Original Article

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Pedometers alone do not increase mobility in inpatient rehabilitation: a randomized controlled trial

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Abstract

Objective: To test if pedometers, as a motivational tool, could affect mobility outcomes in inpatient rehabilitation.
Design: Randomized controlled clinical trial.
Setting: Subacute hospital rehabilitation unit in Australia.
Participants: A total of 78 participants with reduced mobility and clinician-determined capacity to improve.
Interventions: Both groups received usual care. For the intervention group, a pedometer was worn on the hip with the step count visible to participant and recorded daily on an exercise log. For the control group, a pedometer fixed shut was worn on the hip and they recorded estimated distances walked on an exercise log.
Main measures: Primary outcome was functional mobility – De Morton Mobility Index. Secondary outcome measures were walking velocity, functional independence measure, time spent upright and daily step count.
Results: Significant improvements over time ($P < 0.001$) in functional mobility, comfortable walking velocity and functional independence measure were not influenced by the intervention. The daily average upright time (hours) in the first week of intervention was different ($P = 0.004$) between the intervention group (median, interquartile range (IQR): 1.67, 1.77) compared to the control group (median, IQR: 1.12, 0.82).
Conclusion: Pedometers as a motivational tool without targets do not improve functional mobility in this population. Pedometers may improve daily upright time in this setting.

Keywords

Pedometer, mobility, inpatient rehabilitation

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Introduction

Patients in rehabilitation spend a large amount of their time physically inactive.[1–4] Although the optimal level of physical activity on rehabilitation wards is not established, it is likely that increased physical activity such as walking or time spent upright would be associated with improved mobility outcomes for patients. Particularly, given that

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studies to date indicate that more practice of a particular task results in better performance of that task.[5,6] Many strategies have been trialled to increase physical activity, improve mobility outcomes and ultimately decrease length of stay in inpatient rehabilitation. Additional staffing on the weekend has had mixed results.[7–9] Other approaches such as the use of patient individualized timetables,[10] independent programmes,[8,11] group therapy[7] and structured social programmes[10] have been trialled to increase physical activity and improve mobility outcomes. None have displayed clinically significant changes in functional mobility.

Pedometers are a device commonly used in the general population to motivate people to increase their daily physical activity.[12] There is currently limited research available regarding the use of pedometers as a motivational tool in both acute and subacute settings.[13,14] More research is becoming available about the use of accelerometers in a similar role in inpatient rehabilitation with some positive findings on daily walking time.[15,16] A recent review in the stroke population found that activity monitors coupled with a targeted intervention did not increase step count compared to the targeted intervention alone;[17] however, this does not inform the effectiveness of a pedometer as a stand-alone intervention, or the potential impact on clinically validated functional mobility measures. Low-cost pedometers have been observed to be less accurate than accelerometers especially at slower walking velocities;[18] however, these disadvantages are arguably outweighed by availability and simplicity. While there is potential for use in rehabilitation settings there is currently a lack of research in this area.[17,19]

The primary aim of this study was to test if pedometers as a motivational tool can affect functional mobility outcomes in inpatient rehabilitation. The secondary aims were to see if a pedometer increased incidental physical activity and time spent upright on the ward in the first week, and to measure the perceived benefit of the pedometer.

Methods

This was a single blinded randomized controlled trial conducted from November 2016 until February 2018 on a slow to recover rehabilitation unit of a secondary referral hospital (Launceston General Hospital, Tasmania, Australia). Ethical approval for this study was received from Tasmania Health and Medical Human Research Ethics Committee (approval number H0015819). The trial was registered with the Australian and New Zealand Clinical Trials Network (ACTRN12616001161415).

The rehabilitation unit focuses on patients with lower initial functional independence measure scores and longer anticipated length of stay. All patients admitted to the unit were consecutively screened for inclusion by a rehabilitation physiotherapist. Those with reduced mobility, ability to walk a minimum of three metres with or without a gait aid or with or without assistance of one person, and a clinician assessed capacity for improvement were included in this study. Potential participants were excluded if they had either severe receptive or expressive dysphasia, a medical condition that precluded exercise, were not admitted under rehabilitation; or an anticipated length of stay of less than one week. Patients were considered eligible if their mobility status subsequently changed and they met all other inclusion criteria during the duration of their stay.

All participants provided written consent to a researcher who was not part of the clinical treating team. Allocation into intervention or control group occurred using a computer-generated block randomisation sequence of six. The randomisation sequence was generated by a researcher not involved in recruitment or assessment. Group allocation was concealed using consecutively numbered opaque envelopes, opened after completion of baseline assessment in the presence of the participant.

All participants underwent two measurements sessions. Baseline measures were collected on entry into the study prior to randomisation to ensure blinded assessment, and repeated at discharge, by a physiotherapist blinded to group allocation. The primary outcome was functional mobility assessed using the De Morton Mobility Index. This is a valid and accurate measure of mobility within subacute rehabilitation.[20] Secondary outcome measures included gait velocity assessed using the 10-metre walk test, and a pedometer satisfaction scale

adapted from a similar study[13] using five point Likert-type scales assessing perceived levels of enjoyment, helpfulness and ease of use of pedometer. Functional abilities measured by the functional independence measure on recruitment to study and discharge from the ward were also collected. All participants were monitored for the first week during the study using an accelerometer (activPAL™ – PAL technologies, Glasgow, UK), which measured time upright and steps taken between 8 am and 8 pm. This time period was chosen to exclude incidental night time activity and to reflect expected time someone would wear day clothes. Daily number of steps taken according to the pedometers were collected by allied health assistants and nursing staff, and then reset, ensuring the pedometers were fixed shut in the control group. Clinical and demographic data such as gait aid used, walking assistance required, discharge destination and adverse events was also collected at recruitment and discharge of the study.

Both groups received a Yamax Digiwalker SW200 pedometer (Yamax Corp., Tokyo, Japan), a pedometer well used in research with established validity.[18,21,22] They were instructed to wear it on their waist band, in line with their arm pit. It was encouraged to be worn for all waking hours that a participant was in their day clothes for the duration of their rehabilitation stay. For the control group, the pedometer was fixed in a shut position so that the participants could not see the step count, whereas the intervention group could see the step count on the pedometer. All participants received usual care. This included individualized exercise prescribed by a physiotherapist, carried out by either a physiotherapist or allied health assistant in individual and/or group settings. In addition, all participants received an independent exercise programme with up to three to six exercises that they were encouraged to carry out independently or with supervision as required from family, visitors and staff. They were provided with a fresh exercise log each week. All participants had walking included as an exercise in this programme. Participants in the control group were asked to estimate the distance walked each day utilizing support material provided, and the participants in the intervention group were asked to record the number of steps taken at the end of the day as displayed on the pedometer. Family and nursing staff were asked to assist. The standardized wording to participants, family and staff was to 'try to walk more each day' and either 'estimate distance' or 'record steps'.

Changes in the De Morton Mobility Index, comfortable and fast walking speeds, and functional independence measure were assessed using general linear model repeated measures analysis of variance (ANOVA) (SPSS Statistics software, version 23) to compare the interaction of time and group allocation over time. Daily time spent upright and daily step count on pedometers and accelerometers were analysed using Mann–Whitney tests. Study characteristics for both groups were compared using Mann–Whitney tests (for continuous variable) and chi-square test (for categorical variables). Perceived levels of enjoyment, helpfulness and ease of use of pedometer were analysed for the intervention group using medians and interquartile ranges (IQRs).

The sample size for this study was based on a previous study conducted in a subacute rehabilitation setting with a similar cohort.[20] It showed the median De Morton Mobility Index score was 30.2 with a standard deviation of 16.7. Sample size estimation was based on the group achieving a minimal detectable change and clinically meaningful change of 10.5 points on the De Morton Mobility Index. With a two-tailed significance threshold of 0.05 and a power of 80%, 40 participants were required in each group. To account for drop outs, 88 participants were recruited for this study.

Results

A total of 88 participants consented to take part in the study from 239 consecutively screened patients. Three withdrew prior to baseline assessment, therefore 85 participants were randomized and allocated to control or intervention group (Figure 1) and included for analysis. In several outcome measures $n < 85$, due to missed data points when assessments were carried out. Seven people in the control group were aware of their step count at

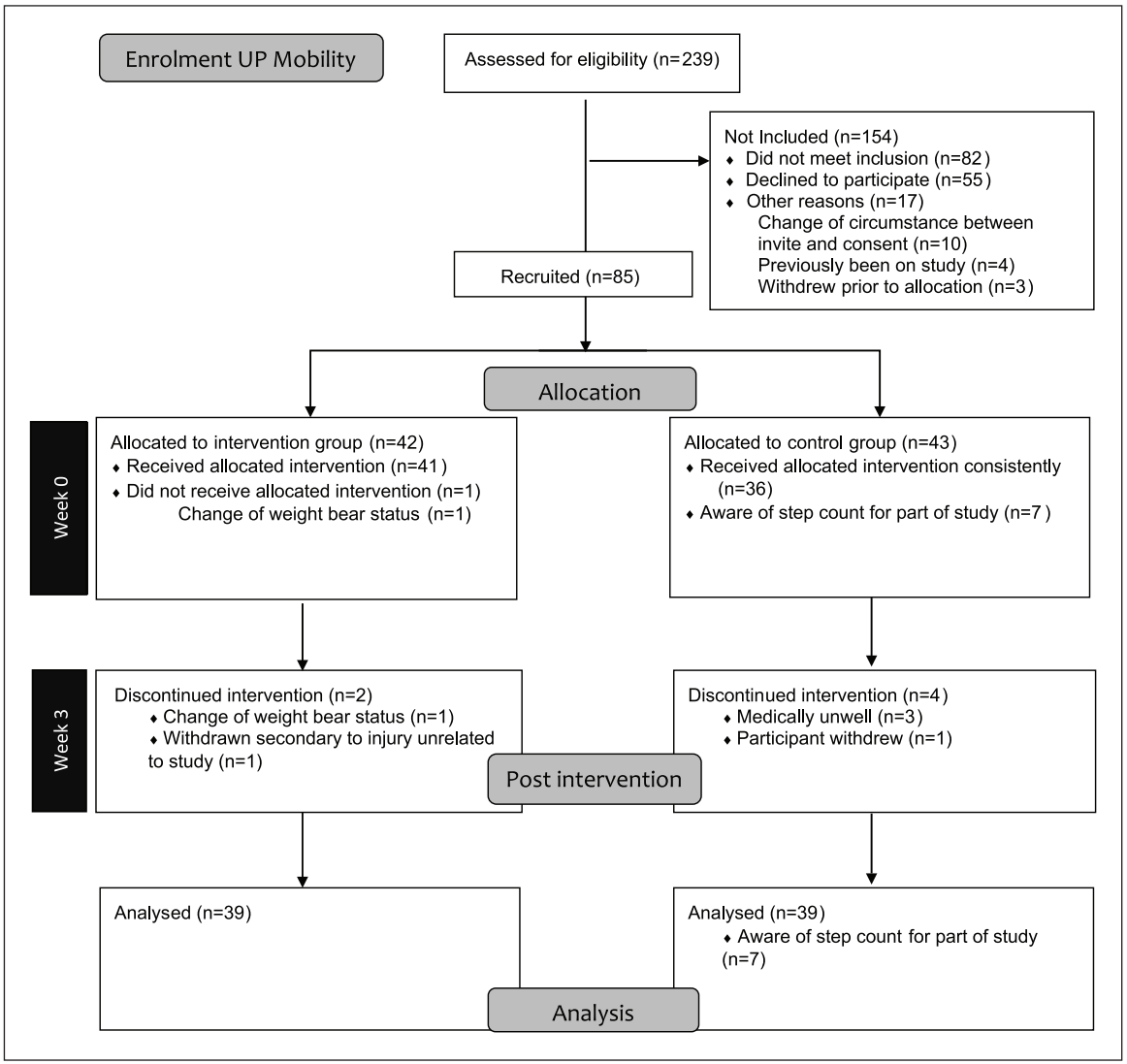

Figure 1. Participant flow through the study.

some point throughout the study but were assessed as per their allocation. Participants wore the pedometer for a mean (SD) of 22 (16) days in the intervention group and 23 (13) days in the control group. There were no significant differences between groups at baseline as shown in Table 1. No adverse events were recorded.

Overall, there was a significant effect of time showing an improvement on the De Morton Mobility Index, but there was no effect of group allocation or interaction effect between time and group allocation. There was a significant effect of time resulting in an increase in functional independence measure score and comfortable walking velocity. There was a significant effect of time and interaction effect between time and group allocation resulting in an increase in fast walking velocity for both groups to a similar speed (Table 2). There were no between group difference in discharge destinations, the length of rehabilitation admissions or the time the pedometer was worn.

The daily average upright time between 8 am and 8 pm was significantly longer for the intervention group. The pedometer significantly under-reported daily step count compared with that measured on the activPAL™ (Table 3). Subsequently, the steps taken per day were significantly more for the intervention group when assessed with the activPAL™ but not the pedometer. Overall, participants in the intervention group found the pedometer enjoyable (median, IQR: 4, 1), helpful for their recovery (median, IQR: 4, 1) and easy to use (median, IQR: 4, 1).

Discussion

There was no significant difference in functional mobility outcomes between those who could and could not see the step count on the pedometer, although those who could see the count spent significantly longer in an upright position in the first week.

No significant differences were found between groups on the primary outcome of functional mobility. This may be due to lack of individualized targets or reduced engagement secondary to inaccuracy of the pedometer. Apart from the consistent wording of 'try to walk more each day', there were no specific targets given to participants. This allowed the pedometer to be assessed as a standalone motivational tool. The feedback provided by allied health staff upon recording and collection of exercise logs and step counts was not standardized. In a recent study, standardized regular feedback around performance did not appear to affect physical activity.[23] In contrast, individualized goal setting around the number of steps appeared to be an important factor in increasing physical activity and step count.[12,24] Perhaps, if targeted step count goals depending on age, mobility and impairment were used, similar to walking programmes done in the community, there may be a greater degree of change between groups.

The majority of participants required a gait aid and/or a person to standby or assist with their mobility. This is of interest as most previous studies in the community have excluded those that require gait aids.[25,26] The need for assistance coincides with slow gait velocities as seen at baseline (Table 1). Recent studies have highlighted the inaccuracy of step counters below walking speeds of 0.6 m/s,[18,19] especially when worn at the hip. The accuracy has found to be improved with more recent activity monitors by wearing them on the ankle,[27] allowing greater chance for the device to detect acceleration. A recent study[15] did include participants with similar gait aid and level of assistance required for walking characteristics at baseline; however, they were investigating the use of accelerometer and its ability to motivate and promote physical activity measured in walking time. They also concluded that upright time may be a more accurate measure secondary to low walking speeds.

With the research on inaccuracy of pedometers in slower walking speeds increasing, pedometers may be demotivating. Those who saw their step counts on the pedometer may feel it did not reflect the number of steps they had taken. This could reduce engagement with the pedometer and contribute to the lack of change in mobility outcomes between groups. Steps taken with the pedometer were not different between groups, however, they were significantly lower than the number of steps detected with

Table 1. Characteristics of the study participants in control and intervention groups at baseline $n = 78$.

Characteristic	Control group ($n = 39$)	intervention group ($n = 39$)	*P* value of difference
Age (years) median (IQR)	78 (18)	74 (17)	0.09
Female *n* (%)	27 (69)	19 (49)	0.11
Body mass index (BMI) median (IQR)	25.99 (8.61) ($n = 37$)	25.10 (6.72) ($n = 35$)	0.88
Walking–supervised or person assist/unassisted *n* (%)	33 (85)/6 (15)	30 (77)/9 (23)	0.57
Walking with / without aids n (%)	38 (97)/1 (3)	35 (90)/4 (10)	0.36
Functional independence measure (FIM) median (IQR)	90 (25) ($n = 31$)	96 (23) ($n = 34$)	0.16
DEMMI median (IQR)	39 (21) ($n = 36$)	44 (24) ($n = 37$)	0.11
Comfortable walking velocity (m/s) median (IQR)	0.44 (0.39)	0.50 (0.44)	0.24
Fast walking velocity (m/s) median (IQR)	0.52 (0.52)	0.61 (0.58)	0.13
Length of rehabilitation admission (days) median (IQR)	32 (33)	27 (37)	0.35
Length of time pedometer worn (days) median (IQR)	21 (13)	16 (26)	0.13

DEMMI: De Morton Mobility Index; FIM: functional independence measure; BMI: body mass index.

Table 2. Comparison of outcomes between control and intervention groups over time, $n = 78$.

Variable	Control group pre mean (SD)	Control group post mean (SD)	Intervention pre mean (SD)	Intervention post mean (SD)
DEMMI	41.25 (11.26) ($n = 32$)	56.06 (16.15) ($n = 32$)	44.67 (13.15) ($n = 36$)	57.25 (15.78) ($n = 36$)
Velocity comfortable (m/s)	0.42 (0.27) ($n = 39$)	0.59 (0.31) ($n = 39$)	0.51 (0.30) ($n = 39$)	0.61 (0.30) ($n = 39$)
Velocity fast (m/s)	0.52 (0.34) ($n = 39$)	0.80 (0.43) ($n = 39$)	0.66 (0.37) ($n = 39$)	0.83 (0.44) ($n = 39$)*
Functional independence measure	85.55 (17.33) ($n = 31$)	101.74 (18.35) ($n = 31$)	90.82 (15.67) ($n = 34$)	103.15 (16.14) ($n = 34$)

Significant interaction of allocation and time *$P < 0.05$.
DEMMI: De Morton Mobility Index; FIM: functional independence measure.

the accelerometer. The lower pedometer step count may also be partially due to reduced time being worn by the participant compared with the accelerometer. As this was a pragmatic study looking at feasibility in a clinical setting, pedometers were donned once the participant was dressed for the day and then removed when they got ready for bed. The time worn was not explicit as it was for the accelerometer, hence they are not directly comparable.

Average daily upright time and steps taken according to the accelerometer between 8 am and 8 pm were significantly different between the two groups in the first week of intervention. The intervention group spent approx. 24 minutes more in an upright position and walked approx. 350 steps more daily than the control group. It is difficult to compare between studies as many use walking time or step count accelerometer data[15,28] and do not specify the time that the accelerometer was in place. Although a recent randomized controlled trial[15] found a statistically significant difference in walking time, the clinical significance of seven minutes more a day is unknown. Similarly, 24 minutes has not translated into significant functional mobility changes. As highlighted in recent research, it may be that upright time is a better measure as slow walking speeds are not accurately captured on some accelerometers.[19] This is supported by other research finding that there is an increase in error differentiating between walking and standing times when gait velocity less than 0.67 m/s.[29]

Table 3. Comparison of average daily upright time and steps taken in first week of study for both groups.

Variable	Control group median (IQR) ($n = 39$)	Intervention group median (IQR) ($n = 39$)	Between group differences *P* value*
Daily average upright time measured by activPAL™ (hrs)	1.12 (0.82) ($n = 34$)	1.67 (1.77) ($n = 35$)	0.004
Daily average step count measured by activPAL	1146 (1446) ($n = 34$)	1494 (1214) ($n = 35$)	0.035
Daily average step count with pedometer	341 (891)	526 (1155)	0.363

*Mann–Whitney.

Walking velocity has been used to predict if someone is a household ambulator, a limited community ambulator or a community ambulator.[30] Both groups started within the limited community ambulatory range (0.4–0.8 m/s), remained in this range for comfortable velocity and improved to the next category within fast velocity. This demonstrates how limited a person's mobility on discharge from subacute rehabilitation is as the average velocity required to cross a street safely is approximately 1.2 m/s.[31,32] Functional mobility required for discharge will likely limit walking speed and functional independence measure scores. Once people get to a certain functional status they will be discharged, so it is perhaps not surprising that they did not achieve faster walking speeds. This is a limitation within this population.

A limitation in this study was a small number of participants in the control group became aware of their step counts for some part of the study when mistakenly written on their exercise log. This may have biased these people to be more physically active than they would have if they had not been provided with feedback on step count. This has proven difficult to monitor despite clear paperwork and perhaps reflects the nature of having multiple clinical staff – nursing and allied health involved with assisting in pedometer use. Despite this, it is not expected that this influenced the results.

To our knowledge, there have been no other randomized controlled trials that have assessed the use of a pedometer as a motivational tool to improve functional mobility outcomes in a subacute setting. There have been increasing number of studies conducted in subacute rehabilitation using accelerometers or other technology to provide regular feedback about their walking ability. Only one of these has found a significant change in walking time,[15] while others have found changes in walking speed.[33] While pedometers are inexpensive and more accessible than accelerometers they do underestimate step counts. This may demotivate users to increase step-related activity. Small increases in upright time and steps taken do not appear to translate into improvements in functional outcome measures. Further studies are warranted using pedometers that are more accurate at slower walking speeds to assess if accurate feedback provides the motivation for patients to be more active, and if this in turn will result in improvements in functional outcomes.

Clinical messages

- Pedometers alone do not improve functional mobility in subacute population
- Pedometers alone do not affect speed of recovery
- Pedometers did increase the time spent upright in the first week of being worn.

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