Risk of Fall for Individuals With Intellectual Disability

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Abstract
Our aim was to identify risk factors for falling and establish a method to assess risk for falls in adults with intellectual disabilities. In a cross-sectional survey of 144 Japanese adults, we found that age, presence of epilepsy, and presence of paretic conditions were independent risk factors. The Tinetti balance and gait instrument was successfully administered to this population and resulted in high diagnostic accuracy (sensitivity 88.9%, specificity 91.9%) for identifying individuals at risk when the cutoff score was set at 25. Participants whose balance and gait deteriorated showed a decrease in the Tinetti score of at least 2 points per year. Thus, the Tinetti instrument may be an effective tool to detect an increased risk of fall in this population.

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Recent advances in medical management and public health programs have vastly increased the lifespan of persons with intellectual disabilities (Bittles et al., 2002; Day & Jancar, 1994; Janicki, Dalton, Henderson, & Davidson, 1999; Patja, Iivanainen, Vesala, Oksanen, & Ruoppila, 2000). This improvement in life expectancy has resulted in rapid expansion of the population of elderly adults with intellectual disabilities. As these individuals age, they present the same clinical challenges as the general elderly population does (Evenhuis, 1997; Fisher & Kettl, 2005; Kapell et al., 1998). Among such clinical problems, falls and fall-associated injuries are among the most serious problems.

Falls are a cause of substantial mortality and morbidity as well as a major contributor to immobility and premature nursing home placement in the general elderly population (Rubenstein, 2006). Rubenstein reported that the rate of
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Falls and their associated complications rise steadily with age, and persons living in long-term care institutions have much higher rates of falls (0.6 to 3.6 per bed annually, with 10% to 25% of such falls resulting in fracture or laceration). Accumulating evidence suggests that the identification and amelioration of risk factors is the most effective way to reduce falls (Rubenstein, 2006). Many researchers have identified risk factors for falling in the general elderly population (Chan et al., 2007; Coutinho, Fletcher, Bloch, & Rodrigues, 2008; Kelly et al., 2003; Kron, Loy, Sturm, Nikolaus, & Becker, 2003; Luukinen, Koski, Kivela, & Laippala, 1996; Takazawa, Arisawa, Honda, Shibata, & Saito, 2003; Tinetti & Williams, 1997).

Previous studies have indicated that falls and fall-associated injuries are also problematic in elderly adults with intellectual disabilities. Hsieh, Heller, and Miller (2001) reported that the risk of injurious falls increased in those who were 70 years of age or older. Tannenbaum, Lipworth, and Baker (1989) found a higher fracture rate for residents of an intermediate care facility for people with intellectual disabilities than in the general United States population, with most fractures being caused by falls. Furthermore, abnormalities in gait and stability have been observed in several syndromes causing intellectual disabilities. Smith and Ulrich (2008) demonstrated that adults with Down syndrome showed stability-enhancing adaptations in gait in ways used by elderly people in general, but at a younger chronological age (CA). Abnormal gait features consistent with cerebellar ataxia have been reported in children with autism (Rinehart et al., 2006). However, there have been few reports in which researchers have focused on the specific risk factors for falls in this population (Hale, Bray, & Littmann, 2007; Hsieh et al., 2001).

The evaluation of risk of fall is essential to prevent fall-associated mortality and morbidity. However, there have been few reports on reliable clinical scales that evaluate risk of fall in adults with intellectual disabilities (Carmeli, Bar-Chad, Lotan, Merrick, & Coleman, 2003; Hale et al., 2007; Konarski & Tassé, 2005). Several clinical scales have been used to assess risk of fall in elderly persons in the general population. Among them, the Tinetti Balance and Gait instrument (Tinetti instrument) (Levine et al., 2001; Tinetti, Williams, & Mayewski, 1986) has been developed as a simple, easily administered, clinical test that measures a person’s balance and gait. The reliability and validity of the Tinetti instrument have been confirmed in a large number of studies in the general elderly population and some patient populations such as those with stroke or Parkinson’s disease (Daly et al., 2006; Kegelmeyer, Kloos, Thomas, & Kostyk, 2007; Lin et al., 2004). The instrument consists of 9 items related to balance tests (maximum score 16) and 7 items related to gait tests (maximum score 12), with lower scores indicative of poor performance in balance and mobility. In the general elderly population, those who score below 19 are considered to be at high risk for falls, and those who score in the range of 19 to 24 are at risk for falls (Levine et al., 2001). However, it is still unknown whether the Tinetti instrument is an effective tool for assessing risk of fall in adults with intellectual disabilities.

We designed the present study to obtain information on the risk factors and risk assessment for falls in adults with intellectual disabilities. The main aims were to (a) identify risk factors for falls in adults with intellectual disabilities, (b) evaluate the effectiveness of the Tinetti instrument for assessing risk of fall in this population, and (c) estimate the increase in the risk of falling with advancing age by yearly follow-up with the Tinetti instrument.

Method

Participants

All individuals in a residential care facility for persons with intellectual disabilities located in Aichi, Japan, who were 20 years of age or older at the start of the present study (October 1, 2003) and those at least 20 years old who entered the facility after the start of the study were invited to participate. Residents who consented to participate and who were ambulatory with or without an assistive walking device were included. Persons who always used a wheelchair for mobility at the start of the study were excluded. All 146 residents or their legal guardians gave their written informed consent. Two persons were excluded because they always used a wheelchair for mobility. The final sample contained 73 females and 71 males, who ranged in age from 28 to 68 years ($M = 44.8, SD = 9.9$). Among the participants, 122 persons were ambulatory, and 22 used assistive walking devices. Of the latter, 9...
used wheelchairs when they went out of the facility. Most of the participants had been residents for more than 10 years. The study protocol was approved by the Ethics Committee of the Institute for Developmental Research, Aichi Human Service Center.

Data Collection
The following data were gathered from the participants’ medical records: level of intellectual disabilities, medications, and presence or absence of epilepsy and paretic conditions. The participants’ characteristics are summarized in Table 1. Their IQs were measured using the Tanaka-Binet Intelligence Scale (Tanaka Laboratory, 1987), a Japanese version of the Stanford-Binet Scale (Thorndike, Hagen, & Sattler, 1986). Central nervous system-active (CNS-active) medications were classified into four mutually exclusive categories: anticonvulsants, antipsychotics, benzodiazepines, and antidepressants. A fall was defined as an event that resulted in a person coming to rest unintentionally on the ground or other lower level not due to any intentional movement, a major intrinsic event, or an extrinsic force (Chu, Chiu, & Chi, 2006; Tinetti, Speechley, & Ginter, 1988). We counted the number of falling episodes with or without injury during the 3 months prior to study entry by referring to the incident reports of the facility recorded by caregivers and the medical records of the Central Hospital, Aichi Human Service Center. The incident reports were reviewed by a nurse of the facility (the fifth author), and the medical records were reviewed by two doctors (the first and third authors).

On the basis of the information obtained, participants who experienced two or more falls during the preceding 3 months were classified as fallers and the remainder, as nonfallers. Deterioration in balance and gait during the follow-up period was defined on the basis of the observations of caregivers as well as the same sources of information as above. The caregivers were asked the following four questions. How many times has the participant fallen during the last 3 months? Has the frequency of occasions in which the participant needs help standing and walking increased? Is there anything that the participant became unable to do or began to have difficulty doing without your help during the past year? Has the participant begun to use any assistive walking devices during the past year? Participants who showed an increased frequency of falls when compared to those in the previous year or who showed an increased time and frequency of needing assistive walking devices or caregivers’ help while standing and walking were classified as having deteriorated.

Clinical Assessment
Seventy-five participants who were 50 years of age or older and/or who had neurological problems, such as epilepsy or paresis, were selected for balance and gait evaluation. We assessed this subpopulation because we were interested in the clinical features of balance and gait in relatively elderly persons and those who had a potential to develop falling and imbalance problems. The characteristics of the selected participants are summarized in Table 2.

Yearly assessments were performed from 2003 to 2006 in a group activity room of the facility by a board-certified neurologist of the Japanese

Table 1. Characteristics of Participants by Group

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Fallers</th>
<th>Nonfallers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (males)</td>
<td>19</td>
<td>52</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>–29</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>30–39</td>
<td>9</td>
<td>31</td>
</tr>
<tr>
<td>40–49</td>
<td>10</td>
<td>35</td>
</tr>
<tr>
<td>50–59</td>
<td>18</td>
<td>24</td>
</tr>
<tr>
<td>60–69</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>Complicated conditions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Epilepsy</td>
<td>26</td>
<td>28</td>
</tr>
<tr>
<td>Paretic conditions</td>
<td>24</td>
<td>6</td>
</tr>
<tr>
<td>Medications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antipsychotics</td>
<td>15</td>
<td>39</td>
</tr>
<tr>
<td>Anticonvulsants</td>
<td>28</td>
<td>35</td>
</tr>
<tr>
<td>Sedatives</td>
<td>14</td>
<td>21</td>
</tr>
<tr>
<td>Antidepressants</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Level of intellectual disability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mild (IQ 50–69)</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Moderate (IQ 35–49)</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>Severe (IQ 20–34)</td>
<td>14</td>
<td>36</td>
</tr>
<tr>
<td>Profound (IQ &lt; 19)</td>
<td>22</td>
<td>46</td>
</tr>
</tbody>
</table>

*Mean age for fallers group = 47.4 years (SD = 9.4) and for the nonfallers group, 44.2 years (SD = 10.1).
Society of Neurology (the first author). During the routine neurological examination, balance and mobility were assessed using the Tinetti instrument (Levine et al., 2001; Tinetti et al., 1986). The instrument details can be found in Levine et al. Sitting, standing, and walking motions were recorded on videotapes to confirm the validity of the on-site evaluation and to measure walking speed and step length. Sitting motion was assessed when the participants sat down on the chair for the examination. Sitting balance was evaluated during the neurological examination in the sitting position. After completion of the examinations in the sitting position, the participants were asked to stand up, and standing motions (arising, attempts to arise, immediate standing balance in the first 5 seconds, standing balance, balance when nudged, balance with eyes closed, and turning) were evaluated within a few minutes. Base width was measured as the distance between medial malleoli when the participants stood with their feet as close as possible. Then participants were asked to go and return twice along a 5-m straight course in the room (four trials); some participants completed only three trials because of fatigue or reluctance. Average walking speed within the 5-m course was calculated for each trial, and the mean values for the trials were recorded. Average step length in each trial was calculated from the number of steps needed in the 5-m course, and the mean values for the trials were recorded. Although acceleration and deceleration in the course were not evaluated in this study, we tried to minimize the effect of acceleration and deceleration by having the participants start from the point one or two steps before the start line and pass through the goal and take a few more steps forward. To ensure the participants’ maximal motivation to comply with the tasks, we explained and demonstrated each task. Visual (demonstration), auditory (verbal encouragement and feedback), and tactile cues (touching legs and body, pushing gently on the back to start walking) were given according to the participant’s needs until each was able to perform the task.

Statistical Analysis
Categorical variables are presented as frequencies and continuous variables, as means and SDs. Continuous variables that were not normally distributed are reported as medians and interquartile ranges. We performed univariate analyses to determine each variable’s ability to predict risk of fall. Differences between fallers and nonfallers were assessed using chi-square tests. To adjust for the prevalence of epilepsy, we used the Mantel-Haenszel procedure to obtain stratified comparison of the distributions of overall risk for falls between participants taking anticonvulsants and those not taking anticonvulsants. Variables with significance levels less than .05 in these analyses were then entered into a multivariate analysis to determine the power of each variable for predicting falls.

We analyzed differences in the Tinetti score, base width, walking speed, and step length between fallers and nonfallers using the Mann-Whitney U test. We constructed a receiver-operating characteristic curve for the Tinetti score to determine the cutoff point that yielded the highest combined sensitivity and specificity with
respect to distinguishing fallers from nonfallers. Longitudinal changes in the Tinetti score were tested using Friedman’s $\chi^2$ test, followed by the Wilcoxon $t$ test with the Bonferroni correction. We also analyzed the correlation between annual changes in the Tinetti score and deterioration in balance and gait based on the data of 62 participants who completed the Tinetti instrument for 2 or more consecutive years. We constructed a receiver-operating characteristic curve for yearly changes in the Tinetti score to determine the cutoff point for predicting deterioration in balance and gait.

The data were analyzed using Excel Statistics 2006 (Social Survey Research Information Co., Ltd, Tokyo, Japan) and StatView (version 5.0, SAS Institute Inc. Cary, NC) except for the analyses of the receiver-operating characteristic curves, for which we employed SPSS version 14.0 for Windows (SPSS Inc., Chicago, IL). A two-tailed $p$ value of less than .05 was considered statistically significant.

Results

Risk Factors for Falls

Of the 144 participants, 41 persons were classified as fallers (28.5%). On univariate analyses, those who were 50 years of age or older, had epilepsy or paretic conditions, and were taking anticonvulsants had a significantly higher risk of falls (Table 3). In contrast, participants taking antipsychotics or antidepressants did not have an increased risk of falls, and taking benzodiazepines was not statistically significant. The participants’ intellectual disability level was not related to the risk of fall. Stratification of the participants based on the presence or absence of epilepsy (Table 4) eliminated the impact of anticonvulsants on the risk of fall (Table 3); this indicates that taking anticonvulsants is not an independent risk factor; therefore, we excluded this variable from the subsequent multivariate analysis.

A logistic regression analysis revealed that age, presence of epilepsy, and presence of paretic conditions were independent risk factors for falls in adults with intellectual disabilities (Table 5). The logistic regression model for predicting the risk of fall in adults with intellectual disabilities was defined as $P = 1/ [1 + \exp (5.408 - 0.060 A - 3.433P - 1.879E)]$, where $A$ is age in years, $P$ is presence or absence of paretic conditions (presence, 1; absence, 0), and $E$ is presence or absence of epilepsy (presence, 1; absence, 0). This model predicted the risk of fall correctly in 81.9% of participants (92.2% of nonfallers and 56.1% of fallers). The Nagelkerke $R^2$ value was .38.

Physical and neurological examination revealed that 23 fallers had spastic paresis, which was the most common finding that related to increased risk of fall. The other findings that were related to an increased risk of fall included cerebellar ataxia (2 cases), Parkinsonism (2 cases), degenerative arthropathy (2 cases), and the presence of involuntary movement (2 cases). There were no physical/neurological abnormalities on the clinical examination of 7 participants that might have accounted for increased risk of fall.

Table 3. Univariate Predictors for Falls in Adults With Intellectual Disability

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Odds ratio</th>
<th>95% CI</th>
<th>$\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (male)</td>
<td>0.85</td>
<td>0.41–1.75</td>
<td>0.20</td>
</tr>
<tr>
<td>Age $\geq 50$ years</td>
<td>2.46</td>
<td>1.17–5.15</td>
<td>5.8*</td>
</tr>
<tr>
<td>Epilepsy</td>
<td>4.64</td>
<td>2.15–10.02</td>
<td>16.42**</td>
</tr>
<tr>
<td>Paretic conditions</td>
<td>22.82</td>
<td>8.13–64.09</td>
<td>49.40**</td>
</tr>
<tr>
<td>Antipsychotics</td>
<td>0.95</td>
<td>0.45–2.00</td>
<td>0.02</td>
</tr>
<tr>
<td>Anticonvulsants</td>
<td>4.19</td>
<td>1.93–9.07</td>
<td>14.03**</td>
</tr>
<tr>
<td>After adjustment for the</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>presence of epilepsy</td>
<td>1.72</td>
<td>0.48–6.17</td>
<td>0.69b</td>
</tr>
<tr>
<td>Benzodiazepines</td>
<td>2.03</td>
<td>0.91–4.52</td>
<td>3.02</td>
</tr>
<tr>
<td>Antidepressants</td>
<td>0.40</td>
<td>0.05–3.47</td>
<td>0.18c</td>
</tr>
<tr>
<td>Level of intellectual disability:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>severe, or profound (IQ $\leq 34$)</td>
<td>1.87</td>
<td>0.59–5.94</td>
<td>1.14</td>
</tr>
</tbody>
</table>

aConfidence interval. bMantel-Haenszel statistics. c$\chi^2$ test with Yates’ correction.
*p < .05. **p < .001.
Risk of Fall Assessment Using the Tinetti Instrument

The Tinetti instrument was administered successfully to most of our participants. During the 4-year study period, of the 75 participants who were assessed clinically, only 2 failed to complete the instrument because they were unable to comprehend well what was required of them. The Tinetti score was significantly lower in fallers than in nonfallers, and fallers also had a significantly wider base width, slower walking speed, and shorter step length (Table 6). The receiver-operating characteristic curve analysis showed that the highest combined sensitivity and specificity was obtained when those with a Tinetti score of 25 and under were classified as having a risk of fall (sensitivity 88.9%, specificity 91.9%; see Figure 1).

Estimation of the Increase in the Risk of Fall With Yearly Follow-Up Using the Tinetti Instrument

Our next step was to evaluate the longitudinal changes in the Tinetti score using data from the 37 participants who completed the Tinetti instrument for 4 consecutive years. The Tinetti score in the fourth year was significantly lower than in the previous 3 years, \( p = .0023 \) (Figure 2). To determine whether one can predict an increased risk of fall from annual changes in the Tinetti score, we conducted an analysis of 140 person-years (37 persons were assessed for 4 consecutive years, 4 persons for 3 consecutive years, and 21 persons for 2 consecutive years). Thirteen participants were assessed only once; 12 persons moved to group homes or nursing homes, and 1 individual lost the ability to walk and started using a wheelchair for mobility all the time after the first assessment. During the follow-up period, there were 24 episodes of deterioration in balance and gait (17.1%). The receiver-operating characteristic curve analysis revealed that the highest combined sensitivity and specificity was obtained when those who had a decrease of 2 points or more in the Tinetti score per year were classified as having deterioration (sensitivity 79.2%, specificity 87.9%—see Figure 3). For 1 male participant with spastic paraparesis due to spondylotic cervical myelopathy, a decrease in the Tinetti score preceded a catastrophic fall event; he had a decrease in the Tinetti score of 3 points in a year, although caregivers reported no worsening in his walking state. Soon after the last evaluation, he fell in the bathroom and suffered a femoral neck fracture.

Discussion

In the present study, age, presence of epilepsy, and presence of paretic conditions were identified as independent risk factors for falls in adults with intellectual disabilities. According to the defined logistic regression model, risk of fall increased by approximately 1.8 \( (1.06^{10}) \) times over 10 years in adults with intellectual disabilities; presence of epilepsy and paretic conditions increased the risk of fall 6.55 times and 30.98 times, respectively. The factor that had the most profound influence on risk of fall in adults with intellectual disabilities was the presence of paretic conditions. Paresis was the most common clinical finding in fallers. The causes of paresis in our sample were cerebral palsy and postencephalitis sequelae, which were nonprogressive in nature. However, there have been several reports in which investigators found an age-related decline in walking ability in persons with cerebral palsy (Bottos, Feliciangeli, Sciuto, Gericke, & Vianello, 2001;
In these persons, musculoskeletal problems, such as lower extremity contracture and scoliosis (Murphy et al., 1995) or disuse muscle atrophy may contribute to age-related impairment of ambulation.

Hsieh et al. (2001) noted that among adults with intellectual disabilities, individuals 70 years of age or older who had seizure attacks once or more per month had the highest risk of falls resulting in injury. Although we included non-injurious falls, our results are compatible with the previous report in that age and the presence of epilepsy were found to be the independent risk factors for falls (Hsieh et al., 2001).

In the present study we found that the level of intellectual disability was not an independent risk factor for falls. In our cohort, however, there were only 3 participants with mild intellectual disabilities; 82% of the participants had severe/profound intellectual disabilities. This deviation in the distribution of intellectual disability levels may have affected the results of our analyses. Whether the level of intellectual disability is a risk factor for falls has been controversial. Spreat and Baker-Potts (1983) reported that individuals with moderate and profound intellectual disabilities were at a higher risk of injury than were those with mild or severe intellectual disabilities. In contrast,

Murphy, Molnar, & Lankasky, 1995; Strauss, Ojdana, Shavelle, & Rosenbloom, 2004). In these persons, musculoskeletal problems, such as lower extremity contracture and scoliosis (Murphy et al., 1995) or disuse muscle atrophy may contribute to age-related impairment of ambulation.

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Hsieh et al. (2001) found that intellectual disability level was not a risk factor for falls. Further study is needed to elucidate the relationship between intellectual disability level and risk of fall.

The risk factors for falls identified in the present study are also known to affect risk of fall in the general elderly population, where age has been recognized as a risk factor for increased falls (Gryfe, Amies, & Ashley, 1977; Prudham & Evans, 1981). Kelly et al. (2003) reported that the adjusted odds ratio of age was 1.07 (95% confidence interval [CI] 1.06 to 1.08) for injurious falls in Canadian community-dwelling elderly persons. They also noted that seizures were an independent risk factor for falls, with an adjusted odds ratio of 2.22 (95% CI 1.30–3.79). Rubenstein (2006) reviewed 16 controlled studies and reported that weakness was one of the important risk factors for falls in the general elderly population, with a mean relative risk-odds ratio of 4.9, ranging from 1.9 to 10.3. Comparison of these previous reports with the present results suggests that the presence of epilepsy and paretic conditions has a greater impact on the risk of fall in the intellectual disability population than in the general elderly population, whereas age has a similar effect in both populations.

There was a discrepancy between the general elderly population and adults with intellectual disabilities as to whether CNS-active agents were independent risk factors for falls. Anticonvulsants, antipsychotics, benzodiazepines, and antidepressants were all reported to be independent risk factors for falls in the general elderly population (Ensrud et al., 2002; Kelly et al., 2003; Landi et al., 2005; Leipzig, Cumming, & Tinetti, 1999; Ray, Thapa, & Gideon, 2000). Kelly et al. (2003) showed that anticonvulsants were a risk factor for falls independent of the presence of seizure disorder or other risk factors, with an adjusted odds ratio of 1.51 (95% CI 1.11–2.06). In the present study, univariate analyses indicated that those who were taking anticonvulsants had a significantly higher risk of falls; however, the Mantel-Haenszel procedure revealed that the presence of epilepsy was a confounding factor for taking anticonvulsants. Those who were taking benzodiazepines, which have been frequently reported as risk factors for falls in the general elderly population, with a pooled odds ratio of 1.40 (95% CI 1.11–1.76) (Leipzig et al., 1999), did not show a significant increase in risk of fall in our cohort. Antipsychotics (pooled odds ratio for the general elderly population 1.90, 95% CI 1.35–2.67) (Leipzig et al., 1999), and antidepressants (pooled odds ratio for the general elderly population 1.62, 95% CI 1.23–2.14) (Leipzig et al., 1999) also had no significant effects on the risk of fall in adults with intellectual disabilities. One possible explanation for this discrepancy is the effect of starting therapy (Leipzig et al., 1999). Tinetti et al. (1986) reported that prescription of a psychotropic drug during the first 3 months after nursing home admission was a risk factor for falling. Aisen, Deluca, and Lawlor (1992) found that in psychiatric patients, fallers were more likely than nonfallers to have received a PRN dose of a psychotropic in the proceeding 24 hours. Most of the general elderly population start taking CNS-active agents later in life; thus, the “starting therapy” effect of these medications could compromise their balance and walking and is reflected in the positive association of these agents with risk of fall. In contrast, adults with intellectual disabilities have been taking these agents since they were much younger; thus, taking these

![Figure 3](image-url). The receiver-operating characteristic curve for the annual changes in the Tinetti score for predicting deterioration in balance and gait in adults with intellectual disabilities. The area under the curve is 0.85 (95% confidence interval, 0.75–0.95), p < .001. The most appropriate cutoff point to discriminate persons with deterioration from those with no deterioration is −2/year (arrow: sensitivity 79.2%, specificity 87.9%).
medications might have little impact on their balance and walking ability.

The Tinetti instrument was used to evaluate balance and mobility status in adults with intellectual disabilities. Several tests have been developed to evaluate risk of fall in the general elderly population, such as the Timed Up-and-Go test (Mathias, Nayak, & Isaacs, 1986), the Forward Reach test (Duncan, Weiner, Chandler, & Studenski, 1990), the Sit-to-Stand test (Liang & Cameron Chumlea, 1998), and One-Legged Standing (Bohannon, 1994). These tests have been found to be applicable to elderly adults with mild intellectual disabilities (Carmeli et al., 2003). However, such tests require the examinees' maximal effort and/or full comprehension of the test procedures, causing difficulty in the completion of the tests with persons who have profound intellectual disabilities (Hale et al., 2007). In contrast, the Tinetti instrument largely consists of observation of standing, sitting, and walking motion, requiring less effort and comprehension by the examinees. This feature enabled us to complete the instrument for most participants, even those with profound intellectual disabilities, who often have difficulty comprehending what is required of them in examinations and tests. Most of the participants with severe/profound intellectual disabilities could complete the task after just giving them visual, auditory, and tactile cues according to their needs. The caregivers in the facility who knew the participants well helped them understand what they were expected to do, by paraphrasing the instructions of the medical staff and leading the participants to the goal using their favorite things.

We found that fallers had a significantly lower Tinetti score than did nonfallers. Other balance and gait parameters (base width, walking speed, and step length) were also significantly different between fallers and nonfallers. The changes in these parameters observed in fallers were similar to those seen in elderly adults who have fear of falling and who show stability-enhancing adaptations in gait (Chamberlin, Fulwider, Sanders, & Medeiros, 2005; Smith & Ulrich, 2008). Using the Tinetti instrument has several advantages over measuring individual gait and balance parameters. First, the Tinetti instrument can be completed on-site without any special equipment, whereas measuring walking speed and step length needs some instruments, such as a video camera, a tape measure, and a stopwatch. Second, by using the Tinetti instrument, investigators can evaluate one at a time the many aspects of balance and mobility, including sitting balance, immediate standing balance, standing balance with and without perturbation (eye-closing, nudging), and walking, whereas measuring individual parameters provides information regarding only a few aspects of the person's balance and mobility status. Finally, the Tinetti instrument has an established cutoff score to discriminate fallers from nonfallers, whereas it is difficult to define the cutoff point in these gait variables. Receiver-operating characteristic curves for base width, walking speed, and step length were constructed to determine the cutoff point to distinguish fallers from nonfallers, but none of the parameters were superior to the Tinetti score in terms of diagnostic accuracy (data not shown). Thus, in the clinical setting, the Tinetti instrument is a simpler and more comprehensive way to assess persons than attempting to measure individual parameters.

The results of the receiver-operating characteristic curve analysis suggest that the optimal cutoff point for the Tinetti score was 25 in adults with intellectual disabilities. This cutoff point was 1 point higher than that for the general elderly population (Levine et al., 2001). This discrepancy in the cutoff point between the general elderly population and adults with intellectual disabilities may arise from the age structure of our cohort. As shown in Table 2, 38.7% of participants who were clinically assessed were 49 years old or younger, and only 17.3% were 60 years old or more. The Tinetti instrument was developed as a measure to detect risk of fall in elderly persons. The cutoff point may shift upward when it is applied to a younger population because balance and gait generally remain stable in younger persons (Balogh et al., 1994; Choy, Brauer, & Nitz, 2003). The relatively small sample size in the present study may also have had some effect on the determination of the cutoff score. A large-scale study that includes a sufficient number of elderly persons would clarify whether a higher cutoff point is necessary for adults with intellectual disabilities.

In the present study, the Tinetti score decreased significantly with advancing age. Individuals whose gait and balance deteriorated lost 2 or more points in the Tinetti score per year. Such a decrease in the Tinetti score with age has also been reported in a longitudinal study of the general elderly population (Balogh, Ying, & Jacobson, 2003). The prospective cohort study
by Chu et al. (2006) showed that elderly adults who had fallen during the 1-year follow-up period had a significantly higher proportion of decliners in the Tinetti score. Therefore, annual follow-up with this instrument appears to be useful for predicting an increased risk of fall, not only in adults with intellectual disabilities, but also in the general elderly population.

There were some limitations in this study. First, the participants were limited to residents in a single facility specialized to provide care for persons with severe/profound intellectual disabilities, which resulted in the relatively small sample size and with the intellectual disability level distribution being skewed towards severe/profound. Adults with intellectual disabilities living in the community were not included in this study. A large-scale investigation including community-dwelling people with intellectual disabilities and those with mild intellectual disabilities is needed to determine whether the intellectual disability level is actually related to the risk of fall or whether a higher cutoff point of the Tinetti score is necessary for adults with intellectual disabilities.

Second, risk factors for falls were identified based on cross-sectional observation, which can only suggest an association and does not necessarily imply a causal relationship between these factors and falls. Prospective studies of nonfallers are needed to test the validity of our results. Future studies are needed to determine whether annual changes in the Tinetti score are useful for predicting an increased risk of fall in the general elderly population. Third, the Nagelkerke $R^2$ value of .38 suggests that the model accounts for only 38% of the variation in risk of fall. Further investigations are necessary to identify other risk factors, such as quadriceps muscle strength (Chan et al., 2007; Takazawa et al., 2003), urinary incontinence (Coutinho et al., 2008; Kron et al., 2003), cognitive impairment (Coutinho et al., 2008; Kron et al., 2003; Rubenstein, 2006), and visual defects (Hale et al., 2007; Rubenstein, 2006).

Despite these limitations, the present results suggest the importance of recognizing an increased risk of fall in elderly persons with intellectual disabilities. To prevent fall-associated mortality and morbidity, it is essential to detect an increase in the risk of fall before a fall results in injury. The Tinetti instrument may be beneficial for this purpose. In particular, individuals with epilepsy and/or paretic conditions should be closely monitored because they have the potential to develop a high risk for falls. Annual assessments using the Tinetti instrument would be the first step in preventing falls in this population.

References


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