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Original Article

Stand-up test overestimates the decline of locomotor function in taller people: a cross-sectional analysis of data from the Kameda Health Study

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Abstract. [Purpose] The purpose of this study was to identify which physical attribute could influence each outcome in the Stand-up test and the Two-step test and the degree of their involvement. [Participants and Methods] The participants were 2,476 people (1,674 males and 802 females), who underwent a two-day health checkup and were requested to take the Locomotive Syndrome Risk Test (Locomo Test). Participants were divided into groups under the Locomo level based on the result of Locomo Test by gender. Furthermore, the relationship between each physical attributes (quartile) based on the result of Locomo Test and the Locomo level was evaluated. [Results] According to the relationship between each physical attributes and Locomo level 1 in the Stand-up test, height showed a positive relationship and the multivariable adjusted odds ratio significantly increased with taller height in both genders. Body weight and BMI showed a negative relationship, although rather weak positive relationship, it was identified in waist circumference. On the other hand, there was no clear correlation between each physical attribute and Locomo level 1 in the Two-step test. [Conclusion] The findings indicate The Stand-up test would overestimate the decline of locomotor function in taller people and would underestimate it in shorter individuals.
Key words: Stand-up test, Two-step test, Physical attributes

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INTRODUCTION

The World Health Organization introduced the concept of healthy life expectancy (HALE) in 2000[1)]. HALE is the number of years of life expected to be lived in full health and in self-reliant life[1)] About 30% of the cause when care was necessary was for locomotor dysfunction, including infirmity with aging, bone fracture, and falls in Japan[2)]. The decline in muscular strength with aging, or joint and spine disorders, can decrease locomotor function, which increases the risk of being bedridden[3)]. The Japanese Orthopaedic Association (JOA) proposed a new term "locomotive syndrome" to describe the state of decreased locomotor function[3)].

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An effective way of preventing locomotive syndrome is to help people understand the decline in locomotor function at an earlier stage, and to encourage recovery and improvement[3–5]. To this end, JOA devised the locomotive syndrome risk test (Locomo Test) as a means of early detection of locomotive syndrome[5]. This test consists of three parts; (1) The stand-up test which evaluates muscle strength in lower extremities, (2) The two-step test which evaluates the ability of locomotion, and (3) The 25-question Risk Assessment which questionnaire is to quantitatively evaluate locomotor dysfunction[6–9]. The deterioration in muscle strength and locomotor function increases the risk of falling, which is a major cause of needing nursing care. The deterioration in particular significantly decreases locomotor function and this could increase the risk of falling and bone fracture because muscle strength in lower extremities is a major function for locomotion and standing up from seating in daily living[10, 11]. The degree of decrease in muscle volume with aging has been reported that the decrease of muscle volume in lower extremities is more significant than that in upper extremities[12–14]. Akune et al. reported that the time required from seated to standing up and walking speed influenced the risk of being in nursing care[15]. Based on these facts, the assessment of muscle strength in lower extremities and walking ability are important as the key indicator to maintain locomotor function, Activity of Daily Living, and Quality of Life, and to extend HALE. The stand-U up test is highly correlated with the muscle strength of knee extension. Individuals who can not standup from 40 cm show weaker grip strength and lower power in knee extension. They tend to show lower muscle strength and lower muscle volume and also show slower Stand-Up time and slower walking speed[16, 17]. Also it is revealed that the two-step test is highly correlated with walking speed in 10 m[8, 18]. Both measurement tests are easy to conduct and provide an objective assessment of one's locomotive syndrome risk level by daily life movement without using a major device and a large place. It is also very useful for children and elderly individuals to understand the results and set goals easily as this test only describes what the individual is able to or unable to do. This test could be used as a very helpful tool for enlightenment of locomotive syndrome. Because of its simplicity, however, the test results may be affected by the physical attributes of individuals (height, weight, etc.), resulting in over- and underestimation of each risk level.

However, there seem to be no previous studies that provide explanations about the relationship between the results of the Locomo Test and individual physical attributes such as height, weight, body mass index (BMI), and waist circumference (WC).

By investigating the relationship between Locomo Test and individual physical attributes, it is clear that the characteristics of each test would help to understand the interpretation of the results. This will increase the usefulness and versatility of the Locomo Test to extend HALE. Therefore, we conducted a large scaled cross-sectional study to determine which individual physical attributes influence the results of the Locomo Test, as well as the significance of the correlation.

PARTICIPANTS AND METHODS

As the Kameda Health Study is a cohort study aimed at investigating medical disorders and locomotive functions of examinee in a Ningen Dock (comprehensive health checkups with lifestyle education and doctor's consultation) by performing musculoskeletal medical examination for examinee in a Ningen Doc at the Kameda Medical Center. This is a cross-sectional study using a part of this Kameda Health Study. During the period between September 1, 2011 and December 31, 2016, a total of 3,334 people underwent a 2-day Ningen Dock (comprehensive health checkups with lifestyle education and doctor's consultation), out of which 2,524 requested to take the Locomo Test. The participants performed the stand-up test and the two-step test. Forty-eight participants were excluded due to the incompletion of the test who did not complete both the stand-up test and the two-step test. The final 2,476 people age 23 to 89, who completed both tests (1,674 males age 24 to 89 and 802 females age 23 to 86) enrolled as participants of this study. Since this study was a study without invasion and intervention and with no sample obtained from the human body, the written or verbal consents from the study participants were not obtained. Instead, information on this study was made public to the study participants (posting on the hospital's homepage: opt out), ensuring opportunities for the participants to refuse to be part of this study. The study was approved by the ethics board of Kameda Medical Center (No.17-037-180919).

The stand-up test is a simple method to mainly assess the participants' muscular strength of the lower extremities by having them stand-up on one or both legs once from four seats of different heights—40 cm, 30 cm, 20 cm, and 10 cm[6, 7].

Based on the instruction by JOA, the risk level of locomotive syndrome (Locomo level) was determined. If the participants were able to standup on one leg—both right and left legs—from the 40 cm seat and to maintain the posture for three seconds, their Locomo level was 0. If they could not complete the task, they were instructed to move to lower seats in increments of 10 cm and standup on both legs. Test results were based on the lowest height of seat from which the participants could standup on both legs. If the participants were unable to standup on one leg from the 40 cm seat, their Locomo level was considered to be 1 (indicating that the decline of their locomotive functions had already begun), while those who were unable to standup on both legs from the 20 cm seat were assigned a Locomo level of 2 (indicating that the decline of their locomotive functions had already advanced). In a previous study, 777 people were investigated and the reliability of the stand-up test was confirmed and the other study found the same result[7, 19].

The two-step test measures the length of two strides of the participants, giving a general assessment of their walking ability, including muscular strength, balance, and flexibility of the lower extremities[6, 7, 18]. Based on the instruction by JOA,

the participants were instructed to take two long strides—The test was conducted twice for each participant. The better record was then divided by the participant's height (cm) to calculate the test result. If the value of their test result was below 1.3, their Locomo level was considered to be 1, while the value below 1.1; Locomo level 2. As in the case of the stand-up test, the two-step test was also confirmed to be highly reliable (r=0.84)[19].

Participants in this study were measured for height and weight as part of the Ningen Doc. Height and weight were measured using a total body composition analyzer with automatic height rod (DC-250, TANITA, Tokyo, Japan), with participants removing their shoes. BMI was calculated by dividing weight (kg) by height squared (m^2). WC which is the size around a location of the standing participant's navel at their terminal respiration, was horizontally measured, using a measuring tape.

Firstly, as descriptive statistics, we aggregated physical attributes and BMI of all participants, as well as separating by gender. To describe the aggregate results, continuous variables were expressed as median and interquartile range, or as mean and standard deviation. Categorical variables were expressed as percentages (%).

Secondly, we classified the results of the stand-up test and the two-step test by gender, and compiled the physical attributes (height, weight, BMI, and WC) of each group by Locomo level. In order to evaluate the relationship between the Locomo level 1 result of the stand-up test and their physical attributes (quartiles), we used a logistic regression model to calculate the age and multivariable-adjusted odds ratios, as well as the 95% confidence interval (95% CI) for each gender group. In the logistic regression model, age was inputted as a covariate to calculate the age-adjusted odds ratios. When considering height as an explanatory variable, age and WC were inputted into the logistic regression model as covariates (model 1). Then, weight was added to model 1 to calculate the multivariable-adjusted odds ratios (model 2). The reason of the classification for model 1 and 2 was to consider the influence of each WC and weight. When considering weight as an explanatory variable, age and WC were inputted (model 3), and then height (continuous variable) was added (model 4). As the same reason as the model 1 and 2, model 3 and 4 were classified to consider the influence of each WC and height. For BMI, age and WC were inputted into the logistic regression model as a covariate (model 5). In terms of BMI, the covariate was only WC because BMI was the value including height and weight. For WC, age and weight were inputted into the logistic regression model as a covariate (model 6), and then height was added to model 6 as covariates (model 7) to calculate the multivariable-adjusted odds ratios. Model 6 and 7 were classified to consider the influence of each weight and height. In the same way, we also evaluated the relationship between the Locomo level 1 result of the Two-step test and their physical attributes. We conducted a trend test, where we inputted the fourth group of each physical attributes (as a continuous variable) into the logistic regression model to evaluate whether a linear relationship existed between the Locomo level 1 result and each physical attribute.

All statistical analyses were performed using SPSS (SPSS for Windows Ver.24, IBM, Japan), with the two-tailed p-values lower than the significance level of 5%.

RESULTS

Table 1 shows participants' physical characteristics and attributes by gender. The median value for males was 61 years old, and for females was also 61 years old. There was no big distinction between the participants' physical characteristics and attributes from the National Health and Nutrition Surveys[20].

Table 2 shows the participants' physical attributes according to the stand-up test and the two-step test results. In these two tests, there were few participants who were assessed as Locomo level 2. In the stand-up test, the group of Locomo level 1 showed the tendency of taller height, heavier weight, and lager WC in both genders compared with that of Locomo level 0. In Two-step test, the tendency of group of Locomo level 1 showed shorter height, heavier weight, lager BMI, and lager WC.

Table 3 shows physical attributes and the odds ratios of the level 1 assessment in the stand-up test by gender. For both males and females, the taller they were the higher the level 1 ratio becomes. The odds ratio of level 1 clearly shows a positive relationship in the height, both with the age-adjusted odds ratios and with the multivariable-adjusted odds ratios used for the WC and weight. The forth quartile of the multivariable-adjusted odds ratio was high: 10.86 for males; 9.09 for females.

As for the weight, although age-adjusted odds ratios show a positive relationship for both males and females, the relationship was attenuated when adjusted for WC. Furthermore, the relationship became negative when adjusted for height. For BMI, as with weight, the age-adjusted odds ratios first showed a positive relationship for both males and females, the relationship became negative when adjusted for WC. For WC, the age-adjusted odds ratios showed a positive relationship. The relationship became less significant when adjusted for height and weight, however the relationship between WC and the Locomo level 1 assessment remained positive.

Table 4 shows physical attributes and the odds ratios of the level 1 assessment in the two-step test by gender. For males, the taller they were, the less they were assessed at level 1. However, the relationship became positive when adjusted for age. When weight and WC were adjusted, there was no clear relationship between height and Locomo level. However, for females, the taller they were, the less they were assessed at level 1. That tendency was maintained even after age, weight, and WC were adjusted as confounding factors. Furthermore, there was no relationship for each weight, BMI, WC in both genders.

Table 1. Physical characteristics and attributes of participants by gender

Variable	All	Males	Females
Number of participants	2,476	1,674	802
Age (years)	61 (56–67)	61 (55–67)	61 (56–67)
Height (cm)	163.7 ± 8.6	168.0 ± 6.1	154.7 ± 5.9
Body weight (kg)	64.4 ± 12.4	69.2 ± 10.8	54.5 ± 9.1
Body mass index (kg/m^2)	23.9 ± 3.4	24.5 ± 3.3	22.8 ± 3.5
Waist circumference (cm)	84.5 ± 9.1	86.3 ± 8.5	80.9 ± 9.3
Stand-up test, possible to stand up from 40 cm, n (%)	1,230/2,476 (49.7)	825/1,674 (49.3)	405/802 (50.5)
Two-Step value	1.52 ± 0.2	1.55 ± 0.1	1.46 ± 0.1
Systolic blood pressure (mmHg)	121.2 ± 16.6	122.7 ± 16.5	118.1 ± 16.6
Diastolic blood pressure (mmHg)	75.7 ± 11.6	77.2 ± 11.5	72.7 ± 11.4
HDL-cholesterol (mg/dl)	62.5 ± 16.2	58.9 ± 14.9	70.1 ± 16.0
Fasting blood glucose (mg/dl)	102.3 ± 18.2	104.2 ± 19.5	98.2 ± 14.1
Smoking status, n (%)			
None smoking	2,081 (16.0)	1,324 (79.1)	757 (94.4)
Smoking	395 (16.0)	35 (20.9)	45 (5.6)
Alcohol intake, n (%)			
None	897 (36.2)	375 (22.4)	522 (65.1)
Moderate	1,179 (47.6)	922 (55.1)	257 (32.0)
Heavy	400 (16.2)	377 (22.5)	23 (2.9)
Prevalence of diabetes, n (%)	309 (12.5)	252 (15.1)	57 (7.1)

Data are the means ± SD or percentages. Only age is interquartile.

Table 2. Physical attributes by the results of stand-up test and two-step test

	Males			Females		
	Locomo level 0	Locomo level 1	Locomo level 2	Locomo level 0	Locomo level 1	Locomo level 2
Stand-up test						
Number of participants (%)	1,207 (72.1)	448 (26.8)	19 (1.1)	472 (58.9)	310 (38.7)	20 (2.5)
Age (years)	60 (53–64)	66 (60–71)	64 (59–74)	60 (54–64)	63 (58–69)	73.5 (65.5–79)
Hight (cm)	167.5 ± 5.9	169.3 ± 6.2	167.6 ± 6.6	153.9 ± 5.6	156.0 ± 6.1	153.4 ± 5.4
Body weight (kg)	68.4 ± 10.1	70.9 ± 11.7	77.3 ± 19.2	53.2 ± 8.5	55.8 ± 9.1	63.7 ± 14.7
Body mass index (kg/m^2)	24.3 ± 3.1	24.7 ± 3.4	27.4 ± 6.1	22.5 ± 3.3	22.9 ± 3.6	26.9 ± 5.1
Waist circumference (cm)	85.2 ± 7.9	88.7 ± 8.9	95.3 ± 15.2	79.2 ± 8.6	82.7 ± 9.4	91.3 ± 12.4
Two-step test						
Number of participants (%)	1,604 (95.8)	60 (3.6)	10 (0.6)	708 (88.3)	83 (10.3)	11 (1.4)
Age (years)	61 (55–66)	70 (62–77)	64 (59–80)	61 (56–66)	66 (60–73)	76 (57–80)
Hight (cm)	168.0 ± 6.1	166.2 ± 6.3	165.8 ± 6.3	155.0 ± 5.8	153.4 ± 5.2	146.7 ± 5.8
Body weight (kg)	69.0 ± 10.6	72.8 ± 15.2	68.8 ± 9.4	54.3 ± 8.9	56.4 ± 10.6	52.6 ± 10.3
Body mass index (kg/m^2)	24.4 ± 3.1	26.3 ± 4.7	25.1 ± 3.7	22.6 ± 3.4	23.9 ± 4.1	24.3 ± 3.7
Waist circumference (cm)	86.1 ± 8.3	91.5 ± 11.8	88.9 ± 12.0	80.4 ± 9.1	83.8 ± 10.0	85.5 ± 10.0

Data are the means ± SD or percentages. Only age is interquartile.

DISCUSSION

In this study, we conducted a large scale a cross-sectional study on groups of Japanese adults of both genders to determine which individual physical attributes influence the results of the Locomo Test, as well as the significance of the correlation. In the stand-up test, the results show a positive relationship, where the tallest group as the 4th quartile, both males and females, tended to have a significantly high multivariable-adjusted odds ratio in the Locomo Level 1 compared with the shortest group as the 1st quartile. In terms of weight and BMI, the results show a negative relationship, while in terms of WC, it showed a weak positive relationship. However, in the two-step test, none of those physical attributes show a clear relationship for

Table 3. Physical attributes and odds ratios of level 1 group in the stand-up test by gender

	Males							Females						
	n	No. of Locomo level 1	Incidence rate*	OR (95%CI)	Age adjusted OR (95%CI)	Multivariable adjusted OR (95%CI)	Multivariable adjusted OR (95%CI)	n	No. of Locomo level 1	Incidence rate*	OR (95%CI)	Age adjusted OR (95%CI)	Multivariable adjusted OR (95%CI)	Multivariable adjusted OR (95%CI
Height														
1st	417	80	192	1.00	1.00	1.00[1)]	1.00[2)]	198	69	348	1.00	1.00	1.00[1)]	1.00[2)]
Quartile				(reference)	(reference)	(reference)	(reference)				(reference)	(reference)	(reference)	(reference)
(Lowest)														
2nd	419	120	286	1.69	2.94	2.71	2.93	203	69	340	0.96	1.38	1.37	1.39
Quartile				(1.22–2.34)	(2.04–4.22)	(1.87–3.92)	(2.00–4.28)				(0.64–1.45)	(0.89–2.15)	(0.87–2.15)	(0.88–2.20)
3rd	420	117	279	1.63	4.52	3.81	4.31	198	77	389	1.19	2.55	2.42	2.51
Quartile				(1.18–2.25)	(3.09–6.61)	(2.58–5.62)	(2.85–6.53)				(0.79–1.79)	(1.60–4.05)	(1.51–3.88)	(1.54–4.11)
4th	418	150	359	2.36	11.07	8.84	10.86	203	115	567	2.44	8.48	8.57	9.09
Quartile				(1.72–3.23)	(7.38–16.61)	(5.83–13.39)	(6.74–17.51)				(1.63–3.66)	(5.04–14.24)	(5.03–14.57)	(5.13–16.11)
(Highest)														
p value for trend				p<0.001	p<0.001	p<0.001	p<0.001				p<0.001	p<0.001	p<0.001	p<0.01
Body weight														
1st	416	93	224	1.00	1.00	1.00[3)]	1.00[4)]	201	60	299	1.00	1.00	1.00[3)]	1.00[4)]
Quartile				(reference)	(reference)	(reference)	(reference)				(reference)	(reference)	(reference)	(reference)
(Lowest)														
2nd	424	115	271	1.29	1.75	1.30	0.75	200	81	405	1.60	1.99	1.66	0.94
Quartile				(0.94–1.77)	(1.24–2.46)	(0.90–1.89)	(0.50–1.11)				(1.06–2.42)	(1.22–2.89)	(1.05–2.64)	(0.57–1.55)
3rd	418	107	256	1.20	1.97	1.18	0.46	200	81	405	1.60	1.98	1.66	0.67
Quartile				(0.87–1.64)	(1.39–2.80)	(0.77–1.82)	(0.28–0.75)				(1.06–2.42)	(1.29–3.06)	(0.96–2.69)	(0.38–1.20)
4th	416	152	365	2.00	5.49	2.40	0.49	201	108	537	2.73	3.90	2.69	0.60
Quartile				(1.48–2.71)	(3.81–7.91)	(1.39–4.14)	(0.26–0.93)							
(Highest)											(1.81–4.11)	(2.51–6.04)	(1.39–5.20)	(0.28–1.30)
p value for trend				p<0.001	p<0.001	0.008	p<0.001				p<0.001	p<0.001	0.01	0.118

Table 3 Continued.

	Males							Females						
	n	No. of Locomo level 1	Incidence rate*	OR (95%CI)	Age adjusted OR (95%CI)	Multivariable adjusted OR (95%CI)	Multivariable adjusted OR (95%CI)	n	No. of Locomo level 1	Incidence rate*	OR (95%CI)	Age adjusted OR (95%CI)	Multivariable adjusted OR (95%CI)	Multivariable adjusted OR (95%CI
Body Mass Index														
1st Quartile (Lowest)	419	96	229	1.00 (reference)	1.00 (reference)	1.00[5] (reference)		199	74	372	1.00 (reference)	1.00 (reference)	1.00[5] (reference)	
2nd Quartile	413	130	315	1.55 (1.14–2.10)	1.60 (1.15–2.21)	0.71 (0.49–1.03)		199	70	352	0.92 (0.61–1.38)	0.90 (0.59–1.37)	0.52 (0.33–0.83)	
3rd Quartile	427	111	260	1.18 (0.86–1.62)	1.32 (0.95–1.84)	0.33 (0.22–0.52)		204	89	436	1.31 (0.88–1.95)	1.21 (0.80–1.82)	0.46 (0.27–0.78)	
4th Quartile (Highest)	415	130	313	1.54 (1.13–2.09)	2.13 (1.52–2.97)	0.21 (0.12–0.37)		200	97	485	1.59 (1.07–2.37)	1.49 (0.99–2.25)	0.28 (0.14–0.55)	
p value for trend				0.044	p<0.001	p<0.001					0.007	0.023	p<0.001	
Waist circumference														
1st Quartile (Lowest)	423	71	168	1.00 (reference)	1.00 (reference)	1.00[6] (reference)	1.00[7] (reference)	200	61	305	1.00 (reference)	1.00 (reference)	1.00[6] (reference)	1.00[7] (reference)
2nd Quartile	390	114	292	2.05 (1.46–2.86)	2.35 (1.64–3.37)	1.61 (1.10–2.35)	1.92 (1.29–2.84)	212	79	393	1.35 (0.90–2.04)	1.38 (0.91–2.11)	1.06 (0.68–1.65)	1.34 (0.84–2.15)
3rd Quartile	446	120	269	1.83 (1.31–2.54)	2.06 (1.45–2.93)	0.98 (0.64–1.49)	1.40 (0.91–2.17)	191	78	388	1.57 (1.04–2.39)	1.46 (0.96–2.25)	0.89 (0.54–1.46)	1.31 (0.77–2.24)
4th Quartile (Highest)	415	162	390	3.18 (2.30–4.38)	4.43 (3.12–6.30)	1.14 (0.67–1.95)	2.32 (1.32–4.09)	199	112	560	2.93 (1.95–4.43)	2.81 (1.84–4.28)	1.08 (0.57–2.06)	2.63 (1.30–5.32)
p value for trend				p<0.001	p<0.001	0.763	0.029				p<0.001	p<0.001	0.958	0.023

Reference: reference group to assess the odds ratio of other groups.
1) Model 1: Adjusted for age and waist circumference.
2) Model 2: Model 1 plus body weight.
3) Model 3: Adjusted for age and waist circumference.
4) Model 4: Model 3 plus height.
5) Model 5: Adjusted for age and waist circumference.
6) Model 6: Adjusted for age and body weight.
7) Model 7: Model 6 plus height.
* Incidence rate for Locomo level 1 per 1,000 males or females.
To calculate the multivariable adjustment odds ratio, the covariate for the logistic regression model was classified into two models to evaluate the influence of each physical attributes.

Table 4. Physical attributes and odds ratios of level 1 group in the two-step test by gender

	Males							Females						
	n	No. of Locomo level 1	Incidence rate*	OR (95%CI)	Age adjusted OR (95%CI)	Multivariable adjusted OR (95%CI)	Multivariable adjusted OR (95%CI)	n	No. of Locomo level 1	Incidence rate*	OR (95%CI)	Age adjusted OR (95%CI)	Multivariable adjusted OR (95%CI)	Multivariable adjusted OR (95%CI)
Height														
1st Quartile (Lowest)	417	23	55	1.00 (reference)	1.00 (reference)	1.00[1)] (reference)	1.00[2)] (reference)	198	36	182	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00[2)] (reference)
2nd Quartile	419	19	45	0.81 (0.44–1.52)	1.17 (0.61–2.23)	0.92 (0.47–2.00)	0.84 (0.42–1.67)	203	24	118	0.6 (0.35–1.01)	0.76 (0.43–1.35)	0.74 (0.41–1.32)	0.7 (0.39–1.25)
3rd Quartile_	420	15	36	0.63 (0.33–1.23)	1.34 (0.66–2.72)	0.97 (0.47–2.00)	0.85 (0.29–1.83)	198	22	111	0.56 (0.32–1.00)	0.93 (0.50–1.71)	0.85 (0.46–1.58)	0.75 (0.39–1.43)
4th Quartile (Highest)	418	13	31	0.55 (0.28–1.10)	1.66 (0.77–3.58)	1.07 (0.48–2.38)	0.83 (0.33–2.12)	203	12	59	0.28 (0.14–0.56)	0.58 (0.28–1.23)	0.52 (0.24–1.10)	0.42 (0.19–0.96)
p value for trend				0.063	0.187	0.891	0.692				p<0.001	0.255	0.135	0.059
Body weight														
1st Quartile (Lowest)	416	10	24	1.00 (reference)	1.00 (reference)	1.00[3)] (reference)	1.00[4)] (reference)	201	23	114	1.00 (reference)	1.00 (reference)	1.00[3)] (reference)	1.00[4)] (reference)
2nd Quartile	424	19	45	1.91 (0.88–4.15)	2.27 (1.21–6.03)	1.7 (0.73–3.97)	1.85 (0.77–4.41)	200	20	100	0.86 (0.46–1.62)	0.98 (0.51–1.87)	0.75 (0.37–1.52)	0.85 (0.41–1.76)
3rd Quartile	418	19	45	1.93 (0.89–4.21)	3.46 (1.53–7.80)	1.59 (0.63–4.03)	1.81 (0.67–4.84)	200	20	100	0.86 (0.46–1.63)	1.08 (0.56–2.07)	0.71 (0.33–1.54)	0.85 (0.38–1.94)
4th Quartile (Highest)	416	22	53	2.27 (1.06–4.85)	6.35 (2.78–14.51)	1.78 (0.56–5.61)	2.24 (0.62–8.03)	201	31	154	1.41 (0.79–2.52)	2.05 (1.12–3.78)	0.99 (0.38–2.58)	1.38 (0.48–4.00)
p value for trend				0.049	p<0.001	0.435	0.295				0.240	0.022	0.913	0.633

Table 4 Continued.

	Males							Females						
	n	No. of Locomo level 1	Incidence rate*	OR (95%CI)	Age adjusted OR (95%CI)	Multivariable adjusted OR (95%CI)	Multivariable adjusted OR (95%CI)	n	No. of Locomo level 1	Incidence rate*	OR (95%CI)	Age adjusted OR (95%CI)	Multivariable adjusted OR (95%CI)	Multivariable adjusted OR (95%CI)
Body Mass Index														
1st Quartile (Lowest)	419	11	42	1.00 (reference)	1.00 (reference)	1.00[5] (reference)		199	18	90	1.00 (reference)	1.00 (reference)	1.00[5] (reference)	
2nd Quartile	413	10	24	0.92 (0.39–2.19)	0.96 (0.40–2.31)	0.62 (0.25–1.56)		199	20	101	1.12 (0.58–2.19)	1.1 (0.56–2.19)	0.91 (0.44–1.87)	
3rd Quartile	427	20	47	1.82 (0.86–3.85)	2.11 (1.00–4.67)	1.07 (0.44–2.57)		204	18	88	0.97 (0.49–1.93)	0.83 (0.41–1.67)	0.58 (0.26–1.32)	
4th Quartile (Highest)	415	29	70	2.79 (1.37–5.66)	4.21 (2.01–8.81)	1.27 (0.44–3.63)		200	38	190	2.36 (1.30–4.30)	2.18 (1.18–4.04)	1.18 (0.45–3.10)	
p value for trend				0.001	p<0.001	0.368					0.005	0.017	0.991	
Waist Circumference														
1st Quartile (Lowest)	423	9	21	1.00 (reference)	1.00 (reference)	1.00[6] (reference)	1.00[7] (reference)	200	16	80	1.00 (reference)	1.00 (reference)	1.00[6] (reference)	1.00[7] (reference)
2nd Quartile	300	13	43	1.59 (0.67–3.75)	1.74 (0.73–4.19)	1.19 (0.48–2.92)	1.16 (0.47–2.86)	212	21	99	1.26 (0.64–2.50)	1.30 (0.65–2.61)	1.13 (0.55–2.33)	1.06 (0.52–2.20)
3rd Quartile_	446	21	47	2.27 (1.03–5.02)	2.60 (1.16–5.84)	1.26 (0.52–3.08)	1.20 (0.49–2.91)	191	22	115	1.50 (0.76–2.95)	1.37 (0.69–2.73)	1.07 (0.49–2.30)	0.95 (0.44–2.07)
4th Quartile (Highest)	415	27	65	3.20 (1.49–6.89)	4.19 (1.90–9.22)	1.08 (0.37–3.20)	0.93 (0.31–2.78)	199	35	176	2.45 (1.31–4.60)	2.25 (1.18–4.28)	1.37 (0.54–3.50)	1.07 (0.41–2.83)
p value for trend				0.001	p<0.001	0.882	0.906				0.003	0.012	0.586	0.984

Reference: reference group to assess the odds ratio of other groups.
1) Model 1: Adjusted for age and waist circumference.
2) Model 2: Model 1 plus body weight.
3) Model 3: Adjusted for age and waist circumference.
4) Model 4: Model 3 plus height.
5) Model 5: Adjusted for age and waist circumference.
6) Model 6: Adjusted for age and body weight.
7) Model 7: Model 6 plus height.
* Incidence rate for Locomo level 1 per 1,000 males or females.
To calculate the multivariable adjustment odds ratio, the covariate for the logistic regression model was classified into two models to evaluate the influence of each physical attributes.

both males and females. This study concludes that physical attributes do not have a significant influence on the results of the two-step test, while the results of the stand-up test can be affected by height as taller people's declining locomotor function, This tends to be overestimated. Therefore, height needs to be considered in the evaluation process of the stand-up test results.

Some studies report that participants who can standup from the lower chair have greater isometric or isokinetic leg extension force[7, 21, 22]. This indicates that for people with longer lower extremities (or with taller height), the chair is relatively low, which requires more leg force in order to standup. From these previous studies, it is considered that one of the reasons taller people showed a higher ratio of Locomo Level 1 is related to the length of their lower extremities; the degree of leg force used to standup from a 40 cm chair varies depending on the length of their lower extremities.

Kigawa et al.[23] investigated the relationship between knee extension muscular strength and the weight of university students, in which he reported there was a significant relationship. In this study, it was also observed that participants with higher values of weight and BMI had a low multivariable-adjusted odds ratio of Locomo Level 1 even after adjusting for height, seeming to indicate a negative relationship between the weight or BMI and the Locomo Level 1. This implies if body weight and BMI is high, muscle volume would also be high. It could also indicate a negative relationship between high muscle volume and the decline of locomotor function. However, a weak positive relationship was observed between the stand-up test results and WC for both males and females. Those facts indicate a negative relationship between muscular strength and the decline in locomotor function. This indicates that weight gain by obesity is due to larger WC. It also shows a positive relationship between obesity and the decline in locomotor function. The two-step value is calculated by dividing the length of two strides by height. It is speculated that the results are not affected by height because height (perhaps the length of extremities) is taken into consideration [in the assessment process], unlike the stand-up test. In addition, there was no clear relationship between the two-step test results and weight, BMI, and WC; the test results were unaffected by those factors. Consequently, as for the two-step test, the influence of physical attributes need not be considered when analyzing the results.

A strength of this study is having identified the problems of the Locomo Test through a large scale a cross-sectional study on groups of Japanese males and females. The Locomo Test is easy to conduct and can be widespread. The test can be evaluated to provide the opportunity to raise awareness of locomotive syndrome risk level and to take measures against the decline in locomotor function in an early stage. Especially stand-up movement, which is the same movement as the stand-up test, is the hardest movement in daily activity[24]. Yoshioka et al. reported that stand-up movement required the certain amount of muscle strength related to knee joint and hip joint[25]. Kamiike et al. resulted the relationship between the stand-up test and knee flexion strength[26]. Based on these results, the stand-up test would be able to be considered as an effective test to evaluate total strength in lower extremity. Because of its simplicity, however, the credibility of the test is considered to be limited. This study clarified the limitation of the Locomo Test and its consideration upon analyzing the results, which can contribute its widespread use.

This study has some limitations. Firstly, age distribution of the participants of this study are limited and it is unclear if the same results can be achieved with elderly or younger people. Secondly, the participants of this study participated in the annual health examination; they may be more health-conscious people compared to other people. Lastly, this study did not measure muscle mass which can affect the results of both tests, so the relationship between muscle mass and the test results remain unclear. However, it is possible to speculate the relationship from the values of BMI and WC from the result of multivariable analysis; it is considered that people with larger mass of muscle tend to have good results in the stand-up test.

In conclusion, this study on the Locomo Test suggests that the results of the two-step test are not affected by any physical attributes of the participants, while those of the stand-up test are significantly affected by height. It also clarifies that the stand-up test overestimates the decline of locomotor function in taller people, while underestimating it in shorter people. When conducting the Locomo Test, it is recommended to take this study into consideration when analyzing the results of the stand-up test.

Presentation at a conference

This study, in part, was presented as a poster at 21th Congress on Japanese Association of Exercise Epidemiology, Shinjuku, Tokyo, Japan, June 23–24, 2018. http://jaee.umin.jp/doc/meeting_21_abstract.pdf.

Conflict of interest

The authors declare that they have no conflicting of interest.

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