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Running head: Balance confidence or performance

Balance confidence was associated with mobility and balance performance in older people with fall-related hip fracture: a cross-sectional study

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Conflict of interest

We certify that no party having a direct interest in the results of the research supporting this article has or will confer a benefit on us or on any organization with which we are associated AND, if applicable, we certify that all financial and material support for this research (eg, NIH or NHS grants) and work are clearly identified in the title page of the manuscript.

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Gerontology Research Center is a joint effort between the University of Jyväskylä and the University of Tampere.

Presentations

Part of the data will be presented on the Nordic Congress on Gerontology, in June 2012 (Copenhagen, Denmark) by the corresponding author Erja Portegijs.

Trial number

This study is a joint analysis of two randomized controlled trials investigating health, functional capacity, and rehabilitation of people with a hip fracture history (study identifiers ISRCTN34271567, ISRCTN53680197).

Balance confidence was associated with mobility and balance performance in older people with fall-related hip fracture: a cross-sectional study

Objective. To study the relationship between balance confidence, a concept closely related to fear of falling, mobility and balance performance and perceived mobility limitation in older people following a fall-related hip fracture.

Design. Cross-sectional analyses of pre-trial data of two randomized controlled trials of physical rehabilitation (ISRCTN34271567; ISRCTN53680197).

Setting. University research center

Participants. Community-dwelling people aged over 60 years, 6 weeks to 7.5 years after a fall-related hip fracture (N=130).

Interventions. Not applicable.

Main Outcome Measures. The main outcome was the self-reported Activity-specific Balance Confidence (ABC) scale. Assessments also included perceived ability to walk outdoors or climb one flight of stairs, and assessments of self-preferred walking speed, modified Timed Up-and-Go, and Berg Balance Scale.

Results. Higher ABC scores were related to better mobility and balance performance (R>0.47) and perceived mobility function (R>0.54). In univariate general linear models, all associations remained significant also after adjustment for age, gender, time since fracture, number of chronic diseases, and in addition either level of physical activity or muscle strength of the fractured leg. An ABC score<85 points identified those with mobility and balance limitation across measures.

Conclusion. In people who have had a fall-related hip fracture, an independent relationship exists between balance confidence and mobility and balance performance as well as perceived mobility function. Since lack of balance confidence may compromise rehabilitation and recovery, the ABC scale may help to identify older hip fracture patients with mobility and balance limitation.

Keywords. Femoral fracture, falls efficacy, balance confidence, mobility limitation, postural balance

List of abbreviations

95%CI	95% Confidence Interval
ABC	Activity-specific Balance Confidence
BBS	Berg Balance Scale
CV	Coefficient of Variation
ICC	Intra-Class Coefficient
TUG	Timed-Up-and-Go
RS	Spearman correlation coefficient

Fear of falls and lack of balance confidence, two closely related concepts[1,2], may exist among older people with or without a history of falls. However, those with experience of a fall or fall-related trauma are likely to adopt their behavior due to fear for a new fall. After hip fracture, older people often experience lack of balance confidence, which may be a correct appraisal of their increased risk for falls.[3] Older people who have suffered a hip fracture have a markedly increased risk for future falls and new fractures in comparison with healthy older people.[4] Partly this increased risk is due to impairments in lower-limb muscle strength, mobility and balance performance that persist even years after the fracture.[4-9] Recovery to pre-fracture levels of functioning occurs in about one-third of persons surviving hip fracture.[4,8,10]

Balance confidence may contribute to the lack of functional recovery after hip fracture. Lack of balance confidence and fear of falling are reported to have a debilitating effect on mobility and functioning in geriatric rehabilitation patients[11] and residents[12], and accelerate the decline in mobility function in relatively healthy older people.[13,14] Lack of balance confidence may cause a vicious circle of further deterioration of function through avoidance of activities in which a person observes an increased fall risk.[3] Avoidance of physical activities causes muscle strength to decrease, which further increases the risk for mobility and balance limitation and even disability.[8,15] On the other hand, engaging in physical activities, even through ordinary daily activities only, or physical rehabilitation has a training effect in more frail older people.[16,17]

Balance confidence is task-specific. The Activity-specific Balance Confidence (ABC) scale assesses a person's confidence to perform different tasks without losing balance or falling.[2] Assessing the ABC scale takes only few minutes and may be thus be feasible in the clinical practice as well.[2] The ABC scale is related to different mobility and balance performance measures in relatively healthy samples of older people.[18-20] Its use in more frail older populations, such as hip fracture patients, has been questioned due to its large range of activities.[21] In hip fracture patients other measures of fear of falling and balance confidence have been associated with both mobility performance and perceived mobility function.[21] A previous study of our group suggested that the ABC scale was feasible in people with a history of hip fracture.[7] The relationship between ABC scale and functional balance was stronger among those with a history of hip fracture than among age- and sex-matched healthy controls.[7]

Our aim was to examine the relationship between performance-based and self-reported measures of mobility and balance function in older people with a previous fall-related hip fracture. In addition, the study aimed to determine whether this relationship remained after adjustment, including potential underlying mechanisms, such as reduced physical activity level and poor muscle strength. Finally, we searched for a cut-off value for the ABC scale to identify those with mobility and balance limitation across the different measures.

METHODS

Study Design

This study is a joint analysis of two randomized controlled trials investigating health, functional capacity, and rehabilitation of people with a hip fracture history (study identifiers ISRCTN34271567, ISRCTN53680197).[22,23] Both studies were performed at the same research center, using the same equipment and participants were recruited from the same Health Care District with identical inclusion and exclusion criteria. Data of these studies were pooled to increase sample size. Only the pre-trial data are used in this cross-sectional study.

Participants

The methods of both trials have been described before.[22,23] Patient records at the Central Finland Central Hospital were reviewed (in the fall of the years 2004-2005 and throughout the years 2008-2010) to recruit community-dwelling people over 60-years-old, who had been operated for femoral neck or trochanteric fracture. All potential patients were informed about the study (N=748). Those willing to participate were interviewed over the telephone or met during the inpatient period at the health care center to ensure suitability (N=268). Exclusion criteria were inability to move outdoors without assistance from another person, amputation of a lower limb, severe progressive

or neurological diseases, alcoholism and severe memory problems (Mini Mental State Examination, MMSE<19).[24] Of the 149 eligible patients, 130 were included in the present analyses based on an additional criterion of having experienced a hip fracture due to a low impact fall, which may exacerbate the perception of lack of balance confidence. The ethical committee of the local Health Care District approved both of the study protocols. Participants gave their written informed consent prior to the assessments. The assessments were performed 6 weeks to 7.5 years after the fracture.

Assessment

A physician and research nurse performed a thorough clinical examination to assess general health status. Details of the fracture and repair (internal fixation vs. arthroplasty) and the number of chronic conditions (present for at least three months) were confirmed according to a questionnaire and medical records. Time since fracture was calculated as the number of days between date of fracture and date of the assessments.

Data collection of the following measures was performed by trained research assistants. Balance confidence in carrying out activities without becoming unsteady was assessed by interview using a modified Finnish version of the Activities-specific Balance Confidence (ABC) scale.[2,25] In this modified version, item 14 and 15 regarding escalators in the original scale were replaced with two items on “riding on a bicycle in a street with light traffic / in a heavily trafficked street with no bike path”. Bicycling was a more relevant activity for Finnish older people as large malls with escalators were very

uncommon until recently. Subjects are asked to report their confidence levels when carrying out 16 different activities, including those performed outdoors. Each activity was rated from 1 (no confidence) to 10 (total confidence); total score ranges from 16 to 160. The ABC scale was reported valid and reliable in older populations.[2] In addition, a close relationship between fear of falls and lack of balance confidence has been shown.[3]

Functional balance was measured using the Finnish translation of the Berg Balance Scale (BBS),[26] which evaluates the ability to perform 14 different tasks related to the subject's skills such as to sit down, stand up, reach forward, turn 360 degrees, and stand on one leg. Each task is rated from 0 (incapable) to 4 (safe and independent); total score ranges from 0 to 56. BBS has high intra- and inter-rater reliability.[27] Participants were categorized as having good and poorer balance performance based on a cut-off point of 45 points, which has been used to predict falls.[26]

Participants were allowed to use their assistive device commonly used for walking indoors during mobility tests. Self-preferred walking speed (m/s) was calculated from the shortest time to walk 10 meters, assessed using photocells.[a] Three meter was allowed for acceleration and deceleration. This test has been shown valid and reliable.[28] Participants were grouped into good, fair and poorer mobility based on cut-off points of 1.0 and 0.8 m/s that have been used to predict falls.[29,30]

The modified Timed Up-and-Go (TUG) measures the time it takes to rise from a chair, walk 2.44m as fast as possible, turn around a cone and return to the chair.[31-33] The shortest time of two trials, measured using a stopwatch, was used for analyses. The TUG test is valid and reliable for assessing mobility.[33] Participants were grouped into good, fair and poorer mobility based on cut-off points of 8.5[32] and 15[34] seconds that have been used to predict falls.

Self-reported mobility was assessed using a questionnaire. Participants were asked about perceived difficulty to walk outdoors and to climb one flight of stairs. The response categories were: (1) no difficulty, (2) some difficulty, (3) major difficulty, (4) unable without help from another person, (5) unable even with help. Due to low frequency in category 3 to 5, they were joined for the analyses ('major difficulty or unable').[35]

Present level of physical activity was assessed with a self-report scale by Grimby[36] with slight modifications. The highest category of the initial scale was divided into two categories, separating those participating in regular exercise fitness activities from those active in competitive sports. The 7-point scale ranged from 1 (mostly sitting) to 7 (participation in competitive sports). Categories 4-7 were combined due to low frequencies, thus leaving four groups: (1) mostly sitting, (2) light physical activity; such as light house hold tasks, (3) moderate physical activity for less than three hours a week, such as walking longer distance, domestic work, and (4) moderate activity for more than 4 hours a week and/or more strenuous activity multiple times a week.

Maximal voluntary isometric knee extension strength of the fractured leg was assessed using an adjustable dynamometer chair.[b] The ankle was attached to a strain-gauge system with the knee angle fixed at 60 degrees from full extension. Participants were encouraged to extend the leg as forcefully as possible. After 2-3 practice trials, the highest force of at least three measurements was used for analysis. Each contraction was maintained for 2-3 seconds. The test has been shown valid and reliable.[37]

Statistical Analysis

Participants with missing variables in knee extension strength (n=15), walking (n=8), TUG (n=13) and BBS (n=6) tests were dropped from the respective analysis only. BBS, walking speed, and TUG were analyzed as continuous as well as categorical variables based on the cut-off points used to predict falls.

Variable distribution was tested with Kolmogorov-Smirnov tests. Group differences were tested with independent T-tests and χ^2-tests. Spearman (rs) and Pearson (r) correlation coefficients were calculated for relationships between ABC score, measures of mobility and balance performance and perceived mobility limitation as well as confounders. Fracture repair type was not significantly ($p<0.05$) associated with any mobility or balance measure and was therefore not included in multivariable analyses. Univariate general linear models were used to compare groups based on the categorized mobility and balance performance measures and perceived mobility limitation. Each model

included ABC score (crude model), and was adjusted for (1) age, gender, time since hip fracture, and number of chronic diseases, and in addition either (2) level of physical activity or (3) knee extension strength of the fractured limb. Separate ROC-curves were drawn for ABC score to identify those with poorer mobility and balance performance, or major difficulty in perceived mobility measures. For each measure the optimal cut-off point(s) (highest sensitivity and specificity) was determined. These cut-off points were then used in sensitivity and specificity analyses to choose the cut-off point most suitable to identify those with mobility and balance limitation across outcomes. Finally, the cut-off score identified was used to predict mobility and balance limitation in logistic regression analyses. Odds ratios and 95% confidence intervals (95%CI) of crude (unadjusted) models are reported. PASW Statistics 18[c] was used for the statistical analyses and statistical significance was set at P≤0.050.

RESULTS

Table 1 shows the participants characteristics. They were on average 77.6± standard deviation 7.2 years old and the majority was female. On average 1.5±1.9 years had passed since the hip fracture.

Correlation analyses

Correlation coefficients between ABC score and continuous mobility and balance performance measures indicated that better performance (higher score; for TUG lower score) was associated with higher balance confidence (higher ABC score; Table 1). Similar correlations were found between ABC score and categorized performance-based measures; rs=0.60 ($p<0.001$) for BBS, rs=0.48 ($p<0.001$) for TUG, and rs=-0.47 ($p<0.001$) for walking speed, respectively. For the self-reported measures, less difficulty was related to higher balance confidence, the correlation coefficients with ABC score were rs=-0.54 ($p<0.001$) for ability to walk outdoors and rs=-0.57 ($p<0.001$) for stair climb ability, respectively.

Group differences were calculated for all confounding variables (data not shown). Those with poorer walking speed, TUG and BBS and those with perceived mobility limitation were significantly older ($p\leq0.014$), they had lower levels of physical activity ($p<0.001$) and muscle strength ($p\leq0.005$) than those with better functioning. For those with poorer walking speed, TUG and those with perceived limitation to walk outdoors significantly less time had passed since the hip fracture($p\leq0.041$). Those with poorer TUG and BBS and those with perceived mobility limitation had a higher number of chronic diseases ($p\leq0.029$) than those with better functioning. Lower ABC score correlated significantly with higher age ($r=0.37$, $p<0.001$) and number of diseases (rs= -0.29 , $p=0.001$), and lower level of physical activity (rs=0.47, $p<0.001$) and muscle strength (rs=0.40, $p<0.001$; Table 1).

Multivariable analyses

Figure 1 shows a clear gradient of decreasing ABC scores in groups with poorer mobility and balance performance and perceived mobility limitation. Group differences remained significant ($p<0.026$) also after adjustment for age, gender, time since hip fracture, and the number of chronic diseases, as well as after additional adjustment for level of physical activity or knee extension strength in the fractured limb (Table 2). Level of physical activity and knee extension strength attenuated the relationship between ABC score and all mobility and balance measures, however, the relationships remained significant.

Sensitivity analysis

ROC curves of each mobility and balance performance or perceived mobility limitation measure with ABC score suggested several potential cut-off points: 68.5 (ability to walk outdoors and walking speed), 76.5 (walking speed and TUG), 78 (ability to walk outdoors and climb stairs), 80.5 (walking speed), 84.5 (ability to climb stairs and TUG), and 85.5 points (BBS). All were used in the following sensitivity and specificity analyses to identify those with poorer mobility and balance performance and perceived mobility limitation for each measure. Using 84.5 points for cut-off rendered good sensitivity (≥0.73) and specificity (≥0.70) across all measures (Table 3). In logistic regression analyses, those with an ABC sum score <85 points had an odds ratio (OR) of 18.7 (95%CI:6.0-58.0) for having major outdoors walking difficulty and 11.7 (4.6-29.9) for

major stair climb difficulty. For the performance-based tests, the OR's were 12.6 (5.3-29.8) for BBS, 7.3 (3.0-17.8) for TUG, and 6.3 (2.6-15.0) for walking speed, respectively.

DISCUSSION

Our study shows that balance confidence was associated with a range of measures of mobility and balance performance and perceived mobility limitation in older people following a fall-related hip fracture. The relationships found remained significant also after considerable adjustment. An ABC score <85 points identified most participants with mobility and balance limitation across the different measures. The ABC scale may be useful for clinicians to identify hip fracture patients with or at risk for mobility and balance limitation. Addressing lack of balance confidence together with improving mobility and balance performance by physical rehabilitation may positively affect the potential for functional recovery of hip fracture patients.

In relatively healthy populations of older people, a reduced ABC score, indicating lack of confidence to perform mobility tasks without loss of balance, has been associated with reduced performance as measured in walking speed[18,20], TUG[18,19], and BBS.[18] The mean ABC score in our study, when converted to a scale from 0-100% (being 55), was similar as the means in two studies of patients about 4 months after hip fracture (being 59 and 61, respectively).[38,39] In addition, the associations with BBS (r=0.77)[38] and gait

speed (r>0.6;)[38,39] were very similar. Previous studies using other measures of fear of falling or balance confidence have shown relationships with TUG[40] and self-reported mobility measures in hip fracture patients.[40,41] Our results showed that the association between ABC score and mobility and postural balance occurred across different self-reported and performance-based measures.

Lajoie et al.[42] has previously determined a cut-off score for the ABC scale. In their study a score of less than 67% (that is 107 points) on the ABC scale increased the risk for falls in relatively healthy older people. Our population with a previous fall-related hip fracture had lower balance confidence (two-third scored below 107p). Therefore, we determined a new cut-off point to identify persons with mobility and balance limitation after a fall-related hip fracture. Those with an ABC score <85 points had a 6-18 times increased risk of having poor mobility and balance performance or perceived mobility limitation than those with higher ABC scores. The association between balance confidence, mobility and balance performance or perceived mobility limitation was independent of time since fracture. This may support the hypothesis that poor balance confidence may implicate poorer recovery potential from an acute event[11] such as hip fracture.

The ABC scale is a relatively quick and easy tool to administer.[2] Identifying older hip fracture patients with low balance confidence and at risk for mobility and balance limitation may be clinically relevant. In our study, the ABC scale had an independent association with all measures of mobility and balance performance and perceived

mobility limitation. Early identification of hip fracture patients at risk may also impact on other health outcomes, such as new falls, disability and loss of independence. The ABC scale may be suitable also in the time-pressured clinical practice.

Early physical rehabilitation, including progressive resistance training or other physical exercises, may prevent or reduce the major functional decline associated with hip fracture.[16,17] In addition, mobility and balance performance can be improved by different physical interventions in healthy older people (for review[43]) as well as in clinical populations (for review[44]). Based on the close relationship between physical performance and balance confidence, and the risk appraisal theory[3,45], intervention aiming to improve physical function may also improve balance confidence. In hip fracture patients attending inpatient rehabilitation no relationship between change in ABC score and change in physical function was observed[46] and a weak association was found with change in dynamic balance following exercise training in older people residing in retirement villages.[47] There is some evidence that fear of falling may be reduced by different interventions in community-dwelling older populations.[48] However, systematic reviews in older hip fracture patients of multidisciplinary interventions and interventions aiming to improve both physical and psychological function were not able to demonstrate better outcomes when compared to regular care after hip fracture.[49,50]

Study limitations

Due to our inclusion criteria (community-dwelling, being able to come to our research center for measurements, being able to walk outdoors independently) participants were relatively well-functioning older people, compared to hip fracture patients in general. Generalization of the results should be done with caution. We included older people with a large time range since the fall-related hip fracture (6 weeks to 7.5 years). The time since fracture was related to performance-based mobility and balance measures, however, it did not affect the relationship between ABC score, mobility and balance performance or perceived mobility limitation. This may suggest that lack of balance confidence persistently affects mobility and balance performance in older people with a history of fall-related hip fracture. The sample size in this study allowed for considerable adjustment. We are therefore confident that the relationship between balance confidence and the different measures of mobility and balance performance and perceived mobility limitation was independent. Due to the cross-sectional study design, the chronological order of lack of balance confidence and limitations in mobility and balance performance and their relationship with the hip fracture event remain unclear. Longitudinal studies are needed to confirm associations and determine cause-effect relationships.

CONCLUSIONS

In older people with a fall-related hip fracture an independent relationship exists between balance confidence and a range of performance-based and self-reported

mobility and balance performance measures. In this group of older people, a score of <85 points on the ABC scale identified those with mobility and balance limitation. Identification of persons with lack of balance confidence seems clinically relevant as it may compromise functional recovery from the hip fracture. Potentially, rehabilitation may be more effective, when lack of balance confidence is taken into account or targeted. However, further study is needed to develop effective strategies to improve balance confidence and reduce the functional decline associated with hip fracture.

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Suppliers

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Table and Figure legends

Table 1. Means (standard deviations; SD) or prevalence of the participant characteristics and Spearman correlation coefficients of each measure with the Activity-specific Balance Confidence scale (N=130).

Table 2. Differences in mean Activity-specific Balance Confidence scale tested with adjusted univariate models for the mobility and balance performance groups based on previously reported cut-off values and the groups with perceived mobility limitation.

Table 3. Sensitivity and specificity analyses using 85 points as cut-off value for the Activity-specific Balance Confidence scale (to identify those with poorer mobility and balance performance or perceived mobility limitation).

Figure 1. Marginal means and 95% confidence intervals of the Activity-specific Balance Confidence scale in the mobility and balance groups derived from crude univariate models.

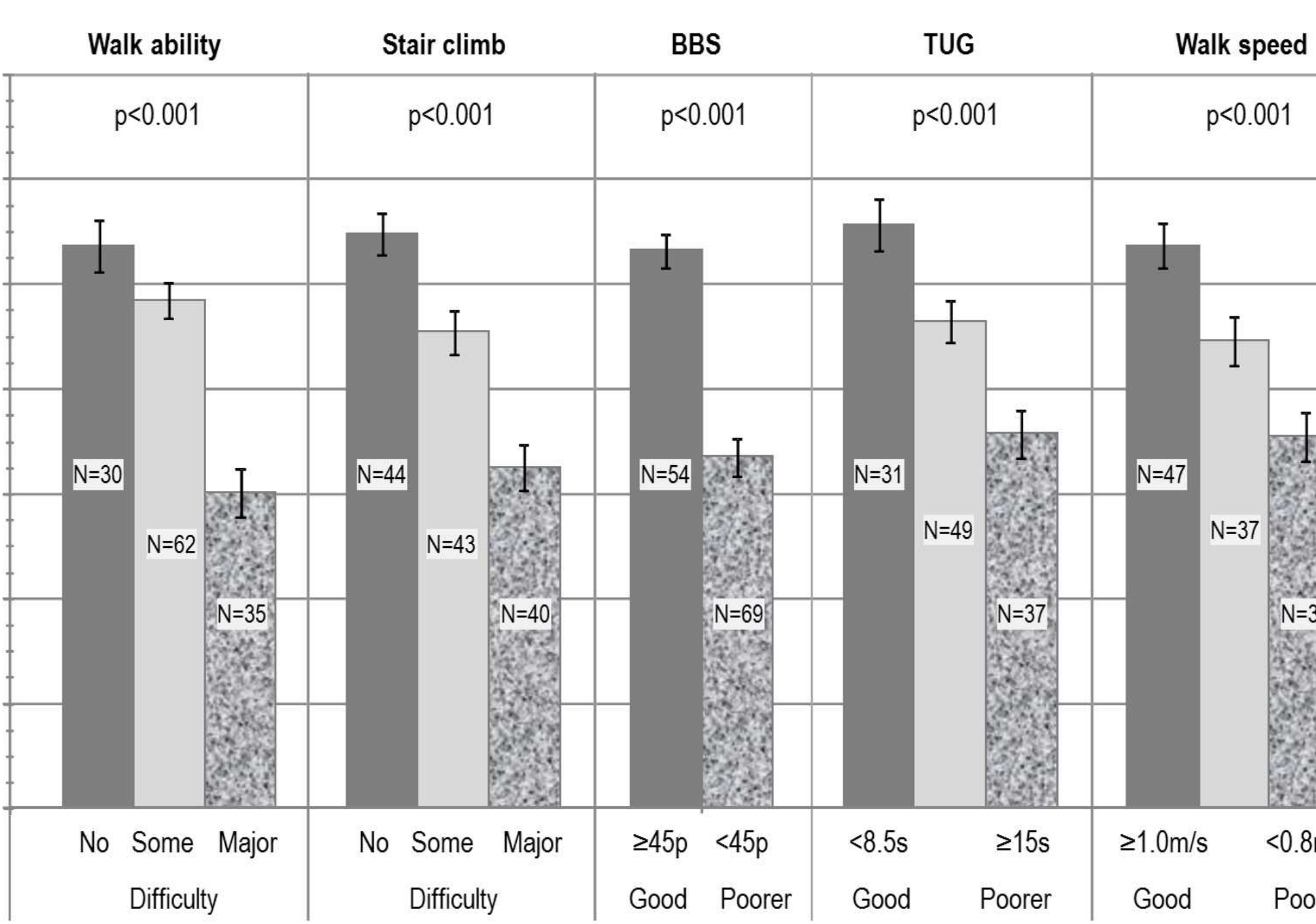
Walk ability
Stair climb
BBS
TUG
Walk speed
p<0.001
p<0.001
p<0.001
p<0.001
p<0.001
N=30
N=62
N=35
N=44
N=43
N=40
N=54
N=69
N=31
N=49
N=37
N=47
N=37
No Some Major
Difficulty
No Some Major
Difficulty
≥45p <45p
Good Poorer
<8.5s ≥15s
Good Poorer
≥1.0m/s
Good

Table 1. Means (standard deviations; SD) or prevalence of the participant characteristics and Spearman correlation coefficients of each measure with the Activity-specific Balance Confidence scale (N=130).

	Mean	SD	rs	P
Age (yrs)	77.6	7.2	0.37*	<0.001
Time since fracture (yrs)	1.5	2.0	0.07	0.437
Number of chronic diseases (n)	3.4	1.9	-0.29	0.001
Knee extension strength fractured leg (N)	202.3	91.2	0.40*	<0.001
BBS (p)	43.3	9.7	0.72	<0.001
TUG time (s)	15.0	10.3	-0.56	<0.001
Walking speed (m/s)	0.9	0.2	0.51*	<0.001
ABC score (p)	89.2	32.5	1.00	
	N	%	rs	P
Gender (female)	98	75.4	-0.05	0.613
Fracture repair (Internal fixation)	60	46.2	-0.03	0.668
(Hemi arthroplasty)	57	43.8		
(Total arthroplasty)	13	10.0		
Physical activity (Mostly sitting)	32	24.6	0.47	<0.001
(Low / moderate physical activity)	67	51.5		
(Moderate physical activity ≤3 hrs/week)	23	17.7		

(Moderate activity ≥4hrs/week or more strenuous)	7	5.4

*Pearson correlation coefficients

Table 2. Differences in mean Activity-specific Balance Confidence scale tested with adjusted univariate models for the mobility and balance performance groups based on previously reported cut-off values and the groups with self-reported mobility limitation.

		ABC	Physical activity	KE
Walk outdoors	Model 1	<0.001		
	Model 2	<0.001	0.001	
	Model 3	<0.001		0.007
Climb stairs	Model 1	<0.001		
	Model 2	<0.001	0.004	
	Model 3	<0.001		0.025
BBS	Model 1	<0.001		
	Model 2	<0.001	0.001	
	Model 3	<0.001		0.014
TUG	Model 1	0.001		
	Model 2	0.026	0.008	
	Model 3	0.014		0.042
Walking speed	Model 1	<0.001		
	Model 2	0.002	0.011	
	Model 3	0.002		0.096

*KE=knee extension strength of the fractured leg

Table 3. Sensitivity and specificity analyses using 85 points as cut-off value for the Activity-specific Balance Confidence scale (to identify those with poorer mobility and balance performance or self-reported mobility limitation).

		ABC		ABC<85	
		<85	≥85	sensitivity	specificity
Walk outdoors	No difficulty	6	24	0.89	0.71
	Some difficulty	21	41		
	Major difficulty/ unable	31	4		
Climb stairs	No difficulty	8	36	0.83	0.71
	Some difficulty	17	26		
	Major difficulty/ unable	33	7		
BBS	Good balance	15	54	0.78	0.78
	Poorer balance	42	12		
TUG	Good mobility	6	25	0.73	0.70
	Fair mobility	18	31		
	Poorer mobility	27	10		
Walking speed	Good mobility	11	36	0.76	0.70
	Fair mobility	14	23		
	Poorer mobility	28	9		