

Boutlength: Towards Identification and Presentation of Bout Lengths Using Physical Activity Counts Data

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Abstract: *Boutlength* is an open program developed in a spreadsheet environment to identify and display activity bout lengths derived from accelerometer count data. The program classifies counts into an active or inactive level based on user-defined cut-off thresholds. Using a bout qualification criterion specified by a minimum length, the program identifies, prints, sorts, and computes basic statistics on resulting valid bout string. The program was tested on a sample of actual database using cut-off values (Sedentary: < 100 counts; Activity: > 2019 counts) and bout qualification criteria (Sedentary: ≥ 5 minutes; Activity: ≥ 2 minutes). Output of the program is a display of identified Sedentary or Activity bouts depending on the application. Program's parameters are modifiable, and the script was designed in a spreadsheet software. *Boutlength* is still in development and yet it may be an interesting resource for researchers analysing bout-based physical activity pattern measures.

1 INTRODUCTION

Sedentary behaviour is associated with adverse health conditions (Bontrup et al., 2019; Millard et al., 2021; Stoner et al., 2019). Sedentary behaviour is typically assessed using metrics based on time spent in inactivity, sitting or reclining (Tremblay et al., 2017). The patterns of inactive time accumulation throughout a day are generally described in terms of bouts (Boerema et al., 2020). A bout is period of activity level above or below a certain threshold criterion (Migueles et al., 2017). While the impact of sedentary bout length on human well-being remains debatable (De Vries et al., 2022), bout length based activity evaluation remains important in physical activity (PA) research (Kuster et al., 2020).

Bout assessment has traditionally relied on self-reported estimates (Stamatakis et al., 2019) of PA patterns. Recently, it has shifted on accelerometer-measured data and devices with software from several brands including Actical, ActiGraph, and Promove3D, etc., have gained popularity in activity pattern representation (Boerema et al., 2020; Kuster et al., 2020). An increasing number of brands are offering devices and software allowing analysis of activity based on different bout data processing methods. As far as bout characteristics are concerned,

ActiGraph's accelerometers and software have become a standard in evaluation of sedentary and activity bout patterns and statistics.

ActiGraph accelerometers rely on pre-processed “counts” as indicators of movement intensity to calculate bout length statistics (LaMunion et al., 2017). The software Actilife processes raw movement intensity data to sum it over a period of measurement (Altenburg et al., 2021) into ‘counts’ of PA. To estimate a bout, an appropriate cut point is applied to call the uninterrupted window of time accumulating prescribed level of activity counts. A typical sedentary bout is a minimum 10-minute length of uninterrupted counts of <100 counts per minute (cpm) (Altenburg et al., 2015) and a few statistical derivations of sedentary bout lengths have been linked to health outcomes (Boerema et al., 2015; Leeger et al., 2019; Peterson et al., 2015).

The growing relevance of bout analysis to health indicators has led to bout length evaluation in accelerometer software. Our laboratory had a chance to test the bout calculation feature in Actigraph's Actilife program. It featured specification of cut point, minimum valid bout length, and display of basic bout length statistics such as the number, total time spent in bouts. However, it did not display a breakdown of individual bout lengths scanned from the input count data. While Actilife's bout summary

statistics are useful enough, it did not print individual bout lengths in its output. We navigated the software to best of our ability but could not find the feature to show the length of each bout in the Actilife package (ver. 6.13.4) at our disposal.

To address this gap, we developed and tested a program, *BoutLength*, aimed to compute and display the length of each bout from counts data. The program transforms each count into two activity levels based on a cutoff or threshold specification. It then scans for consecutive sequences of a specified level to compute and display series of valid bouts using a bout qualification criterion. We tested the program's capability using actual counts database developed as part of the work in progression by Khan et al. (2023). By classifying each indexed count as per Troiano et al. (2008) into 0 (<100: Sedentary) or 1 (>2019: moderate to vigorous), *Boutlength* identified respective bouts by summing the length of classified sequences. The program can compute and display individual bout lengths and basic bout statistics on counts distributed over any unit of time, cutoff threshold, or desired bout qualification criteria. With the bout length breakdown printed on screen, users can conveniently derive additional statistics by making minor additions to the program built within the popular spreadsheet environment.

2 METHODOLOGY

The program was scripted in a standard Microsoft Excel Macro framework with runtime libraries enabled to allow single-click execution. To ensure that the program functions as expected, it is important to refer the data columns in the macro script correctly. For instance, the first column in the sheet may contain time index with the counts vector in the second column. The third column has classified activity levels (e.g., '1' indicating counts < 100 and '0' indicating counts > 100). The fourth column shows an index of the bout number, and the fifth column displays bout length computed by the program. The sixth column has sorted bout lengths printed in ascending order. Successive columns may display bout statistics calculated from the bout series. It may be appropriate to name each column in the first row of the input data sheet as shown in Figure 2.

Input: Counts, Threshold (100 or 2019 or any), Minimum Bout Length (2 or 5 or any)

Process:

For each count: If count < Threshold, record "activity"; else, record "inactivity".

Find Bouts:

For recorded activity levels:

If "inactivity", add position to "current bout".

If "activity": If "current bout" length >= Bout Length, save as valid bout; clear "current bout".

Show Results:

If bouts found:

Display bout lengths, total bouts, total length, longest bout.

Else: Restart.

Algorithm 1: Program flow sequence. Flow chart can be found in Figure 1. Navigate to availability section for the link to the script.

3 DISCUSSION

Boutlength was designed for calculating and displaying individual bout lengths in a simple way. The program is short, easy to modify, and quick in operation. Unlike paid bout analysis software, it provides open access to individual bout lengths all within the widely used spreadsheet software.

The program enables use of popular activity cut points by Troiano et al. (2008) as well as common bout length specification, e.g., Healy et al. (2011) or Dunstan et al. (2012). It allows direct utilization of fixed epoch sized activity counts data of any length. PA counts data can be directly copied into the input column with minimum prior processing. The algorithm does not restrict time units over which counts are accumulated thus making it possible to calculate bout lengths in minutes or hours and so on.

Another key aspect of the program is that it can scan for any 'type' of bouts. Depending on the type of activity label to look for, *Boutlength* can provide the length of the contrasting activity sequences. In other words, it can identify 'breaks' of moderate to vigorous PA (MVPA) in sedentary behaviour data or inactivity bouts enclosed within physical activity episodes.

The program is our pilot effort towards open-source bout length analysis. Despite it is currently limited in features, code accessibility enables parameter adjustments. This program allows printing individual bout lengths; a feature absent in Actilife (ver. 6.13.4) as tested.

Boutlength takes advantage of the spreadsheet software's built-in statistical capabilities. Since the computed bout lengths are displayed in a column, user can conveniently calculate any number of

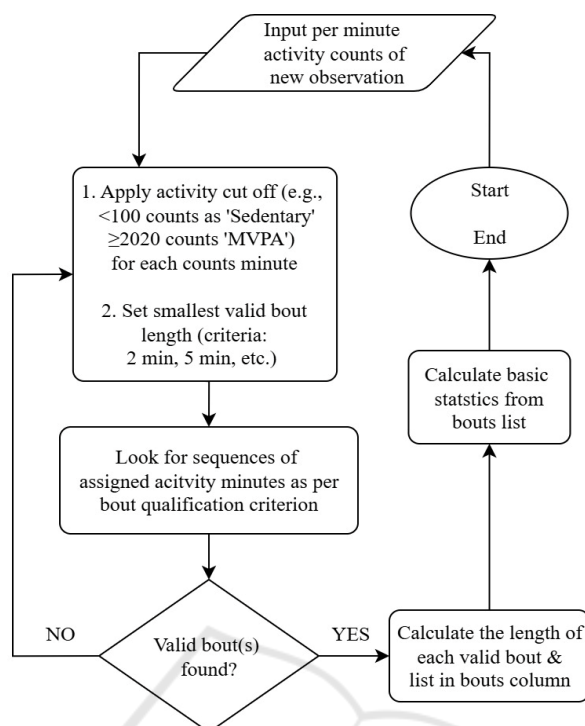


Figure 1: The flow chart of *Boutlength* algorithm. After insertion of input as counts vector, the program classifies activity into levels as per cut-off thresholds adapted from Troiano et al. (2008). Next, it scans for sequences of a level as per minimum bout qualification criteria to print valid bout lengths. For sedentary, a 5-minute and for MVPA, a 2-minute length was specified as reference from Healy et al. (2011) and Dunstan et al. (2012). Navigate to availability section for the link to the script.

statistics and sketch plots from the bout length series output.

There is still room for improvements and additions in the program. For example, the use of a single cut point restricts activity categorization in two levels only. Some users may desire multilevel activity classification. Having enough labels for each activity type using multiple cut points makes bout length computation for each activity level a powerful feature for practical applications. Moreover, some users may also be interested in ‘interruption’ or ‘tolerance’ feature in the program’s bout length specification. On the usability aspect, macro programming may seem complicated to new users. Modifications to the macro needs correct referencing variables to the data column in the worksheet.

Given the importance of bout analysis in physical activity research, not much remains freely available for bout length presentation to date. A study by Salim

et al. (2024) proposed a tool for bout length estimation from count data and its code was openly available for use and modification. Apart from that, there is no other tool for the provision of individual bout lengths to the user, to our best knowledge.

Limited number of accessible tools for bout length presentation may hinder interested users from calculating bout statistics, such as the median bout length, or the half-life bout duration, as described in Boerema et al. (2020) and Chastin et al. (2015). *Boutlength* intends to address the gap by enabling the computation and display of bout length breakdown from physical activity counts data. The program is structured for simplicity and modification in classification threshold, bout qualification criteria, and activity level characterization. For future, we are considering transforming the code into a graphical user interface for easier navigation.

Minute	Counts (data source: Khan et al. 2024)	MVPA assignment (Troiano 2008) (counts > 2019: 1, otherwise: 0)	MVPA bout number	MVPA bout length (≥ 2 minutes, Dunstan et al. 2012)	MVPA bout length (sorted)	Total number of MVPA bouts	Smallest MVPA bout	Largest MVPA bout
1	0	0	1	4	3	4	3	8
2	1963.49	0	2	6	4			
3	0	0	3	8	6			
4	2008.05	0	4	3	8			
5	4524.17	1						
Minute	Counts (data source: Khan et al. 2024)	Sedentary assignment (Troiano 2008) (counts 0-99: 1, otherwise: 0)	Sedentary bout number	Sedentary bout length (≥ 5 minutes, Healy et al. 2011)	Sedentary bout length (sorted)	Total number of Sedentary bouts	Smallest Sedentary bout	Largest Sedentary bout
1	281.49	0	1	8	5	2	5	8
2	0	1	2	5	8			
3	0	1						
4	293.9	0						
5	0	1						

Figure 2: Snippet of program input and output display space in the spreadsheet. Top (Green): The first row contains header information. The first two columns are input comprising time unit index (minutes) and a sample observation as counts data from Khan et al. (2023). The third column is a result of activity classification based on MVPA cut-off (counts > 2019: 1, otherwise: 0). The subsequent columns are identified MVPA bouts. From the 50-minute recording for a participant, it found 4 bouts of MVPA activity that are at least 2 minutes (or longer). The longest of them was 8 uninterrupted minutes. The next columns are basic statistical operations applied on the identified bout length series. Bottom (Yellow): Another participant's count data was analysed for sedentary bout identification in the second column. The operations of third column onwards use Troiano's sedentary threshold for level assignment (counts < 100: 1, otherwise: 0) and bout length specification (5 minutes or longer). From the 50-minute recording, it identified 2 sedentary bouts of 5 and 8 minutes. Likewise, successive columns apply basic statistics on the identified sedentary bout string.

4 CONCLUSION

Boutlength was designed to print individual bout lengths derived from activity count data. It allows the use of a cut-off threshold to identify sequences of activity levels into usable bout strings as per defined bout qualification criteria. The program operates in a commonly used spread sheet software environment that allows easy data handling, and changes to bout classification parameters. The printed bout length series can be used for statistical analysis, deriving new measures of bout patterns, or creating plots. The open availability of code promotes transparency, scrutiny, and adaptability. Future work will prioritize the development of a graphical user interface, making the script more accessible and convenient for a wide range of users.

5 APPLICATION

The program was demonstrated using two observations of Actigraph wGT3X-BT vector magnitude time series (30Hz, 1 minute epoch) obtained from Khan et al. (2023). Each of the two participants had one ankle mounted unit and sat in a classroom lesson for 50 minutes. Both sedentary and MVPA cut-off values were adapted from Troiano et al. (2008) as Sedentary: 0-99 cpm, MVPA: > 2019

cpm).

Minimum valid bout lengths were adapted from Dunstan et al. 2012 (MVPA: length ≥ 2 min) and Healy et al. 2011 (Sedentary: length ≥ 5 min). The program was executed once for each observation by changing the specification for both types of activities. As a result, cells of third column and onwards were filled with output as shown in Figure 2. Indexed and sorted bout length breakdown are printed along with basic statistics.

Depending on the computer performance, the spreadsheet macro processes the input counts column, performs classification, computes bouts, and prints output within seconds.

AVAILABILITY

Boutlength is available in a public repository at www.github.com/asadkh21/fidgeting.git

Counts database used for the demonstration can be provided upon reasonable request to Khan et al. (2023).

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