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Usefulness of Assessment Tests for Locomotive Syndrome in Young Japanese Women

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Abstract: Background: Too few studies on the risk of locomotive syndrome in young women have been performed. Aim: To evaluate the relationship between the physique of healthy young Japanese women and their risk of developing locomotive syndrome in the future. Subjects and Methods: Young Japanese women (n=215, mean 19.0 ± standard deviation 0.6 y) were enrolled in the study. Anthropometric measurements were obtained. The participants performed a stand-up test and a two-step test for the assessment of the risk of locomotive syndrome as proposed by the Japanese Orthopaedic Association. Results: In the stand-up test, most participants (61.4%) could stand up from a seated position on one leg from a 30 cm or 40 cm stool. The median (Q1, Q3) of the two-step test was 1.51 (1.41, 1.59). These results were lower than the reference values for people in their 20s reported in the literature [J Orthop Sci 2020; 25: 1084]. In the stand-up test, as compared to the poor performers (stand on both legs from a 10 cm or 20 cm stool), better performers (stand on one leg from a 10 cm stool) had lower body height, weight, waist and hip circumferences, waist/hip ratio, %fat mass, visceral fat area, and lower-leg length and had higher %skeletal muscle and %limb muscle mass. In the two-step test, better performers (1.56–1.93) had longer upper-leg length and higher back muscle strength as compared to poor performers (1.13–1.45). Conclusion: The values obtained in the stand-up test and two-step test for young Japanese women were lower than the reference values reported. Subjects with a smaller physique had an advantage in the stand-up test, and in the two-step test, those with longer upper legs had an advantage. Precision will be necessary in these tests to compensate for stature, particularly higher/lower leg length. The results also indicate that back muscle strength may be an important factor for the two-step test performance.

Keywords: Locomotive Syndrome, Young Japanese Women, Stand-Up Test, Two-Step Test, Stature, Upper-Leg Length, Lower-Leg Length, Back Muscle Strength

1. Introduction

In the long-term care insurance system in Japan, subjects requiring care are divided first into two classes: Requiring Help and Long-Term Care. Requiring Help is divided into levels 1 and 2, and Long-Term Care is divided into levels 1–5. Long-Term Care is more severe than Requiring Help, and in each class, a higher number means greater severity. According to the National Livelihood Survey by the Ministry of Health, Labour and Welfare of Japan, the main causes of requiring care at the Long-Term Care levels are dementia (24.3%) and cerebrovascular disease (19.2%) [2]. However, at the Requiring Help levels, articular diseases are ranked first (18.9%), asthenia due to advanced age or frailty is second (16.1%), and fractures and falls are third (14.2%), with the three causes totaling 49.2%. At the Long-Term Care levels, these three causes account collectively for only 30.3%. This indicates that the main causes of being classified as Requiring Help, namely mild or early conditions requiring insurance care, are mainly related to disorders of the bones, joints, and muscles, namely locomotive syndrome, frailty, and sarcopenia. Moreover, the levels of physical fitness in young Japanese people are reported to have decreased over the past several years [3, 4].

Accordingly, the Japanese Orthopaedic Association (JOA) proposed the concept of "locomotive syndrome" (LS), defined as a condition requiring nursing care, or being at risk of developing such a condition, because of a decline in mobility,

such as walking, climbing stairs, and standing up from a chair, as a result of a disorder of the locomotive system, namely bones, joints, muscles, and nerves [5]. In order to assess the risk of LS, the following three measures have been proposed: a stand-up test, a two-step test, and a 25-question geriatric locomotive function scale (GLFS) questionnaire.

However, because there have been insufficient studies on the risk of LS in young women, the present study aimed to evaluate the relationship between the physique of apparently healthy young Japanese women and the risk of LS in the future.

2. Subjects and Methods

2.1. Subjects

Female sophomore students (n=215, mean 19.0 ± standard deviation 0.6 y) of Sugiyama Jogakuen University (Nagoya, Japan) were enrolled in the study. The Ethical Committee of Sugiyama Jogakuen University School of Life Studies approved this study (No. 2020-20). The subjects provided written informed consent to participate. The protocol was performed in accord with the revised Helsinki Declaration of 1983.

2.2. Physical Examination

Body height was measured using standard methods. Waist circumference was assessed as the abdominal girth at the level of the umbilicus, and hip circumference was measured at the level of the greater trochanters. The waist-to-hip (W/H) ratio was calculated next. The lengths of right upper and lower legs were also measured. The length of the upper leg (ULL) is the distance from the greater trochanter to the lateral epicondyle, and the length of the lower leg (LLL) is the distance from the head of the fibula to the lateral malleolus. Body weight and composition were determined using the 8-polar bioimpedance method (InBody720, Biospace, Tokyo, Japan). The items included body weight, fat mass, muscle mass, skeletal muscle mass, limb muscle mass, visceral fat area (VFA), and bone mineral content (BMC). Body mass index (BMI), %fat mass (%FM), %skeletal muscle mass (%SMM), %limb muscle mass (%LMM), and %BMC were calculated. Bone density (BD) was determined by measuring the ultrasound velocity in the right calcaneus (CM-300, Cannon Life Care Solutions, Tokyo). Back muscle strength (BMS) was measured using a back dynamometer (Back D, TKK5402, Takei, Niigata, Japan).

2.3. Tests for the Risk of LS

In order to assess the LS risk, two physical tests and one self-reported questionnaire were developed [4]. In this study, physical tests—a stand-up test and a two-step test—were performed. We did not adopt the self-reported questionnaire (GLFS), because it is appropriate for elderly people but not for young people.

2.3.1. Stand-Up Test

This test assesses the ability to stand up from a seated position on stools of different heights (10, 20, 30, and 40 cm). For a successful trial, individuals are required to stand up, on one or both legs, from a seated position on a stool and maintain their posture for three seconds after standing. First, participants stood up from a seated position on a 10 cm stool using both legs and maintained their posture for three seconds. If participants succeeded at this task, they then stood up from a seated position on a 40 cm stool using one leg. Participants also stood on the other leg. If they could complete the tasks, they lowered the stool by 10 cm and repeated the same procedures. The evaluation value was based on the lowest stool height from which the participant could stand up on both the left and right leg separately.

2.3.2. Two-Step Test

This test measures the maximum length of the two-step stride of participants. Subjects conducted the test from a standing posture without losing balance. The two-step test score is the standardized value of the maximum two-step stride length (cm) divided by height (cm).

2.4. Statistical Analyses

Statistical analyses were performed using SPSS ver. 26 software (IBM, Tokyo). A normal distribution of continuous data was examined using the Shapiro–Wilk test, but data were not normally distributed; hence, they were treated as non-parametric data and presented as the median (Q1, Q3). For multiple comparisons, the Kruskal–Wallis test and then Bonferroni corrections were performed. $p<0.05$ was considered statistically significant.

3. Results

The physical characteristics and nutritional intake of the subjects are presented in Tables 1 and 2, respectively. Their physique was average or typical of young Japanese women as described in the National Health and Nutrition Survey by the Ministry of Health, Labour and Welfare of Japan [6]. The intake of the three major nutrients was also comparable to the reference values. However, the intake of calcium and salt was higher, and that of dietary fiber was slightly lower.

Table 1. *Physical characteristics of subjects.*

	Unit	Number	Median	(Q1, Q3)	Range
Height	cm	215	158.6	(154.7,161.7)	143.0－174.9
Weight	kg	215	49.0	(45.6,53.7)	37.6－79.2
BMI	kg/m^2	215	19.5	(18.5,21.2)	15.1－30.8
Waist	cm	215	69.6	(66.0,73.5)	52.8－95.9
Hip	cm	215	89.8	(87.5,93.0)	79.0－110.3
W/H		215	0.77	(0.74,0.80)	0.67－1.00
%SMM	%	215	39.7	(37.5,41.7)	18.8－47.8

	Unit	Number	Median	(Q1, Q3)	Range
%LMM	%	215	23.4	(22.1,24.6)	10.7－33.6
%FM	%	215	25.5	(22.0,29.9)	13.8－56.6
VFA	cm^2	215	22.2	(9.7,33.4)	1.1－139.6
%BMC	%	215	4.4	(4.2,4.6)	1.5－7.2
BD	m/sec	172	1547	(1523,1576)	1470－1732
ULL	cm	215	41.4	(39.8,43.3)	33.5－49.4
LLL	cm	215	36.8	(35.5,38.5)	31.4－45.2
BMS	kg	116	54.8	(46.0,70.2)	22.5－117.8

Table 2. *Nutritional intake of subjects.*

		This study	National Health and Nutrition Survey	
	Unit	19-20 y	15-19 y	20-29 y
Energy	kcal	1841	1896	1600
Protein	g	67.8	71.8	61.1
Lipid	g	68.1	67.7	55.5
Carbonhydrate	g	233.3	241.4	202.1
Dietary fiber	g	13.1	17.0	14.6
Calcium	mg	509	454	408
Iron	mg	7.5	7.0	6.2
Salt	g	9.3	4.7	5.3
Height	cm	158.5	156.7	158.6
Weight	kg	50.0	48.7	49.0

All are averages.

The results of the stand-up test are shown in Table 3. In the stand-up test, most participants (61.4%) were able to stand up on one leg from a 30 cm or 40 cm stool. This result was slightly lower than the reference value for people in their 20s. The reference point for women in the 20s is to be able to stand up on one leg from a stool with a median height of 30 cm (Q1: 40 cm, Q3: 10 cm). The results of the stand-up test are shown categorized in five groups. Group I: stand on both legs from a seated position from a 10 cm or 20 cm stool; Group II: stand on one leg from a seated position on a 40 cm stool; Group III: stand on one leg from a seated position on a 30 cm stool; Group IV: stand on one leg from a seated position on a 20 cm stool; and Group V: stand on one leg from a seated position on a 10 cm stool. As compared to Group II, Group V participants' body height, weight, waist and hip circumferences, W/H ratio, %FM, VFA, and LLL were significantly lower, and %SMM and %LMM were higher. However, as compared to Group I, although a similar tendency was observed in Group V, there were no significant differences except for the LLL, probably because the number of subjects in Group I was smaller than those in the other groups.

Table 3. *Results of the stand-up test categorized in five groups.*

Group		I		II		III		IV		V	
		On Both legs		On one leg		On one leg		On one leg		On one leg	
		10 cm or 20 cm		40 cm		30 cm		20 cm		10 cm	
Number		16		68		64		29		38	
Height	(cm)	158.6	(155.5,162.2)	160.3	(156.8,163.5)	158.7	(154.6,161.6)	157.6	(154.6,161.7)	156.5	(153.1,158.3)***
Weight	(kg)	51.6	(47.6,54.5)	50.0	(46.9,56.3)	48.8	(45.6,53.2)	48.7	(44.8,55.1)	46.6	(43.1,50.3)*
BMI	(kg/m^2)	20.7	(18.5,21.9)	19.5	(18.5,21.6)	19.5	(18.5,20.6)	19.5	(18.4,21.8)	19.3	(17.5,21.0)
Waist	(cm)	72.0	(67.3,74.2)	71.3	(68.3,76.5)	68.7	(65.0,72.1)**	67.9	(64.4,72.3)**	66.5	(63.5,72.2)***
Hip	(cm)	89.9	(88.7,92.6)	90.5	(87.7,94.4)	90.3	(87.6,92.9)	90.5	(87.1,94.0)	88.3	(84.9,91.1)*
W/H		0.78	(0.76,0.81)	0.79	(0.76,0.82)	0.76	(0.74,0.79)**	0.76	(0.73,0.79)*	0.76	(0.73,0.80)**
%SMM	(%)	39.2	(36.6,40.9)	38.5	(35.9,40.8)	39.6	(37.8,41.8)	40.0	(39.0,41.6)	41.5	(39.9,42.4)***
%LMM	(%)	23.4	(21.0,24.5)	22.6	(21.4,24.3)	23.2	(22.2,24.8)	23.9	(22.4,24.8)	24.1	(22.7,25.1)*
%FM	(%)	26.7	(23.1,31.9)	27.7	(23.6,32.0)	25.8	(21.9,29.2)	25.2	(21.9,28.2)	22.3	(20.5,25.6)***
VFA	(cm^2)	20.2	(11.4,39.2)	28.0	(18.6,41.2)	23.1	(8.9,30.7)	21.5	(7.6,31.2)	13.5	(5.0,22.9)***
%BMC	(%)	4.4	(4.0,4.6)	4.3	(4.1,4.6)	4.4	(4.2,4.6)	4.4	(4.3,4.6)	4.4	(4.3,4.6)
BD	(m/sec)	1559	(1522,1580)	1547	(1522,1569)	1534	(1521,1568)	1550	(1538,1585)	1541	(1525,1574)
ULL	(cm)	41.2	(39.7,42.2)	41.2	(39.5,43.3)	42.2	(40.2,43.6)	41.6	(38.9,43.5)	41.2	(40.1,43.6)
LLL	(cm)	37.8	(36.4,39.4)	37.3	(36.3,39.7)	36.4	(35.2,37.7)	36.7	(35.5,38.0)	36.1	(34.6,37.2)**#
BMS	(kg)	51.3	(43.5,62.0)	56.4	(48.6,70.9)	56.2	(48.0,68.4)	53.0	(48.3,81.3)	54.0	(41.7,84.1)

Results are shown as median (Q1, Q3).
* p<0.05, **p<0.01, ***p<0.001 compared to Group II.
# p<0.05 compared to Group I.

The results of the two-step test are shown in Table 4. In the two-step test, the median was 1.51 (1.41, 1.59). The results were slightly lower than the reference value for people in their 20s. The reference value of women in their 20s is a mean of

1.55 ± SD 0.14 [6]. The results of the two-step test are classified into tertiles: Group A (1.13–1.45), Group B (1.46–1.55), and Group C (1.56–1.93). The ULL and BMS in Group C were significantly higher than those in Group A.

Table 4. *Results of the two-step test classified into tertiles.*

Group		A		B		C	
		1.13-1.45		1.46-1.55		1.56-1.93	
Number		**68**		**74**		**73**	
Height	(cm)	158.9	(153.7,161.6)	158.9	(155.1,162.7)	158.3	(154.9,160.1)
Weight	(kg)	49.3	(46.7,52.4)	49.3	(45.2,55.3)	48.6	(45.2,53.3)
BMI	(kg/m^2)	19.6	(18.7,20.7)	19.6	(18.4,21.6)	19.2	(18.2,21.3)
Waist	(cm)	68.6	(64.8,72.2)	70.5	(66.9,75.0)	69.8	(66.0,74.2)
Hip	(cm)	89.7	(87.8,92.0)	90.0	(87.6,94.0)	90.4	(86.6,93.1)
W/H		0.77	(0.73,0.81)	0.77	(0.75,0.81)	0.77	(0.75,0.80)
%SMM	(%)	39.7	(38.2,41.9)	39.7	(37.7,41.3)	40.0	(37.2,41.6)
%LMM	(%)	23.5	(22.4,24.6)	23.4	(21.6,24.7)	23.0	(22.0,24.4)
%FM	(%)	25.6	(22.1,28.3)	25.3	(21.7,31.0)	25.5	(22.1,24.4)
VFA	(cm^2)	18.2	(7.3,30.0)	22.8	(9.8,36.6)	23.1	(12.0,33.3)
%BMC	(%)	4.4	(4.2,4.6)	4.4	(4.2,4.6)	4.4	(4.2,4.6)
BD	(m/sec)	1547	(1531,1578)	1547	(1522,1574)	1544	(1522,1572)
ULL	(cm)	41.1	(38.6,42.5)	41.4	(39.6,43.3)	42.3	(40.7,43.9)**
LLL	(cm)	36.5	(35.4,37.7)	36.8	(35.7,39.1)	37.0	(35.6,38.5)
BMS	(kg)	52.0	(43.6,63.5)	54.5	(46.4,70.8)	68.0	(53.8,82.2)*

Results are shown as median (Q1, Q3).
* $p<0.05$, ** $p<0.01$ compared to Group A.

4. Discussion

In the stand-up test, the better performers had generally smaller physiques, including lower body height, LLL, weight, waist and hip circumferences, W/H ratio, %FM, and VFA and higher muscle mass, including %SMM and %LMM. These results suggest that subjects with smaller physiques may have an advantage over those with larger physiques. Therefore, results of the test should be adjusted by each participant's physique, including LLL. In the two-step test, the better performers had longer ULL and greater BMS. Therefore, the results of the test should be adapted by the length of the upper leg, although they were adjusted by body height beforehand. The results in the two-step test also indicate that BMS may be an important factor for test performance.

The values of the stand-up test and two-step test obtained in this study were slightly lower than the reference values reported [1]. In females, aging is associated with a decrease in skeletal muscle mass, mainly due to a decrease in body muscle of the lower half occurring after the fifth decade [7, 8]. In females, bone mass was also reported to be at its peak when women were in their 20s [9, 10]. Moreover, it was shown that the stand-up test score got worse in an age-dependent manner in females [11, 12]. Physical abilities are closely associated with mobility, such as lower-extremity muscle strength, flexibility, and balance; these were highest in women in their 20s and declined with age. Therefore, it may be important to take preventive measures beginning at a young age. Some young women are at risk for LS, and if the risk is overlooked, they may need long-term care for LS in the future.

In female Chinese students, 27.5% were classified as "normal weight obese," which was defined as having a BMI of 18.5–23.9 kg/m^2 and a body fat percentage >30% [13]. They showed significantly poorer performance in the 10 min intermittent endurance running test, countermovement jumps, and a 5×5 m shuttle-run test as compared to the "normal weight non-obese" subjects. The lower levels of physical fitness in those subjects were partially explained by lower skeletal muscle mass. It is reported that young Japanese women have problems with "thinness" accompanied by muscle loss and atrophy, and "hidden obesity" with a normal BMI and low lean mass [14–16]. However, in young Japanese women, "hidden thinness," with normal weight (near underweight) but a low percentage of lean mass, and hence a high percentage of body fat, is the major problem. The major problem may not be an excess of fat but a shortage/deficiency of lean mass, namely bones and muscles.

This study has some limitations. We examined only young Japanese women. However, they have a special problem of "thinness" or "low normal weight with low lean body mass and a high percentage of body fat." Therefore, the present results may not be applicable to other ethnicities or populations and should be interpreted with caution.

5. Conclusion

The values of the stand-up test and two-step test in young Japanese women were lower than the reference values reported. A smaller physique may be advantageous in the stand-up test, and longer leg length, particularly upper leg length, may be advantageous in the two-step test. Therefore, these tests proposed by the JOA may not be optimal for predicting future LS risk in young women. For test precision, it will be necessary to compensate for stature, particularly the lengths of upper and/or lower legs.

Conflicts of Interest

The authors state that they have no competing interests.

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