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Title

Characteristics of very slow stepping in healthy adults and validity of the activPAL3™ activity monitor in detecting these steps

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Conflict of Interest Statement

Stansfield has received grant funding in the past from PAL Technologies Ltd (manufacturer of the activPAL3 monitor) towards unrelated research work. Stansfield has received no personal payment as part of the current study or for previous research work.

Hajarnis and Sudarshan have no conflict of interest to declare.

Highlights

The validity of the activPAL3™ activity monitor was assessed at low speed and cadence

A treadmill walking protocol was used from 1.0 down to 0.1m/s

Above 0.5m/s and 69 steps/min over 90% of steps were detected.

Below these thresholds performance reduced rapidly.

At 0.1m/s and below 27 steps/min no steps were detected.

Title

Characteristics of very slow stepping in healthy adults and validity of the activPAL3™ activity monitor in detecting these steps

Abstract

The use of activity monitors to objectively measure stepping activity allows the characterisation of free-living daily activity performance. However, they must be fully validated. The characteristics of very slow stepping were examined and the validity of an activity monitor, the activPAL3™ (PAL Technologies Ltd. Glasgow, UK) to detect these steps was assessed. 10M/10F healthy adults (36±10y) performed a treadmill walking protocol from 1.0m/s down to 0.1m/s (0.1m/s increments) whilst wearing AM under video observation (gold standard). Within the 800 stepping periods recorded the proportion of steps correctly detected by the activPAL3™ was explored against speed and cadence. Below 0.4m/s walking began to be intermittent, stepping interspersed with stationary postures. At 0.1m/s almost 90% of walking periods were intermittent. The percentage of steps detected was over 90% for walking speed at or above 0.5m/s and cadence at or above 69 steps/min. However, below these limits % steps detected reduced rapidly with zero steps detected at 0.1m/s and at or below 24 steps/min. When examining the stepping activity of groups with limited stepping cadence the above thresholds of performance should be considered to ensure that outcomes are not misinterpreted and important very slow stepping activity missed.

Keywords

Gait speed; cadence; step length; validity; activPAL3 activity monitor.

Main text word count: 3986

Introduction

Physical activity performance is essential for the maintenance of good health with international guidelines recommending the performance of minimum volumes of physical activity [1]. Stepping is one of the key activities that can be used to fulfil the physical activity recommendations. It has been estimated that 7,000 steps per day are associated with the development and maintenance of musculoskeletal, cardiorespiratory and neuromotor fitness [2]. Engagement in stepping activity is also required to facilitate the performance of every-day activities around the home and into the wider community. Therefore, it is of interest to be able to quantify the volume of stepping activity that individuals perform in a free-living context, both to gauge the health benefits accrued and to characterise daily living activity.

Stepping is performed at a range of different stepping rates (cadences) which equate to a range of different translational speeds. Usual purposeful 'healthy' self-selected walking speed has been observed to occur at approximately 1.3m/s (e.g. men 20-30y, 1.39m/s, women 70-80y, 1.27m/s [3]). However, slower stepping activity is performed both in healthy populations and in populations with pathology affecting walking speed. In their review of the literature Peel et al [4] report gait speeds as low as 0.11m/s in geriatric populations. Studenski et al [5] reviewed evidence of the relationship between self-selected gait speed and survival, providing information relating to speeds down to 0.2m/s to fully characterise life course outcomes. It is possible that relatively slow stepping activity forms a considerable proportion of daily activity for sections of the population who do not regularly perform purposeful walking out of the home (e.g. those with limited cardiorespiratory function). If stepping activity is to be accurately objectively measured the full range of stepping rates used should be characterised. Therefore, if the purpose of a device is to measure stepping activity it is important that it is able to adequately detect stepping at slow stepping rates.

Accelerometer based devices are able to monitor stepping activity through analysis of the signal resulting from movement of the wearer. An example, the PAL Technologies Ltd. family of monitors (activPAL™ (uniaxial) and activPAL3™ (tri-axial), PAL Technologies Ltd, Glasgow, UK), use proprietary analysis algorithms to determine stepping performance. Output from these monitors is in the form of individual strides with allocated durations. This allows the calculation of instantaneous cadence or true cadence [6]. The assessment of the activPAL™ monitor's performance has been carried out across a range of speeds. Typical outcomes of the lowest speeds tested in healthy populations are, mean 9.9y, 0.88m/s, correlation with video observation: r=0.88 [7]; females mean 18.5y, 0.89m/s stepping agreement 0.3 steps [LOA 3.9- -3.3] [8]; mean 23y, speed 0.89m/s, within 1±9 steps out of approx. 200 [9]; mean 28y, speed 0.6m/s, 1.7% error [10]; mean 34.5y, speed 0.9m/s, <0.94% error in step count [11]; older adults mean 72y, speed 0.67m/s, <1% error [12]. According to the outcomes of these studies the activPAL™ has excellent validity for step detection. However, there is emerging evidence that the monitor does not detect all steps when walking below these speeds. Taraldsen et al [13] indicate that in both a reference population (mean 46.3y) and people with stoke (mean 75.2y) and inpatients (mean 84.0y) steps were under-detected below 0.47m/s. Kanoun [14] presents provisional results indicating that at 0.45m/s, for a group mean 23.5y, the percentage error in steps detected was 3.5% with a range of 0-30%. Lutzner et al [15] report outcomes of assessment in young healthy adults (23.6 SD 4.4y) of step detection for a treadmill based protocol across a wide range of walking speeds from very slow 0.1m/s to very fast 2.6m/s. They indicate for the standard placement of the activPAL™ that there is considerable reduction in step detection below 0.7m/s, with a mean of less than 50% of steps detected at 0.4m/s compared to manual step count.

Whilst the literature reports stepping activity as low as 0.11m/s [4] it is possible that the mode of progression at this speed is discontinuous, i.e. one step is taken followed by a pause before the next step. The mode of stepping is not usually described in the literature. Knowledge of the minimum continuous speed for linear progression would provide information for interpreting very slow cadence stepping as recorded by a monitor. Intermittent stepping may be recorded as very slow continuous stepping, perhaps leading to misinterpretation of free-living activity patterns. Low cadence outcomes have been reported in the literature for the activPAL™ (e.g. Dall et al [6] report cadence as low as 20 steps/min). It is important to understand what this stepping activity represents and if these are likely to be continuous stepping bouts or to be intermittent stepping reported as continuous stepping activity.

Ideally the validity of the monitors would be established under free-living conditions. However, this is extremely time-consuming as the recognised gold standard is manually counted steps, usually from a video recording. Long periods of data monitoring are, therefore, difficult to perform. A compromise is to use laboratory based data collection methods over short time periods. These can either involve over-ground walking or treadmill based protocols. If the aim of a study is to systematically analyse a range of speeds of walking this is difficult to achieve using over-ground walking; participants can only be asked to walk 'normally' or 'faster' or 'slower' than normal. Treadmill walking provides a compromised in that speed can be finely controlled [15].

The aims of the current study were twofold: First to establish the relationship between speed of walking and cadence at slow stepping rates, including the determination of the slowest speeds of continuous stepping and secondly to establish the validity of the activPAL3^{TM} physical activity monitor to detect stepping at these slow stepping rates.

Methods

Twenty (10M/10F) participants, between 18 and 60 years of age, were recruited from staff and students of Glasgow Caledonian University. Informed consent was obtained from the participants and ethical approval for the study was obtained from the Glasgow Caledonian University School of Health and Life Sciences Ethics Committee. Participants did not have any known neurological conditions, lower limb dysfunction, vascular dysfunction that might affect walking or injury to the lower limb sustained within the preceding 6 weeks. Participants' gender, height, weight and age were recorded.

The physical activity monitor, the activPAL3™ (PAL Technologies Ltd, Glasgow, UK) was used in this study. Two monitors were used, one on each thigh. The monitors were attached using PALStickies™ (PAL Technologies Ltd, Glasgow, UK) on the mid-line of the thigh at the mid-point between the anterior superior iliac spine and the superior border of the patella as measured in a supine position. Participants wore their own clothing and shoes (not high heels). The activPAL3™ detects each stride. The number of steps was calculated as strides multiplied by 2 for each of the monitors. Version 7.1.18 of the activPAL3™ software was used for all data processing.

Once the activPAL3™s had been put in place the participant mounted the treadmill (Woodway, Waukesha, USA, Model PPS 55med, accuracy ±0.007m/s across 0.1-1.0m/s settings) and the session commenced. The protocol outlined in Table 1 was followed with four stepping cycles performed by each participant. Each stepping cycle followed one of two protocols:

A (Descending cycle) = decreasing from 1.0 m/s to 0.10 m/s, in 0.1m/s decrements each 30 seconds

B (Ascending cycle) = increasing from 0.10m/s to 1.0m/s, in 0.1m/s increments each 30 seconds

Each participant completed 2xA and 2xB cycles with the order of cycles manipulated to ensure equal numbers of participants completed AB and BA sequences before and after the mid-testing break. The walking cycles were programmed to run automatically under the control of the treadmill. Acceleration and deceleration was completed within the first 1-2s of transition between speeds within each cycle. Each cycle took 5 mins giving an overall protocol time of approximately 25 mins.

The entire session was video recorded in High Definition.

Insert Table 1 here

Data analysis

Time synchronisation was achieved between the video record and the activity monitors by identifying the first stride of walking commencing at 1.0m/s in the activPAL3™ record and the corresponding time point in the video. This time synchronisation was used across the whole walking sequence which was continuously recorded on video.

From the video the timing of the 20s of stepping activity at the middle of the 30s period was selected, i.e. leaving a 10s gap between evaluation periods for sequential speeds. Within the identified 20s periods all steps (either left or right foot initial contact with the ground) were counted and agreed by two observers. The total number of steps observed on video within the 20s period was used as the gold standard measure.

The activPAL3™ Event output file (individual stride occurrence recorded against time) was examined to identify the number of strides recorded during the same 20s periods as determined from the video analysis. A stride was allocated to a time period if its start time was either precisely at the start of the time period or it was within the time period. The number of steps was determined as the number of strides multiplied by 2. The proportion of steps detected was determined by calculating:

% steps detected = (number of steps detected by the activPAL3™ /video step count) x 100

Observations from the video were made to classify walking as either continuous (always one leg moving in relation to the treadmill belt) or intermittent (where both legs were stationary in relation to the belt at some point during the time period). The proportion of walks performed in an intermittent manner was determined within speed and cadence bands.

If walks were performed in an intermittent way, then the time of walking would not have been the entire 20s period. This means that the calculated mean speed and mean cadence would not be the same as the true speed and cadence of the walking activity within the time period. For the purposes of this report the mean speed and mean cadence are used to represent the stepping activity within each time period.

The mean cadence of walking was calculated from the video based step count within the known time period of 20s. The mean step length was calculated based on the calculated mean cadence and the treadmill speed.

The relationship between the percentage of steps detected and the stepping speed and cadence of stepping was explored by examining the percentage of steps detected by the activPAL3™. For all walks performed at each stepping speed the median and interquartile range of the % steps detected were determined. Also for all those bouts of stepping performed at a certain cadence the median and interquartile range of the % steps detected were calculated. This provided a profile of how the % steps detected changed with speed of stepping and cadence of stepping.

To take account of any effects due to synchronisation error or discrepancy in time point of step detection definition, a further analysis was performed: Time periods where activPAL3™ outcomes were within ±4 steps (i.e. ±2 strides – one for the start and one for the end of the time segment) were identified. The proportion of walks within ±4 steps was examined against speed and cadence. This analysis allowed for a difference in interpretation of the number of steps taken between the video observation and activPAL3™. This might have arisen due to a difference in the exact point of a step being detected/counted between the video observation and the activPAL3™. Such differences would simply have been due to the definitions used in the analysis and not necessarily true differences in outcomes. This method of data analysis, therefore, provides insight into 'definite' discrepancies between outcomes of the video observation and activPAL3™.

As one monitor was used on each thigh and as the monitors output is based on strides detected the outcomes of the two monitors were compared. To provide an overview of outcomes, results are presented using all outcomes from both right and left activPAL3^{TM} together as examples of possible outcomes arising from the monitor.

Normality of outcomes was tested (Shapiro-Wilk test). The outcomes of the monitors across the range of speeds were compared using the Wilcoxon Signed Rank Test and the correlation tested using paired sample correlations.

Results

All twenty participants (age 36±10;20:54 years, (mean ± standard deviation; minimum: maximum), height 172±9;154:189 cm, weight 68±10;55:87 kg) completed all parts of the testing protocol giving 800 walking periods with 80 at each walking speed.

Distributions of outcomes at lower speeds were not normal, therefore, for consistency, all data is presented as median with interquartile range. Both cadence (Figure 1) and step length calculated from video observation reduced with reduction in speed of walking. Across the range from 0.1 to 1.0 m/s the best fit second order polynomials between speed (m/s), cadence (steps/min) and step length (m) were:

Cadence (steps/min) = -47.727 x [Speed (m/s)]^2 + 132.23 x [Speed (m/s)] + 13 (R^2 = 0.9963)

Step length (m) = -0.1741 x [Speed (m/s)]^2 + 0.5795 x [Speed (m/s)] + 0.1998 (R^2 = 0.9975)

Insert figure 1 here

The proportion of walks with intermittent stepping was higher at lower speeds and cadences (Figure 2). Only 11% of walks were continuous at 0.1m/s, whilst all were continuous at and above 0.4m/s. In general below 40 steps/min walking was predominantly intermittent. However, there were examples of intermittent stepping at up to 100 steps/min. Intermittent stepping predominantly occurred at low cadences and relatively high step length. Combinations of cadence and step length appeared to fall into two patterns with a set of combinations not used by participants (Figure 2).

Insert figure 2 here

The outcomes from the two monitors (left and right legs) were not identical (% steps across speeds; related samples Wilcoxon Signed Rank Test, p=0.008), but the overall outcomes demonstrated similar trends (paired sample correlations, 0.870). Therefore to provide an overview of activPAL3™ performance the following results are derived from the outcomes of the activPAL3™ on the right leg and that on the left leg combined.

The percentage of steps detected dropped from 95.2% at 0.6m/s to 0% at 0.1m/s (Figure 3A). There was rapid reduction in % steps detected below 0.5m/s. With cadence (Figure 3B) there was a similar trend for reduced % step detection with reduction in cadence. Below 69 steps/min (% steps detected 95.6%) the step detection became erratic (large interquartile range), again reducing to 0% step detection at 24 steps/min.

Insert figures 3A and 3B here

The percentage of trials within ±4 steps of that determined from video observation was over 90% at and above 0.6m/s (Figure 4A). However, there was a marked reduction at 0.5m/s (67%), with smaller proportions of trials within ±4 steps below this speed, reducing to 17% at 0.2m/s. When examined by cadence of stepping all trials above 75 steps/min had over 90% of trials within ±4 steps (Figure 4B). There was a steep reduction in % of trials within ±4 steps below this cadence reaching approximately 30% at a cadence of 50 steps/min.

Insert figures 4A and 4B here

Discussion

The characterisation of stepping activity provides insight into physical activity performance and can be used to provide objective evidence of engagement in free-living everyday activity. Establishing the validity of activity monitors across the range of outcome measures reported is important to ensure correct interpretation of outcomes. Stepping activity at low stepping rates (cadences) has been reported in the literature for the activPAL™ [6], yet there is limited evidence of the validity of these outcomes for either the activPAL™ or the activity monitor examined in this work, the activPAL3™. Not only is it important to understand if the monitor can detect slow stepping, but it is also important to understand if the reported stepping activity is actually continuous or might be constituted of intermittent stepping portrayed as continuous very slow cadence stepping.

There is emerging evidence that the activPAL™ monitor does not have a high level of validity at low speeds of walking [13-15]. Whilst examination of monitor validity by walking speed is useful, the monitor actually outputs cadence. Very low cadence has been reported [6] without evidence of the validity of these measurements. If the monitor does not reliably detect stepping below a certain cadence threshold it is likely that any stepping reported below this threshold is actually intermittent stepping interpreted by the monitor signal analysis algorithms as continuous stepping. This may be individual or very short bouts of relatively high cadence stepping joined together with intervening standing events to appear as very low cadence stepping.

The outcomes of this study indicate that there is a relatively consistent relationship between apparent speed of progression, mean step length and mean cadence across the speed range studied with excellent fit to a quadratic best fit line (Figure 1).

Participants were asked to walk in a self-selected manner at the prescribed treadmill speeds. There was considerable variation in the way that the participants walked at the slower speeds, with some choosing to use an intermittent pattern of walking. This was particularly prevalent below a speed of

0.4m/s and a cadence of 45 steps/min (Figure 2). The variation in stepping pattern is emphasised by the range of combinations of cadence and step length that were chosen at each speed of stepping (Figure 2). There appeared to be combinations of cadence and step length that were not used, perhaps indicating that these were the least physiologically appropriate combinations for efficiency of movement. However, some participants chose to use high cadence and short step length combinations at the lower speeds distinct from the majority of participants who used lower cadence and longer step length.

The results are presented by cadence and speed calculated across each 20s period, however, for intermittent walking there would have been periods where stepping did not occur. Some individuals were able to walk continuously at 0.1m/s, although it would appear that a speed of 0.2m/s might be considered the minimum continuous walking speed for the majority of the participants.

The % of steps detected is used here as a means of characterising the validity of the activPAL3™s. The results demonstrate that the activPAL3™ s were capable of determining stepping activity well (>90% median step detection) at and above 0.5m/s (Figure 3A) and 69 steps/min (Figure 3B). Below this level the ability of the monitor to detect steps declined rapidly. The speed threshold of 0.5m/s is in agreement with activPAL™ outcomes previously reported by Tarandsen et al [13], Kanoun [14] and Lutzner et al [15] who identified weaker performance below this level: Taraldsen below 0.47m/s, Kanoun at 0.45m/s and Lutzner below 0.6m/s. It should be noted that the equivalence of outcomes between the activPAL™ and activPAL3™ has not been demonstrated. The addition of information on the decrease in step detection with cadence provides evidence of a validity threshold that can be directly related to the results generated by the activPAL3™, as the activPAL3™ does not characterise speed of walking, only cadence.

Whilst the examination of the results by % steps detected provides insight into performance, the protocol used provided challenges with data interpretation that could result in overestimation of errors. Within each 20s period there would have been differences in video vs. activPAL3™

interpretation at the start and end of the period. The exact point of stride detection by the activPAL3™ was not known and may not be the point of foot contact as used in this study. Therefore, it is possible that an extra stride may have been detected or one missed by the activPAL3™ at the start and end of each period of stepping compared to those counted by video analysis. By examining the results based on all trials within ±4 steps, absolute errors in step detection could be identified (Figures 4A and 4B). This analysis revealed that performance dropped below 90% of trials within this range at and below 0.5m/s or 75 steps/min. This indicates that there were definite missed steps below these thresholds. This type of end effect error would have an impact on any examination of the validity using a fixed time period analysis. If stepping had been observed over longer time periods then this apparent error would have still been present, but its overall percentage impact on outcomes would have been smaller. However, there was a close relationship between the thresholds below which performance deteriorated for % steps and trials within ±4 steps. This agreement provides reassurance that the thresholds are true representations of monitor validity.

The activPAL3™ outputs steps and the time at which these occur. Therefore, its main output is instantaneous cadence. When steps were missed by the activPAL3™ this was sometimes classified as upright standing with no stepping, but in other cases consecutive steps were lumped together as one with an allocated very low cadence. The misclassification of output of the activPAL3™, as seen by the user, might therefore be either stepping activity classed as quiet standing or artificially low cadence stepping. It was not possible to determine a consistent pattern of how stepping at low speeds/cadences would be characterised by the activPAL3™.

The outcomes of this study, indicating a low or reduced percentage of steps detected for slower speeds, are similar to those found for other step detection devices. For example, Cyarto et al [16] report for the Yamax Digiwalker (DW-200) that for nursing home residents that from 0.80±0.35m/s down to 0.42±0.17m/s the percentage error in step count increased from 46.3±38.1 to 73.9±34.8%.

However, in contrast there are reports for other monitors that slow stepping can be detected: Macko et al [17] report that it is possible using the SAM monitor to gain high levels of accuracy at low cadences, achieving an accuracy of 98.5±1.0% for step detection at cadences of 46±8.9 steps/min in stoke patients. Therefore, with the right combination of technology and data analysis methods it is clearly possible to detect stepping at very slow speeds.

Limitations

The participants were a convenience sample of healthy adults, without pathology. It is not possible to say how these results would apply to other groups, especially those with movement pattern disorders.

These results are based on treadmill stepping activity. It is possible that stepping activity performed over-ground may be performed differently to that on a treadmill at very low speeds.

The activPAL3™ did not have any real time output and it was, therefore, not possible to automatically synchronise its output with that of the video recorder. This meant that synchronisation had to be accomplished manually by identifying matching points in the data streams. The approach taken was to use walking at 1.0m/s as the reference within the activPAL3™ s. This method explicitly assumed that the activPAL3™ s were recording the first stride of walking at 1.0m/s. Inspection of the results confirmed this assumption. However, it is possible that the synchronisation was out by up to the time of one stride. This fact contributed to the need to use only the middle 20s of each 30s walking block within the walking cycles. Whilst longer walking blocks may have been desirable, this duration was used to reduce overall burden on participants whilst allowing repetition of the walking cycles. It would be beneficial for future protocols to extend recording time of constant speed stepping to reduce the significance of end effect errors. However, this must take into account the limits of participant performance to reduce the chance of fatigue affecting results.

Conclusion

Participants were likely to use an intermittent stepping pattern below 0.4m/s or a cadence of 45 steps/min. The activPAL3™ detects over 90% of steps taken at and above a walking speed of 0.5m/s and a cadence at and above 69 steps/min. Below these thresholds the monitor detects decreasing numbers of steps with no steps detected at 0.1m/s and at or below 24 steps/min.

When using the activPAL3™ to determine outcomes of stepping activity, cadence reported below 69 steps per minute should be interpreted cautiously. Similarly when stepping activity below 0.5m/s is anticipated careful consideration of outcome validity should be made to reduce the possibility of misinterpretation of outcomes.

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Table legends

Table 1

Treadmill protocol including a warm up, 4 stepping cycles (see text for description of cycles A and B) and rest breaks.

Figure legends

Figure 1

Relationship between video derived cadence and treadmill speed. Median and interquartile range of all results at each speed. The best fit second order polynomial line is overlaid.

Figure 2

The combination of mean cadence and mean step length used to achieve stepping speed and the occurrence of continuous (closed circles) and intermittent stepping (open circles). All trials of all participants are included. The distinct rows of outcomes are related to speed of treadmill walking as indicated (m/s).

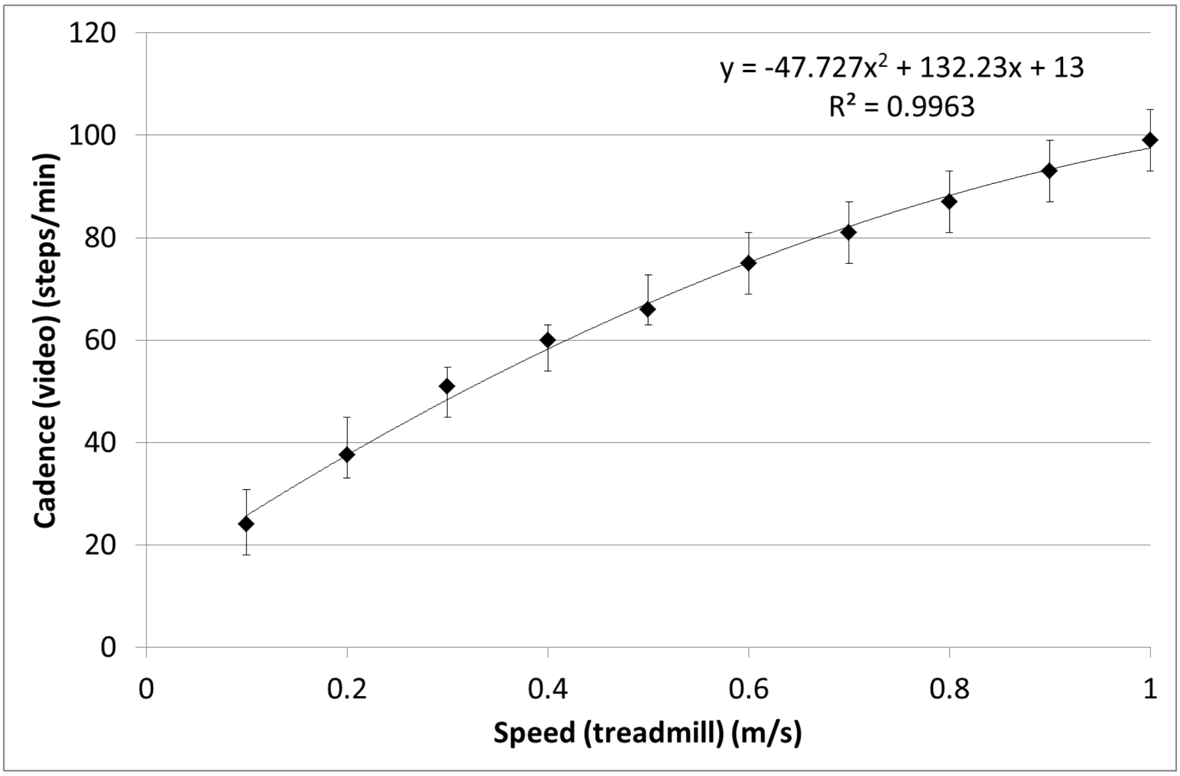
Figure 3

Percentage of steps detected by A) treadmill speed and B) video cadence (median and interquartile range).

Figure 4

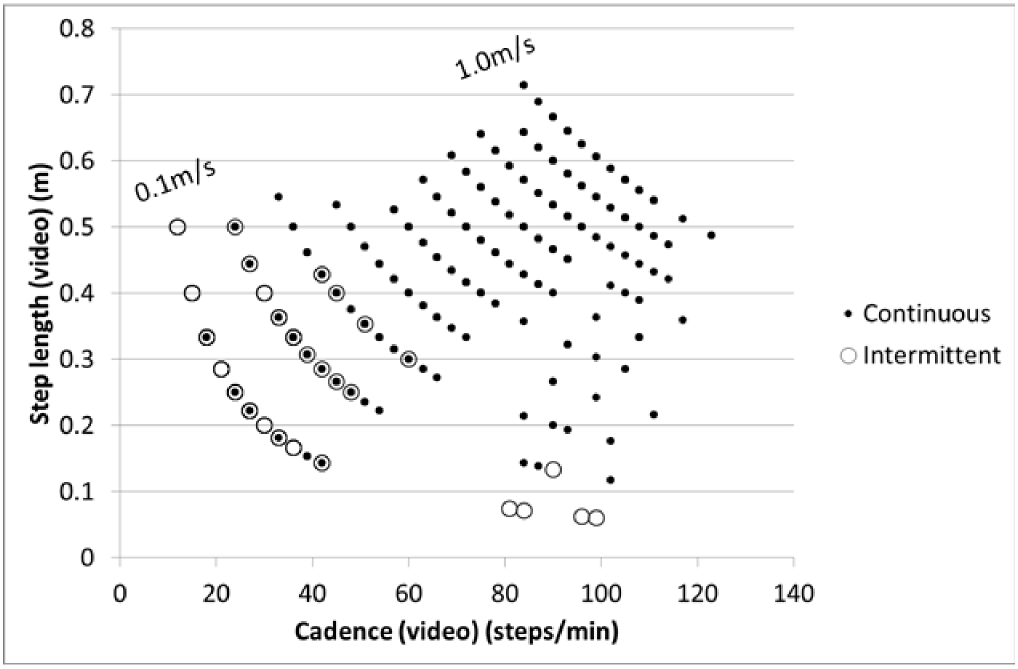
Percentage of activPAL3™ outputs within +/- 4 steps of video steps by A) treadmill speed and B) video cadence (median and interquartile range).

Figure 1



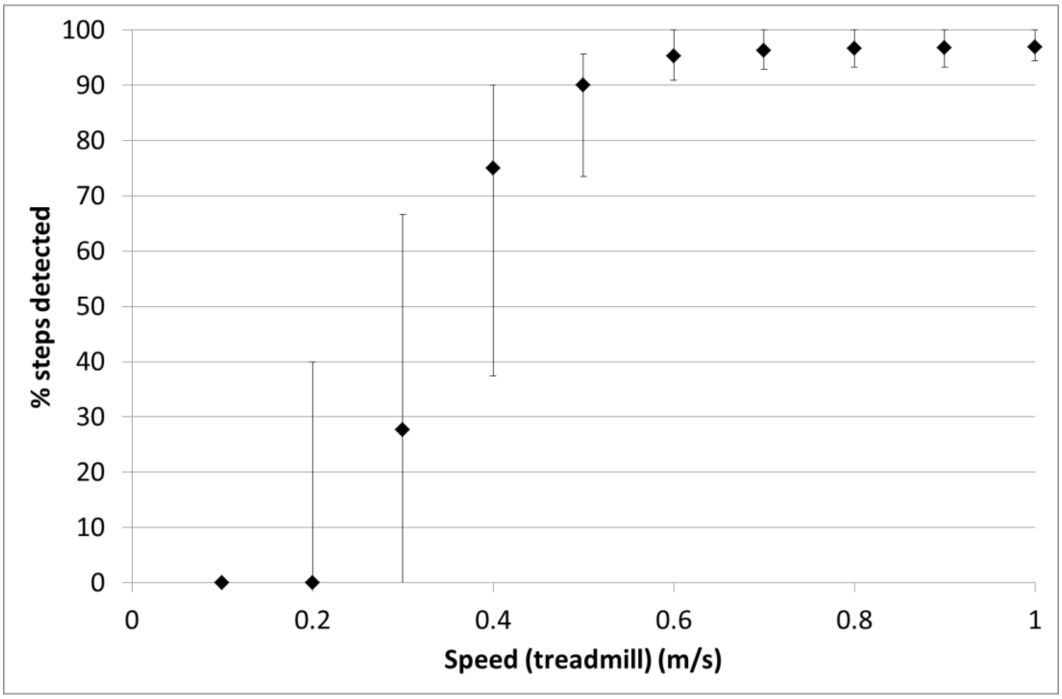
y = -47.727x2 + 132.23x + 13
R² = 0.9963
120
100
80
60
40
20
0
Cadence (video) (steps/min)
0
0.2
0.4
0.6
0.8
1
Speed (treadmill) (m/s)

Figure 2



0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Step length (video) (m)
0.1m/s
1.0m/s
0
20
40
60
80
100
120
140
Cadence (video) (steps/min)
Continuous
Intermittent

Figure 3A



100
90
80
70
60
50
40
30
20
10
0
% steps detected
0
0.2
0.4
0.6
0.8
1
Speed (treadmill) (m/s)

Figure 3B

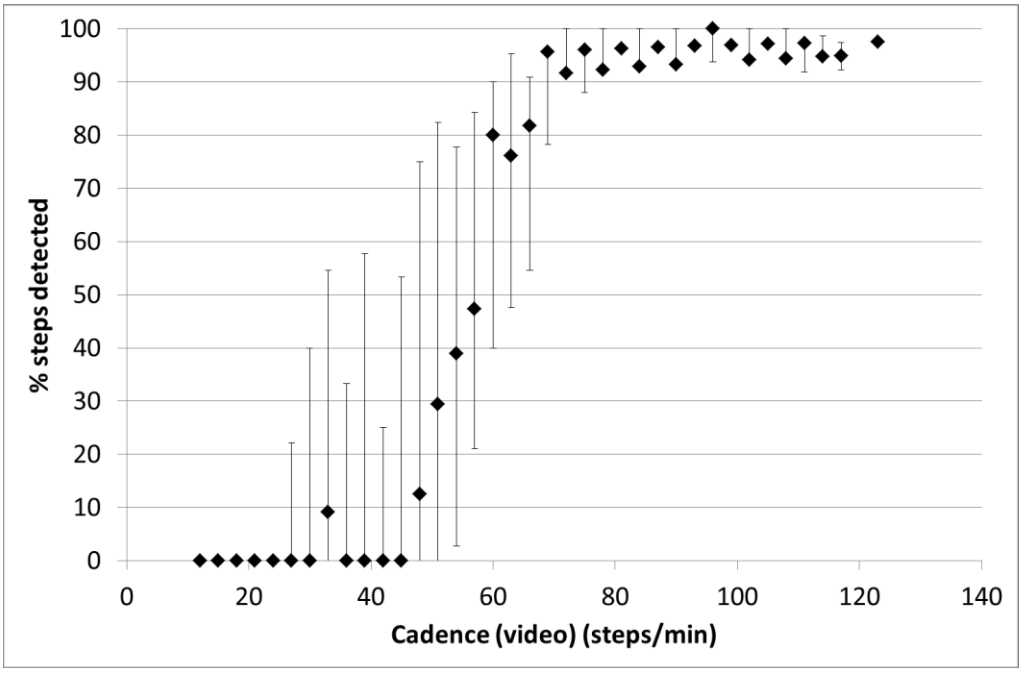

% steps detected
100
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
120
140
Cadence (video) (steps/min)

Figure 4A

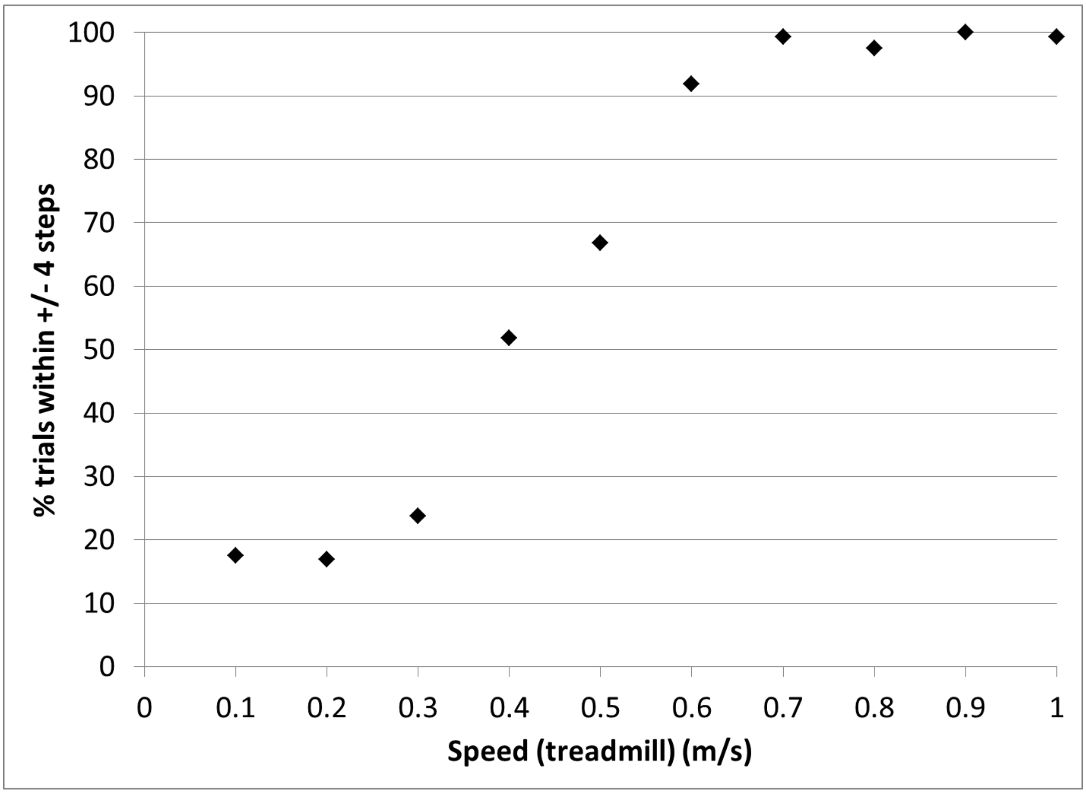
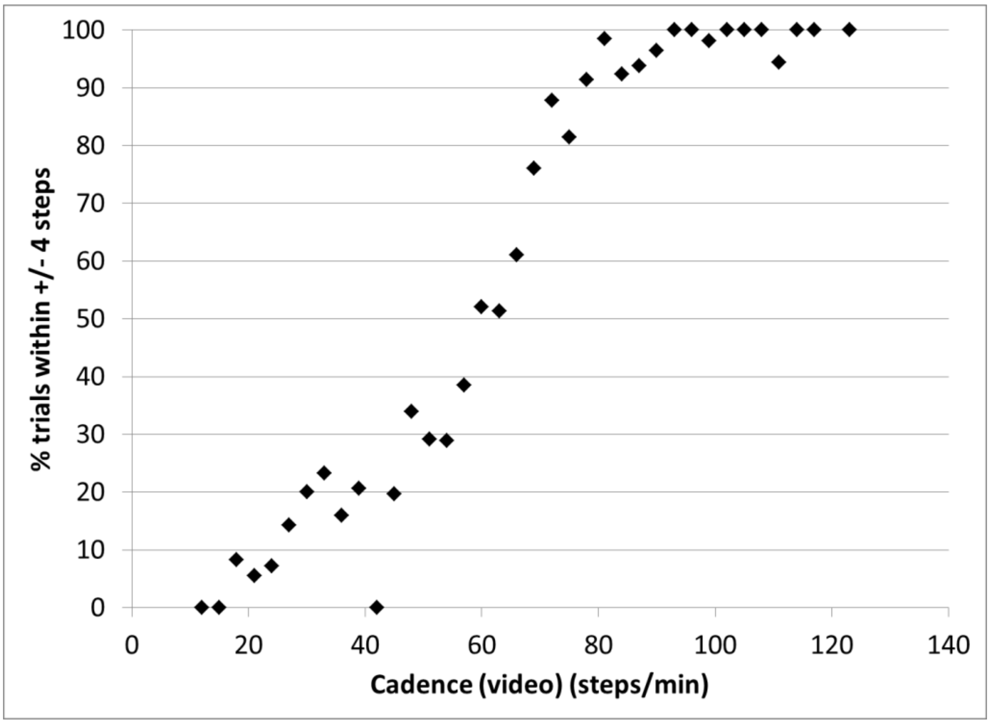

100
90
80
70
60
50
40
30
20
10
0
% trials within +/- 4 steps
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Speed (treadmill) (m/s)

Figure 4B



% trials within +/- 4 steps
100
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
120
140
Cadence (video) (steps/min)

Table 1

Table 1 Treadmill protocol including a warm up, 4 stepping cycles and rest breaks. There were two stepping cycles, A and B:

A (Descending cycle) = decreasing from 1.0 m/s to 0.10 m/s, in 0.1m/s decrements each 30 seconds

B (Ascending cycle) = increasing from 0.10m/s to 1.0m/s, in 0.1m/s increments each 30 seconds

Treadmill protocol	Action	Duration
Warm up	Stepping, 0.1m/s to 1.0m/s	2 mins
rest	Standing on the treadmill	1 min
Stepping cycle 1	Stepping, either cycle A or B	5 mins
rest	Standing on the treadmill	1 min
Stepping cycle 2	Stepping, either cycle A or B	5 mins
rest	Standing on the treadmill	2 min
Stepping cycle 3	Stepping, either cycle A or B	5 mins
rest	Standing on the treadmill	1 min
Stepping cycle 4	Stepping, either cycle A or B	5 mins
rest	Standing on the treadmill	1 min