ORIGINAL RESEARCH

Step-Count Distribution as an Indicator of Walking Reserve in People with Gait Vulnerabilities

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ABSTRACT

Background

Steps per day can provide a lot of information about the activity of the average person whose main source of activity is derived from walking. This study looks at the distribution of step-count data to identify different subgroups of people which could be used to indicate walking reserve.

Methods

A time series design of a secondary data analysis was conducted to track the variability of daily step count for 44 seniors post-fracture. The mean age was 75.8 years (SD: 9.75). The full percentile distribution was used in a cluster analysis and group-based trajectory analysis was used for the longitudinal data. Ordinal regression was used to identify factors associated with cluster membership.

Results

Four clusters best represented the distribution of reserve in this sample, hypothesized to be defined as the difference between the median and 90th percentile of the step-count distribution. Cluster 1, with the lowest reserve would also be classified as sedentary based on median step count (1,555 step count; 1,314 reserve). Cluster 2 represented people with limited activity with low reserve (4,081 step count; 2,439 reserve). Cluster 3 represented active people with high reserve (7,197 step count; 4,370 reserve). Cluster 4, was very active with very high reserve (9,202 step count, 6,964 reserve).The factors associated with cluster membership were gait speed, sit-to-stand, and depression.

Conclusions

The median and 90th percentile over a longer period indicates the potential "reserve" for participating in activities that demand additional walking.

Key words: steps per day, seniors, walking reserve, fracture, cluster analysis

INTRODUCTION

Steps per day, a widely used physical activity indicator, can provide rich information about the activity of the average older person whose main source of activity is derived from walking.(1-3) According to the International Classification of Functioning, Disability and Health (ICF), walking is moving along a surface on foot, step by step, so that one foot is always on the ground, such as when strolling, sauntering, walking forwards, backwards, or sideways.(4)

For the average person, for whom walking is the most practical and accessible physical activity, the pattern of steps taken per day over a time period can indicate not only what they typically do, but also what they are capable of doing if they need or want to do more, termed "reserve".(5) The concept of walking reserve is comparable with the concept of physical reserve which are the physiological and functional resources an individual has to call upon to meet health challenges, and represents the latent or dormant abilities that can be called upon in times of perceived need.(6) In other words, what the person has in their "tank".

For older persons, walking is the most common and safest form of physical activity. Walking for exercise requires a normal gait pattern otherwise, with gait deviations there is a risk of exacerbating existing muscle and/or joint impairments. Age-related decline in physiological functions renders older people vulnerable to gait deviations. Gait vulnerability is defined as a physiological health state or disease that results in the person being at an increased risk of developing deviation in gait parameters, limitation in walking capacity, and/or sustaining walking for purposes of health promotion.

Tudor-Locke,(7,8) a leader in step-count analytics, has provided targets for different populations. She has critiqued the

"10,000 steps a day" value as being unrealistic, and too high for some (older persons and those with chronic conditions) and not enough for younger populations. Based on her work using population level data for the United States from the National Health and Nutrition Examination Survey (NHANES), the following activity categories were defined: i) < 2,500 steps/day (basal or sedentary activity); ii) 2,500–4,999 steps/day (limited activity); iii) 5,000 to 7,499 typically active, typical of daily activity without steps from exercise or sports; iv) 7,500 to 8,999, very active, reflecting steps accumulated from exercise/sports or high occupational demands; and v) ≥9,000 highly active steps/day. Another way of thinking about these values is "3", "5", "7" and "9" (000) defining activity levels as sedentary, limited activity, active, and very active, respectively. Typically, active seniors would fall between the "5" and "7" values.

In a 2011 update of literature on "how many steps per day are enough", Tudor-Locke concluded that 3,000 steps at a cadence of 100 steps per minute over and above steps for usual daily activities would be a target.[9] This translates to around 7,000 to 8,000 steps per day. This "3,000 steps per day" value accumulated over and above usual activities through targeted exercise was suggested as a public health approach for health promotion. This value would also apply to older populations as they take fewer steps for daily activities.

How many steps are enough is a topic of high interest, and many studies demonstrated that health benefits can be achieved with moderate doses of walking.[10-13] Even increments of 1,000 steps per day over baseline have been associated with reductions in all cause mortality and cardiovascular disease ranging from 5 to 36%.[14] Considering that people accumulate 1,200 to 4,000 incidental-to-slow steps[15] per day to accomplish basic activities of daily living and household activities, health benefits will emerge by adding 1,000 to 2,000 moderate-to-brisk steps per day.

Most studies on step counts report median and mean values over a short period of time (days). For example, in a 2019 study published in *JAMA Internal Medicine,*[16] some 16,000 older women who participated in the Women's Health Study (mean age 72 years) wore an accelerometer for seven days. Mean (median) step count was 5,499 (5,094) per day, with a high degree of variability (interquartile range of 2,128 for 25th percentile to 9,954 for 75th percentile). The full distribution would be more informative, especially if longer term data (weeks or months) on step counts were available.

In another paper, Tudor-Locke *et al*. showed the full distribution of step-count data for men and women by age.[17] There was steady declines in step counts over age groups for all the percentiles presented (50th, 75th, and 95th), but the steepest decline over age groups was observed at the 95th percentile. This was particularly noticeable for women where the 95th percentile value at age 60 was ≈10,000 steps (median ≈4,500), but by age 85, only ≈4,000 steps (median ≈1,500). These data show that a reserve index based on the difference between the median and 95th percentile was ≈5,500 for women at age 60, and ≈2,500 at age 85, compatible with known deterioration in physical reserve with age. The corresponding 95th percentile values for men at age 60 were ≈13,000 steps (median ≈6,200) and at age 85, ≈6,000 steps (median ≈2,800), with estimated reserve values of ≈6,800 and ≈3,200, respectively for age group. Overall age categories, the greatest difference between men and women was between the 50th and 95th percentile. This suggests that men and those of younger years have greater capacity to tap into resources to accomplish high step counts on some days. This capacity could be a measure of walking reserve. While walking reserve is a new concept, these data support its presence.

Most of the studies on step counts are done while participants wear an accelerometer for a short time (e.g., days),[17-20] usually for a maximum of seven days. For longer periods of time, taking a simple average does not do justice to the richness of the longitudinal data and a different approach is needed to summarize these longitudinal data. We propose here that the full distribution of step counts over weeks to months can be used to identify subgroups of the population that differ not only on habitual physical activity, but also on the amount of reserve they have at their disposal for augmenting typical activity days with more intensive exercise days.

The purpose of this study is to estimate the extent to which the distribution of step-count data over a period of weeks to months identifies different subgroups of people which could be used to indicate walking reserve. The specific hypothesis is that the difference between the 90th percentile and the 50th percentile (median) will distinguish different clusters of people, and that people in the lowest reserve cluster will differ from people in the higher reserve clusters on variables with the potential to influence step-count distribution.

METHODS

The data for this study came from a completed pragmatic randomized trial: *Hip Mobile: A Community-based Monitoring, Rehabilitation and Learning e-System for Patients following a Fracture* (SN Morin, NE Mayo, *et al*; NCT03153943). The global aim of the Hip Mobile project was to test the value of using technology to enable recovery and improve quality of life following a hip fracture through the implementation of the Hip Mobile technology eight weeks post-fracture repair. As part of the study, participants were provided with a pedometer to track their daily step count. The Morin & Mayo study obtained ethical approval from the Institutional Review Boards of the McGill University Health Center (MUHC).

Because of challenges with recruitment, the study sample was expanded to comprise community dwelling men and women ≥ 60 years, treated for any fracture excluding hands, feet, patella, cervical spine, skull, rubs, or clavicle, at three Montreal affiliated hospitals with McGill University. Excluded were people living in, or discharged to, a long-term care institution, or who had sustained multiple traumas, an open fracture, or a cancer-related fracture. Recruitment started on May 31, 2017 and was completed on March 10, 2020 when the COVID-19 pandemic closed recruitment. Humerus and wrist fractures were included as restricted upper limb mobility effects gait and overall mobility in older people.[21-23] Interviews were conducted with the participants, gathering self-reported data on any complications they may have experienced. During the assessments, no complications were identified that affected enrollment in the study or recovery outcomes.

A time series design of a secondary data analysis was conducted to track the variability of daily step count. Each participant was provided with a Piezo® SC-StepX pedometer (Omron Healthcare Co. Ltd., Kyoto, Japan; www.omronhealthcare.com) and was asked to record the number steps at the end of each day for the duration of the study intervention period (three months post-intervention) which ranged from five to 12 weeks.

The measures for this analysis included patient reported outcomes (PRO), performance outcomes (PerfO), administered at baseline (Time 0) only, and a technologically assessed outcome (TechO) assessed longitudinally over three months.[24] The primary outcome, daily step count, was obtained from records kept by participants of the steps from the pedometer. For each participant, the distributional parameters for the daily step-count data were extracted: mean, standard deviation (SD), median, minimum, maximum, and percentiles. The full distribution was calculated but was only presented by decile. The activity categories of sedentary, limited activity, active, and very active were based on the "3", "5", "7" and "9" (000) step thresholds derived from the work of Tudor-Locke.[7,8]

The concept of measuring walking reserve is novel, but the concept of reserve as resources available to meet additional demands is not.[6] Thus, to quantify reserve, there needs to be a difference between usual activity and some higher value. We discarded the maximum, as experience shows that sometimes people overdo an activity and regret this for days or weeks. We also wanted a higher value that had some repeatability, so the 95%ile was considered too rare. When seven-day physical activity monitoring is used, the only possibility to measure reserve is difference between "usual", which can be the mean or median, and the maximum which is what is done on one day, which would be the 86th percentile. With a longer period of time, this would correspond to the 90th percentile. By choosing the 90th percentile, more days (1/10) can be included, and this value may be less affected by outlier days.

PROs potentially affecting reserve were general health perception, pain, and low mood measured on a visual analogue health scale (VAHS)[25] from 0 to 10, with higher values indicating better general health but greater pain and low mood. Also measured were PerfOs of comfortable gait speed (meters per sec), sit-to-stand (STS: count in 30 sec), and tandem stance, item from the Berg Balance Scale (5 level ordinal scale). Participants were permitted to use a gait aid for the performance tests. Daily step count over the entire study period was provided by a pedometer (TechO). Details on the administration of these tests are included in the Appendix (Table A1).

Statistical Analysis

K means cluster analysis on the percentile distribution of step count over all recorded days and was used (proc fastclus) to identify groups of people with similar step-count distributions. Classically, the number of clusters is determined by the inflection point on the elbow plot along with theory and existing knowledge. Since Tudor-Locke defined four activity groups,[26] we chose a model with four clusters. The clustering was done on the basis of Euclidean distances. Indicators of good quality clusters is when the intra-cluster distance—the distance between members of a cluster—is small compared to intercluster distances. The sample was described according to cluster membership and for the group as a whole.

The longitudinal pattern of step count was also described using group-based trajectory analysis (GBTA).[27,28] This analysis identifies the number of unique longitudinal trajectories in the data. To select the best trajectory model, the best one-group model was identified and then the number of groups was increased one by one until the maximum logical number of groups was reached or the Bayesian Information Criteria (BIC) value started to rise. The final best model was chosen based on absolute BIC value,[29] clinical knowledge, reasonable judgment (e.g., group size is reasonably large, >5%),[27] and the difference of BICs between two models with different numbers of trajectory groups where a difference larger than 10 is considered a strong evidence in favor of the model with a larger number of groups.[30] The shape of the trajectories are parameterized by the intercept, linear, and quadratic terms. Posterior probabilities of group membership are also >0.7 area considered to indicate good fit. Appendix Table A2 presents the fit parameters for competing models. Crude agreement between the cluster and trajectory groups was also calculated.

Ordinal regression, the proportional odds model, was used to identify factors associated with being in a cluster with higher reserve. A multivariable model was used to identify the strongest predictors, and the final model was the most parsimonious. This model estimates the odds of being in a higher reserve cluster for each level of each variable compared to the odds associated with the lowest level of that variable, for each cut-point. An odds ratio (OR) and 95% confidence intervals (CI) across all cut-points are derived from the model. Homogeneity of the cut-point specific ORs is assessed using a score test. All analyses were done using Statistical Analysis Software (SAS 9.4™; SAS Institute Inc., Cary, NC).

RESULTS

Data were available on 44 of the 62 trial participants, 16 men (36%) and 28 women (64%); all but three (upper extremity) sustained a fracture. The mean age of the participants was 75.8 years (SD: 9.75); step-count data were available for an average of 95 days (SD: 21.5), ranging from 47 to 123 days. At the baseline assessment, 13 people used a walker, 13 people used a cane, one person still needed a wheelchair and did not complete the walking tests, the remaining 17 people completed tests without a walking aid. At the time of final assessment no one used a walking aid to perform the walking tests.

The 44 people contributed 4,180 person-days of step counts. The study period was 90 days: four people contributed data for 91 days; 16 people contributed data for less than 90 days for a total of 276 missing person-days of step data; 24 people contributed more than 91 days for an excess of 488 person-days of step data.

The percentile distribution for each person was calculated and the 50th and 90th percentile is displayed in Figure 1 which is sorted according to the 50th percentile. The difference between the 90th and 50th percentile is smallest for people with the lowest average step count and increases with increasing median number of steps. The full percentile (10th to 90th) distribution was used in a cluster analysis.

The elbow plot identified three clusters, but four clusters produced the same categories as Tudor-Locke, so we chose four clusters. The intracluster distances were small compared with the intercluster distances indicating good quality clusters. The distribution of step counts in these four clusters over the study period are presented in Table 1. Cluster 1 comprises eight people who would be classified as sedentary, mean

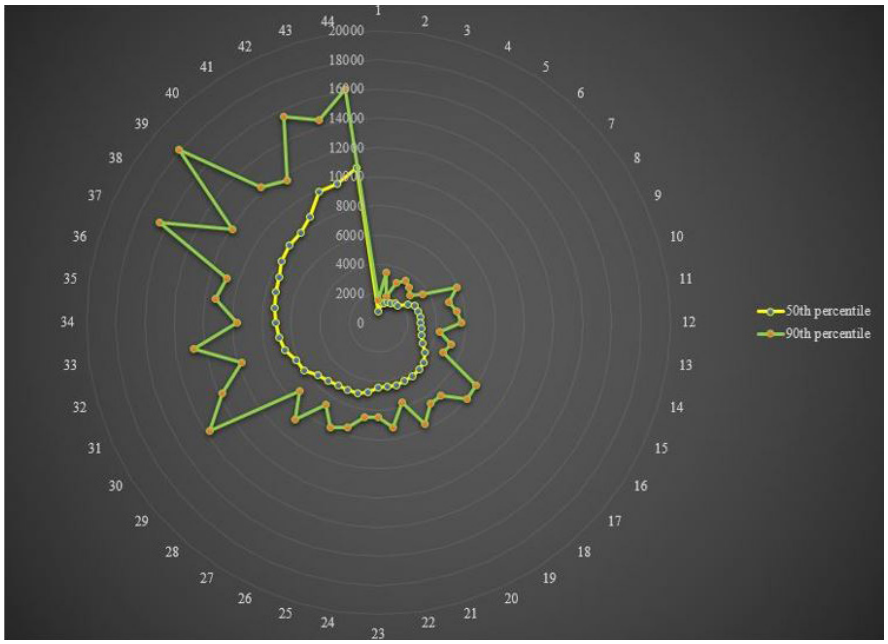


FIGURE 1. Radar graph of the distribution of step count (50th and 90th percentile) for all participants (n=44)

TABLE 1.
Step-count distribution by clusters

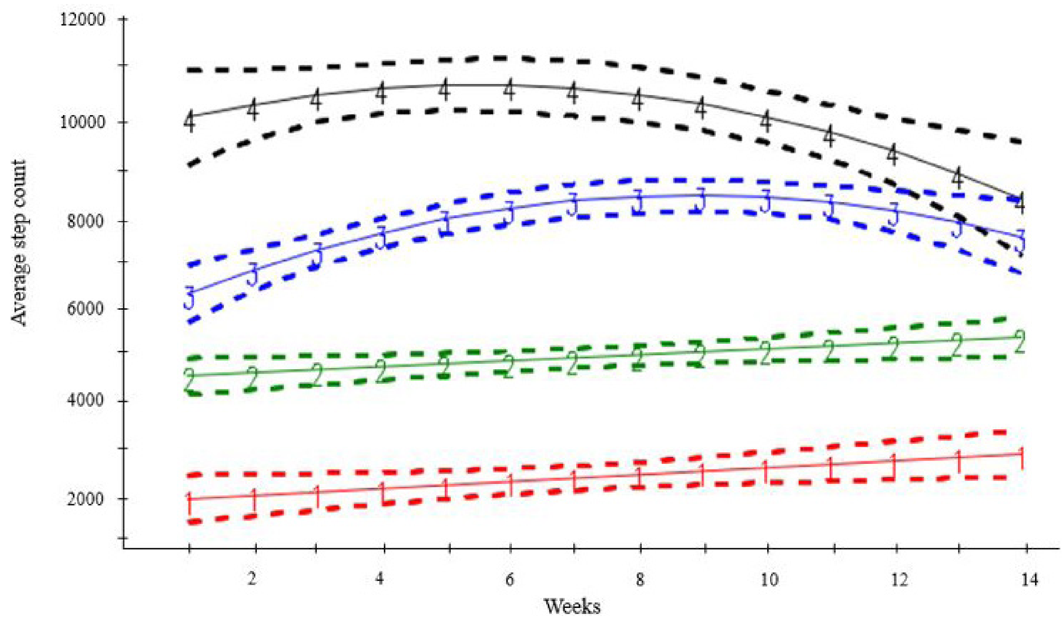
Step Count Percentiles & Mean	*Sedentary, Low Reserve Cluster 1 (N=8)*	*Limited Activity, Low Reserve Cluster 2 (N=21)*	*Active, High Reserve Cluster 3 (N=10)*	*Very Active, Very High Reserve Cluster 4 (N=5)*
10th	725	2,351	3,820	4,293
20th	931	2,847	4,795	5,776
30th	1,078	3,205	5,566	7,112
40th	1,301	3,641	6,293	8,192
Mean ± SD	1,678 ± 448	4,297 ± 877	7,408 ± 593	9,633 ± 906
50th	1,555	4,081	7,197	9,202
60th	1,741	4,568	7,923	10,183
70th	1,941	5,045	8,723	11,329
80th	2,356	5,675	9,692	13,080
90th	2,870	6,520	11,566	16,166
Maximum	4,779	9,508	16,325	20,372
90th– 50th	1,314.3	2,439	4,370.1	6,964.2

Sedentary = 3+(000) steps/day; Low active = 5+(000) steps/day; Active = 7+(000) steps/day; Very active = 9+(000) steps/day.

<3,000 steps per day. They took the fewest steps (median 1,555 steps/day) and the difference between the median (50th percentile) and the 90th percentile was 1,314 steps, which kept them in the sedentary class. Cluster 2 comprises 21 people with a higher step count, median 4,081 steps/day, considered limited activity, with low "reserve" as the 90th percentile still keeps them in the limited activity. Cluster 3 comprises 10 people classified in an active cluster (median 7,197 steps/day) with high reserve (4,370 steps). Cluster 4 comprises five people who would be classified as very active (median 9,202 steps/day). This group had the highest reserve (6,964 steps) and their 90th percentile placed them in the very active class for at least 10% of the time.

Figure 2 shows the variability of daily step counts over time. Four groups of people were identified with distinct longitudinal trajectories. The trajectory groups corresponded with the cluster groups, as shown in Table 2. Overall, 36 of 44 (81.1%) people were classified in the same step-count pattern, using the cumulative clustering approach and the longitudinal trajectory approach. Thus, the cumulative approach was used to identify factors associated with cluster membership.

The characteristics of participants in each cluster are presented in Table 3. These factors were used in the regression model to identify the extent to which they were associated to cluster membership. Table 4 shows that only gait speed, sit-to-stand, and low mood were associated with cluster



	Group Based Trajectory Analysis Group Membership n=44 n (%)			
	Group 1 *15 (34.05)*	*Group 2* *14 (31.85)*	*Group 3* *11 (24.97)*	*Group 4* *4 (9.11)*
Mean Step Count (SD)	1,833.6 (207.3)	4,421.2 (212.8)	5,647.3 (400.6)	9,507.9 (668.4)

FIGURE 2. Average step count over 14 weeks for different groups of participants

TABLE 2.
Concordance of cluster groupings with trajectory groupings[a]

		Cluster				
		1	*2*	*3*	*4*	*Total*
GBTA	1	8	7			15
	2		14			14
	3			10	1	11
	4				4	4
	Total	8	21	10	5	44

[a]Crude agreement = 36/44 (81.8%).

membership. Goodness-of-fit tests for the ordinal regression showed good fit for the largest cluster.

DISCUSSION

While it is possible to measure physical capacity after sustaining a fracture, there is no direct measure of reserve, which is defined as the resources that a person has to combat an incoming stressor.[31] Reserve is important as it can be used to reduce the impact of injuries or illnesses and hasten recovery from these stressors. Reserve can also allow older people to participate in special activities that demand more walking than they typically do. We proposed a new method of characterizing walking activity and walking reserve from data provided by a simple technology, the pedometer. Thus, the results serve as proof-of-concept.

The concept of walking reserve has not been studied and would be very relevant for the fracture population as this concept may provide important insight into the recovery process post hip fracture. Typical walking activity, walking reserve, and associated factors would provide information for developing a more personalized rehabilitation program based on data collected from a simple, widely used, technology, the pedometer.

We defined walking reserve as the difference between the long-term 90th percentile value and the long-term median value, where long-term would be defined as 30 days or more. Tudor-Locke *et al*. described how percentile distribution of daily step counts differed by age group.[17] While the median declined over age, the sharpest decline was at the 95th percentile. This difference between the median and the 95th percentile diminished with age, supporting this metric as an indicator of reserve. Our data show (see Table 1) that Clusters 1 and 2 differed on median step count (1,555 and 4,081 steps/day, respectively), but neither group had enough reserve to move them into the next active level on many days (<10%). However, Cluster 3 did have enough reserve to move into the next activity level, and Cluster 4 was already very active.

TABLE 3.
Characteristics of study participants at study entry according to step-count cluster (n=44)

Variables	*Sedentary, Low Reserve Cluster 1 (N=8)*	*Limited Activity, Low Reserve Cluster 2 (N=21)*	*Active, High Reserve Cluster 3 (N=10)*	*Very Active, Very High Reserve Cluster 4 (N=5)*
	Mean ± SD or n (%)			
Age	80 ± 9.2	77 ± 11.4	73 ± 8.3	68 ± 5.4
Sex				
Men	3 (37)	5 (24)	4 (40)	4 (80)
Women	5 (63)	16 (76)	6 (60)	1 (20)
Fracture Site				
Lower Extremity proximal (hip, sacrum, pelvis)	6 (75)	15 (71)	4 (40)	1 (20)
Lower Extremity distal (tibia, ankle)	2 (25)	4 (19)	5 (50)	4 (80)
Upper Extremity (humerus, wrist)	0 (0)	2 (10)	1 (10)	0 (0)
Gait speed	0.6 ± 0.15	0.81 ± 0.3	1.1 ± 0.3	1.1 ± 0.13
Tandem[a] N [%]	2 (25)	9 (43)	7 (70)	4 (80)
Sit-to-stand	5 ± 5.7	9 ± 3.8	11 ± 4.4	14 ± 2.6
General health perception	5.1 ± 1.9	2.9 ± 2.3	2.6 ± 2.4	4.2 ± 1.1
Low mood	3 ± 3.5	0.9 ± 1.7	0.9 ± 1.4	0.6 ± 0.9
Pain	3.4 ± 2.8	2 ± 2.1	3.2 ± 2.5	3 ± 1.4

[a]Percentage with score of 4 on tandem (item from Berg Balance Test).

TABLE 4.
Important predictors of high step count

Variables	*β^a*	*Standard Error*	*OR (95% CI)*
Gait Speed (per 0.1m/sec)	0.27	0.13	1.31 (1.02, 1.69)
Sit-to-Stand	0.22	0.08	1.24 (1.06, 1.46)
Low Mood	-0.29	0.18	0.75 (0.53, 1.1)

[a]The beta coefficient in regression analysis.

Little is known about recommended steps per day for older people following fractures. Studies have reported steps per day but for shorter time periods. The 2019 Lee *et al*. study involved some 16,000 women from the Women's Health Study (mean age 72 years) who wore an accelerometer for only seven days.[16]

As we had the hypothesis a priori that people would differ on our "reserve" metric, the difference between the 90th percentile and the 50th percentile was used a cluster analysis. The four clusters supported this hypothesis, as two had low reserve (despite differences in median step count) and two had high or very high reserve. We classified reserve as low or high based on whether the people in the cluster had enough reserve to move into a higher activity group (Table 1). Other "reserve" indices could have been used. We discarded the maximum, as experience shows that sometimes people overdo an activity and regret this for days or weeks. We also wanted a higher value that had some repeatability, so the 95%ile was considered too rare. The 90th seemed just right. Once a week would be the 86th percentile, close to the 90th.

It is interesting to note that neither age nor sex was associated with cluster membership in our study. In addition, there was a wide range of step counts across this sample, with several people in Cluster 3 and 4 having days where they walked more than 10,000 steps. The often-reported value of 10,000 steps per day does not have strong scientific rationale, particularly for older people, and no information is available for post fractures. In 2004, Tudor-Locke[8] critiqued the "10,000 steps a day" value as being unrealistic, and too much for some (older persons and those with chronic conditions) and not enough for younger populations; thus, it is important to have goal-oriented step-count targets based on individual walking reserve and capacity.

To build reserve, gradual increase in time spent in activity rather than increased intensity has been suggested and tested.[32] Walking is an accessible form of exercise, but for many people post fracture, walking is done to accomplish activities of daily living, not in a goal-directed manner to improve capacity and reserve. A systematic review and meta-analysis showed that step count monitoring interventions can lead to sustained increases in people's walking.[33]

The observation that the cumulative approach to creating groups concurred with the longitudinal approach supported our decision to identify reserve factors using the cluster analysis groupings. Of the factors from Table 3 that we used in the ordinal model, only gait speed, sit-to-stand, and low mood had an important association with cluster membership (Table 4). Here inference was made on the magnitude of the estimate of effect and the confidence interval rather than solely on the p value, as the sample size was small. All of the estimates of effect in Table 4 were closely similar, ranging from 0.22 to 0.29 (absolute values) for each meaningful difference in the explanatory variables with low mood (VAHS) having the largest effect (-posterior probability 0.29) although the upper limit of the confidence interval was 1.1.

It has been reported by Tuka *et al*.[34] that targeted physical activity is the holy grail of modern medicine, and is claimed to have the potential to reduce depressive symptoms and improve overall physical function and capacity. Targeted steps per day as per the walking capacity and reserve would give recommendations to improve walking capacity and health promotion walking.

Interestingly, a study by Costa *et al*. proposed that walking speed reserve in people with chronic stroke could be measured by taking the difference between maximal and self-selected speed over a 10-meter course.[35] Arbitrarily, a difference of walking speed of 0.2 m/s between self-selected and the maximal speed was set as an indicator of walking speed reserve. This, however, is a clinical test, and may not be reproduced in the real world if people have to rely on this reserve to avoid accidents such as when crossing the street. Mate and Mayo[36] showed that, among people with Multiple Sclerosis, the most able did not reproduce clinically assessed walking speed tests in the real world.[36] This would suggest that our approach using real world data would provide a better indication of walking reserve than a clinical test.

One challenge with interpreting step-count data is that there are different labeling conventions depending on age.[4,5] We have adopted a "3", "5", "7", "9" (000) system to simplify setting personalized step-count targets. Interestingly, Tudor-Locke identified that older persons typically take between "5" and "7" (000) steps per day, supporting these values as targets: below typical, typical, or above typical.

The data arose from a clinical trial with inherent limitations to this methodology in terms of eligibility and recruitment. The design would exclude the most frail. The sample size was also small, and only 44 of the 62 trial participants contributed step-count data, although there were 4,180 person-days of walking. The duration of the study was three months; some people recorded fewer days and some more days. Also, some participants failed to record their number of steps for all days, leading to some error in the distribution. Other technology is available to eliminate the need for people to record their steps using other types of wearable sensors. No data were available on cadence or duration of walking bouts. Not all persons provided health outcome data. Replication in a large sample size is warranted. With a larger sample size, it would also be possible to estimate the effect of other clinical characteristics that are typical of this older population such as comorbidity and previous level of physical activity. There are also different clustering methods; we chose the one best suited to the data, but other machine learning approaches are available for this type of high dimensional data and would be appropriate for larger datasets.

Another limitation was the assessment of balance using only a single measure, tandem stance. This measure likely underrepresents the construct of balance and was scored as normal for 50% of the sample, providing insufficient variability to predict effectively. While we needed to keep assessments to a minimum due to the trial's focus on technology, the lack of variability in the balance measure affected its predictive value.

CONCLUSION

The vast amount of data collected from a pedometer over time can be used to describe the activity pattern of older adults who have sustained a fracture. Rather than focusing on the mean over a restricted time period, the median and 90th percentile over a longer period of time indicates not only typical patterns, but also the potential "reserve" the person could tap into for participating in special events that demand additional walking. Slow gait, muscle weakness, and low mood were identified as limiting walking reserve, and would guide how to build up this reserve.

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Not Applicable

CONFLICT OF INTEREST DISCLOSURES

We have read and understood the *Canadian Geriatrics Journal*'s policy on conflicts of interest disclosure and declare the authors have nothing to disclose.

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APPENDIX

TABLE A1.
Description of the tests used for reserve indicators

Test	*Description of the Instructions*
Gait Speed	For the in-clinic assessment, a distance of 9 meters was marked on the floor with two markers. An additional 2 meters at each end were marked for acceleration and deceleration but these distances were excluded from the timing. The participant starts 2 meters from the first marker and on the mark of "go" is instructed to walk at a pace which is safe and comfortable until passing the last marker. If done at participants home, the available distance is recorded.
Sit-to-Stand (STS)	For the 30-second STS, the participant was seated on a folding chair without arms, with seat height of 17 inches (43.2 cm). The chair, with rubber tips on the legs, was placed against a wall to prevent it from moving. The participant is seated back straight; feet approximately shoulder width apart and placed on the floor at an angle slightly back from the knees, with one foot slightly in front of the other to help maintain balance. Arms are crossed at the wrists and held against the chest. The task was demonstrated by assessor, both slowly and quickly and replicated one or two times by the participant. At the signal "go," the participant rises to a full stand (body erect and straight) and then returns back to the initial seated position. The participant is encouraged to complete as many full stands as possible within 30 seconds. The participant is instructed to fully sit between each stand. While monitoring the participant's performance to ensure proper form, the tester silently counts the completion of each correct stand. The score is the total number of stands within 30 seconds (more than halfway up at the end of 30 seconds counts as a full stand). Incorrectly executed stands are not counted; final score is the total number of stands within 30 seconds. If a patient must use their arms to complete the test they are scored 0.
Tandem Stance from Berg Balance Scale	STANDING UNSUPPORTED ONE FOOT IN FRONT (affected leg is in the back, unaffected crosses in front) INSTRUCTIONS: (DEMONSTRATE TO SUBJECT) Place the unaffected foot directly in front of the other. If you feel that you cannot place your foot directly in front, try to step far enough ahead that the heel of your forward foot is ahead of the toes of the other foot. Score 4 able to place foot tandem independently and hold 30 seconds Score 3 able to place foot ahead independently and hold 30 seconds Score 2 able to take small step independently and hold 30 seconds Score 1 needs help to step but can hold 15 seconds Score 0 loses balance while stepping or standing

TABLE A2.
Fit parameters for models with different numbers of trajectories

N Trajectories	*BIC (n=44)*	*Difference*		*1*	*2*	*3*	*4*	*5*	*6*
6	-5326.7	-5.7	N	7	8	14	10	2	3
			PP	0.942	0.989	0.999	0.999	0.999	1.0
5	-5332.4	-9.7	N	9	6	14	11	4	
			PP	0.946	0.999	0.999	1.0	1.0	
4	-5342.1	-48.9	N	15	14	11	4		
			PP	0.998	1.0	1.0	0.999		
3	-5391.0	Referent	N	15	14	15			
			PP	0.997	1.0	0.997			

N = number; PP = posterior probability; BIC = Bayesian information criterion.