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1 **BALANCE CONFIDENCE AND FUNCTIONAL BALANCE ARE**
2 **ASSOCIATED WITH PHYSICAL DISABILITY AFTER HIP FRACTURE**

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11 **Key words:** Functional capacity, Fracture, Aging, Fear of falling, Postural balance

12

1 ABSTRACT

2 **Background:** This cross-sectional study investigated the associations between balance
3 confidence, functional balance, and physical disability among older people after hip
4 fracture. **Material and methods:** The study utilizes baseline data of two randomized
5 controlled trials (ISRCTN34271567 and ISRCTN53680197). The participants were 159
6 community-dwelling over 60-year-old people. Health, fracture status, the date and type of
7 surgery, and contraindications for participation were assessed in a clinical examination.
8 Balance confidence was assessed by the Activities-specific Balance Confidence Scale
9 (ABC) and functional balance by the Berg Balance Scale. Physical disability was assessed
10 by a questionnaire containing 14 questions on perceived difficulty in basic (ADL) and
11 instrumental activities of daily living (IADL). Two sum scores were composed: ADL score
12 (range 0–6) and IADL score (range 0–8). Isometric knee extension force was measured
13 using a dynamometer. Pain and use of walking aids were assessed by a questionnaire. The
14 negative binomial regression analysis was used to analyze the associations. **Results:** A
15 higher ABC score was associated with a lower risk for ADL (IRR 0.99, 95% CI 0.98–0.99)
16 and IADL disability (0.99; 0.98–0.99) in the fully adjusted models. Also a higher BBS
17 score was associated with a lower risk for ADL (0.98; 0.96–0.99) and IADL disability
18 (0.98; 0.97–0.99) in the fully adjusted models. **Conclusion:** Decreased balance confidence
19 and impaired functional balance are associated with physical disability in older people after
20 hip fracture.

1 INTRODUCTION

2 Hip fracture is a common and severe trauma in older people, leading to balance
3 impairments, decreased muscle strength, and loss of independence in daily activities [1,2].
4 It's also known that only half of the hip fracture patients regains their pre-fracture level of
5 functional ability [2] and 15% will be institutionalized permanently [3]. Long-lasting
6 mobility limitation after hip fracture may lead to prolonged physical disability as well as
7 new injurious falls and fractures [2]. The incidence of hip fractures increases with age and
8 the total number of fractures is expected to rise due to ageing of the population [4].

9
10 Although only five percent of all falls cause a fracture, approximately 95% of all hip
11 fractures are caused by a fall [5,6]. The risk factors for falls interact with each other and
12 large individual variation exists. The risk of falling increases rapidly with the number of
13 risk factors. Impaired functional balance is considered the most common risk factor for
14 further falls and fractures after a previous hip fracture [7]. Balance control has also a
15 fundamental role in various activities of daily living, especially in those that require
16 independent standing or walking. Furthermore, those who have had a fall with a traumatic
17 consequence often experience fear of falling even years after the incident [7]. Additionally,
18 fear of falling has been strongly associated with future falls [8,9].

19
20 One method of operationalizing fear of falling is to assess self-reported balance confidence
21 using the Activities-specific Balance Confidence Scale (ABC) described by Powell et al.
22 [10]. Decreased balance confidence has been associated with poor functional balance,
23 increased disability, and reduced quality of life in community-dwelling older people
24 [8,11,12]. Individuals with low balance confidence and balance impairments are also likely
25 to reduce their physical and social activity, which in turn predicts the onset of disability

1 [13]. Based on our clinical experience, self efficacy and balance confidence are low in hip
2 fracture patients who have suffered a traumatic fall accident, which might drastically slow
3 down or disable the rehabilitation process. At the moment the scientific evidence regarding
4 the association between balance confidence and rehabilitation outcome after hip fracture is
5 insufficient.

6

7 To our knowledge there are no other studies that have simultaneously examined
8 associations of low balance confidence and balance impairments in relation to physical
9 disability, in older people who have suffered a hip fracture. However, these associations
10 should be studied to better understand the factors potentially affecting the recovery and
11 rehabilitation processes after hip fracture. The purpose of this study was to investigate the
12 associations between decreased balance confidence, impaired functional balance, and
13 physical disability among older people who have sustained a previous hip fracture.

14

15

16 **MATERIAL AND METHODS**

17

18 **Participants**

19 This cross-sectional study pooled the baseline data of two randomized controlled trials
20 (ISRCTN34271567 and ISRCTN53680197). In both studies the participants were recruited
21 from the Central Finland health care district with identical inclusion and exclusion criteria
22 [14, 15]. Patient records at the Central Finland central hospital were reviewed (in the fall of
23 the years 2004-2005 and throughout the years 2008-2010) to recruit over 60-years-old,
24 ambulatory and community-dwelling people who were living in the city of Jyväskylä or
25 the neighboring municipalities, and had been operated for femoral neck or trochanteric

1 fracture (ICD code S72.0 or S72.1). All potential participants (n=748) were informed of
2 the study by a written information letter. Those willing to participate (n=293) were
3 interviewed over the telephone or met during the inpatient period at the health care centre
4 to ensure their suitability for the study. The exclusion criteria were: inability to move
5 outdoors without assistance of another person, amputation of a lower limb, severe
6 progressive or neurological diseases, alcoholism and severe memory problems (Mini
7 Mental State Examination, MMSE<18 [16]). The pooled analysis includes information
8 collected from 159 participants (113 women, 46 men) who had sustained a hip fracture on
9 average 1.7 years earlier. Measurements were performed in the same research center using
10 the same equipment and protocols. The Ethical Committee of the Central Finland health
11 care district approved both studies. Before the laboratory assessments all participants gave
12 their written informed consent.

13

14

15 **Methods**

16

17 *Review of the medical data and health status*

18 During a medical examination performed by a nurse and physician, the presence of chronic
19 conditions, the use of prescription medication, fracture status, and the date and type of
20 surgery were confirmed according to a pre-structured questionnaire, current prescriptions,
21 and medical records obtained from the local hospital and health care centers.
22 Contraindications for participation in muscle strength and balance assessments were
23 evaluated by the physician [17].

24

25

1 ***Balance confidence***

2 A modified Finnish version of the Activities-specific Balance Confidence Scale (ABC
3 [10,18]) was used to assess confidence in performing specific activities without becoming
4 unsteady. Balance confidence can be regarded as a measure of fear of falling [10]. The
5 modified ABC scale consists of 16 items. Subjects are requested to describe, how
6 confident they are in carrying out different tasks, indoors and outdoors. Answers for each
7 question were rated from 1 (no confidence) to 10 points (total confidence). The total score
8 ranges from 16 to 160 and higher scores indicate better balance confidence.

9

10 ***Functional balance***

11 Functional balance was assessed by the Berg Balance Scale (BBS [19]) which evaluates
12 the ability to perform 14 different tasks such as standing up, sitting down, reaching and
13 turning around oneself, looking over the shoulders and standing on one foot. The ability to
14 perform each task is rated from 0 (incapable) to 4 (safe and independent). The total score
15 ranges between 0–56 and higher scores indicate better functional balance.

16

17 ***Physical disability***

18 Physical disability was assessed by a validated questionnaire [20] estimating perceived
19 difficulties in basic (ADL) and instrumental activities of daily living (IADL). The
20 questionnaire included six questions on ADL (eating, transferring from/to bed, dressing,
21 bathing, cutting toe nails, and toileting [20,21]) and eight questions on IADL (preparing
22 food, doing laundry, coping with light house work, coping with heavy house work,
23 handling medication, using the telephone, using public transportation, and handling
24 finances [20,22]). There were five response categories: 1) I manage without difficulties, 2)
25 with some difficulties, 3) with lots of difficulties, 4) I can't manage without assistance of

1 another person, and 5) I can't manage even when assisted. The original categorical
2 variables were dichotomized; a) Without difficulty (category 1) and b) Difficulty
3 (categories 2–5). Subsequently, two sum scores were composed: ADL score (ranging from
4 0–6) and IADL score (ranging from 0–8). Higher scores indicate more difficulty.

5

6 ***Confounders***

7 Isometric muscle force (Newton) for knee extension was measured on the fractured side by
8 an adjustable dynamometer chair (Metitur Ltd, [23]). During the measurement the ankle
9 was attached to a strain-gauge system with the knee angle fixed at 60° from full extension.
10 Participants were encouraged to extend the leg as hard as possible. After two to three
11 practice trials, measurements were performed at least three times until no further
12 improvement occurred. Each contraction was maintained for two to three seconds. The
13 inter-trial rest period was 30 seconds. The performance of the highest maximal force was
14 used for analysis.

15

16 Pain on the fractured side was assessed by two questions “Have you experienced pain in
17 the lower back, hip, knee, ankle or foot on your left/right side? Has the pain compromised
18 your mobility?” The response alternatives were 1) No, 2) Yes, but it is not offending, 3)
19 Yes, and it is offending. A new variable “offending pain of the fractured side” was
20 composed based on the answers. The use of walking aids outdoors was assessed by the
21 question: “Do you use walking aids when going outdoors? Response alternatives were
22 Yes/No.

23

24

1 *Statistical analysis*

2 The means, standard deviations, frequencies, and percentage values were calculated for the
3 background variables. The associations between balance confidence and physical disability
4 as well as between functional balance and physical disability were assessed by negative
5 binomial regression which is a generalization of the Poisson regression that accounts for
6 the over dispersion detected in Poisson models. The negative binomial regression model
7 takes into account that disability tends to be a cumulative phenomenon and that having
8 difficulty in one activity makes it more likely to have difficulty in two or more activities.
9 Thus, the observations of the increasing number of difficulties are non-independent of each
10 other. With this approach, it is possible to enter the Poisson-distributed count variable for
11 the number of difficulties in the models. The risk values are expressed as incidence rate
12 ratios (IRR) obtained by exponentiation of the regression coefficients ($\exp[\beta]$), and their
13 95% confidence intervals (CI). The expression $100*(IRR-1)$ indicates the percentage
14 change in ADL and IADL scores relative to ABC or BBS score. The crude model was
15 adjusted for age and gender and the second model additionally for time since fracture,
16 offending pain on the fractured side, number of chronic diseases, maximal force of the
17 fractured leg, and the use of walking aids outdoors. Finally, both ABC and BBS scores
18 were included simultaneously in the negative binomial regression model.

19

20 The Kolmogorov-Smirnov test was used to test the normality of distributions. Only the
21 ABC score was normally distributed. Thus, the Spearman correlation was used to analyze
22 the association between the ABC and BBS. The Spearman ρ was raised to the second
23 power to express the coefficient of determination (R^2) for ABC relative to BBS.
24 Regression modeling was performed using STATA 12 statistical software. All other
25 analyses were performed using PASW Statistics 18.

1 RESULTS

2 The average age of the participants was 77.4 (SD=7.2) years and the mean time elapsed
3 since the fracture was 1.7 (2.1) years. Seventy-three percent was female, 47 % had an
4 internal fixation and 53 % an arthroplasty operation. The mean ABC score was 91.5 (32.3)
5 points, i.e. 58 % of the maximum score. Furthermore, the mean BBS score was 44.1 (9.3)
6 points, i.e. 79 % of the maximum. The median values of ADL and IADL score were one
7 and three, respectively. The participant characteristics are presented in Table 1.

8

9 [Table 1]

10

11 Table 2 shows the IRR's and 95% CI's for ADL and IADL disability relative to balance
12 confidence and functional balance. A higher ABC score was associated with a lower risk
13 for ADL disability (fully adjusted IRR 0.99, 95% CI 0.98–0.99). This indicates that e.g. a
14 10-point increase in ABC score decreased the risk for ADL disability with 10 percent. The
15 association between balance confidence and IADL disability was similar (0.99; 0.98–0.99).
16 Furthermore, a higher BBS score was associated with a lower risk for ADL (0.98; 0.96–
17 0.99) and IADL disability (0.98; 0.97–0.99) in the fully adjusted models. This indicates
18 that e.g. a 10-point increase in BBS score decreased the risk for ADL and IADL disability
19 with 20 percent.

20

21 [Table 2]

22

23 The ABC and BBS scores correlated highly but not fully (Spearman $\rho=0.69$) and the ABC
24 score explained 48% of the variation in BBS score ($R^2=0.476$). However, placing the ABC
25 and BBS scores together in the same regression model with ADL or IADL did not

1 materially change their individual IRR's (Table 2). This implies that the ABC and BBS
2 represent partly different phenomena and they cannot be considered as surrogate
3 measurements. However, in the fully adjusted models the associations between the BBS
4 score and ADL as well as IADL disability were attenuated.

7 **DISCUSSION**

8 This cross-sectional study investigated the associations between balance confidence,
9 functional balance, and physical disability in community-dwelling older men and women
10 who had sustained a previous hip fracture. We found an independent association between
11 decreased balance confidence and ADL/IADL disability as well as between impaired
12 functional balance and ADL/IADL disability. To our knowledge, this is the first study
13 which has simultaneously examined the associations of balance confidence and functional
14 balance with disability in this group of older people with high risk of losing independence.

15
16 Balance confidence and functional balance both have an essential role in coping with daily
17 activities. Moreover, among older hip fracture patients, reduced balance confidence and
18 impaired functional balance may complicate and delay the rehabilitation process. In the
19 present study examining older people with a history of traumatic fall accident, we showed
20 that decreased balance confidence was significantly associated with ADL disability. The
21 association between decreased balance confidence and IADL disability was similar. Our
22 results are in line with previous studies pointing out that fear of falling is associated with
23 increased physical disability in community-dwelling older people [8,11,13]. The majority
24 of hip fractures are a consequence of falls [5,6] and falls with traumatic consequences
25 often generate long-lasting fear of falling [8]. On the other hand, fear of falling leads to

1 activity restriction and exercise avoidance, which in turn results in more severe functional
2 limitations and disability. Few randomized controlled trials that have concentrated on
3 methods of reducing fear of falling among hip fracture patients have yielded inconsistent
4 results [24-26]. Thus, there is need for further research in order to develop better
5 rehabilitation practices.

6
7 Additionally, our results indicate that also impaired functional balance was significantly
8 associated with both ADL and IADL disability, and adjusting for several known
9 confounders marginally changed the associations. Our findings are consistent with prior
10 studies showing that functional balance is strongly associated with independence in daily
11 activities after hip fracture [27,28]. Thus, our study together with prior studies indicate that
12 hip fracture patients comprise a special group of older people who have impaired
13 functional balance and a greater risk for increased physical disability.

14
15 As far as we know, this is the first study to show a strong association between decreased
16 balance confidence and physical disability together with impaired functional balance and
17 physical disability in this important clinical group of older people. In our study, balance
18 confidence was strongly associated with functional balance explaining half of the variation
19 in functional balance. However, including both of them simultaneously in the regression
20 model did not materially change the individual IRR's. This suggests that the Activities-
21 specific Balance Confidence Scale and Berg Balance Scale cannot be considered
22 equivalent for each other. Thus, when new rehabilitation practices are developed for hip
23 fracture patients, it should be taken into account that balance training by itself may not be
24 successful without balance confidence management.

25

1 The strengths of the present study include firstly that we recruited a unique clinical group
2 of community-dwelling older people who had sustained a hip fracture. The patient records
3 of the Central Finland central hospital were used for this purpose. Secondly, we included a
4 comprehensive battery of laboratory based physical and functional assessments as well as
5 medical review for health and fracture status. By these assessments we were able to design
6 a valid statistical model, with relevant and necessary confounders, to estimate the
7 association between physical disability, balance, and balance confidence.

8

9 Some study limitations should be noted. The results of this study can't be generalized to all
10 hip fracture patients because the participants in the present study were all relatively healthy.
11 They were all community-dwelling, and those who were unable to walk independently
12 outdoors or had severe diseases or cognitive problems were excluded. Thus, our results
13 probably underestimate the association between functional balance, balance confidence,
14 and physical disability among older hip fracture patients. If we had been able to study also
15 more frail patients, the association would have been even stronger. Additionally, because
16 of the cross-sectional study design, the causality between balance confidence, functional
17 balance, and physical disability remains unclear. Therefore, it is possible that disability
18 caused a sedentary lifestyle and was followed by low balance confidence and impaired
19 functional balance. Either way, there is need for effective physical rehabilitation.

20

21 In conclusion, decreased balance confidence and impaired functional balance are important
22 determinants of physical disability in older people who have sustained a hip fracture.
23 Additionally, the ABC scale complements the functional balance assessment and may
24 potentially be used as a screening tool for impaired functional balance in clinical practice
25 when instant assessment of functional balance is not possible. Furthermore, it is essential

1 to examine what kind of interventions are effective in enhancing functional balance and
2 especially balance confidence among older hip fracture patients. It is also important to
3 study what kind of rehabilitation is effective to reduce physical disability and how older
4 people can be encouraged to be physically active even in the presence of fear of falling,
5 balance impairments, and increased physical disability. In the future, long-enough follow-
6 up studies with adequate sample size are needed to assess the effects of different kind of
7 rehabilitation programs as well as the determinants of physical disability after hip fracture.

8

9

10 **CONFLICT OF INTEREST STATEMENT**

11 The authors of this manuscript have no financial or personal relationships with other
12 people or organizations that could inappropriately bias this work.

13

14

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18

19

20

1 **Table 1.** Characteristics of older people with a previous hip fracture

	n=159
Age (yr)	77.4 ± 7.2
Gender: female, n (%)	116 (73)
Time since fracture (yr)	1.7 ± 2.1
Number of chronic diseases	3 ± 2
Operation type, n (%)	
Internal fixation	74 (47)
Arthroplasty	85 (53)
Offending pain/fractured side, n (%)	93 (59)
Maximal force/fractured limb (N)	208,3 ± 96.3
Use of walking aids outdoors, n (%)	110 (69)
BBS (total score)	44.1 ± 9.3
ABC (total score)	91.5 ± 32.3
Median of the ADL sum score (range)	1 (0-6)
Median of the IADL sum score (range)	3 (0-8)

All means are expressed: ± SD

BBS = Berg Balance Scale

ABC = Activities-specific Balance Confidence Scale

ADL = activities of daily living

IADL = instrumental activities of daily living

Table 2. IRR's and 95% CI's for physical disability (ADL and IADL) in negative binomial regression model with ABC and BBS scores

	ADL				IADL			
	Model 1.*	p	Model 2.**	p	Model 1.*	p	Model 2.**	p
ABC	0.99 (0.98–0.99)	<0.001	0.99 (0.98–0.99)	<0.001	0.99 (0.98–0.99)	<0.001	0.99 (0.98–0.99)	<0.001
BBS	0.96 (0.95–0.98)	<0.001	0.98 (0.96–0.99)	<0.001	0.96 (0.95–0.97)	<0.001	0.98 (0.97–0.99)	<0.001
ABC	0.99 (0.98–0.99)	<0.001	0.99 (0.98–0.99)	0.009	0.99 (0.98–0.99)	<0.001	0.99 (0.98–0.99)	<0.001
BBS	0.98 (0.96–0.99)	0.015	0.98 (0.97–1.00)	0.055	0.99 (0.97–0.99)	0.009	0.99 (0.97–1.00)	0.118

ABC = Activities-specific Balance Confidence Scale

BBS = Berg Balance Scale

* Adjusted for age and gender

** Adjusted for age, gender, time since fracture, offending pain on the fractured side, number of chronic diseases, maximal force of the fractured leg, and the use of walking aids outdoors