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Original Article

A study and tests for the age range at risk to Locomotive Syndrome Disease by standing–up test: A case study of sample group in Bangkok Metropolitan Region

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Abstract

This research aims to find the references of potential risks in Locomotive Syndrome in each age range using the sit - up (Standing up-Sitting) test. There were 408 population samples which were divided into the six age range groups 20-30, 31-40, 41-50, 51-60, 61-70, and 71 years and up. There were 34 males and 34 females in each age range. The standing up-sitting test with a chair using one leg and both legs, with chair heights of 40 cm, 30 cm, 20 cm and 10 cm, were used to collect data for a Benchmarks table. The results showed that if the male and female participants could not reach the Benchmarks criterion, that person had potential risks of Locomotive Syndrome. In statistical analysis gender was found to be a more significant factor than age group affecting the risk toward Locomotive Syndrome (males are less at risk than females). The age range had no significant effect on the risk of having Locomotive Syndrome.

Keywords: gender, age range, standing up-sitting, Locomotive Syndrome, binary logistic regression

1. Introduction

Presently, Locomotive Syndrome Disease including Osteoarthritis (OA) and Osteoporosis (OP) is considered a crucial problem in elderly, affecting the quality of life and leading to increasing numbers of sickness and deaths. According to a formal study in Japan, the death rate from OP was increasing. Of a total population of 47,000,000 (21,000,000 males and 26,000,000 females), the ages from 40 years up were increasingly affected by OA and OP (Yoshimura & Nakamura, 2016). This shows that striving to prevent the Locomotive Syndrome Disease (LSd) is necessary. Faced with an aging population and a declining birth rate, the Japanese Government has undertaken a comprehensive reform of the healthcare system and released the Cabinet Office’s report “New Health Frontier Strategy” in April 2007. The report identified nine areas that require government intervention: nursing care was taken up together with cancer, metabolic syndrome, women’s health, children’s health, mental health, and others. The Ministry of Health, Labor and Welfare announced a concrete strategy to decrease demand for nursing care, which involved the establishment of a new fund for scientific research focusing on locomotive ability in the elderly. This research focuses on early detection of any decline in locomotive ability caused by “undouki diseases”, and on early action to prevent deterioration. Moreover, as people are now looking for easy-to-understand medical services, the Japanese Orthopedic Association (JOA) plans to develop simple pretests to assess care. We propose

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that the term "locomotive syndrome" should be adopted to designate the evident condition in this high-risk group. If this term can be easily remembered by the general public, it is hoped that this helps gain more attention to the prevention of "undouki diseases". If people can evaluate their own locomotive ability using the simple tests proposed, they might recognize the value of early prevention more easily. With the growth of the "super-aged" society, the role of orthopedic surgery will undoubtedly become more prominent. Therefore, the JOA will continue to emphasize publicizing the importance of preventing "locomotive syndrome" and will continue its efforts to provide high-quality orthopedic treatment to those in need. Presently, the body strength tests according to various age ranges in Thailand have not yet been investigated for reference preparation. So, the aim of this research is benchmarks of LSd among relevant factors and correlation analysis of the factors involved in risk of LSd in sample groups in Thailand

2. Materials and Methods

2.1 Materials

2.1.1 Population and sample size limitation

The population is the people living in Bangkok and Nakhon Pathom, a province that has a total population of 452,060. The sample size is 408 calculated from Yamane's formula.

2.1.2 Variable limitations

Independent variables are gender and age range. Dependent variable is binary logistic variable of people at risk to disease (Y = 1) and people at no risk to disease (Y = 0).

2.2 Methods of study

2.2.1 Documentary research

The data in this method are collected from theoretical documents and research studies regarding the locomotive syndrome disease.

2.2.2 Survey research

The data in this method is collected from the stand-up tests, with both one leg and two legs. Each participant has only one test for each test condition.

2.3 Study tool

This research used the former tool for testing and collecting data, and the study follows the scheme in Figure 1.

The stand-up test. This test assesses leg strength by stand up on one or both legs from a specified height. The test is as follows: (Muranaga, S., 2001)

Determine locomotive syndrome risk level from the present state of locomotive functions as revealed by results on the stand-up test. (Japanese Orthopaedic Association, 2015).

- Risk level 1: Can't stand up from a height of 40 cm on one leg or the other.

(A locomotive syndrome risk level of 1 indicates that the decline of your locomotive functions has already begun. Your muscular strength and balance are deteriorating, so you need to get into the habit of performing regular exercise such as locomotion training. Also take care to eat a balanced diet with plenty of protein and calcium.)

- Risk level 2: Can't stand up from a height of 20 cm on both legs.

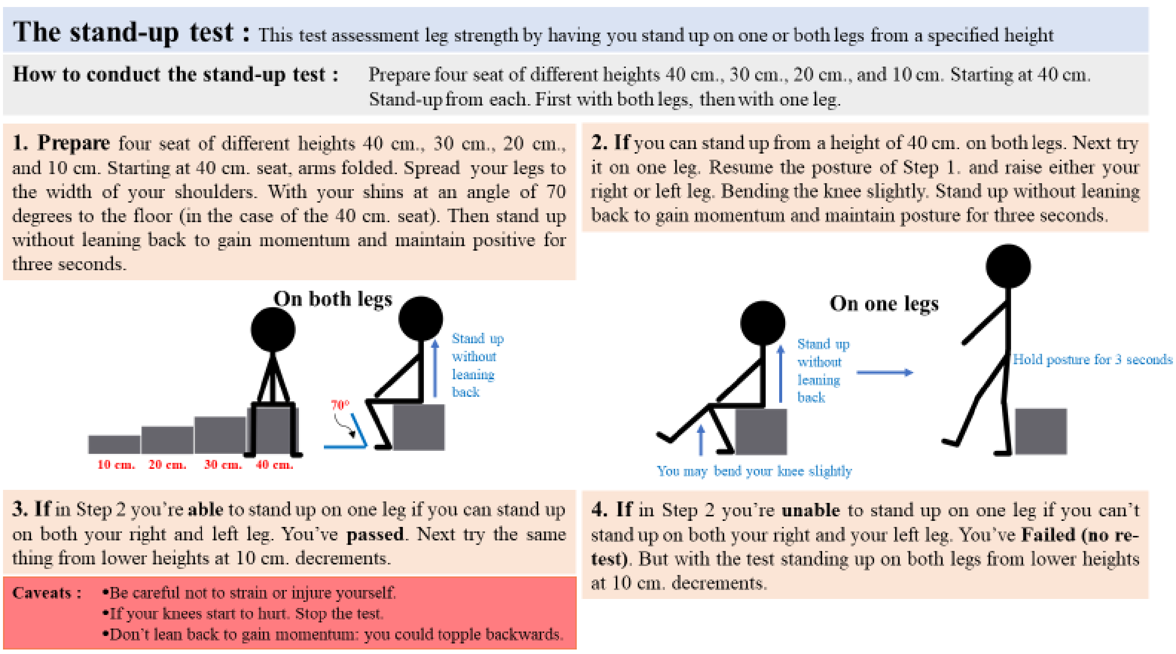


Figure 1. The testing method of stand-up test

2.4.2 Binary logistic regression analysis

(A locomotive syndrome risk level of 2 indicates that the decline of your locomotive functions is already advanced. You're at high risk of becoming unable to lead an independent lifestyle. You may have a locomotive organ disorder, so it's recommended you see an orthopaedist.)

2.4 Theory

2.4.1 Locomotive syndrome

Locomotive syndrome is a hazardous condition in which one's degree of autonomy declines within daily life, due to not being able to stand up or walk, owing to the weakening of the locomotive system: bones, joints, muscles, and nerves. Loss of muscle mass, nerve damage, pain, limited range of motion, loss of muscle strength, poor balance, decline in mobility (disturbance), restricted daily activities, limited social participation, and need for nursing care. The ability to move the body in different ways, including standing, walking, running, and climbing, gradually weakens and eventually ends in locomotive syndrome. There are many causes for this decline in mobility, including lack of regular exercise, being under- or overweight, unheeded pain and listlessness, and injuries, overdoing sports, injured body bone or joint, reduced physical activity by taking the elevator or escalator and driving everywhere (Ikemoto & Arai, 2018). A conceptual diagram of Locomotive syndrome is shown in Figure 2 (Nakamura & Ogata, 2016).

Logistic regression is used to describe data and to explain the relationship between one dependent binary variable and one or more nominal, ordinal, interval or ratio-level independent variables, in this case a single categorical variable; $\pi = \Pr(Y = 1|X = x)$.

Variables:

- Let Y be a binary response variable

$Y_i = 1$ if the trait is present in observation (person, unit, etc...) i

$Y_i = 0$ if the trait is NOT present in observation i

- $X = (X_1, X_2, ..., X_k)$ is a set of explanatory variables which can be discrete, continuous, or a combination of them. x_i is the observed value of the explanatory variable for observation i. In this section of the notes, we focus on a single variable X.

Model:

$$\pi_i = \Pr(Y_i = 1|X_i = x_i) = \frac{\exp(b_0 + b_1 x_i)}{1 + \exp(b_0 + b_1 x_i)}$$

or,

$$\begin{aligned} \operatorname{logit}(\pi_i) &= \log\left(\frac{\pi_i}{1 - \pi_i}\right) \\ &= b_0 + b_1 x_i \\ &= b_0 + b_1 x_{i1} + \\ &\cdots + b_k x_{ik} \end{aligned}$$

In general, the logistic model stipulates that the effect of a covariate on the chance of "success" is linear on the log-odds scale, or multiplicative on the odds scale.

If $b_j > 0$, then $\exp(b_j) > 1$, and the odds increase.

If $b_j < 0$, then $\exp(b_j) < 1$, and the odds decrease.

The Pennsylvania State University. (2018). Binary Logistic Regression with a Single Categorical Predictor. (Retrieved from http ://onlinecourses.science.psu.edu/stst504/ node/150.)

2.4.4 Correlation analysis

Correlation Analysis is a statistical method that is used to discover if there is a relationship between two variables/datasets, and how strong that relationship may be. It is performed to identify the strength of relationships between a pair of variables. The correlation coefficient r varies between −1 and +1 where a perfect correlation is ±1 and 0 indicates absence of correlation. If r is positive (+), it indicates that x and y are positively correlated (x rises when y rises; or x decreases when y decreases). If r is negative (-), it indicates that x and y are negatively associated (Cohen, Cohen, West, & Aiken, 2002).

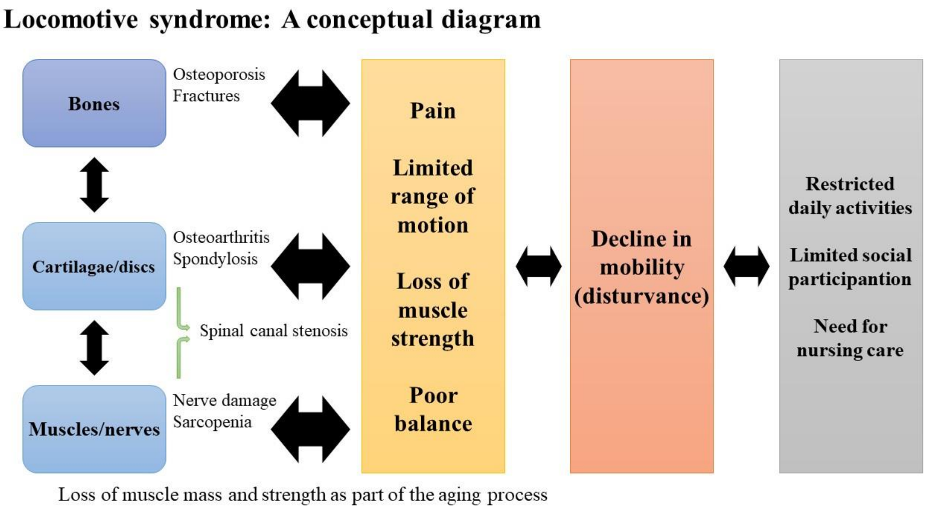


Figure 2. A conceptual diagram of Locomotive syndrome

2.4.5 Measures of association

The measures of association refer to a wide variety of coefficients that measure the statistical strength of the relationship on the variables of interest; these measures of strength, or association, can be described in several ways, depending on the analysis. (Berry & Mielke, 1992).

2.5 Literature review

Nakamura (2011) stated that the locomotive organs consist of three main elements: bones, which give the body a framework; joints and intervertebral discs, which enable the body to be mobile; and muscles and a nervous system, which move the body and/or regulate its motion. These elements work together by forming a kind of network. If these elements deteriorate beyond a specific point, they are diagnosed as osteoporosis related fractures, osteoarthritis, spondylosis, sarcopenia nerve disorders, etc. When an elderly person reaches the point where he finds it difficult to walk, he risks having to rely on nursing care from then on. Among the signs and symptoms of “locomo” are pain, a limitation of the range of joint mobility, deformation, reduced balance capability and a slow pace of walking. In many cases, however, degeneration of the locomotive organs develops and progresses so slowly that people often fail to sense it. This makes it important for individuals to become aware of these signs and to recognize that they could be at risk of “locomo”. It is known that those experiencing difficulty in walking, climbing stairs, going shopping, putting on a pair of socks, or doing housework in their daily life have a significantly higher risk of requiring nursing care services than those who are able to do these things without difficulty. The Locomotive Challenge! Council, Japanese Orthopaedic Association showed the mean of leg strength from the survey of working groups and the benchmarks by age group (Figure 3). The Japanese Orthopaedic Association (2015) published a risk assessment and prevention of Locomotive Syndrome disease in the Locomotive Syndrome Pamphlet 2015, which was designed and produced by the Locomotive Challenge! Council, the Japanese Orthopedic Association. Ishibashi (2018) reviewed the results of risk in Locomotive Syndrome disease by stand-up test. Yoshimura, Muraki, Nakamura, and Tanaka (2017) study investigated the age-specific rate of each stage of Locomotive Syndrome (LS) in a large regional residential cohort in Japan that consisted of 3000 community-dwelling people aged 40-80. The prevalence of LS stage 1 (Level 1) was 69.8% of the total (males, 68.4%; females, 70.5%), and that of LS-stage 2 (Level 2) was 25.1% of the total (males, 22.7%; females, 26.3%). That study also found that the prevalence of LS stages 1 and 2 increases with age, reaching 50% in those aged in their 70s.

3. Results and Discussion

3.1 Results

3.1.1 The mean of ability testing result by stand-up test in each age range of males and females

The mean of ability testing result by stand-up test in each age range of males and females is illustrated in Figure 4.

3.1.2 Benchmark of stand-up test.

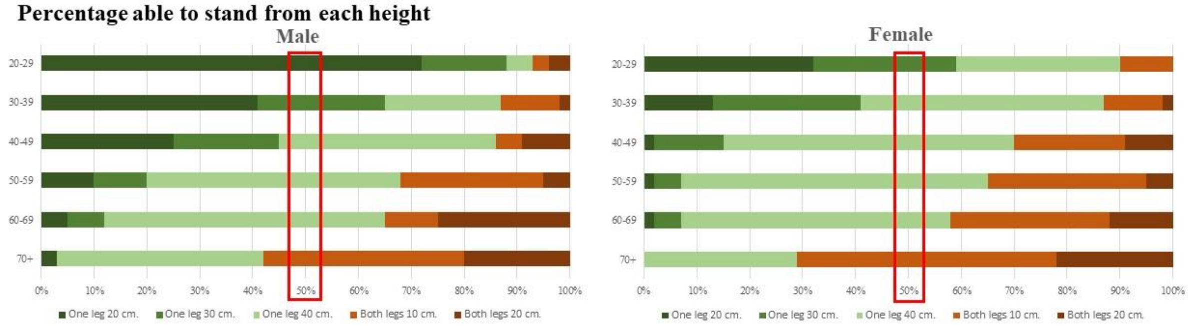
Measuring standard criteria of benchmark of stand-up test is summarized in Table 1.

Are your legs as strong as they should be for your age?

Test result Your test result is the lowest height from which you are able to stand up on both your right and left leg. If you are unable stand up on one leg even from a height of 40 cm. Your test result is the lowest height from which you are able to stand up on both legs.

Assessment If your test result meets the benchmark for your age group. Your legs are as strong as they should be for your age.

Percentage able to stand from each height



Benchmarks by age group

(height from which 50% of each age group can stand up)

	Males		Females	
20-29	One leg	20 cm.	One leg	30 cm.
30-39	One leg	30 cm.	One leg	40 cm.
40-49	One leg	40 cm.	One leg	40 cm.
50-59	One leg	40 cm.	One leg	40 cm.
60-69	One leg	40 cm.	One leg	40 cm.
70+	Both legs	10 cm.	Both legs	10 cm.

Figure 3. Assessment method of stand-up test. (Source: Locomotive challenge! council locomotive syndrome risk test working group survey data)

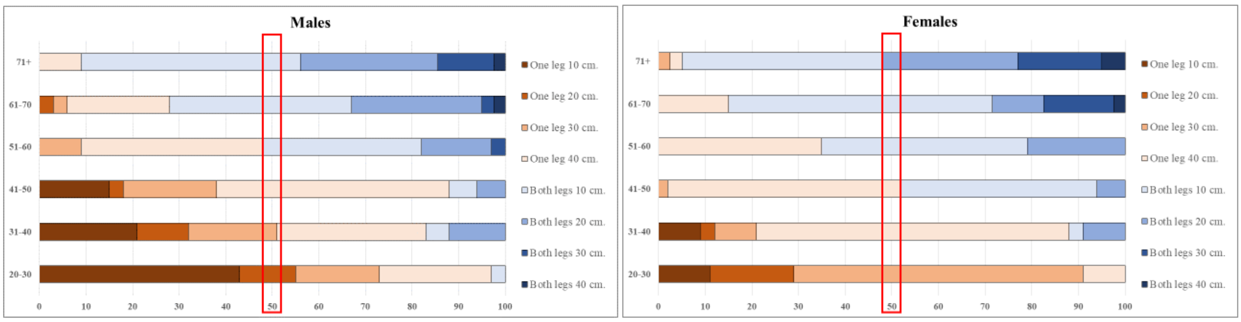


Figure 4. The ability testing result by stand-up test in each age range of males and females

Table 1. Measuring standard criteria of benchmark of stand-up test

Age range	Males		Females	
20-30	One leg	20 cm.	One leg	40 cm.
31-40	One leg	30 cm.	One leg	40 cm.
41-50	One leg	40 cm.	One leg	40 cm.
51-60	Both legs	10 cm.	Both legs	10 cm
61-70	Both legs	10 cm.	Both legs	10 cm.
71 up	Both legs	10 cm.	Both legs	20 cm.

In the age range 20-30, the mean ability allows performing a one-leg stand-up at 20 cm chair height for males, and a one-leg stand up at 40 cm chair height for females.

In the age range 31-40, the mean ability is to perform a one-leg stand-up at 30 cm chair height for males, and a one-leg stand up at 40 cm chair height for females.

In the age range 41-50, the mean ability is to perform a one-leg stand-up at 40 cm chair height for males, and one-leg stand up at 40 cm chair height for females.

In the age range 51-60, the mean ability is to perform a both-legs stand-up at 10 cm chair height for males, and a both-legs stand up at 10 cm chair height for females.

In the age range 61-70, the mean ability is to perform a both-legs stand-up at 10 cm chair height for males, and a both-legs stand up at 10 cm chair height for females.

In the age range 70 and up, the mean ability is to perform a both-legs stand-up at 10 cm chair height for males, and a both-legs stand up at 20 cm chair height for females.

3.1.3 The result of Locomotive Syndrome risk level

Risk level 1: The percentage of participants that can't stand up from a height of 40 cm on one leg or the other is illustrated in Figure 5.

- In the age range 20-30, risk to have locomotive syndrome disease is 2.94% in males and 8.82% in females.
- In the age range 31-40, risk to have locomotive syndrome disease is 17.65% in males and 11.76% in females.
- In the age range 41-50, risk to have locomotive syndrome disease is 11.76% in males and 47.06% in females.
- In the age range 51-60, risk to have locomotive syndrome disease is 52.94% in males and 64.71% in females.

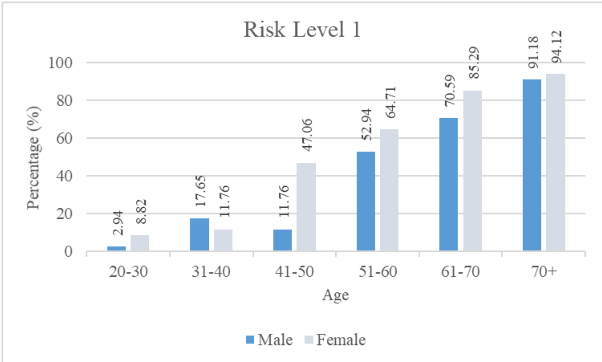


Figure 5. The result of Locomotive Syndrome risk level 1

- In the age range 61-70, risk to have locomotive syndrome disease is 70.59% in males and 85.29% in females.
- In the age range 70 and up, risk to have locomotive syndrome disease is 91.18% in males and 94.12% in females.

Risk level 2: The percentage of participants that can't stand up from a height of 20 cm on both legs is illustrated in Figure 6.

- In the age ranges 20-30, 31-40 and 41-50 there is no risk to have locomotive syndrome disease at level 2.
- In the age range 51-60, risk to have locomotive syndrome disease is 2.94% in males and no risk in females.
- In the age range 61-70, risk to have locomotive syndrome disease is 5.88% in males and 17.64% in females.
- In the age range of 70 and up, risk to have locomotive syndrome disease is 14.71% in males and 23.53% in females.

3.1.4 The results of binary logistic regression analysis

The independent variables were gender and age range. Response was binary (y = 0 for no risk to disease, y = 1 for risk to disease). Independent variables were indicator variables.

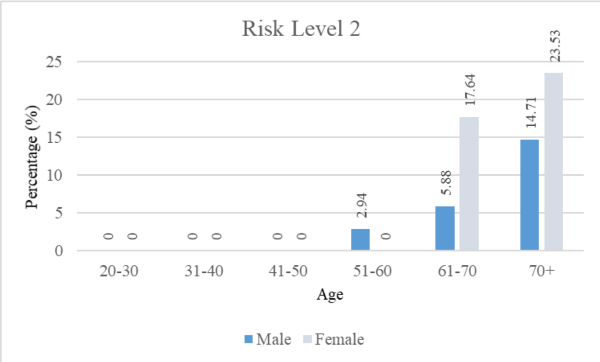


Figure 6. The result of Locomotive Syndrome risk level 2

1) Gender: Gender was male or female. There were 2 levels of gender. There was one variable that was X_1 where $X_1 = 0$ was female and $X_1 = 1$ was male.
2) Age range: There were 6 age ranges. There were 5 variables, that were X_2, X_3, X_4, X_5, and X_6

The declaration of age range by the indicator variables is summarized in Table 2

Table 2. The declaration of age range by the indicator variables

Age range (years)	X_2	X_3	X_4	X_5	X_6
20-30	0	0	0	0	0
31-40	0	0	0	0	1
41-50	0	0	0	1	0
51-60	0	0	1	0	0
61-70	0	1	0	0	0
71 up	1	0	0	0	0

The result of Binary Logistic Regression Analysis is illustrated as follows in Figure 7:

						Odds	95%	CI
Predictor		Coef	SE Coef	Z	P	Ratio	Lower	Upper
Constant		-1.29394	0.303569	-4.26	0.000			
x1	β_1	0.513502	0.223032	2.30	0.021	1.67	1.08	2.59
x2		0.355318	0.378427	0.94	0.348	1.43	0.68	3.00
x3		0.287918	0.380386	0.76	0.449	1.33	0.63	2.81
x4		-0.425535	0.415449	-1.02	0.306	0.65	0.29	1.48
x5		0.148113	0.385126	0.38	0.701	1.16	0.55	2.47
x6		0.218924	0.382608	0.57	0.567	1.24	0.59	2.63

Figure 7. Binary logistic regression analysis

Odds ratio = $\exp(b_i)$, such as $\exp(b_1)$ = $\exp(0.513502)$ was that the value of $\frac{P(event)}{P(nonevent)}$ for one unit of x_1 increase was 1.67 when y = 1 compared with y = 0. The 95% confidence interval of odds ratio was (1.08, 2.59) for X_1. The p-value of b_1 was 0.021 (< 0.05), this meant that gender significantly affected the risk to have the disease. The p-values of b_2, b_3, b_4, b_5, and b_6 were 0.348, 0.449, 0.306, 0.701, and 0.567, respectively (> 0.05), this meant that age range did not significantly affect the risk to have the disease.

3) Goodness-of-fit tests: The p-value of Hosmer-Leme was 0.216 (> 0.05). This meant that the regression model was appropriate. The data had normal distribution.
4) Observed and expected frequencies: Observation and expected frequency (Hosmer-Leme show Test for the Pearson Chi-square Statistic) are illustrated as follows in Figure 8.

	Group						
Value	1	2	3	4	5	6	Total
1							
Obs	10	22	14	23	21	27	117
Exp	12.5	16.0	17.8	20.2	24.1	26.3	
0							
Obs	58	46	54	45	47	41	291
Exp	55.5	52.0	50.2	47.8	43.9	41.7	
Total	68	68	68	68	68	68	408

Figure 8. The goodness of fit between expectation and observation frequency

The goodness of fit between expectation and observation frequency was not different.
5) Measures of association: The concordant percentage was 57.1% which meant that measure of association was 57.1%. Somers' D ratio was 0.22 which meant that the correlation coefficient was probably low. Goodman-Kruskal Gamma was 0.23 which meant that the correlation coefficient was probably low and changing in a positive direction. Summary Measures indicated that response variable and predicted probability had low predictive ability. The measures of association were illustrated as follows in Figure 9:

(Between the Response Variable and Predicted Probabilities)

Pairs	Number	Percent	Summary Measures	
Concordant	19438	57.1	Somers' D	0.22
Discordant	12060	35.4	Goodman-Kruskal Gamma	0.23
Ties	2549	7.5	Kendall's Tau-a	0.09
Total	34047	100.0		

Figure 9. Measures of association

3.1.5 Correlation analysis

The correlation analysis was illustrated as follows in Figure 10.

This study uses Pearson Correlation to find the relationship between variables. The p-value of x_1 and y was 0.021(< 0.05) which meant that there was relationship between gender and risk to have the disease. The p-value of x_2 and y was 0.305(> 0.05), the p-value of x_3 and y was 0.464 (> 0.05), the p-value of x_4 and y was 0.056 (> 0.05), the p-value of x_5 and y was 0.884 (> 0.05), and the p-value of x_6 and y was 0.660 (> 0.05) which meant that there was no relationship between age range and risk to have the disease.

	x1	x2	x3	x4	x5	x6
x2	0.000					
	1.000					
x3	0.000	-0.200				
	1.000	0.000				
x4	0.000	-0.200	- 0.200			
	1.000	0.000	0.000			
x5	0.000	-0.200	-0.200	-0.200		
	1.000	0.000	0.000	0.000		
x6	0.000	-0.200	-0.200	-0.200	-0.200	
	1.000	0.000	0.000	0.000	0.000	
y	0.114	0.051	0.036	-0.095	0.007	0.022
	0.021	0.305	0.464	0.056	0.884	0.660

Figure 10. The correlation analysis

3.2 Discussion

Results on the mean of ability in stand-up test by age range in males and females show that within the age range 20-30 years, males should be able to stand with one leg on a 20 cm height chair and females should be able to stand with one leg on a 40 cm height chair. The age range 31-40 years in males should stand with one leg on a chair of 30 cm height, and a female should stand with one leg on a chair of 40 cm height. The age range 41-50 years in males should stand with one leg on a chair of 40 cm height, and females should stand with one leg on a chair of 40 cm height. The age range 51-60 years in males should stand with both legs on a chair of 10 cm height, and females should stand with both legs on a chair of 10 cm height. The age range 61-70 years in males should stand with both legs on a chair of 10 cm height, and females should stand with both legs on a chair of 10 cm height. The ages range 71 years and up in males should stand with both legs on a chair of 10 cm height, and females should stand with both legs on a chair of 20 cm height. The mean of ability testing results by stand-up test for each age range have been adjusted from Benchmarks table by age group of Japanese persons. (Source: Locomotive challenge! council locomotive syndrome risk test working group survey data). The risk analysis results of the LSd from the tests are inconsistent with the ROAD (Research on Osteoarthritis Against Disability) in Japan (Ishibashi., H., 2018). From the statistical analysis, gender affected significantly more vulnerability to Locomotive Syndrome (males are at less risk than females). The age range was related to Locomotive Syndrome but it was not significant, potentially because the data were collected in a small area.

4. Conclusions

The mean of ability testing results by stand-up test in each age range of males and females are shown in Figure 4. Table 1 was built using the data shown in Figure 4. The considerations of probability of the person who had risk to have the disease in level 1 was 84 out of 204 for a total of 41.18% of males, and 106 out of 204 for a total of 51.96% of females. The number of males who had a risk to have the disease in level 2 was 8 out of 204 or 3.92%; and 14 out of 204 for 6.86% of females. In statistical analysis gender was found to be a more significant factor than the age group as regards risk toward Locomotive Syndrome. The age range had no significant effect on the risk of having Locomotive Syndrome.

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