decided and whether one or two epochs can fall below the intensity threshold. Calculation of EE is possible
Other	
Programming language, operating system	Program runs in windows, programmed in Delphi
Study uses to date	European Youth Heart Study (EYHS), The ProActive study, The SPEEDY study, The CHASE study, The Pelotas 1993 birth cohort, Physical activity and environmental determinants in Cameroon, and many more

1. Corder K, et al., Comparison of two Actigraph models for assessing free-living physical activity in Indian adolescents. *J. Sports Sci.* 2007;25:1607-1611.
2. Simmons R, Griffin S, Steele R, Wareham NJ, Ekelund U. Increasing overall physical activity and aerobic fitness is associated with improvements in metabolic risk: cohort analysis of the ProActive trial. *Diabetologia (in press)*
3. Nilsson A, Anderssen SA; Andersen LB, Froberg K, Riddoch C, Sardinha L, Ekelund U. Between and with-in day variability in physical activity and in-activity in 9- and 15-year old children. *Scand J Med Sci Sports* 2008, Feb 1 (Epub ahead of print)
4. Nyberg G, Ekelund U, Marcus C. Physical activity in children measured by accelerometry: stability over time. *Scand J Med Sci Sports* 2008, Feb 1 (Epub ahead of print)
5. Hemmingsson E, Hellenius ML, Ekelund U, Bergström J, Rössner S. Impact of social support intensity in the severely obese: a randomised clinical trial, *Obesity* (in press)
6. Nilsson A, Brage S, Riddoch C, Anderssen SA, Sardinha L, Wedderkopp N, Andersen LB, Ekelund U. Comparisons of equations for predicting energy expenditure from accelerometer counts in children. *Scand J Med Sci Sports* 2008, Jan 14 (Epub ahead of print)
7. Sardinha L, Anderson LB, Anderssen SA, Quiterio A, Ornelas R, Froberg K, Riddoch C, Ekelund U. Objectively measured time spent sedentary is associated with insulin resistance independent of overall and central body fat in 9 to 10 year old Portuguese children. *Diabetes Care* 2007 Dec 10 (Epub ahead of print)
8. Ekelund U, Anderssen SA, Froberg K, Sardinha LB, Andersen LB, Brage S. Independent associations between physical activity and aerobic fitness with metabolic risk factors in children: The European Youth Heart Study. *Diabetologia* 2007;50:1832-40
9. Ekelund U, Griffin SG, Wareham NJ. Physical activity and metabolic risk in individuals with a family history of type 2 diabetes. *Diabetes Care* 2007;30:337-342
10. Ekelund U, Särnblad S, Brage S, Ryberg J, Wareham NJ, Åman J. Does physical activity equally predict gain in fat mass in obese and non-obese young adults? *Int J Obes*. 2007;31:65-71
11. Hemmingsson E & Ekelund U. Is the association between physical activity and body mass index obesity dependent? *Int J Obes* 2007;31:663-68
12. Ekelund U, Brage S, Froberg K, Harro M, Anderssen SA, Sardinha LB, Riddoch C, Andersen LB. TV viewing and physical activity are independently associated with metabolic risk in children: The European Youth Heart Study. *PLoS Medicine* 3(12):e488 doi:10.1371/journal.pmed.0030488

13. Särnblad S, Ekelund U, Åman J. Dietary fat intake predicts one year change in body fat in adolescent girls with type 1 diabetes. *Diabetes Care*. 2006;29:1227-30

SOFTWARE NAME	N/A
Summary	
Features/ Benefits	Flexible routines in SAS allow programs to be adapted to fit specific needs of projects. Programming is done in steps with screening done first to eliminate non compliant cases and then cleaning done to address non-compliant days.
Functions	Coding is completely flexible to allow data to be reanalyzed with different compliance assumptions, different cutpoints etc…
Strengths/weaknesses	Can adapt to any monitor or data format
Costs	Variable depending on scope
Training/Manual availability	By request
Devices used with/compatible with	Any accelerometry-based monitor
Last update date	As needed
Contact person and details	Greg Welk (gwelk@iastate.edu)
Filtering	
Epoch options	Any
How is data viewed such as when screening for valid wearing time?	Customized routines are created to allow the effects of different screening conditions to be compared. Some studies may require more stringent criteria while others may necessitate maximizing sample size.
How is invalid data handled (exported, coded as invalid, imputations?)	Invalid data is coded and tracked. Missing days are omitted and averages are based on compliant days. No imputation procedures are used. I don't believe in them.
Outlier filters	Customized as needed
Equations used	Any
Count cut off options (fixed, multiple simultaneously, age?)	Any
Is batch processing supported	Yes
Other filter options (e.g. time of day)	Complete flexibility to look at discrete time periods in the day
Output Options	
Fields/variables exported	Any
Option to filter output	
Output format (CSV, Tabs, SPSS, SAS)	Any
Activity bouts, EE?	Any
Other	
Programming language, operating system	SAS
Study uses to date	**Primary in validation studies of Self-report surveys in youth**

Welk, G.J., Wickel, E., Petersen, M., Heitzler, C.D., Fulton, J.E., Poitter, L. (2007). Validity and Reliability of the Youth Media Campaign Longitudinal Survey. *Medicine and Science in Sports and Exercise*, 39(4), 612-621.

Welk, G.J., Dzewaltowski, D.A., Ryan, G.J., Sepulveda-Jowers, E.M., & Hill, J.L. (2004). Convergent validity of the Previous Day Physical Activity Recall and the *ACTIVITYGRAM* Assessment. *Research Quarterly for Exercise and Sport*, 75(4): 370-380.

SOFTWARE NAME	Pam
Summary	
Features/ Benefits	Processes data already in accelerometer
Functions	Counts minutes in various zones + Calories
Strengths/weaknesses	Strengths: easy data analysis because most is already done in device; the weight independent Pam Score (derivative of MET) makes comparison easy; internet based database. Weakness: no time information except daily totals, although newest version has also hourly data (epoch=60 min)
Costs	For research purposes software is free with devices. Devices are €50-€75/unit.
Training/Manual availability	No
Devices used with/compatible with	Pam (Kam in US)
Last update date	March 2008
Contact person and details	Dr. E. P. N. Damen, Pam bv, erikd@pam.com
Filtering	
Epoch options	Fixed epoch: in device analysis of intensity in four zones each second. Newest version also hourly averages
How is data viewed such as when screening for valid wearing time?	Bar graph on website; downloadable to excel
How is invalid data handled (exported, coded as invalid, imputations?)	Not handled
Outlier filters	None
Equations used	Correction algorithms inside device to make energy values equivalent to VO2 data
Count cut off options (fixed, multiple simultaneously, age?)	Output is not counts but real data (Pam/MET/Calories)
Is batch processing supported	No
Other filter options (e.g. time of day)	No
Output Options	
Fields/variables exported	Pam (day), Calories (day), minutes per day in four intensity zones, hourly averages
Option to filter output	None
Output format (CSV, Tabs, SPSS, SAS)	CSV
Other	
Programming language, operating system	Windows XP/Vista; Mac will be available soon
Study uses to date	Netherlands: VU Amsterdam, Maxima hospital Veldhoven, Atrium hospital Heerlen, Radboud hospital Nijmegen; Canada: Brock University
Citations	Scand. J. Med. Sci. Sports; Slootmaker et al.

SOFTWARE NAME	
Summary	
Features/ Benefits	
Functions	Calculates average counts/min, time spent, and percent of time spent in intensity levels, across all days with acceptable data, weekdays, weekends and time periods within weekdays. Output is in .txt format that can be imported into Excel or SAS.
Strengths/weaknesses	Uses raw data files. Accounts for time monitor not being worn (specified in code) and sets this data to missing. The main weaknesses are that a number of the variables (epoch length, count cutoffs, non-wearing time) are not user input, rather coded in the program.
Costs	Usually as consultant if program code needs major modifications. None if only minor changes are needed.
Training/Manual availability	Limited. I can supply an executable program that is very straightforward to use but the user would not be able to modify the program without the software package used to create the program. People either 1) send me the data and I process it and return the output or 2) give me specifics about the project (and possibly several sample data files) and I manipulate the program and create the executable file that the person can run on their own PC.
Devices used with/compatible with	ActiGraph Model 7164 and GT1M
Last update date	Ongoing
Contact person and details	John Sirard, sirar001@umn.edu
Filtering	
Epoch options	Any (can change within the program code)
How is data viewed such as when screening for valid wearing time?	I like to visually look at files first then process them through the program. I produce one output file with daily data and look for anomolies (unusually high or low minutes of VPA, etc...). I also generate a file that counts the number of non-wearing bouts by day.
How is invalid data handled (exported, coded as invalid, imputations?)	No imputation is done. Data considered to be non-wearing time is set to missing and not included in calculations for averages.
Outlier filters	The program code flags data points that are indicative of capacitor failure. I look at this data manually and decide if it was an isolated occurrence or if the entire file is corrupt
Equations used	
Count cut off options (fixed, multiple simultaneously, age?)	The cutoffs are defined within the code but easy to change. One set of cutoffs are applied at a time, not simultaneously.
Is batch processing supported	YES. The program is set up as a loop structure that processes all of the data files within a user-specified folder. It takes about 3-5 seconds per data file, depending on the length of the files.
Other filter options (e.g. time of day)	Originally designed for children and adolescents, my program also calculates outcome variables by time periods during weekdays (e.g., before, during and after school, nighttime). The definitions for these time periods are changed within the code and could apply to before, during and after work for adults

Output Options	
Fields/variables exported	Average cnts/min, Average min spent in intensity categories, Average percent of time spent in intensity categories, Average number of 10-min bouts of MVPA, Number of non-wearing bouts per day. These variables are calculated for all useable days (defined within the code as number of hours of data that need to be present to constitute a valid day of data - most often 10 hours), weekdays, and weekends. The user can then determine, in their statistical package who they want to filter out based on number of days of data.
Option to filter output	
Output format (CSV, Tabs, SPSS, SAS)	Output format (CSV, Tabs, SPSS, SAS): Text file. I usually convert this to .CSV and then use PROC IMPORT in SAS.
Activity bouts, EE?	Currently only calculate 10-min bouts of MVPA
Other	
Programming language, operating system	Visual Basic 6.0, PC operating system (VB is a MicroSoft product)