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ABSTRACT

OBJECTIVES: To measure the step-count accuracy of an ankle-worn accelerometer, a thigh-worn accelerometer and one pedometer in older and frail inpatients.

DESIGN: Cross-sectional design study**.**

SETTING: Research room within a hospital**.**

PARTICIPANTS: Convenience sample of inpatients aged ≥65 years, able to walk 20 metres unassisted, with or without a walking-aid.

INTERVENTION*:* Patients completed a 40-minute programme of predetermined tasks while wearing the three motion sensors simultaneously. Video-recording of the procedure provided the criterion measurement of step-count.

MAIN OUTCOME MEASURES: Mean percentage (%) errors were calculated for all tasks, slow *versus* fast walkers, independent *versus* walking-aid-users, and over shorter *versus* longer distances. The Intra-class Correlation was calculated and accuracy was visually displayed by Bland-Altman plots.

RESULTS*:* Thirty-two patients (78.1 ±7.8 years) completed the study. Fifteen were female and 17 used walking-aids. Their median speed was 0.46 m/sec (interquartile range, IQR 0.36-

0.66). The ankle-worn accelerometer overestimated steps (median 1% error, IQR -3 to 13). The other motion sensors underestimated steps (40% error (IQR -51 to -35) and 38% (IQR -93 to -27), respectively). The ankle-worn accelerometer proved more accurate over longer distances (3% error, IQR 0 to 9), than shorter distances (10%, IQR -23 to 9).

CONCLUSIONS: The ankle-worn accelerometer gave the most accurate step-count measurement and was most accurate over longer distances. Neither of the other motion sensors had acceptable margins of error.

KEY WORDS: walking, dimensional measurement accuracy, frail elderly, in-patients

ABBREVIATIONS

ActivPAL3: AP3

Interquartile ranges: IQR

Intra-class correlation: ICC

Metabolic equivalents: METS

Metres per second: m/sec

PA: physical activity

Percentage: %

Piezo® Step MV: STEP

Stepwatch Activity Monitor: SAM

INTRODUCTION

Research has established that older patients are physically inactive in hospitals [1-5] possibly leading to their functional decline [6-8]. Knowledge of patients' levels and patterns of physical activity (PA) could help healthcare professionals to prevent this decline by targeting particularly at-risk individuals, aiding individual therapy, and providing feedback and motivation to increase PA.

Patients' PA can be objectively measured through direct observation or by motion sensors[4, 9, 10]. While direct observation is suitable for research, it is labour-intensive and often impractical in the hospital setting. Motion sensors could be a more feasible option. Motion sensors report PA as (1) energy expenditure, measured in metabolic equivalents (METS)[11], (2) PA intensity, categorised into sedentary, light, moderate or vigorous[12], (3) step-count[13] or (4) time-spent-upright[14]. Neither METS nor intensity classification are suitable measurements in older or frailer patients. METS can be altered by age and acute illness by 20-25% [15] and older patients spend most of their time in sedentary PA [4, 9]. Therefore, step-count and time-spent-upright would appear most clinically meaningful in this group.

Time-spent-upright can be accurately measured in the hospital setting [16, 17] and studies have shown that older inpatients spend as little as 43 minutes per day [1] to 1.2 hours per day [18] either standing or walking. While time-spent-upright indicates how inactive the patients are in hospital, it does not tell us the nature of their physical activity as it cannot differentiate between standing (static PA) and walking (dynamic PA). Step-count indicates clearly patients' progress from static to dynamic PA and progression to mobility independence. Many older patients need to take rests during physical tasks. Time-stamped PA outlines patterns of PA – whether the patients sustain more frequent and longer bouts of PA or whether they are able to walk a certain distance in less time, with fewer steps. Researchers currently suggest that this measurement (bouts of PA) is a valuable indicator of overall PA and health [19, 20], informing clinicians of the patient's progress to independent functional activity, necessary for community-dwelling.

Two important factors should be considered when choosing a suitable sensor for clinical use: accuracy and affordability. Many motion sensors are not sensitive to steps at speeds slower than 0.8 m/sec [17, 21-23]. Frail older inpatients walk at an average of 0.5 m/sec [17] rendering these motion sensors inaccurate for use in this cohort[24]. In fact, a recent review concluded that no motion sensor has shown accurate step-count measurement in older medical inpatients[24]. However, the authors identified the Stepwatch Activity Monitor accelerometer and Piezo®Step MX and the Yamax-200 (if worn at the knee) pedometers, as accurate in older community-dwellers who walked less than 1.0 m/sec and suggest that they should be further validated.

While the Stepwatch Activity Monitor (SAM) has not been tested in older inpatients, its error in community-dwellers with chronic illnesses was found to be less than 10% [25, 26]. There are a number of factors which may be linked to its accuracy in slow walkers. Firstly, it is a kind of accelerometer worn at the ankle, positioned well to detect trajectories of the foot. Secondly, it uses a set-up procedure to programme its sensitivity to steps which, in theory, has advantages for this population. And finally, it has a high sampling frequency of 128 Hz.

All motion sensors which measure time-stamped activity are more costly than simple pedometers (which count steps only). If a pedometer was found accurate in frail older patients, it could become a readily affordable and an easy-to-use alternative. Previously, Webber et al [27] found the Piezo® Step MV pedometer recorded step-count accurately in older community-dwellers walking at 0.8 m/sec, but found the Yamax-200 and the GT3X+ were inaccurate. Yet, when the Yamax-200 was worn at the knee (rather that at the hip), Vanroy et al[28] found it accurate in stroke community-dwellers walking at 0.5 m/sec [28]. Nonetheless, we chose to test the Piezo® Step MV over the Yamax-200 for two reasons. Firstly, Vanroy et al[28] stated that it was well tolerated by the participants, but as inpatients spend long periods of the day sitting down, a strap holding the pedometer firmly at the knee could become uncomfortable and possibly compromise circulation of the lower limb. Secondly, Yamax-200 is a mechanical pendulum pedometer, and Piezo® Step MV is a pedometer with a piezoelectric internal mechanism which thought to be more accurate [27]. We therefore decided to measure the accuracy of the Piezo® Step MV.

Time-spent-upright is a useful measurement of PA in older medical inpatients, which the ActivPAL can measure accurately. However, it has failed to measure step-count accurately either in frail older patients [17] or older community-dwellers [21]. The ActivPAL 3 (AP3), a new triaxial version of the ActivPAL accelerometer has not been tested in this population, and its potential accuracy in measuring both parameters merits its inclusion in the study.

Therefore, the aim of this study was to measure the step-count accuracy of three motion sensors (SAM, ActivPAL3 and Piezo® Step MV (STEP)) in old, frail inpatients and explore how their accuracy is affected by (1) walking distances, (2) walking speed, (3) use of walking aids, and (4) specific to the SAM only, its set-up procedure.

METHODS

Participants

This prospective cross-sectional design study was conducted in a 350-bedded teaching hospital between January and June 2014 and took place in a clinical research room, similar to a single bedroom on a ward. Ethical approval was granted by the local Research Ethics Committee [EMC 3 ffff 03/12/13].

A convenience sample of 32 inpatients, aged 65 years and over, not requiring surgical intervention, who were able to walk approximately 15-20 metres independently with/without a walking aid, and able to follow simple commands in English, participated in the study. This number was deemed feasible and in line with previous studies [17, 21, 28]. Patients with or without a walking aid were purposively recruited to compare accuracy between these groups. The nursing staff was initially consulted to identify patients who fitted the criteria and only those patients were approached. If the patient appeared confused during the initial interview, the nursing staff was again consulted before proceeding with recruitment.

Equipment

The three motion sensors tested were the SAM (Orthocare Innovations, LLC, OK, 7.5cm x 5cm x 0.2cm, 38g), the AP3, a triaxial accelerometer, (Pal Technologies Ltd, Glasgow, UK, 3.5cm x 5.3cm x 0.7cm, 15g), and the Piezo® Step MV (STEP), a piezoelectric pedometer

(StepsCount, Deep River, ON, 5.6cm x 3.2cm x 1cm, 20g). Video recordings using a Sony Handycam DCR-HC35 provided the gold-standard step-count measurement as it would provide the least biased measurement and is commonly used gold-standard measurement in previous studies[17, 23, 28].

Procedure and Baseline Measurements (See Figure 1)

The procedure was fully explained to all participants, who all gave written informed consent. Baseline data included patients' demographics, home environment and family/carer support. Comorbidity and chronic illness burden was measured using the Cumulative Illness Rating Scale-Geriatrics (CIRS-G) [30], and a higher score reflects greater impairment in several systems. The SHARE FI [31] was used to determine the patient's frailty category (frail, pre-frail or not frail). Fear of falling was measured using the Falls Efficacy Scale-International [32] and a higher score reflects a greater concern about falling. A cut-off of above 19 points indicates a moderate to high concern about falling[33]. Physical Performance was measured using the Short Physical Performance Battery (SPPB) [34]. This quick, practical and safe measurement tool assesses patients' balance, walking and chair-stand ability, and a higher score reflects better physical ability.

Equipment Preparation

The STEP is a pedometer, and therefore, did not require any synchronisation to the computer. In line with the manufacturer's instructions, it was attached at the dominant hip, directly above the knee. A belt was used to attach the STEP if the patients' clothes were loose-fitting (nightdress or pyjamas). The patient then walked 20 steps, and the step-count was checked. The pedometer attachment was adjusted until it reached the acceptable level of accuracy of 20±2 steps (in line with the manufacturer's instructions).

Both the AP3 and the SAM required computer synchronisation, and the SAM required sensitivity adjustment as part of the set-up procedure. For both, all data from the sensors was cleared prior to use and were synchronised to the computer. The AP3 was then ready for recording. It was attached to the dominant mid-thigh, in line with the manufacturer's instructions.

Sensitivity adjustment is a required step in the set-up procedure for the SAM. Its sensitivity is programmed specifically for each participant according to the manufacturers' instructions before it is attached. The level of sensitivity is based on the answer selected by the user to four questions appearing on the screen, relating to the participants' height, gait pattern and gait cycle. For each question, the user chooses the most appropriate answer from a range of answers presented. For this study, the same answers were selected for all the participants, to represent a typical older hospitalised patient, as follows:

(Question 1) "Does the client regularly participate in activities that involve short quick steps?" (Our answer) "No".

(Question 2) "Is their walking speed fast or slow? (relative to people of similar height.)" (Our answer) "Slow".

(Question 3) "What is the client's range of walking speeds?" (Our answer) "Rarely changes"

(Question 4) “Describe the appearance of the client’s leg motion” (Our answer) “Gentle/geriatric”.

The number of steps was saved in periods of 15 seconds (time interval/epoch). This is fixed at 15 seconds in the AP3 so it was replicated in the SAM to allow comparability. The SAM was attached to above the dominant lateral malleolus, in line with the manufacturers’ instructions. The patients then walked 20 steps and the LED light, (which only flashes for the first 40 steps recorded), was checked.

While wearing all three motion sensors simultaneously, the participants were video-recorded completing a 40-minute programme of predetermined tasks. These included bed-to-chair transfers, activities in the standing position and six walks over distances between 2.4 and 20 metres. The tasks were performed in the research room and the walks over 10 metres were completed in the corridor of the research facility. Each task began and ended in a seated position. Patients wore footwear and used their required walking aid. A 30-second rest between tasks allowed the sensors to register the break. A more detailed description of the tasks is provided (see Appendix A). At the end, the sensors were returned to their respective docking stations for data retrieval.

Both the raw steps counts and summary data were downloaded. The STEP step-count for each task was documented manually on the data collection sheet and manually inputted once all the recordings had been completed.

To measure how the set-up procedure affected the accuracy of the SAM, a subset of 12 patients wore two SAMs simultaneously, each with a different set-up procedure. The second SAM (SAM 2) was attached directly above the first (SAM 1). The set-up procedure for SAM 2 differed as follows: (1) the information required for programming was not standardised; instead it was specific to each patient's presentation (e.g., if the participant walked slowly or used a walking frame, we would enter "slow" for walking speed and "rarely changes" for ranges of speed) and (2) an accuracy trial was completed by counting the LED flashes while the patient took 4 sets of 12 steps and checking whether 48±2 steps count was recorded. If inaccurate, the sensor was reprogrammed by rechecking the programming information and if necessary, by adjusting "cadence" and "sensitivity" (in Advanced Settings) by two numerical values at a time until accurate.

A step was defined as a definite foot displacement with movement of body mass into a new position[35]. Two research physiotherapists analysed the recordings separately, beginning with the video recordings, and resolved any disagreements by analysing them together to reach a consensus. The video recordings were analysed first, when the researchers were blind to the motion sensors' measurements.

The twenty-metre walk was used to measure walking speed. The time taken to walk between the two-metre and the twelve-metre points was used and converted to metres per second.

Statistical Analysis

All continuous data was tested for normality using the Shapiro-Wilk normality test. Non-normally distributed data are reported in medians (and interquartile ranges, IQRs) and normally distributed data are reported in both means (and SD) and medians (and IQRs) in the text. Both are also reported in Table 1 to allow comparison with other studies. The percentage error was calculated to determine the motion sensors' accuracy, which was calculated as: (sensor count – video count)/video count multiplied by 100. A positive result indicated overcounting and a negative indicated undercounting. The Intra-class Correlation (ICC) was calculated to determine association and accuracy was visually displayed by Bland-Altman plots, where the differences between two measurements are plotted against the averages of the two measurements, allowing visual analysis of bias or trends in the measurements. Stata (Version 13.1) was used for data analysis.

Percentage error was measured over the complete set of tasks, shorter distances (< 5 metres) *versus* longer distances (5 metres – 20 metres), independent walkers *versus* walking-aid users, for slow walkers (< 0.5 m/sec) *versus* fast walkers (≥ 0.5 m/sec) and between the two different set-up procedures. Over the complete set of tasks, correlation was measured and the Bland Altman plots graphically display the measurement accuracy.

RESULTS

Forty patients were approached to participate in the study. Two patients appeared confused on initial interview, two refused because they did not want to leave the ward and four others declined to participate. Thirty-two patients consented and completed the study. No adverse events occurred during the recording procedure. The baseline data of the study participants are described in Table 1. Individual analyses of the video recordings were in agreement for 28 patients. The remaining four patients' recordings were analysed together and consensus was reached.

Accuracy over the total programme of tasks

The SAM generally overestimated steps (median error 1%, IQR -3 to 13) but overall, was more accurate than the AP3 and STEP, which underestimated steps (mean 44% (±0.3) and 43% (±0.2) respectively; median 40% (IQR 51 - 35) and 38% (IQR 93 - 27) respectively). Mean and median errors for all tasks are presented in Table 2 for comparison. Similarly, the intra-class correlation (ICC) was excellent between the video and the SAM (ICC 0.9, 95% CI, 0.9 to 1.0) but poor between the video and the AP3 (ICC 0.3, 95% CI, -0.2 to 0.6), and the STEP (ICC 0.1, 95% CI, -0.2 to 0.4).

The Bland Altman plots (Figure 2) display that, in the overall task, the SAM overestimated steps by an average of 10.31 steps, while the AP3 and the STEP underestimated steps by 79.96 and 86.88 respectively. No trend is apparent in the SAM or the STEP data, while the difference between the video-count and the AP3-count grew larger as the step-count increased. The margins of error between the SAM and the video are narrower than the AP3 and the STEP, while they are similarly wide for both the AP3 and the STEP data. When the percentage errors of the motion sensors were compared over the shorter and longer distances, they were all found to be more accurate over the longer distances. (See Table 2 and Figure 3).

Accuracy for different walking speeds

The results showed that the AP3 and STEP were more accurate in patients with faster walking speeds and in independent walkers, while the SAM was more accurate in walking-aid-users and in slower walkers (see Table 2).

Influence of set-up procedure on accuracy (SAM only)

Results from the subgroup (n=12) wearing two SAM devices simultaneously (SAM 1 at the dominant ankle and SAM 2 just above SAM 1; SAM 1 programmed with standardised sensitivity and SAM 2 with individualised sensitivity) showed that while SAM 1 overestimated, SAM 2 underestimated step-count. However the set-up procedure for SAM 2 yielded marginally better accuracy (SAM 1, (median error 6%, (IQR, -1 to 16%) *versus* SAM 2, median error -6%, (IQR, -11 to -1%), p=0.003)).

DISCUSSION

There are three main findings from this study. First, overall the SAM gives more accurate step-count measurement in older and frail inpatients than the AP3 and STEP. Secondly, the SAM is most accurate over both long and short distances. Finally, the set-up procedure for the SAM motion sensor appeared to affect step-count accuracy.

Previous literature has shown that the SAM is accurate in slower community-dwellers [25, 36] which is similar to our findings. However, the error margins reported of up to 23% over shorter distances and up to 22% with independent walkers are large and may be unacceptable in some cases. It appears that its set up procedure, which may lead to errors in measurement, should be completed carefully. Accuracy of the AP3 appears similar to that of the uniaxial ActivPAL[17]. Both have an inclinometer and are worn at the mid-thigh, designed well to measure time-spent-upright. Previously the ActivPAL has been found to measure time-spent-upright accurately but measured step-count inaccurately in older inpatients [17]. Results of this study are similar; the AP3 appeared unable to detect the slower steps of this cohort. Finally, while the STEP was accurate in older community-dwellers [27], their study group walked faster at 0.8 m/sec than our group (median walking speed, 0.46 m/sec) and suggests that the motion sensor is not accurate for slower walking inpatients. We also attempted to attach the STEP as securely as possible, and occasionally used a belt when the patient wore nightclothes. Whether both of these factors affected its accuracy is unclear.

Older frail patients have low PA levels and need regular rests. Therefore each task began and ended in the seated position. No other accuracy study including this position transfer was found during the literature review. As patients transferred back into the chair, the walking pattern became more “shuffling” increasing potential error. There was a higher error margin over shorter distances; this may be as a result of a greater portion of the task being the transfer back into the chair. These short walks were included to mimic the typical walking activity of older inpatients, which would often include moving from the chair to their locker or transferring back to bed.

Unlike the AP3 and STEP, the SAM was found to be less accurate for faster and/or independent walkers, but as the analysis of set-up procedure suggests, this maybe because the sensor was programmed for slow and gentle/geriatric walkers and thus the sensor was over-sensitive. This may have also caused the wider interquartile ranges and error found over the shorter distances (Table 2 and Figure 2). The subgroup analysis showed that while the SAM 1 overestimated steps, the SAM 2 in contrast, underestimated steps and was marginally more accurate. Both SAM 2 and SAM 1 were worn on the same leg to ensure consistency, but SAM 2 was worn slightly above the recommended placement of above the lateral malleolus (where SAM 1 was placed). Whether its placement, programming, or both, lessened its sensitivity, needs to be re-examined, especially over shorter distances.

For daily clinical use in hospitals (rather than for research purposes), it is important that use of the motion sensor does not increase the workload for the staff of a busy ward or that it is handled excessively during recording. It was noted during the 40 minute-observation period, that one patient who was slightly confused, interfered with the AP3 (at the thigh), but ignored the SAM (at the ankle), suggesting that patients may be less inclined to handle or interfere with the SAM at the ankle.

Study Limitations

There are a number of limitations to this study. We monitored 40 minutes of activity which was felt appropriate for frail older patients, but a longer period of observation would have strengthened these findings and identified false step-counts with habitual movements (i.e., fidgeting, tapping). There is no way of filtering out these habitual movements, but previous work has suggested that they do not appear to affect accuracy over a 24-hour period of monitoring [37]. However, the effect of habitual movements on the accuracy of longer periods of monitoring needs to be further evaluated. Subgroups of approximately 20-25 participants would be more appropriately sized for secondary analyses, including the set-up procedure. In hindsight, the SAM should have been programmed differently, for those who noticeably walked faster or were more restless at rest, rather than our preselected "frail/slow" programming (patient-specific programming only occurred in the subgroup analysis of the dual SAM testing). Finally, placement of the SAM 2 higher than recommended may have affected its accuracy.

CONCLUSIONS

PA in older and frail medical inpatients is low. An accurate, valid measurement of the levels and patterns of their PA would inform and guide healthcare. The results of this study show that while the SAM was the most accurate motion sensor to measure step-count in this population, the error margins of up to 23% may not be acceptable in many cases. Further work is indicated to clarify the effects of its set up procedure, its placement at the ankle, and whether habitual movements affect its overall accuracy.

Conflict of Interest

The authors declare that there are no conflicts of interest. This study has not received funding or assistance from a commercial organisation.

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Table 1: Patient Baseline Data

	Frequency (%)	*Mean (SD)* ***Median (25-75 IQR)***
Demographics		
Female	15 (46%)	
Age *(yrs)*		78.1 (± 7.8)
BMI *(kg/m^2)*		26.9 (± 6.1)
Medical Status		
CIRS-G *(range 0 - 56)*		6.5 (± 2.9)
Medications prescribed *(number)*		6.8 (± 3.6)
Presenting complaint:		
Respiratory	12 (38%)	
Impairments as a result of falling	9 (29%)	
Other	11 (34%)	
Frailty classification (SHARE F-I)		
Not frail	9 (28%)	
Pre-frail	7 (22%)	
Frail	16 (50%)	
Physical Ability		
No walking aid	15 (46%)	
Stick	3 (15%)	
Walking frame	7 (35%)	
Fallen in the previous six months	17 (53%)	
Falls Efficacy Scale-International (range 16 – 64; >19, moderate-high concern about falling)		***18.5 (16.3 – 37.5)***
Short Physical Performance Battery (range 0 – 12)		***4 (2 - 6)***
Walking speed (m/sec)		***0.46 (0.36 - 0.66)***
Independent walkers		***0.5 (0.39-0.63)***
Walking-aid-users		***0.41 (0.35-0.44)***

Table 2: Percentage Error of SAM, AP3 and STEP Motion Sensors Compared to Video.

Percentage Error

	STEP Mean (SD) *Median (IQR)*	**AP3** Mean (SD) *Median (IQR)*	**SAM** Mean (SD) *Median (IQR)*
complete tasks (n=32)	-44 (0.3) *-38 (-93 to -27)*	-43 (0.1) *-40 (-51 to -35)*	8 (0.2)* *1(-3 to 13)*
shorter distances (< 5 m) (n=32)	-68 (0.4)* *-79 (-100 to -54)*	-71 (0.8)* *-74 (-85 to -62)*	-4 (0.3)* *-10 (-23 to 9)*
longer distances (> 5 m) (n=32)	-25 (0.3)* *-15 (-45 to -4)*	-28 (0.2)* *-23 (-38 to -17)*	5 (0.8)* *3 (0 to 9)*
independent walkers (n=15)	-28 (0.2) *-29 (-42 to -24)*	-36 (0.1) *-38 (-44 to -27)*	14 (0.2)* *-7 (-2 to 22)*
walking aid users (n=17)	-59 (0.3) *-60 (-77 to -36)*	-49 (0.2) *-48 (-59 to -38)*	4 (0.1) *0 (-5 to -9)*
walking speed <0.5m/sec (n=12)	-65 (0.2) *-65 (-85 to -46)*	-54 (0.2) *-54 (-66 to -46)*	-1 (0.1) *0 (-7 to 5)*
walking speed ≥0.5m/sec (n=20)	-32 (0.3) *-33 (-43 to -20)*	-36 (0.1) *-38 (-43 to -30)*	14 (0.2)* *11 (0 to 21)*

*Non-normally distributed data

Figure 1: Flow diagram

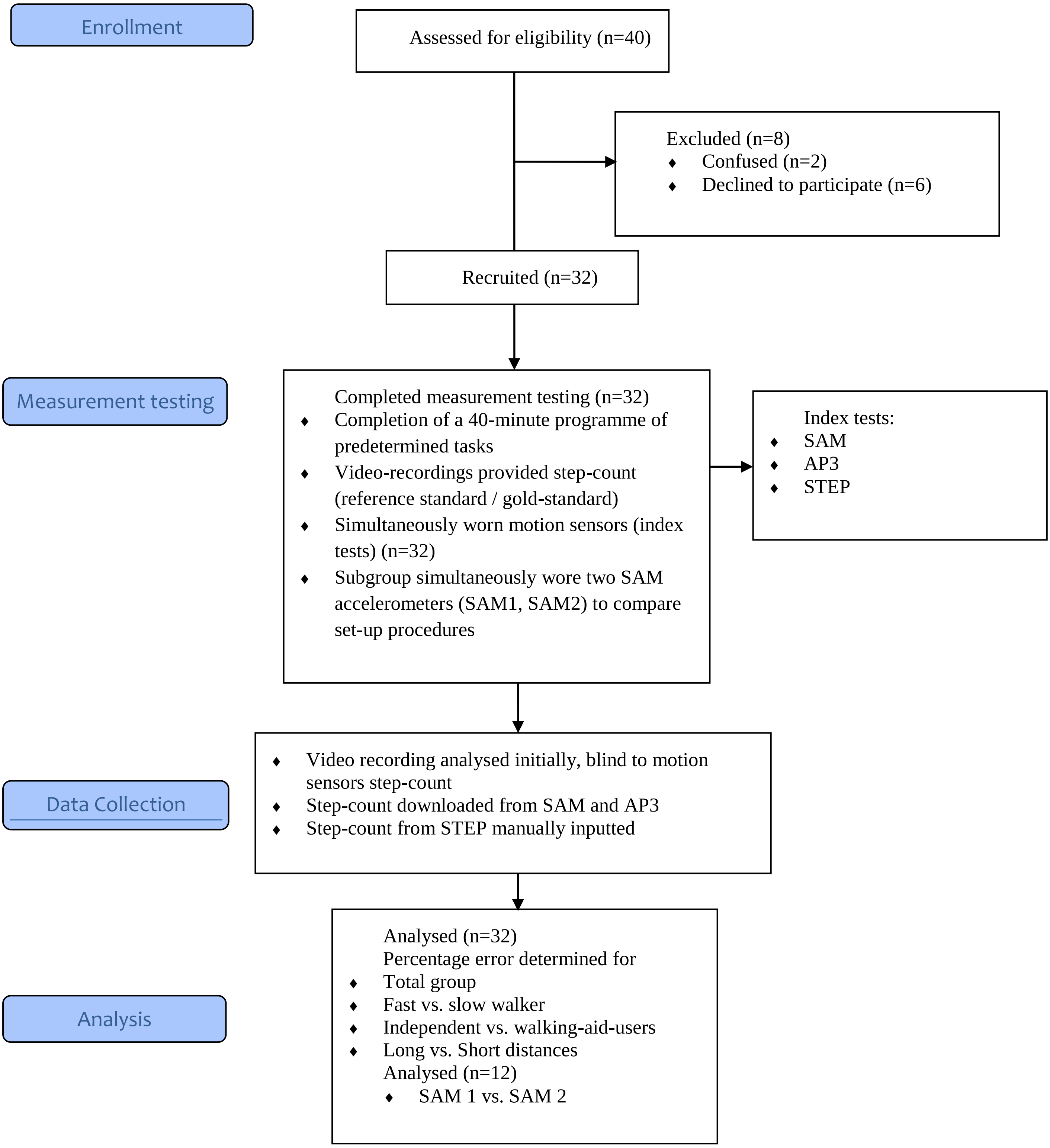
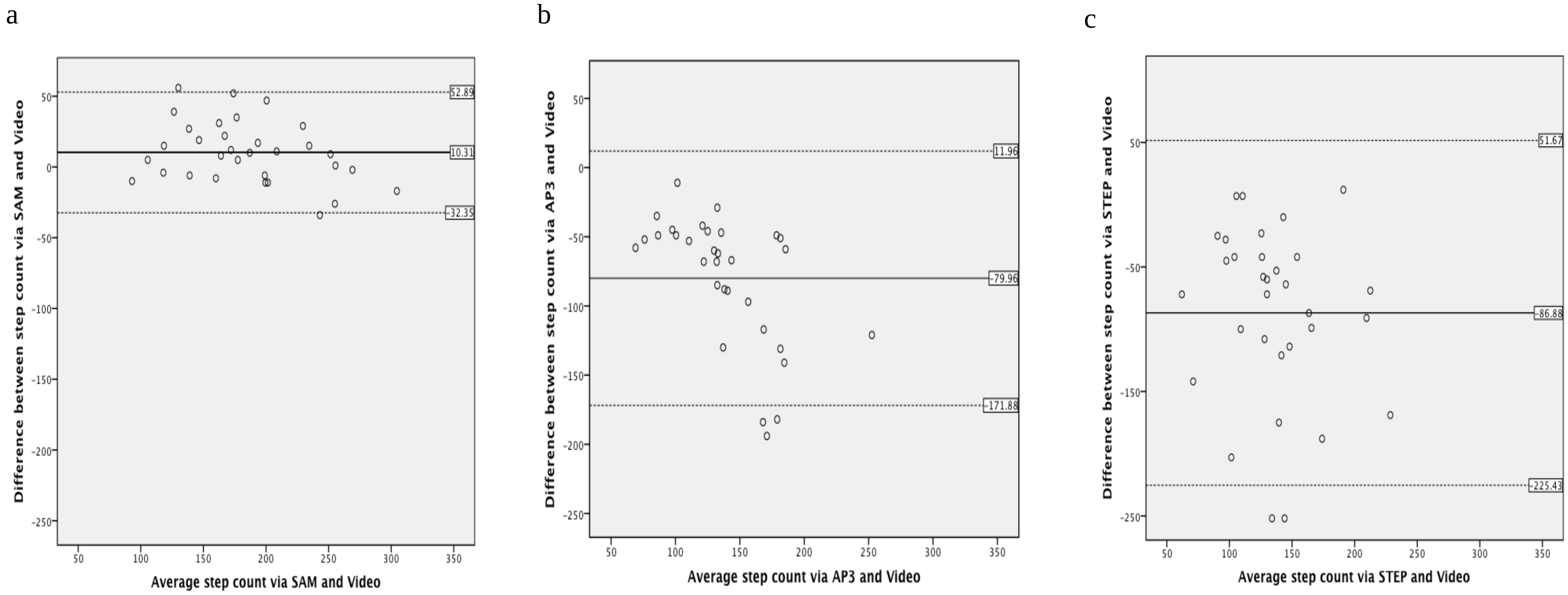


Figure 2: Bland Altman plots of (a) SAM (b) AP3 (c) STEP and Video Step-Count for All Patients over the Total Number of Tasks

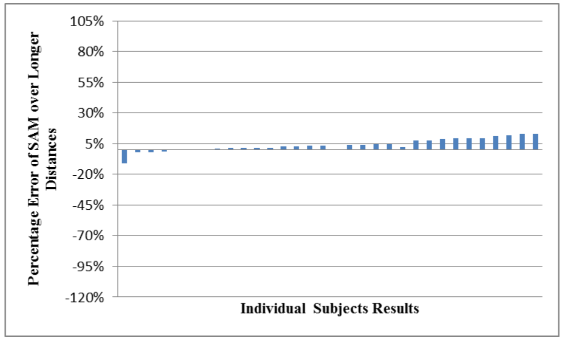


Legend: Bland Altman plots for the total step-count obtained via the motion sensors and the video. The solid line presents the mean difference between the motion sensor and the video; the dotted lines represent the 95% confidence intervals.

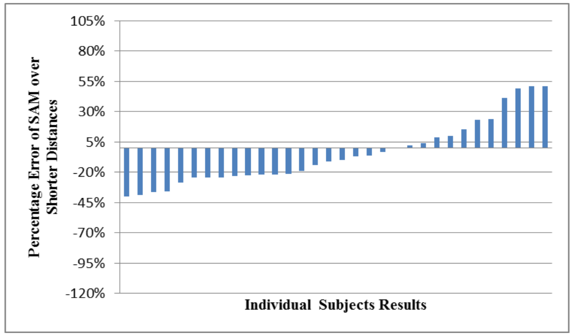
Figure 3: Percentage Error of SAM, AP3 and STEP Compared to Video Step-Count over (a) Shorter (5 Metres or Less) and (b) Longer Distances (over 5 Metres)

SAM data

a

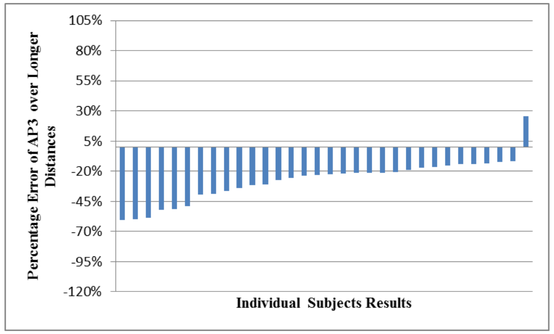


b

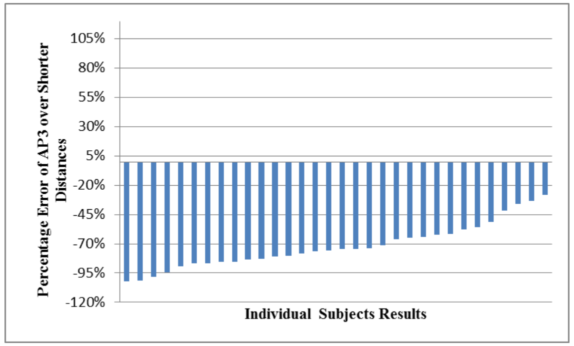


AP3 data

a

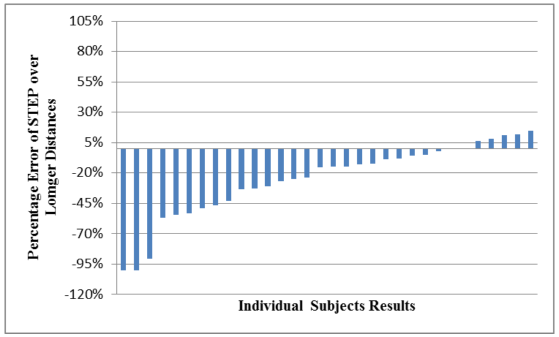


b

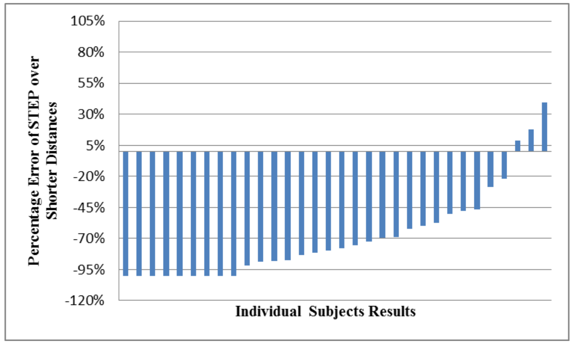


STEP data

a



b



Appendix A: Description of the pre-determined tasks undertaken during video recording

	Task	**Measurement**
1	Sitting to lying on bed	False step-count
2	Lying to sitting at edge of bed	False step-count
3	*Sitting at edge of bed (30 seconds)*	*None- rest period**
4	Transfer from bed to chair†	Step-count
5	*Sit in chair (30 seconds)*	*None- rest period**
6	Standing without assistance (30 seconds)†	False step-count
7	*Sit down (30 seconds)*	*None- rest period**
8	Stand up, turn to walk to cupboard, return to chair, turn, sit down†	Step-count
9	*Sit in chair (30 seconds)*	*None- rest period**
10	Stand up, walk 8ft *(2.5m)*, turn, sit down†	Step-count
11	*Sit in chair (30 seconds)*	*None- rest period**
12	Stand up, turn to sink, wash and dry hands and return to chair, turn, sit down†	Step-count
13	*Sit in chair (30 seconds)*	*None- rest period**
14	Stand up, walk from room to corridor, turn, sit down†	Step-count
15	*Sit in chair (30 seconds)*	*None- rest period**
16	Stand up, walk 5 metres, turn, walk back 5 metres, turn, sit down†	Step-count
17	*Sit in chair (30 seconds)*	*None- rest period**
18	Stand up, walk 20 metres, turn, sit down†	Step-count
19	Sit in chair (FINISH)	*None- test completed**

Legend:

* Each task was timed and followed by a 30-second rest period to clearly demarcate the start and end of each task

† A walking aid was used as required for these tasks