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Original article

Relation between the stand-up test and gait speed, knee osteoarthritis, and osteoporosis using calcaneal quantitative ultrasound – Cross-sectional study

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ABSTRACT

Objective: The aim of the present study was to clarify the relationship between the stand-up test and gait speed, knee osteoarthritis (OA), and osteoporosis using calcaneal quantitative ultrasound.
Study design: Cross-sectional study.
Methods: A total of 185 subjects (55 men, 130 women) aged ≥40 years (mean age, 63.7 years; range, 40–79 years) were evaluated using the stand-up test to screen for locomotive syndrome. We also assessed OA of the knee using X-rays and a subjective questionnaire, physical characteristics, 6-m gait speed (m/s), and bone density. If results on the stand-up test were worse than benchmarks by age group (i.e., the height at which 50% of each age group could stand-up), the subject was defined as having a risk for locomotive syndrome (L group). We analyzed the relationship between the stand-up test and other variables.
Results: Of 185 subjects, 50 (27.0%) were classified into the L group. In univariate analysis, there were significant differences between the L group and non-L group in bone density ($p < 0.001$), gait speed ($p < 0.001$), osteoporosis ($p < 0.001$), slow gait speed group (SGSG) (cut off 1 m/s), and Japanese knee osteoarthritis measure score. Multivariate logistic regression analysis adjusted for age, height, weight, and gender showed a significant association between the stand-up test and bone density (OR 0.960, 95% confidence interval (95% CI) 0.927-0.994), gait speed (m/s) (OR 0.073, 95% CI 0.016–0.342), osteoporosis (OR 3.710, 95% CI 1.410–9.764), and SGSG (OR 7.849, 95% CI 1.628–37.845).
Conclusions: The stand-up test to screen for the risk for locomotive syndrome was associated with bone density, gait speed, osteoporosis, SGSG. The stand-up test is an easy test to use to screen for possible disability among the elderly.

1. Introduction

Average life expectancy has increased worldwide, and as a result, the number of elderly people has also increased. In addition, the number of elderly who require nursing care or are bedridden has risen as well. Several articles indicate that sarcopenia [1,2] and osteoporosis [3] affect the activities of elderly persons. Sarcopenia is a known risk factor for falls, and osteoporosis is a known risk factor for bone fractures.

Data from 2009 indicate that life expectancy in Japan from birth is 79.6 years for men and 86.4 years for women; these are the highest life expectancy rates worldwide [4]. The Japanese Orthopedic Association (JOA) suggests that it is important for elderly people to maintain their walking ability to avoid becoming bedridden [5]. In 2007, the JOA cited “Locomotive syndrome” as a way to recognize the importance of preventing reduced walking ability. JOA suggested using a simple test to screen for locomotive syndrome. Nakamura [6] suggested screening for locomotive syndrome using loco-check, which is an easy, seven-item, self-check test. Seichi et al. [7] reported using the 25-question Locomotive Function Scale to screen for locomotive disabilities. In 2013, the JOA suggested using the stand-up test [8] to screen for the risk for locomotive syndrome. The test is objective and simple to perform.

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The aim of this study was to clarify the relationship between the stand-up test and gait speed, knee osteoarthritis (OA), and osteoporosis.

2. Materials and methods

A medical health examination is conducted every year among subjects who live in Katashina village in Gunma prefecture, Japan (population 5076 in 2014), where the main industry is agriculture farming and sightseeing. This annual examination is performed to detect adult diseases like cancer, high blood pressure, and diabetes. A health center of Katashina village conducts this examination. In 2014, a total of 1069 subjects (481 men and 588 women) underwent this examination. Of these 1069 residents, 432 residents also underwent an orthopedic examination, and 550 residents underwent weight-bearing anterior-posterior X-ray of bilateral knees for screening of OA of the knees. Among the residents who underwent orthopedic examinations and X-rays, 185 (55 men, 130 women) were ≥40 years (mean age, 63.7 years; range, 40–79 years). These 185 subjects were included in this study. Additional inclusion criteria for the 185 subjects were (1) ability to walk to the place where the examinations were performed; and (2) ability to respond to a self-reported questionnaire. Subjects who underwent total knee arthroplasty were excluded.

All subjects provided written informed consent, and the study was approved by the institutional review board of Gunma University.

2.1. The stand-up test

Four seats of different heights (40 cm, 30 cm, 20 cm, and 10 cm) were used for the stand-up test. First, if subjects could stand up from a height of 40 cm on both legs, they next tried standing from 40 cm on one leg with their arms folded. We recorded the lowest height from which subjects were able to stand up on both their right and left leg individually. If the results were worse than benchmarks by age group (i.e., the height at which 50% of each age group could stand-up), the subject was defined as having a risk for locomotive syndrome (L group). Subjects were also divided by age into the following groups: 40–49, 50–59, 60–69, and 70–79 years old.

2.2. Knee X-rays

Weight-bearing anterior-posterior X-rays of bilateral knees were taken for screening for OA of the knees as parts of this study. All X-rays were evaluated and graded by two well-trained orthopedic doctors who did not know the subjects. We used the Kellgren–Lawrence grade (K-L grade) for grading the X-rays. Intraclass correlation coefficient (ICC) between the two trained doctors was 0.861 (2, 1). Eight weeks after evaluating the first X-ray, one of the doctors evaluated the X-rays again. ICC (1, 2) in one person was 0.943. If the evaluations were different between the two doctors, they consulted each other about their evaluations until a consensus was reached. We defined the presence of OA as a K-L grade ≥2 on X-rays. If the evaluation of bilateral knees was different, we used the worse knee. Of the 185 subjects, 54 had OA (Table 1).

Table 1
Number of residents at risk for locomotive syndrome (L group) based on radiographic knee OA.

Age, yr	L group (n = 50)					Non-L group (n = 135)				
	K-L grade					K-L grade				
	0	1	2	3	4	0	1	2	3	4
	OA−		OA+			OA−		OA+		
40–49	2	4	0	0	0	2	8	0	0	0
50–59	1	8	2	0	0	7	17	8	1	0
60–69	1	17	6	0	0	3	25	12	2	0
70–79	0	5	2	1	1	5	26	15	4	0

Abbreviations: OA, osteoarthritis; K-L grade, Kellgren–Lawrence.

2.3. Investigation of knee complaints

The presence of knee pain and patient-based outcomes were investigated by medical interviews using the Japanese knee osteoarthritis measure (JKOM) [9]. All 185 subjects completed this measure. This measurement reflects pain, limitations in mobility related to Japanese daily activities, and restriction of participation in social life and health perception, and higher scores represent worse condition of the knees.

2.4. Bone density measurements

Bone density was measured using ultrasound technology (CM-200, Furuno Electric Co., Ltd., Hyogo, Japan) during the annual health checkup, and all 185 subjects underwent the measure. The measurement site was the calcaneus, and the measurement method was ultrasound pulse penetration. We analyzed results based on the % young adult mean (YAM). Osteoporosis was defined as values <70% of %YAM [10].

2.5. Measure of physical characteristics

Height, weight, body mass index (BMI:kg/m^2), and skeletal muscle (SM) mass were determined for all subjects. BMI and SM were investigated using Bioelectrical Impedance Analysis (BIA) using the Tanita MC-780A body composition analyzer (Tanita Co., Ltd., Tokyo, Japan). SM was calculated by Janssen's methods [11], where SM mass (kg) = [(Ht^2/R × 0.401) + (gender × 3825) + (age × −0.071)] + 5102; Ht is height in centimeters; and R is BIA resistance in ohms. To exclude an effect of differences in height, we used the SM index (SMI) [SM/height (m^2)] to analyze skeletal muscle mass [12].

2.6. Measurement of gait speed

Gait speed during a 6-m walk at a usual pace was calculated for all subjects. The start time was when the first foot came off the ground, and the stop time was when the first foot crossed the 6-m line. An examiner used a stop watch to record times. The median of three trials was used in the analysis. Gait speed per 1 s (m/s) was also analyzed. We defined the slow gait speed group (SGSG) (cut off 1 m/s) according to Cesari et al. [13] SGSG represents a gait speed slower than 1 m/s.

2.7. Statistical analysis

Data were expressed as mean ± standard deviation (SD). The Student's t-test, Welch's t-test, and Pearson's chi-square test were used for univariate analysis to determine variables that had a p value < 5%, which were included in the multivariate logistic regression analysis. Odds ratios (OR) and 95% confidence intervals (CI) were determined for these variables. A p value <5% was considered significant. All statistical analyses were conducted using IBM SPSS Statistics 21 software (IBM Japan, Tokyo, Japan). Power was analyzed by G*power 3.1.9 (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany) [14].