

EUR Research Information Portal

The predictive value of physical fitness for falls in older adults with intellectual disabilities

Published in:

Research in Developmental Disabilities

Publication status and date:

Published: 01/01/2014

DOI (link to publisher):

[10.1016/j.ridd.2014.03.022](https://doi.org/10.1016/j.ridd.2014.03.022)

Document Version

Early version, also known as preprint

Citation for the published version (APA):

Oppewal, A., Hilgenkamp, T., van Wijck, R., Schoufour, J., & Evenhuis (2014). The predictive value of physical fitness for falls in older adults with intellectual disabilities. *Research in Developmental Disabilities*, 35(6), 1317-1325.
<https://doi.org/10.1016/j.ridd.2014.03.022>

[Link to publication on the EUR Research Information Portal](#)

Terms and Conditions of Use

Except as permitted by the applicable copyright law, you may not reproduce or make this material available to any third party without the prior written permission from the copyright holder(s). Copyright law allows the following uses of this material without prior permission:

- you may download, save and print a copy of this material for your personal use only;
- you may share the EUR portal link to this material.

In case the material is published with an open access license (e.g. a Creative Commons (CC) license), other uses may be allowed. Please check the terms and conditions of the specific license.

Take-down policy

If you believe that this material infringes your copyright and/or any other intellectual property rights, you may request its removal by contacting us at the following email address: openaccess.library@eur.nl. Please provide us with all the relevant information, including the reasons why you believe any of your rights have been infringed. In case of a legitimate complaint, we will make the material inaccessible and/or remove it from the website.

The predictive value of physical fitness for falls in older adults with intellectual disabilities

Running head: Physical fitness and falls older adults with ID

Authors: Alyt Oppewal^a, Thessa I.M. Hilgenkamp^{a,b},

Ruud van Wijck^c, Josje D. Schoufour^a, Heleen M. Evenhuis^a

^a Intellectual Disability Medicine, Department of General Practice, Erasmus MC, University Medical Center Rotterdam, P.O. Box 2040, 3000 CA Rotterdam, The Netherlands

^b Abrona, Amersfoortseweg 56, 3712 BE Huis ter Heide, The Netherlands

^c Center for Human Movement Sciences, University of Groningen, University Medical Center Groningen, A. Deusinglaan 1, 9713 AV Groningen, The Netherlands

Corresponding author:

Alyt Oppewal at Erasmus MC, University Medical Center Rotterdam, Department of General Practice, Intellectual Disability Medicine, P.O. Box 2040, 3000 CA Rotterdam, The Netherlands.

Tel.: +31 107032118

E-mail address: a.oppewal@erasmusmc.nl (A. Oppewal).

Abstract

A high incidence of falls is seen in people with intellectual disabilities (ID), along with poor balance, strength, muscular endurance, and slow gait speed, which are well-established risk factors for falls in the general population. The aim of this study was to assess the predictive value of these physical fitness components for falls in 724 older adults with borderline to profound ID (≥ 50 years). Physical fitness was assessed at baseline and data on falls at baseline and after three years. Gait speed was lowest in participants who fell three times or more at follow-up. Gait speed was the only physical fitness component that significantly predicted falls, but did not remain significant after correcting for confounders. Falls at baseline and not having Down syndrome were significant predictors for falls. Extremely low physical fitness levels of older adults with ID, possible strategies to compensate for these low levels, and the finding that falls did not increase with age may explain the limited predictive value of physical fitness found in this study.

Keywords: Falls, physical fitness, risk factors, intellectual disabilities, older adults

1. Introduction

A high incidence of falls and related injuries is seen in people with intellectual disabilities (ID) (Cox, Clemson, Stancliffe, Durvasula, & Sherrington, 2010; Enkelaar, Smulders, van Schrojenstein Lantman-de Valk, Weerdesteyn, & Geurts, 2013b; Hale, Bray, & Littmann, 2007; Hsieh, Rimmer, & Heller, 2012; Sherrard, Tonge, & Ozanne-Smith, 2001). Falling is not restricted to the elderly in the population of ID (Sherrard et al., 2001), but fall risk does increase with advancing age (Chiba et al., 2009; Cox et al., 2010; Hsieh, Heller, & Miller, 2001; Willgoss, Yohannes, & Mitchell, 2010).

A number of personal and medical characteristics can lead to an increased fall risk. In people with ID, older age, being female, more severe level of ID, impaired mobility, physically active, back pain, arthritis, fracture history, cerebral palsy, good visuo-motor capacity, good attentional focus, urinary incontinence, heart condition, epilepsy, visual impairments, polypharmacy, and behavioral problems have been mentioned as possible risk factors for falls (Cox et al., 2010; Enkelaar et al., 2013b; Finlayson, Morrison, Jackson, Mantry, & Cooper, 2010; Hsieh et al., 2012; Willgoss et al., 2010). Having Down syndrome (DS) was found to reduce the risk for falls and related injury (Finlayson et al., 2010).

Next to personal and medical characteristics, physical fitness may be an important aspect for falls in people with ID. Older adults with ID have poor balance, strength, muscular endurance, and slow gait speed (Hilgenkamp, van Wijck, & Evenhuis, 2012b; Oppewal, Hilgenkamp, van Wijck, & Evenhuis, 2013). In the general population, these physical fitness components are well-established risk factors for falls (American Geriatrics Society, British Geriatrics Society, & American Academy of Orthopaedic Surgeons Panel on Falls Prevention, 2001; Close, Lord, Menz, & Sherrington, 2005; Deandrea et al., 2010; Muraki et al., 2013; Quach et al., 2011; Stenhagen, Ekstrom, Nordell, & Elmstahl, 2013; Tinetti & Kumar, 2010). However, results from prospective studies performed in the general population may not apply to older adults with ID. The predictive value of physical fitness for falls in the general population is related to an age-related decrease in physical fitness or due to diseases. This relationship may be confounded by the lifelong cognitive impairment of people with ID. This lifelong cognitive impairment may negatively influence their motor development since childhood, which may negatively influence their balance, strength, endurance, and gait throughout their life, and not just at an older age. This line of thinking is supported by the finding that motor and cognitive

functioning are fundamentally interrelated, with similar developmental trajectories and the use of similar brain structures (Diamond, 2000). Impairments in physical fitness may not necessarily be related to an increased fall risk in the same amount as in the general population because people with ID may have developed different compensation strategies and utilize them over their entire lifespan. For example, people with DS show more variability in gait than people with normal intelligence, but they use this variability functionally to optimize their movement. This implies the use of different control strategies to compensate for their limitations (Black, Smith, Wu, & Ulrich, 2007; Smith, Stergiou, & Ulrich, 2011). Based on this hypothesis, the correlation between a decrease in physical fitness and falls may be less strong.

A recent prospective study investigating risk factors for falling in older adults with mild to moderate ID did not find balance and gait speed to differ between fallers and non-fallers. However, adults who fell indoors, performed worse on balance and gait tests (Enkelaar et al., 2013b). In contrast, retrospective studies did find strength and gait impairments to be associated with an increased fall risk in people with ID (Chiba et al., 2009; Hale et al., 2007; Hsieh et al., 2012). More knowledge is needed to identify the predictive value of the physical fitness in predicting fall risk. This will help to identify people at risk and thereby the decision-making for treatment.

The aim of this study was to assess the predictive value of balance, gait speed, strength, and muscular endurance for falls, over a 3-year period, in a large sample of older adults with ID.

2. Methods

2.1 Study design and participants

This study was part of the large Dutch 'Healthy ageing and intellectual disabilities' (HA-ID)

study performed in a consort of three ID care organizations in collaboration with two university departments in the Netherlands (Intellectual Disability Medicine, Erasmus MC, University Medical Center Rotterdam and the Center for Human Movement Sciences, University of Groningen, University Medical Center Groningen). For the baseline measurements all 2150 older clients with ID (≥ 50 years) of the care organizations were invited to participate, resulting in a near-representative sample of 1050 clients. Themes in the study were physical activity and fitness, nutrition and nutritional state, and mood and anxiety. Data collection on these themes took place between February 2009 and July 2010. Details about design, recruitment, and representativeness of the sample have been presented elsewhere (Hilgenkamp et al., 2011). Three years after the baseline measurements, follow-up data on falls were collected with a questionnaire.

This study was approved by the Medical Ethical Committee at Erasmus Medical Center (MEC 2008-234 and MEC 2011-309) and by the ethical committees of the participating ID care organizations. Informed consent was obtained from all participants or their legal representatives for both baseline and follow-up measurements; however, unusual resistance was a reason for aborting measurements at all times. This study followed the guidelines of the Declaration of Helsinki (Helsinki, 2008).

2.2 Baseline measurements

Of the risk factors for falls mentioned in the introduction, the following risk factors were collected in the HA-ID study: age, gender, level of ID, Down syndrome (DS), mobility, physical activity levels, fracture history, spasticity of the legs (as an aspect of cerebral palsy), urinary incontinence, heart condition, epilepsy, visual impairments, polypharmacy, and behavioral

problems. In this study, these risk factors are used to describe the study sample and as possible confounders in the analyses.

2.2.1 Personal characteristics

Age and gender were collected from administrative systems of the care organizations. Level of ID was categorized by behavioral therapists or psychologists as borderline (IQ = 70 – 84), mild (IQ = 50 – 69), moderate (IQ = 35 – 49), severe (IQ = 20 – 34), or profound (IQ < 20) (World Health Organization, 1996). The presence of (DS) was collected through the medical files. Professional caregivers provided information about mobility (independent, walking with an aid, or wheelchair-bound). Physical activity was measured with pedometers (NL-1000 pedometer, New Lifestyles, Missouri, USA). A minimum of 7500 steps per day was classified as sufficient.

2.2.2 Medical information

Professional caregivers provided information about urinary incontinence. Information on the history of fractures and the presence of spasticity of the legs, heart condition (arrhythmias and coronary heart disease), epilepsy, visual impairments, and polypharmacy was retrieved from medical files. Polypharmacy was defined as taking four or more medications. The presence of behavioral problems was obtained from behavioral therapists' records.

2.2.3 Physical fitness

Balance was measured with the Berg Balance Scale (BBS) (Berg, 1989; Berg, Wood-Dauphinee, Williams, & Maki, 1992). The BBS consists of 14 static and dynamic functional balance tasks varying in difficulty, ranging from unsupported sitting in a chair to tandem stance and standing

on one leg. The original test instructions were followed with some aids to enhance understanding of the tasks: two carpet feet and a carpet circle on the floor, to point out where the participant had to stand or turn around on. Walking aids were not allowed. The items were scored on a 5-point scale from 0 (inability to complete the task) to 4 (completion of the task) points, with a maximum of 56 points. A score of 45 is used in the general population as a cut-off to differentiate between those at risk for falls (< 45) and those not at risk for falls (≥ 45) (Berg et al., 1992). Validity and reliability has been previously demonstrated in the general population (Berg, Wood-Dauphinee, & Williams, 1995; Conradsson et al., 2007; Wang et al., 2006). In the population with ID, the BBS was also reliable (de Jonge, Tonino, & Hobbelen, 2010; Sackley et al., 2005) and feasible for older adults with borderline to moderate ID (Enkelaar, Smulders, van Schrojenstein Lantman-de Valk, Weerdesteyn, & Geurts, 2013a; Hilgenkamp, van Wijck, & Evenhuis, 2013).

Comfortable gait speed (GSC) was measured over a distance of 5 meters, after 3 meters for acceleration. Participants walked three times and the average gait speed in m/s was the result of the test. Participants had to walk without someone walking alongside or physically supporting them to avoid influencing their comfortable speed. Validity and reliability in the general population is good (Abellan van Kan et al., 2009; Connelly, Stevenson, & Vandervoort, 1996; Cooper et al., 2010; Steffen, Hacker, & Mollinger, 2002; Steffen & Seney, 2008). In older adults with ID, measuring GSC was feasible and reliable (ICC of 0.96 for same-day interval and 0.93 for two-week interval) (Hilgenkamp, van Wijck, & Evenhuis, 2012a; Hilgenkamp et al., 2013).

Muscular endurance was measured with the 30s Chair stand test (30sCS) (Rikli & Jones, 2001). Participants had to stand upright and sit down again as often as possible in 30 seconds without using their hands. The total number of complete stances was the result of the test.

Validity and reliability has been demonstrated in the general population (Jones, Rikli, & Beam, 1999). In older adults with ID, feasibility and test-retest reliability was moderate to good (ICC of 0.72 for same-day interval and 0.65 for two-week interval) (Hilgenkamp et al., 2012a, 2013).

Grip strength (GS) was measured with the Jamar Hand Dynamometer (#5030J1, Sammons Preston Rolyan, USA). Participants squeezed the dynamometer with maximum force in seated position, according to the recommendations of The American Society of Hand Therapists (Fess & Moran, 1981), three times for both hands with a one-minute pause between attempts. Participants were able to practice by squeezing a rubber ball, to assure understanding. The best results was recorded (in kg). The result was only recorded if the test instructor was convinced the participant had squeezed with maximum effort. Validity and reliability in the general population is good (Abizanda et al., 2012; Stark, Walker, Phillips, Fejer, & Beck, 2011). In older adults with ID, measuring grip strength was feasible and test-retest reliability was good (ICC of 0.94 for same-day interval and 0.90 for two-week interval) (Hilgenkamp et al., 2012a, 2013).

The physical fitness assessment was conducted at locations familiar or close to participants. Tests were guided by trained test instructors, who all were physiotherapists, physical activity instructors, or occupational therapists with experience with people with ID. To motivate the participants we prescribed 'maximal motivation' to the test instructors for all tests. In some cases, this meant that participants were motivated to engage in the tests by constant verbal encouragement and verbal rewarding, in other cases the test instructor had to remain very calm and quiet to motivate the client as much as possible and to prevent stress or anxiety. The background, knowledge, and experience of the test instructors were important for ensuring the most suitable 'maximal motivation' for every participant, while regarding safety as well.

2.2.4 Baseline fall assessment

A fall was defined as an unexpected event in which the participant comes to rest on the ground, floor, or lower level (Lamb et al., 2005). Professional caregivers provided information on how often the participants fell in the last three months (not fallen, 1 – 2 falls, 3 – 5 falls, 6 – 10 falls, 11 falls or more) before the baseline measurements. We chose for a recall period of three months because we expected this period to be long enough to distinguish non-fallers from recurrent fallers, because of the high fall incidence in people with ID (Chiba et al., 2009).

2.3 Follow-up fall assessment

Professional caregivers provided information at three years after baseline on how often the participant fell in the last three months (not fallen, 1 – 2 falls, 3 – 5 falls, 6 – 10 falls, 11 falls or more).

2.4 Statistical analyses

Falls at baseline and follow-up were recoded into three categories: ‘non-fallers’, ‘one or two time fallers’, and ‘three times or more fallers’. Baseline personal characteristics, medical information, falls, and physical fitness were described for the three categories of fallers at follow-up. Differences between groups were analyzed with Pearson’s chi-square tests and one-way independent analysis of variance (ANOVA), with post hoc tests. Bonferroni correction was used to correct for multiple testing. Spearman’s correlation coefficient was calculated to assess the correlation between falls at baseline and follow-up.

Simple and multiple logistic regression analyses were used to assess the predictive value of each physical fitness component for falling at follow-up. Because the aim was to predict falling, falls at baseline and follow up were recoded into categories non-fallers and fallers (≥ 1 fall).

First, the predictive value of physical fitness for falls was assessed with a simple logistic regression, with each physical fitness component as the independent variable and falls at follow-up as the dependent variable.

Second, a multiple logistic regression was performed to adjust for confounders. Spearman's correlation coefficients were calculated between baseline personal characteristics and medical information and falls at follow-up to identify potential confounders. Variables that significantly correlated with falls at follow-up were considered potential confounders. Dummy variables were constructed for independent categorical variables with more than two categories. Age, gender, and the potential confounders were entered in the first block, and each physical fitness component was entered in the second block. Multicollinearity was checked with the Variance Inflation Factor (VIF), which had to be below 10 for all independent variables (Field, 2005). Results are presented as unstandardized coefficients (B) and their standard errors (SE), representing the strength of the relation between each independent variable and the outcome; odds ratios (provided as $Exp(B)$ by SPSS) and its confidence intervals, representing the magnitude of the influence of the predictors and is defined as the change in odds resulting from a unit change of the predictor; the explained variance by the model (Cox & Snell R^2 and Nagelkerke R^2); and the model chi-square statistic, representing the fit of the model (Field, 2005).

Statistical significance was set at 5% ($p < 0.05$). Analyses were performed with the Statistical Package for Social Sciences (SPSS) version 21 (IBM Corporation, New York).

3. Results

3.1 Baseline characteristics and falls

Of the 1050 participants in the HA-ID study follow-up fall data were available from 724 participants. Of these participants, 25.5% (185 participants) fell at follow-up, of whom 19.6% (142 participants) fell one or two times and 5.9% (43 participants) fell more than two times. The personal characteristics and medical information are shown in table 1, for the three categories of fallers. Due to missing data, the number of participants differed per variable. Fallers had more often mobility impairments ($\chi^2 [4, n = 694] = 17.26, p = 0.002$) and epilepsy ($\chi^2 [2, n = 636] = 17.27, p < 0.001$).

Falls at baseline was significantly correlated to falls at follow-up ($r_s = 0.13, p < 0.001$). At baseline, 22.6% experienced at least one fall in three months. Compared to falls at baseline, 107 participants (15.5%) fell more often at follow-up and 94 participants (13.6%) fell less often at follow-up. The remaining 488 participants (70.8%) were in the same category of falls at follow-up as they were at baseline.

The results of the baseline physical fitness assessment for the three categories of fallers are presented in the final part of table 1. Because not all participants performed all physical fitness tests the number of participants differed across the tests. Comfortable gait speed (GSC) ($F [2, 503] = 5.71, p = 0.004$) was significantly different across the three categories. Post hoc tests

revealed that GSC was significantly lower in participants that fell three times or more times than in participants that did not fall ($p = 0.005$).

Table 1. Baseline characteristics of the participants categorized according to follow-up fall data.

	<i>n</i>		Non-fallers (<i>n</i> = 539)	1 – 2x fallers (<i>n</i> = 142)	≥3x fallers (<i>n</i> = 43)
<i>Personal characteristics</i>					
Age	724	Years (<i>m ± sd</i>)	60.7 ± 7.8	61.5 ± 6.8	63.2 ± 8.0
Gender	724	Female	261 (48.4%)	74 (52.1%)	25 (58.1%)
		Male	278 (51.6%)	68 (47.9%)	18 (41.9%)
Level of ID	707	Borderline	13 (2.4%)	5 (3.5%)	0
		Mild	104 (19.3%)	33 (23.2%)	7 (16.3%)
		Moderate	263 (48.8%)	72 (50.7%)	24 (55.8%)
		Severe	100 (18.6%)	22 (15.5%)	7 (16.3%)
		Profound	47 (8.7%)	5 (3.5%)	5 (11.6%)
Down syndrome	619	Yes	80 (14.8%)	11 (7.7%)	1 (2.3%)
Mobility	694	Independent	407 (75.5%)	105 (73.9%)	24 (55.8%)
		Walking-aid	63 (11.7%)	22 (15.5%)	12 (27.9%) ^a
		Wheelchair	52 (9.6%)	4 (2.8%) ^b	5 (11.6%)
Physical activity	191	Steps/day	6830.1 ±	8003.5 ±	5682.7 ±
		(<i>m ± sd</i>)	3772.9	4115.0	2207.8
<i>Medical information</i>					
Fracture history	626		39 (7.2%)	12 (8.5%)	8 (18.6%)
Spasticity legs	632	Unilateral	13 (2.4%)	4 (2.8%)	4 (9.3%)
		Bilateral	39 (7.2%)	5 (3.5%)	2 (4.7%)
Urinary incontinence	694		231 (42.9%)	60 (42.3%)	23 (53.5%)
Heart condition	640		16 (3.0%)	7 (4.9%)	0

Epilepsy	636		85 (15.8%)	29 (20.4%)	18 (41.9%) ^a
Visual impairments	627		121 (22.5%)	20 (14.1%)	8 (18.6%)
Polypharmacy	649		225 (41.7%)	77 (54.2%)	21 (48.8%)
Behavioral problems			148 (27.5%)	39 (27.5)	10 (23.3)
Falls at baseline					
Falls in 3 months	689	None	436 (80.9%)	82 (57.7%)	15 (34.9%)
before baseline?		1 or 2 times	70 (13.0%)	36 (25.4%)	10 (23.3%)
		≥3 times	13 (2.4%)	11 (7.7%)	16 (37.2%)
Physical fitness					
Balance	352		<i>n</i> = 271	<i>n</i> = 63	<i>n</i> = 18
		<i>m</i> ± <i>sd</i>	47.4 ± 10.3	47.3 ± 8.7	43.7 ± 11.8
Comfortable gait speed	506		<i>n</i> = 386	<i>n</i> = 92	<i>n</i> = 28
		m/s (<i>m</i> ± <i>sd</i>)	0.996 ± 0.346	0.935 ± 0.323	0.784 ± 0.362 ^c
Grip strength	512		<i>n</i> = 389	<i>n</i> = 94	<i>n</i> = 29
		kg (<i>m</i> ± <i>sd</i>)	24.4 ± 10.4	24.4 ± 10.3	22.8 ± 8.8
Muscular endurance	383		<i>n</i> = 296	<i>n</i> = 68	<i>n</i> = 19
		<i>m</i> ± <i>sd</i>	9.4 ± 3.2	10.1 ± 3.8	7.7 ± 2.9

m = mean; *sd* = standard deviation; *n* = number of participants; ID = intellectual disability.

^a Observed value significantly higher than expected value

^b Observed value significantly lower than expected value

^c Significantly different from non-fallers.

3.2 Predictive value of physical fitness for falls

Simple logistic regression analyses showed that a slower comfortable gait speed was a significant predictor for falls, with an odds ratio of 0.47, 95% CI [0.24, 0.95] (model 1, table 2). None of the other physical fitness components significantly predicted falls.

Older age ($r_s = 0.10$, $p = 0.008$), epilepsy ($r_s = 0.13$, $p = 0.001$), polypharmacy ($r_s = 0.11$, $p = 0.005$) and falls at baseline ($r_s = 0.31$, $p < 0.001$) were significantly positively correlated with

falls at follow-up. Having DS ($r_s = -0.12, p = 0.004$) was significantly negatively correlated with falls at follow-up. Together with gender, these characteristics were entered as confounders in the multiple logistic regression models. Multiple logistic regression analyses revealed that gait speed did not significantly add to the prediction of falls after adjustments for confounders (model 2, table 2). Falls at baseline was a significant predictor for falls. Not having DS was a significant predictor in the regression models with comfortable walking speed and muscular endurance as physical fitness component. The Cox & Snell explained variances of the final multiple logistic regression models ranged from 7.6% to 11.5%, and the Nagelkerke explained variance range from 10.4% to 17.3% (table 2).

Table 2. Results of the simple (model 1) and multiple (model 2) logistic regression analyses for the predictive value of the physical fitness for falls.

		B (SE)	Exp(B) [95% CI]	Model characteristics
Balance				
Model 1				
	BBS	-0.01 (0.01)	0.10 [0.97, 1.02]	$n = 271$, C&S $R^2 = 0.001$,
	Constant	-1.00 (0.62)	0.37	Nagelkerke $R^2 = 0.001$, $\chi^2 = 0.145$
Model 2				
<i>Block 1</i>	Age	0.01 (0.02)	1.01 [0.97, 1.06]	$n = 271$, C&S $R^2 = 0.068$,
	Female	0.30 (0.31)	1.35 [0.73, 2.46]	Nagelkerke $R^2 = 0.104$, $\chi^2 = 19.21^{**}$
	Down syndrome	-0.25 (0.54)	0.78 [0.27, 2.25]	
	Epilepsy	0.58 (0.41)	1.79 [0.80, 4.03]	
	Polypharmacy	0.18 (0.32)	1.20 [0.64, 2.23]	
	Falls at baseline	1.15 (0.34)**	3.14 [1.63, 6.07]	
<i>Block 2</i>	BBS	0.01 (0.01)	1.01 [0.98, 1.04]	
	Constant	-3.00 (1.64)	0.05	
Comfortable walking speed				
Model 1				
	GSC	-0.75 (0.36)*	0.47 [0.24, 0.95]	$n = 409$, C&S $R^2 = 0.011$,
	Constant	-0.50 (0.34)	0.60	Nagelkerke $R^2 = 0.016$, $\chi^2 = 4.47^*$
Model 2				
<i>Block 1</i>	Age	-0.01 (0.02)	0.99 [0.96, 1.03]	$n = 409$, C&S $R^2 = 0.115$,
	Female	0.09 (0.26)	1.09 [0.66, 1.80]	Nagelkerke $R^2 = 0.173$, $\chi^2 = 49.86^{**}$
	Down syndrome	-1.38 (0.51)**	0.25 [0.09, 0.69]	
	Epilepsy	0.51 (0.32)	1.66 [0.88, 3.12]	
	Polypharmacy	0.24 (0.27)	1.27 [0.75, 2.14]	

	Falls at baseline	1.32 (0.28)**	3.73 [2.14, 6.40]	
<i>Block 2</i>	GSC	-0.49 (0.41)	0.62 [0.28, 1.37]	
	Constant	-0.57 (1.30)	0.56	
Muscular endurance				
Model 1				
	30sCS	-0.01 (0.04)	0.99 [0.91, 1.08]	$n = 301$, C&S $R^2 < 0.001$,
	Constant	-1.16 (0.42)**	0.31	Nagelkerke $R^2 < 0.001$, $\chi^2 = 0.05$
Model 2				
<i>Block 1</i>	Age	-0.001 (0.02)	1.00 [0.96, 1.04]	$n = 301$, C&S $R^2 = 0.096$,
	Female	0.11 (0.30)	1.12 [0.63, 2.01]	Nagelkerke $R^2 = 0.146$, $\chi^2 = 30.29^{**}$
	Down syndrome	-1.26 (0.58)*	0.28 [0.09, 0.89]	
	Epilepsy	0.29 (0.40)	1.33 [0.61, 2.90]	
	Polypharmacy	0.19 (0.31)	1.20 [0.65, 2.22]	
	Falls at baseline	1.43 (0.33)**	4.17 [2.17, 8.01]	
<i>Block 2</i>	30sCS	-0.01 (0.05)	0.99 [0.91, 1.09]	
	Constant	-1.53 (1.49)	0.22	
Grip strength				
Model 1				
	GS	-0.01 (0.01)	0.99 [0.96, 1.01]	$n = 405$, C&S $R^2 = 0.003$,
	Constant	-0.92 (0.30)**	0.40	Nagelkerke $R^2 = 0.004$, $\chi^2 = 1.04$
Model 2				
<i>Block 1</i>	Age	0.00 (0.02)	1.00 [0.97, 1.04]	$n = 405$, C&S $R^2 = 0.076$,
	Female	0.05 (0.28)	1.05 [0.61, 1.81]	Nagelkerke $R^2 = 0.116$, $\chi^2 = 32.12^{**}$
	Down syndrome	-0.55 (0.44)	0.58 [0.25, 1.36]	
	Epilepsy	0.50 (0.32)	1.65 [0.89, 3.07]	
	Polypharmacy	0.15 (0.27)	1.16 [0.69, 1.96]	

	Falls at baseline	1.21 (0.27)**	3.34 [1.96, 5.70]
<i>Block 2</i>	GS	-0.01 (0.02)	0.99 [0.96, 1.02]
	Constant	-1.46 (1.21)	0.23

Model 1: simple logistic regression excluding potential confounders; model 2: multiple logistic regression including potential confounders.

Age (in years), gender (male = 0, female = 1), Down syndrome (no = 0, yes = 1), epilepsy (no = 0, yes = 1), polypharmacy (no = 0, yes = 1), falls at baseline (non-faller = 0, faller = 1).

B = unstandardized coefficient; SE = standard error; $Exp(B)$ = odds ratio; CI = confidence interval; R^2 = explained variance; C&S R^2 = Cox & Snell explained variance; χ^2 = model chi-square statistic; BBS = Berg Balance Scale; GSC = comfortable gait speed; 30sCS = 30s Chair stand; GS = grip strength.

* $p < 0.05$

** $p < 0.01$

4. Discussion

We assessed the predictive value of the balance, gait speed, strength, and muscular endurance for falls, over a 3-year period, in 724 older adults with intellectual disabilities (ID). Falls at follow-up occurred in 25.5% of the participants. Gait speed was a significant predictor for falls, however, after adjustment for confounders, gait speed did not significantly add to the prediction of falls. Only falls at baseline and not having Down syndrome (DS) were significant predictors for falls.

One-fourth of the participants experienced a fall in the three months prior to the follow-up fall assessment, of whom 19.6% fell one or two times and 5.9% fell three times or more. Other studies regarding falls in the population of ID found percentages of fallers, ranging from 25% to 46% during one year (Cox et al., 2010; Enkelaar et al., 2013b; Finlayson et al., 2010; Hsieh et al., 2012) and 70% during five years (Grant, Pickett, Lam, O'Connor, & Ouellette-Kuntz, 2001). Our lower percentage of fallers may be due to the shorter time period and/or a possible underestimation due to retrospective data collection (Ganz, Higashi, & Rubenstein, 2005).

Participants with DS fell less. This is in line with the results of Finlayson et al. (2010), who found a lower risk for falls and related injuries for people with DS. A possible explanation may be the stability-enhancing gait pattern of people with DS, implying an effective strategy. However, we only found this result in the regression models with comfortable walking speed and muscular endurance as the physical fitness component. This limits the generalizability of this result to other subgroups than those performing these tests.

In our study, falls at baseline were an important predictor for future falls. This has also been found to be an important predictor for falls in the general population (American Geriatrics

Society et al., 2001; Close et al., 2005; Deandrea et al., 2010; Tinetti & Kumar, 2010). It is therefore important to provide fall prevention programs for people who have already fallen once, to limit the risk of recurrent falls. Unfortunately, to date no fall prevention guidelines are available for the population of adults with ID. However, a recent study showed that a 10-session obstacle exercise training was effective in reducing the number of falls, alongside with improvements in balance, gait capacity and speed, in adults with mild to profound ID with a high fall risk (Van Hanegem, Enkelaar, Smulders, & Weerdesteyn, 2013). This result implies that, although physical fitness was not predictive for falls in this study, it can be effective in reducing fall risk. More research is needed to establish the beneficial effects of exercise training on falls and develop fall prevention guidelines for adults with ID.

Gait speed was lowest in participants who fell three times or more at follow-up. However, gait speed did not remain a significant predictor after correcting for confounders. Therefore, the predictive value of physical fitness for falls found in the general population (American Geriatrics Society et al., 2001; Close et al., 2005; Deandrea et al., 2010; Muraki et al., 2013; Quach et al., 2011; Stenhagen et al., 2013; Tinetti & Kumar, 2010), and the relation between physical fitness and falls found in retrospective studies with people with ID (Chiba et al., 2009; Hale et al., 2007; Hsieh et al., 2012), was not confirmed in our study. This result is in line with the results of Enkelaar et al. (2013b), who also found that balance and gait measures (Berg Balance Scale, Timed up and go test, Functional reach, Single leg stance, Ten meter walking test, Comfortable gait speed) did not predict falls in older adults with ID. However, in the study of Enkelaar et al. (2013b), the participants who fell indoors were significantly older and performed significantly worse on the balance and gait tests than those who fell outdoors.

Possible explanations for the limited predictive value of physical fitness for falls are described below. In order to find a predictive value of physical fitness for falls, the number of falls should increase with age along with a decrease in physical fitness. We found that the number of fallers did not increase with age. In addition, physical fitness of people with ID seems to be low across the lifespan. In previous studies, we found that the balance, strength, muscular endurance, and gait speed of older adults with ID were comparable to, or even worse than, that of age groups 20 to 30 years older in the general population (Hilgenkamp et al., 2012b; Oppewal et al., 2013). Low fitness levels are seen at younger ages as well (Golubovic, Maksimovic, Golubovic, & Glumbic, 2012; Lahtinen, Rintala, & Malin, 2007; Salaun & Berthouze-Aranda, 2012). Due to these lifelong low physical fitness levels, the age-related decrease in physical fitness and (related) increase in falls may be less pronounced in older adults with ID than in the general population. This may limit the predictive value of physical fitness for falls in this population, which is in line with our results. Nevertheless, an exercise program may reduce the risk of falling.

In addition, the predictive value of physical fitness for falls may be limited in people with ID because they may have developed compensation strategies to deal with their low physical fitness. For example, it has been found that people with DS and Williams syndrome have slower gait speed, shorter step and stride lengths, wider base of support, and a longer stance and double support phase than people with normal intelligence, which may be a compensatory strategy to maintain stability and postural control (Hocking, Rinehart, McGinley, & Bradshaw, 2009; Horvat, Croce, Zagrodnik, Brooks, & Carter, 2012; Rigoldi, Galli, & Albertini, 2011; Smith & Ulrich, 2008). Further research is needed to establish the relationship between these gait patterns

of people with ID and falls. This would provide information about the effectiveness of these compensation strategies and identify areas for fall prevention.

This study had some limitations. First, our power to find significant effects of personal, medical, and physical fitness factors in predicting falls may have been limited because the number of participants who fell three times or more at follow-up was relatively small. This could be an alternative explanation for the fact that risk factors for falls found in other studies with people with ID, were not identified as risk factors in our study. Second, it was recommended in previous studies to make a distinction between fallers and recurrent fallers (Lamb et al., 2005), while this study combined both fallers and recurrent fallers in one group (one or two time fallers). Unfortunately, we could not split this group in to fallers and recurrent fallers due to the structure of the questionnaire used in this study. Third, we retrospectively collected falls, which is less reliable than prospectively monitoring falls (Ganz et al., 2005). Last, because not all participants performed all physical fitness tests, the selection of participants differed for each regression analysis (with that specific test as independent variable). The selection of participants that performed the physical fitness tests was the functionally more able part of the study sample (Hilgenkamp et al., 2012b; Oppewal et al., 2013). This limits the generalizability of our results to the entire population of older adults with ID. However, to keep our sample size as large as possible, we chose to not only select those participants who performed all tests.

In conclusion, we found that balance, comfortable gait speed, strength, and muscular endurance were not significant predictors for falls in older adults with ID. Non age-related increase in falls, extremely low physical fitness levels, and possible strategies to compensate for these low levels, may explain the limited predictive value of physical fitness found in this study. The low explained variance of our regression models show that more research is needed

regarding the role of physical fitness and other risk factors for falls. This will help in developing fall prevention programs for older adults with ID.

Acknowledgements

The authors thank the management and professionals of the care organizations, Abrona (Huis ter Heide), Amarant (Tilburg) and Ipse de Bruggen (Zoetermeer), involved in the HA-ID consort for their collaboration and support. We also thank all participants, their family members and caregivers for their collaboration. This study was carried out with the financial support of ZonMw (No. 57000003).

Conflict of interest

None

References

- Abellan van Kan, G., Rolland, Y., Andrieu, S., Bauer, J., Beauchet, O., Bonnefoy, M., Cesari, M., Donini, L. M., Gillette Guyonnet, S., Inzitari, M., Nourhashemi, F., Onder, G., Ritz, P., Salva, A., Visser, M., & Vellas, B. (2009). Gait speed at usual pace as a predictor of adverse outcomes in community-dwelling older people an International Academy on Nutrition and Aging (IANA) Task Force. *The journal of Nutrition, Health & Aging*, *13*(10), 881-889.
- Abizanda, P., Navarro, J. L., Garcia-Tomas, M. I., Lopez-Jimenez, E., Martinez-Sanchez, E., & Paterna, G. (2012). Validity and usefulness of hand-held dynamometry for measuring

- muscle strength in community-dwelling older persons. *Archives of Gerontology and Geriatrics*, 54(1), 21-27.
- American Geriatrics Society, British Geriatrics Society, & American Academy of Orthopaedic Surgeons Panel on Falls Prevention. (2001). Guideline for the prevention of falls in older persons. *Journal of the American Geriatrics Society*, 49(5), 664-672.
- Berg, K. O. (1989). Measuring balance in the elderly: preliminary development of an instrument. *Physiotherapy Canada*, 41(6), 304-311.
- Berg, K. O., Wood-Dauphinee, S. L., & Williams, J. I. (1995). The Balance Scale: reliability assessment with elderly residents and patients with an acute stroke. *Scandinavian Journal of Rehabilitation Medicine*, 27(1), 27-36.
- Berg, K. O., Wood-Dauphinee, S. L., Williams, J. I., & Maki, B. (1992). Measuring balance in the elderly: validation of an instrument. *Canadian Journal of Public Health*, 83 Suppl 2, S7-11.
- Black, D. P., Smith, B. A., Wu, J., & Ulrich, B. D. (2007). Uncontrolled manifold analysis of segmental angle variability during walking: preadolescents with and without Down syndrome. *Experimental Brain Research*, 183(4), 511-521.
- Chiba, Y., Shimada, A., Yoshida, F., Keino, H., Hasegawa, M., Ikari, H., Miyake, S., & Hosokawa, M. (2009). Risk of fall for individuals with intellectual disability. *American Journal on Intellectual and Developmental Disabilities*, 114(4), 225-236.
- Close, J. C. T., Lord, S. L., Menz, H. B., & Sherrington, C. (2005). What is the role of falls? *Best Practice & Research Clinical Rheumatology*, 19(6), 913-935.

- Connelly, D. M., Stevenson, T. J., & Vandervoort, A. A. (1996). Between- and within-rater reliability of walking tests in a frail elderly population. *Physiotherapy Canada, 48*(1), 47-51.
- Conradsson, M., Lundin-Olsson, L., Lindelof, N., Littbrand, H., Malmqvist, L., Gustafson, Y., & Rosendahl, E. (2007). Berg balance scale: intrarater test-retest reliability among older people dependent in activities of daily living and living in residential care facilities. *Physical Therapy, 87*(9), 1155-1163.
- Cooper, R., Kuh, D., Hardy, R., Mortality Review, G., Falcon, & Teams, H. A. S. (2010). Objectively measured physical capability levels and mortality: systematic review and meta-analysis. *BMJ, 341*, c4467.
- Cox, C. R., Clemson, L., Stancliffe, R. J., Durvasula, S., & Sherrington, C. (2010). Incidence of and risk factors for falls among adults with an intellectual disability. *Journal of Intellectual Disability Research, 54*(12), 1045-1057.
- de Jonge, P. A., Tonino, M. A. M., & Hobbelen, J. S. (2010). *Instruments to assess risk of falls among people with intellectual disabilities*. Paper presented at the International congress of best practice in intellectual disability medicine, Bristol, UK.
- Deandrea, S., Lucenteforte, E., Bravi, F., Foschi, R., La Vecchia, C., & Negri, E. (2010). Risk factors for falls in community-dwelling older people: a systematic review and meta-analysis. *Epidemiology, 21*(5), 658-668.
- Diamond, A. (2000). Close interrelation of motor development and cognitive development and of the cerebellum and prefrontal cortex. *Child Development, 71*(1), 44-56.
- Enkelaar, L., Smulders, E., van Schrojenstein Lantman-de Valk, H., Weerdesteijn, V., & Geurts, A. C. (2013a). Clinical measures are feasible and sensitive to assess balance and gait

- capacities in older persons with mild to moderate intellectual disabilities. *Research in Developmental Disabilities*, 34(1), 276-285.
- Enkelaar, L., Smulders, E., van Schrojenstein Lantman-de Valk, H., Weerdesteyn, V., & Geurts, A. C. (2013b). Prospective study on risk factors for falling in elderly persons with mild to moderate intellectual disabilities. *Research in Developmental Disabilities*, 34(11), 3754-3765.
- Fess, E. E., & Moran, C. (1981). *Clinical assessment recommendations*. Indianapolis, USA: American Society of Hand Therapists Monograph.
- Field, A. (2005). *Discovering statistics using SPSS* (2nd ed.). London: SAGE Publications Ltd.
- Finlayson, J., Morrison, J., Jackson, A., Mantry, D., & Cooper, S. A. (2010). Injuries, falls and accidents among adults with intellectual disabilities. Prospective cohort study. *Journal of Intellectual Disability Research*, 54(11), 966-980.
- Ganz, D. A., Higashi, T., & Rubenstein, L. Z. (2005). Monitoring falls in cohort studies of community-dwelling older people: effect of the recall interval. *Journal of the American Geriatrics Society*, 53(12), 2190-2194.
- Golubovic, S., Maksimovic, J., Golubovic, B., & Glumbic, N. (2012). Effects of exercise on physical fitness in children with intellectual disability. *Research in Developmental Disabilities*, 33(2), 608-614.
- Grant, H. J., Pickett, W., Lam, M., O'Connor, M., & Ouellette-Kuntz, H. (2001). Falls among persons who have developmental disabilities in institutional and group home settings. *Journal of Developmental Disabilities*, 8(1), 57-73.

- Hale, L., Bray, A., & Littmann, A. (2007). Assessing the balance capabilities of people with profound intellectual disabilities who have experienced a fall. *Journal of Intellectual Disability Research*, 51(Pt 4), 260-268.
- Helsinki. (2008). World Medical Association Declaration of Helsinki, Ethical Principles for Medical Research Involving Human Subjects. Retrieved from <http://www.wma.net/en/30publications/10policies/b3/>
- Hilgenkamp, T. I., Bastiaanse, L. P., Hermans, H., Penning, C., van Wijck, R., & Evenhuis, H. M. (2011). Study healthy ageing and intellectual disabilities: Recruitment and design. *Research in Developmental Disabilities*, 32(3), 1097-1106.
- Hilgenkamp, T. I., van Wijck, R., & Evenhuis, H. M. (2012a). Feasibility and reliability of physical fitness tests in older adults with intellectual disability: A pilot study. *Journal of Intellectual & Developmental Disability*, 37(2), 158-162.
- Hilgenkamp, T. I., van Wijck, R., & Evenhuis, H. M. (2012b). Low physical fitness levels in older adults with ID: Results of the HA-ID study. *Research in Developmental Disabilities*, 33(4), 1048-1058.
- Hilgenkamp, T. I., van Wijck, R., & Evenhuis, H. M. (2013). Feasibility of eight physical fitness tests in 1,050 older adults with intellectual disability: results of the healthy ageing with intellectual disabilities study. *Intellectual and Developmental Disabilities*, 51(1), 33-47.
- Hocking, D. R., Rinehart, N. J., McGinley, J. L., & Bradshaw, J. L. (2009). Gait function in adults with Williams syndrome. *Experimental Brain Research*, 192(4), 695-702.
- Horvat, M., Croce, R., Zagrodnik, J., Brooks, B., & Carter, K. (2012). Spatial and temporal variability of movement parameters in individuals with Down syndrome. *Perceptual and Motor Skills*, 114(3), 774-782.

- Hsieh, K., Heller, T., & Miller, A. B. (2001). Risk factors for injuries and falls among adults with developmental disabilities. *Journal of Intellectual Disability Research*, 45(Pt 1), 76-82.
- Hsieh, K., Rimmer, J., & Heller, T. (2012). Prevalence of falls and risk factors in adults with intellectual disability. *American Journal on Intellectual and Developmental Disabilities*, 117(6), 442-454.
- Jones, C. J., Rikli, R. E., & Beam, W. C. (1999). A 30-s chair-stand test as a measure of lower body strength in community-residing older adults. *Research Quarterly for Exercise and Sport*, 70(2), 113-119.
- Lahtinen, U., Rintala, P., & Malin, A. (2007). Physical performance of individuals with intellectual disability: a 30 year follow up. *Adapted Physical Activity Quarterly*, 24(2), 125-143.
- Lamb, S. E., Jorstad-Stein, E. C., Hauer, K., Becker, C., Prevention of Falls Network, E., & Outcomes Consensus, G. (2005). Development of a common outcome data set for fall injury prevention trials: the Prevention of Falls Network Europe consensus. *Journal of the American Geriatrics Society*, 53(9), 1618-1622.
- Muraki, S., Akune, T., Oka, H., Ishimoto, Y., Nagata, K., Yoshida, M., Tokimura, F., Nakamura, K., Kawaguchi, H., & Yoshimura, N. (2013). Physical performance, bone and joint diseases, and incidence of falls in Japanese men and women: a longitudinal cohort study. *Osteoporosis International*, 24(2), 459-466.
- Oppewal, A., Hilgenkamp, T. I., van Wijck, R., & Evenhuis, H. M. (2013). Feasibility and outcomes of the Berg Balance Scale in older adults with intellectual disabilities. *Research in Developmental Disabilities*, 34(9), 2743-2752.

- Quach, L., Galica, A. M., Jones, R. N., Procter-Gray, E., Manor, B., Hannan, M. T., & Lipsitz, L. A. (2011). The nonlinear relationship between gait speed and falls: the Maintenance of Balance, Independent Living, Intellect, and Zest in the Elderly of Boston Study. *Journal of the American Geriatrics Society*, *59*(6), 1069-1073.
- Rigoldi, C., Galli, M., & Albertini, G. (2011). Gait development during lifespan in subjects with Down syndrome. *Research in Developmental Disabilities*, *32*(1), 158-163.
- Rikli, R. E., & Jones, C. J. (2001). *Senior fitness test manual*. USA: Human Kinetics.
- Sackley, C., Richardson, P., McDonnell, K., Ratib, S., Dewey, M., & Hill, H. J. (2005). The reliability of balance, mobility and self-care measures in a population of adults with a learning disability known to a physiotherapy service. *Clinical Rehabilitation*, *19*(2), 216-223.
- Salaun, L., & Berthouze-Aranda, S. E. (2012). Physical fitness and fatness in adolescents with intellectual disabilities. *Journal of Applied Research in Intellectual Disabilities*, *25*(3), 231-239.
- Sherrard, J., Tonge, B. J., & Ozanne-Smith, J. (2001). Injury in young people with intellectual disability: descriptive epidemiology. *Injury Prevention*, *7*(1), 56-61.
- Smith, B. A., Stergiou, N., & Ulrich, B. D. (2011). Patterns of gait variability across the lifespan in persons with and without down syndrome. *Journal of Neurologic Physical Therapy*, *35*(4), 170-177.
- Smith, B. A., & Ulrich, B. D. (2008). Early onset of stabilizing strategies for gait and obstacles: older adults with Down syndrome. *Gait Posture*, *28*(3), 448-455.
- Stark, T., Walker, B., Phillips, J. K., Fejer, R., & Beck, R. (2011). Hand-held dynamometry correlation with the gold standard isokinetic dynamometry: a systematic review. *Physical*

Medicine and Rehabilitation: the journal of injury, function, and rehabilitation, 3(5), 472-479.

Steffen, T. M., Hacker, T. A., & Mollinger, L. (2002). Age- and gender-related test performance in community-dwelling elderly people: Six-Minute Walk Test, Berg Balance Scale, Timed Up & Go Test, and gait speeds. *Physical Therapy*, 82(2), 128-137.

Steffen, T. M., & Seney, M. (2008). Test-retest reliability and minimal detectable change on balance and ambulation tests, the 36-item short-form health survey, and the unified Parkinson disease rating scale in people with parkinsonism. *Physical Therapy*, 88(6), 733-746.

Stenhagen, M., Ekstrom, H., Nordell, E., & Elmstahl, S. (2013). Falls in the general elderly population: a 3- and 6- year prospective study of risk factors using data from the longitudinal population study 'Good ageing in Skane'. *BMC Geriatrics*, 13, 81.

Tinetti, M. E., & Kumar, C. (2010). The patient who falls: "It's always a trade-off". *Journal of the American Medical Association*, 303(3), 258-266.

Van Hanegem, E., Enkelaar, L., Smulders, E., & Weerdesteyn, V. (2013). Obstacle course training can improve mobility and prevent falls in people with intellectual disabilities. *Journal of Intellectual Disability Research*.

Wang, C. Y., Hsieh, C. L., Olson, S. L., Wang, C. H., Sheu, C. F., & Liang, C. C. (2006). Psychometric properties of the Berg Balance Scale in a community-dwelling elderly resident population in Taiwan. *Journal of the Formosan Medical Association*, 105(12), 992-1000.

Willgoss, T. G., Yohannes, A. M., & Mitchell, D. (2010). Review of risk factors and preventative strategies for fall-related injuries in people with intellectual disabilities.

Journal of Clinical Nursing, 19(15-16), 2100-2109.

World Health Organization. (1996). *ICD-10 Guide for Mental Retardation*. Geneva, Switzerland:

World Health Organization.