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

**Running head: Physical fitness and falls older adults with ID**

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**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 Dynanometer (#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 SPPS) 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.

| | ***n*** | | **Non-fallers (*n* = 539)** | **1 – 2x fallers (*n* = 142)** | **≥3x fallers (*n* = 43)** |
|---|---|---|---|---|---|
| ***Personal characteristics*** | | | | | |
| Age | 724 | Years (*m* ± *sd*) | 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 (*m* ± *sd*) | 6830.1 ± 3772.9 | 8003.5 ± 4115.0 | 5682.7 ± 2207.8 |
| ***Medical information*** | | | | | |
| 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 | | *n* = 271 | *n* = 63 | *n* = 18 |
| | | *m* ± *sd* | 47.4 ± 10.3 | 47.3 ± 8.7 | 43.7 ± 11.8 |
| Comfortable gait speed | 506 | | *n* = 386 | *n* = 92 | *n* = 28 |
| | | m/s (*m* ± *sd*) | 0.996 ± 0.346 | 0.935 ± 0.323 | 0.784 ± 0.362[c] |
| Grip strength | 512 | | *n* = 389 | *n* = 94 | *n* = 29 |
| | | kg (*m* ± *sd*) | 24.4 ± 10.4 | 24.4 ± 10.3 | 22.8 ± 8.8 |
| Muscular endurance | 383 | | *n* = 296 | *n* = 68 | *n* = 19 |
| | | *m* ± *sd* | 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 | | | | |
| *Block 1* | 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] | |
| *Block 2* | 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 | | | | |
| *Block 1* | 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] | |
| *Block 2* | 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 | | | | |
| *Block 1* | 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] | |
| *Block 2* | 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 | | | | |
| *Block 1* | 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] |
| *Block 2* | 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; $\chi^2$ = 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.

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**Conflict of interest**

None

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