Journal of Frailty, Sarcopenia and Falls

Original Article

Association Between Eyes-Open One-Leg Standing Time and Previous-Year Fall History Among Employees Aged 50-65 Years: A Cross-Sectional Study

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Abstract

Objectives: To examine the association between previous-year fall history and eyes-open one-leg standing time among employees aged 50-65 years. **Methods**: This worksite-based cross-sectional study invited 115 employees of a Japanese transportation company; 106 enrolled and 100 with complete, valid records were analyzed. Fall history was defined as at least one self-reported fall during daily life in the previous year. Eyes-open one-leg standing was measured twice, with the longer value used and a maximum of 120 seconds. Group comparisons, age- and body mass index-adjusted logistic regression, and receiver operating characteristic analysis were performed. **Results**: The sample included 98 men and 2 women; 60 reported a fall. Median standing time was shorter with than without fall history (45.48 versus 76.74 seconds; p=0.018). The adjusted odds ratio per 10-second increase was 0.90 (95% confidence interval, 0.81-0.99; p=0.035). The area under the curve was 0.64 (95% confidence interval, 0.53-0.74). **Conclusions**: Shorter standing time was associated with previous-year fall history, but discrimination was limited. The test may support worksite fall-risk awareness and further assessment, but should not be used alone for diagnosis or employment decisions.

Keywords: Accidental falls, Postural balance, One-leg standing, Physical performance, Workplace health promotion

Introduction

Population ageing and prolonged working life have made the safety and health of middle-aged and older workers an important occupational health issue. In Japan in 2024, falls were the most frequent type of occupational injury requiring at least 4 days of work absence, accounting for 36,378 cases, while land freight transportation recorded 16,292 occupational injuries[1]. Falls can lead to injury, activity limitation, fear of falling, and reduced functional ability. In workplaces, their occurrence may reflect interactions between individual factors and environmental or task-related demands, including floor conditions, lighting, footwear, carrying loads, time pressure, and vehicle ingress or egress. Japanese guidance for older-worker safety therefore emphasizes both work-environment modification and maintenance of workers' physical capacity[2].

Falls are not confined to old age. Across four population-based cohorts of adults aged 40-64 years, the annual prevalence of falls ranged from 17.6% to 27.8% and generally increased across middle age[3]. Coordinated analyses of adults aged 50-64 years further identified mobility, health, and lifestyle factors associated with falls[4]. In a Japanese cohort, 12.9% of adults aged 40-59 years reported at least one fall during the previous year[5]. These findings indicate that middle age is a relevant life stage for understanding fall risk and considering preventive approaches.

The authors have no conflict of interest.

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Edited by: *Dawn Skelton*

Accepted *3 August 2026*

Occupational fall risk also varies according to work tasks and environments. A Japanese national database study of same-level falls in the transportation sector found substantial differences in fracture occurrence across taxi, cargo transportation, bus, rail, and airline sub-sectors[6]. Separate studies of older Japanese workers found that frailty was associated with occupational falls in both prospective and cross-sectional analyses[7,8]. However, these studies focused primarily on occupational or injurious events and older workers. Evidence linking simple physical performance measures obtained in a worksite with broader daily-life fall history among employees in late working age remains limited.

Eyes-open one-leg standing time is a simple static balance measure that requires little space, no specialized equipment, and only a short measurement period. A 6-month longitudinal study in community-dwelling older adults reported that shorter tandem and one-leg standing times were associated with subsequent falls[9], and a cross-sectional study of healthy adults aged over 50 years identified marked age-related decline in unipedal standing duration[10]. Nevertheless, an umbrella review of gait, balance, and functional mobility instruments concluded that no single test has sufficient certainty to predict falls with high accuracy when used alone[11]. Thus, one-leg standing should be considered one component of broader fall-risk awareness rather than a stand-alone diagnostic tool.

The present study therefore examined the association between previous-year fall history during daily life and eyes-open one-leg standing time among employees aged 50-65 years at a transportation company in Japan. We also evaluated the discriminative ability of the test while interpreting its potential role cautiously in a worksite health-assessment context.

Materials and Methods

Study design, setting, and participants

This was a worksite-based cross-sectional study involving male and female employees aged 50-65 years at a transportation company in Japan. Measurements were conducted during a single-day assessment session in the cooperating company. A total of 115 eligible employees were invited to participate, and 106 enrolled (participation proportion, 92.2%). Recruitment was based on company employment and age rather than a specific job title. Individual occupational roles were not collected; therefore, participants are described as transportation-company employees, and the findings should not be interpreted as task-specific evidence for drivers, delivery workers, administrative staff, or other occupational subgroups.

Among the 106 enrolled employees, six were excluded before analysis. Two discontinued the assessment after reporting fatigue during the testing session. For two employees, one or more required assessment items were inadvertently omitted during the time-limited session. The remaining two had incomplete or internally inconsistent basic-information entries that could not be reliably verified retrospectively. Because a common complete-case dataset with complete and valid records was used for the planned group comparisons and regression analyses, these six records were excluded. The final analysis included 100 employees, and no imputation was performed.

The study used all enrolled participants whose records met the complete-case criteria. Because this was an exploratory worksite-based analysis of existing cross-sectional measurements, no a priori sample-size calculation was performed. The conservative complete-case approach and the inability to reconstruct the six excluded records retrospectively are considered in the limitations.

Fall history

Fall history was assessed by self-report and defined as one or more falls during daily life in the previous year. A fall was defined as an event in which the participant unintentionally came to rest on the ground, floor, or a lower level[12]. The questionnaire did not record the number, timing, location, occupational context, or injury consequences of individual falls. Accordingly, the outcome was not restricted to falls occurring at work or to events classified as occupational accidents.

Physical function measures

Age, sex, height, and weight were collected as basic characteristics, and body mass index (BMI) was calculated. Physical function measures included the two-step value, seated stepping, Functional Reach, eyes-closed one-leg standing time, eyes-open one-leg standing time, ability to stand from a 40-cm seat on one leg, and Finger Floor Distance.

The two-step test, seated stepping test, Functional Reach, and eyes-closed one-leg standing test followed procedures described in the Japanese Ministry of Health, Labour and Welfare physical-ability self-check for fall prevention[13]. For the two-step test, participants took two maximal steps without losing balance; two trials were performed, and the greater distance was divided by height. For seated stepping, participants sat near the front of a secured chair, stabilized the trunk by holding the seat, and moved both feet repeatedly across two lines 30 cm apart; after a brief practice, the number of completed inward contacts during 20 seconds was recorded. For Functional Reach, participants stood with a fixed base of support and reached both arms forward at shoulder height without stepping or rotating the trunk; two trials were performed, and the greater distance was retained. For eyes-closed one-leg standing, participants removed their shoes and performed two trials; the longer duration was retained, and the trial ended if the eyes opened, the raised foot touched the supporting leg or floor, or the supporting foot moved.

Eyes-open one-leg standing time was measured using

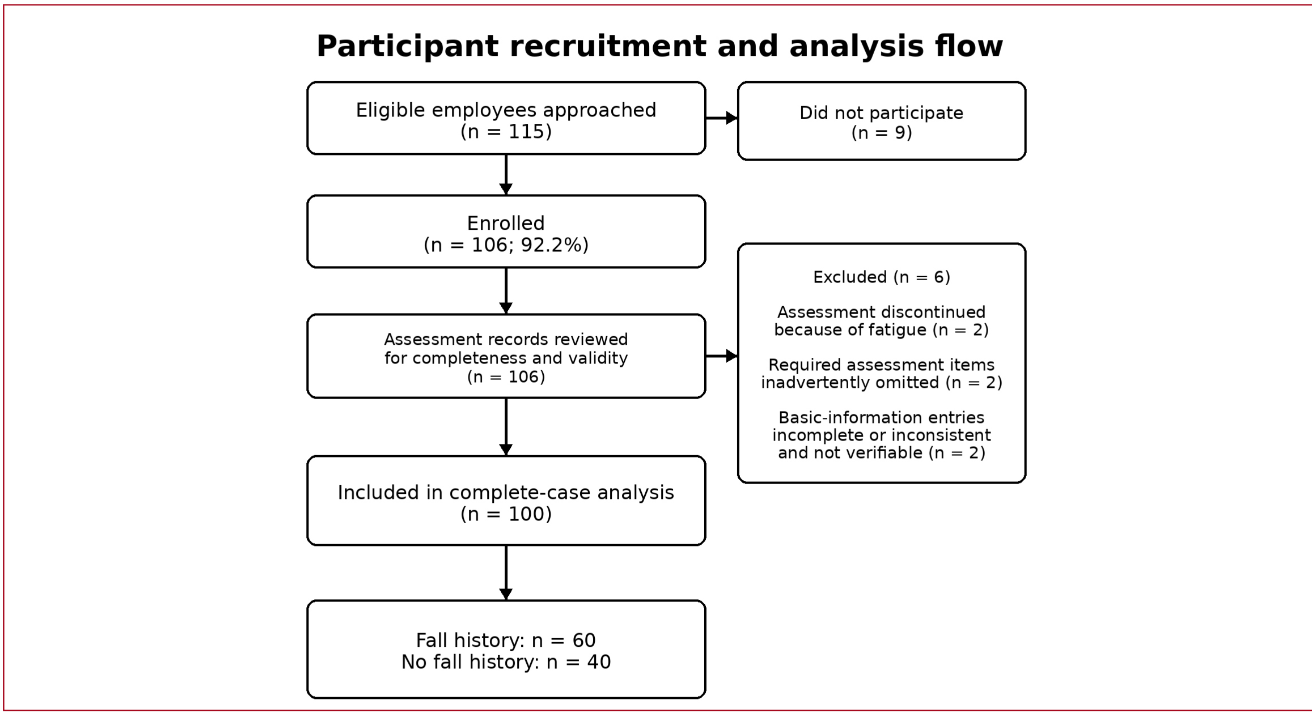

Figure 1. Participant recruitment and analysis flow. Of 115 eligible employees approached, 106 enrolled and 100 were included in the complete-case analysis after six exclusions.

a standardized Japanese protocol with a prespecified maximum duration of 120 seconds[14]. Participants removed their shoes, placed both hands on the waist, selected a comfortable supporting leg, and stood with the supporting knee extended while the raised foot was held forward without touching the supporting leg. Measurement ended when the raised foot touched the supporting leg or floor, the supporting foot moved from its original position, or either hand left the waist. Two trials were performed, and the longer recorded time was used for analysis. Participants maintaining the position for 120 seconds were recorded as reaching the upper limit. Values slightly exceeding 120 seconds because of stopwatch operation were truncated to 120 seconds for analysis.

The 40-cm one-leg stand-up task followed the standard stand-up procedure: participants attempted to rise from a 40-cm seat on one leg without using momentum and to maintain the standing posture for 3 seconds[15]. Finger Floor Distance was measured during maximal forward trunk flexion in standing with the knees extended; the vertical distance between the fingertips and the floor was recorded in centimeters[16].

Data collection procedure

Data were collected in an indoor room provided by the cooperating company. All physical assessments were performed on a level floor, and participants removed their shoes for the standing balance tests. Ambient noise and transient distractions were not formally quantified. Measurements were performed by the first author and two assistants. Before data collection, the assessors confirmed the measurement posture, termination criteria, and recording procedures to reduce inter-assessor variability. Participant safety was prioritized during balance and stand-up tasks, and an assessor remained close enough to provide support if balance was lost. All assessments were completed within a limited single-day worksite window; consequently, completeness and internal consistency of every form could not always be confirmed in real time. The records were therefore reviewed for completeness and validity before analysis.

Statistical Analysis

Continuous variables were summarized as medians and interquartile ranges because of skewed distributions and the ceiling effect in eyes-open one-leg standing time. Categorical variables were summarized as numbers and percentages. Group comparisons between employees with and without fall history were performed using the Mann-Whitney U test for continuous variables and Fisher's exact test for categorical variables. No correction for multiple

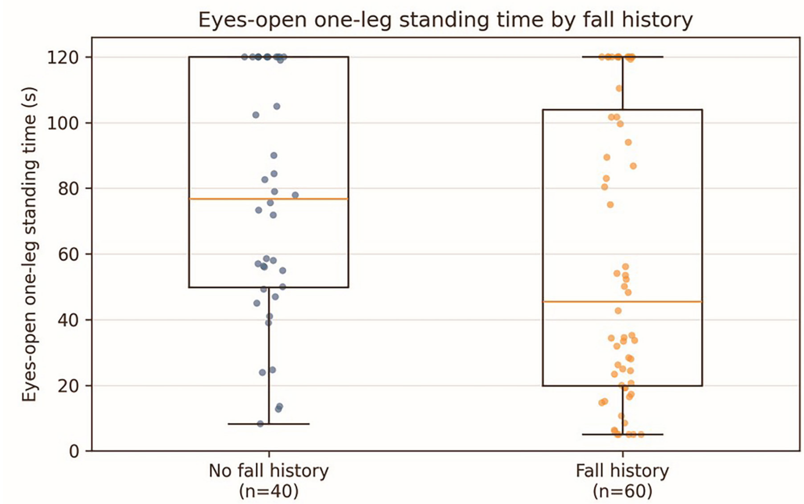

Figure 2. Eyes-open one-leg standing time by fall history. The box indicates the interquartile range, the horizontal line indicates the median, and points indicate individual observations. The maximum measurement time was 120 seconds.

Variable	Fall history (n=60)	No fall history (n=40)	p value
Female sex, n (%)	0 (0.0)	2 (5.0)	0.158
Age, years	59.0 [56.0-61.0]	58.0 [56.0-60.0]	0.347
Height, cm	170.0 [165.0-173.0]	170.0 [168.0-174.2]	0.136
Weight, kg	71.0 [64.0-80.0]	71.0 [62.0-82.0]	0.938
BMI, kg/m²	24.71 [22.95-27.23]	24.12 [22.32-27.99]	0.431
Two-step value	1.58 [1.47-1.68]	1.53 [1.45-1.64]	0.275
Seated stepping, repetitions	28.5 [24.0-35.0]	31.5 [26.8-34.0]	0.273
Functional Reach, cm	35.0 [30.0-40.0]	37.0 [34.8-42.0]	0.215
Eyes-closed standing time, s	5.58 [3.05-9.83]	5.05 [3.41-9.80]	0.874
Eyes-open one-leg standing time, s	45.48 [19.77-103.87]	76.74 [49.80-120.00]	0.018[a]
Finger Floor Distance, cm	0.0 [-0.8-0.0]	-2.0 [-8.0-0.0]	0.013[a]
Able to stand from 40-cm seat on one leg, n (%)	47 (78.3)	31 (77.5)	1.000

Values are medians [interquartile ranges] unless otherwise indicated. BMI, body mass index. p values were calculated using the Mann-Whitney U test for continuous variables and Fisher's exact test for categorical variables. [a] p < 0.05. The Finger Floor Distance comparison should be interpreted as exploratory because many values were recorded as 0 cm, limiting interpretation of the observed group difference.

Table 1. Participant characteristics and physical function measures by fall history

Model	Variable	OR	95% CI	p value
Univariable model	Eyes-open one-leg standing time, per 10 s	0.90	0.81-0.99	0.030[a]
Age- and BMI-adjusted model	Eyes-open one-leg standing time, per 10 s	0.90	0.81-0.99	0.035[a]
Age- and BMI-adjusted model	Age, per 1 year	1.04	0.92-1.18	0.523
Age- and BMI-adjusted model	BMI, per 1 kg/m²	1.02	0.92-1.13	0.734

The dependent variable was fall history during daily life in the previous year (1=yes, 0=no). OR, odds ratio; CI, confidence interval; BMI, body mass index. [a] p < 0.05.

Table 2. Logistic regression analysis of the association between eyes-open one-leg standing time and fall history.

Cutoff	Sensitivity	Specificity	PPV	NPV	Youden index
<=30 s	0.38	0.88	0.82	0.49	0.26
<=35.2 s (Youden)	0.48	0.88	0.85	0.53	0.36
<=40 s	0.48	0.85	0.83	0.52	0.33
<=45 s	0.50	0.80	0.79	0.52	0.30
<=50 s	0.52	0.73	0.74	0.50	0.24
<=60 s	0.60	0.58	0.68	0.49	0.18

Participants with eyes-open one-leg standing time at or below each cutoff were classified as having fall history. PPV, positive predictive value; NPV, negative predictive value. PPV and NPV depend on the prevalence of fall history in this sample and should not be directly generalized.

Table 3. Exploratory discrimination indices for eyes-open one-leg standing time cutoffs.

comparisons was applied.

The primary analysis used logistic regression with fall history as the dependent variable and eyes-open one-leg standing time as the independent variable. Odds ratios (ORs) were expressed per 10-s increase in eyes-open one-leg standing time. An additional model adjusted for age and BMI. The discriminative ability of eyes-open one-leg standing time for fall history was assessed using the area under the receiver operating characteristic curve (AUC). The 95% confidence interval (CI) of the AUC was estimated by bootstrap resampling. Exploratory cutoffs were calculated using the Youden index, and sensitivity, specificity, positive predictive value, and negative predictive value were calculated. The significance level was set at $p<0.05$. Analyses were performed using Python 3, SciPy, statsmodels, and scikit-learn.

Results

Participant characteristics

Of the 115 eligible employees approached, 106 enrolled (92.2%). After exclusion of six records, 100 employees were included in the complete-case analysis (Figure 1). The analysis included 98 men and 2 women. The median age was 59.0 [56.0-61.0] years, and the median BMI was 24.64 [22.72-27.54] kg/m^2. Sixty employees reported fall history during the previous year and 40 reported no fall history.

Comparison by fall history

Eyes-open one-leg standing time was significantly shorter among employees with fall history than among those without fall history (45.48 [19.77-103.87] s vs. 76.74 [49.80-120.00] s, p=0.018) (Table 1, Figure 2). Twenty-five employees reached the measurement ceiling: 13 in the fall-history group and 12 in the no-fall-history group. There were no significant differences in the two-step value, seated stepping, Functional Reach, eyes-closed standing time, or ability to stand from a 40-cm seat on one leg. Finger Floor Distance differed between groups, but because many values were recorded as 0 cm, this result was considered exploratory and was not treated as a primary finding.

Association between eyes-open one-leg standing time and fall history

In the univariable logistic regression model, the OR for fall history per 10-s increase in eyes-open one-leg standing time was 0.90 (95% CI, 0.81-0.99; p=0.030). After adjustment for age and BMI, eyes-open one-leg standing time remained significantly associated with fall history (OR, 0.90; 95% CI, 0.81-0.99; p=0.035). Age and BMI were not significantly associated with fall history in the adjusted model (Table 2).

Receiver operating characteristic analysis

The AUC for identifying fall history using eyes-open one-leg standing time was 0.64 (bootstrap 95% CI, 0.53-0.74) (Figure 3). The Youden-index cutoff was 35.2 s or less, with a sensitivity of 0.48 and specificity of 0.88. When a practical threshold of 40 s or less was used, sensitivity was 0.48 and specificity was 0.85 (Table 3). Because these thresholds were derived from the same exploratory dataset, were influenced by the high fall-history prevalence in this sample, and were not externally validated, they should not be used directly as clinical or employment decision criteria.

Discussion

This worksite-based cross-sectional study found that employees aged 50-65 years at a transportation company who reported a fall during the previous year had shorter eyes-open one-leg standing time than employees without fall history. Longer standing time was associated with lower odds of reporting a previous-year fall, and this association remained after accounting for age and BMI. However, the

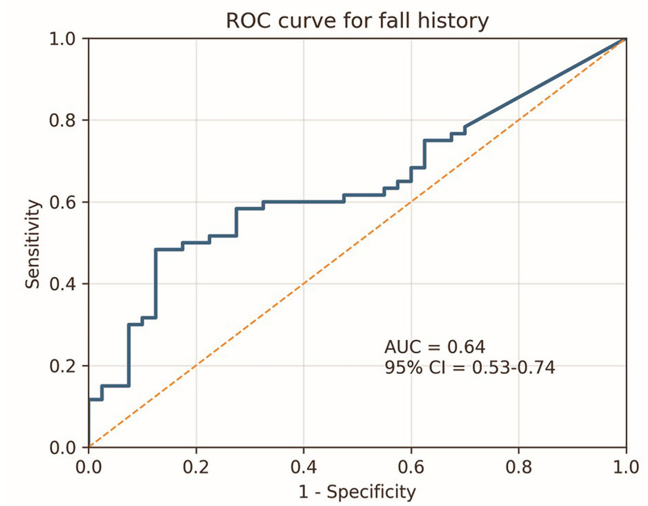

Figure 3. Receiver operating characteristic curve for identifying fall history using eyes-open one-leg standing time. Lower values indicate a greater likelihood of fall history. AUC, area under the curve; CI, confidence interval.

AUC was 0.64, indicating limited discriminative ability. These findings suggest that eyes-open one-leg standing time may be useful as a simple component of worksite fall-risk awareness, but not as a stand-alone diagnostic or employment decision-making tool.

The proportion reporting at least one fall during the previous year was notably high at 60%. Population-based studies have generally reported lower annual prevalence in middle-aged adults, including 17.6-27.8% across four international cohorts and 12.9% among Japanese adults aged 40-59 years[3,5]. Several factors may have contributed to the present finding: the broad outcome definition included falls during all daily activities; the sample was concentrated toward the upper end of the eligible age range; participation was voluntary; and recall-related misclassification was possible. The median age of 59 years may reflect the age structure of the cooperating workforce, differential participation by age, or both. Because the age distribution of all eligible employees and the characteristics of nonparticipants were not available, representativeness with respect to the full company workforce could not be determined.

The balance finding is consistent with evidence that static tasks requiring a narrowed base of support are related to falls and age-related functional decline. De Abreu and colleagues reported that tandem and one-leg standing tests were associated with subsequent falls in older adults[9], and Rezaei and colleagues found marked age-related decline in unipedal standing duration among healthy adults over 50 years[10]. Although the present study was cross-sectional and involved employed adults aged 50-65 years rather than a general older population, it suggests that individual differences in static balance may already be relevant in late working age.

At the same time, the results reinforce the limitations of relying on a single physical function test. An umbrella review concluded that fall prediction using individual gait, balance, or functional mobility instruments remains uncertain[11]. Falls are multifactorial events involving physical function, previous falls, medication use, comorbidities, visual and vestibular function, fatigue, sleep, footwear, environmental hazards, and task characteristics. The absence of statistically significant differences in several other physical measures does not establish that those measures are unrelated to falls. The sample size, relatively high functional level of employed participants, ceiling or floor effects, and heterogeneity of fall circumstances may have reduced the ability to detect differences.

The occupational contribution of this study should be interpreted carefully. Transportation companies may include tasks involving vehicle ingress and egress, walking in warehouses or yards, handling loads, and working under time pressure, as well as office-based duties. National injury data demonstrate heterogeneity in same-level fall outcomes across transportation sub-sectors[6], and frailty has been linked to occupational falls among older workers[7,8]. However, the present study did not collect individual job roles or the location and circumstances of falls. The high prevalence cannot therefore be attributed specifically to transportation work, and the findings represent worksite-collected health-assessment data rather than direct evidence regarding occupational falls prevention.

In practice, a short eyes-open one-leg standing time should prompt further assessment and preventive support rather than work restriction. Such follow-up may include asking about the frequency, location, circumstances, and injury consequences of falls; evaluating lower-limb strength and dynamic balance; reviewing dizziness, vision, sleepiness, or medication-related concerns when appropriate; encouraging exercise habits; and inspecting environmental factors such as flooring, steps, lighting, footwear, and vehicle ingress or egress. Exercise interventions including balance and functional exercise reduce falls among community-dwelling older adults, although transferability to specific occupational settings requires further evaluation[17].

Finger Floor Distance differed between groups, but many values were recorded as 0 cm. This distribution may reflect the recording protocol rather than a truly continuous measure, and the result should be considered exploratory. More broadly, the comparisons of secondary physical-function measures were not adjusted for multiple testing and should not be interpreted as confirmatory findings.

This study has several limitations. First, the cross-sectional design prevents causal inference. Second, fall history was self-reported for the previous year and may be affected by recall bias, underreporting, or telescoping[18,19]. Third, fall frequency, timing, location, occupational context, and injury consequences were not recorded, so workplace and community falls could not be distinguished. Fourth, the study was conducted in a single transportation company, almost all participants were men, and individual job roles were not collected, limiting generalizability. Fifth, although 92.2% of invited employees participated, workforce-wide age and occupational distributions and the characteristics of nonparticipants were unavailable. Sixth, six enrolled employees were excluded because of fatigue-related discontinuation, inadvertently omitted assessments, or unverifiable basic-information entries; the time-limited single-day data-collection process and complete-case approach may have introduced selection bias. Seventh, ambient noise and transient distractions were not formally measured. Eighth, medication, visual function, dizziness, neurological disease, comorbidities, and other potential confounders were not fully assessed. Finally, the cutoff values were derived and evaluated in the same dataset without external validation.

In conclusion, among employees aged 50-65 years at a transportation company in Japan, previous-year fall history during daily life was associated with shorter eyes-open one-leg standing time. Eyes-open one-leg standing is not sufficient as a stand-alone diagnostic test, but it may be a feasible component of worksite fall-risk awareness and health guidance. Future prospective studies should collect detailed job roles and fall circumstances and examine whether this simple test predicts future occupational falls and fall-related injuries in larger and more diverse worker populations.

Ethics Approval

This study was approved by the Ethics Review Board, Graduate School of Humanities and Social Sciences, Hiroshima University (approval number: HR-PSY-004145). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Consent to Participate

Written informed consent was obtained electronically from all participants before participation.

Authors' Contributions

Yuusuke Harada contributed to conceptualization, methodology, investigation, data curation, formal analysis, visualization, supervision, and preparation of the original draft. Tomomi Kitazawa contributed to interpretation of the findings and critical revision of the manuscript for important intellectual content. Both authors reviewed and approved the final version and accept accountability for the work.

Acknowledgements

The authors thank the participating employees for their cooperation, the measurement assistants for supporting standardized data collection, and the cooperating transportation company for providing the study setting and logistical support.

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