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Correlation between physical activity and hand grip strength in elderly with locomotive syndrome

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***Abstract*---**Background Locomotive syndrome (LS) is due to locomotive organ disorders which decrease mobility function, especially in the elderly. LS interferes with physical activity and is decreased in the elderly which could potentially decrease muscle strength. Hand grip strength (HGS) has been associated with overall

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strength and lower limb strength, but its correlation with physical activity in LS is unknown. Objectives This study aims to analyze the correlation between physical activity and HGS in elderly with LS. Methods 44 elderly were screened with Indonesian version of the Loco-check, a screening tool for LS. Physical activity was assessed with Indonesian version of the International Physical Activity Questionnaire – Short Form and HGS was assessed with a digital hand dynamometer respectively. The correlation between physical activity and HGS with Loco-check were analyzed using the Spearman correlation test. Results Significant correlation were found between physical activity with Loco-check in question number six (p = 0.027) and seven (p = 0.006), with a correlation coefficient of 0.333 and 0.407 respectively. No correlation was found between HGS with Loco-check, neither between physical activity with HGS. Conclusion There are positive correlations between physical activity and LS.

***Keywords*---**locomotive syndrome, loco-check, physical activity, IPAQ, hand grip strength, elderly.

Introduction

As many as 25% of Indonesia's population aged over 40 years old suffer from a progressive decline in mobility[1]. This decline can lead to Locomotive syndrome (LS) which could impact physical activity (PA) limitations and ultimately resulting in muscle mass loss. LS has been widely studied in Japan but few data have mentioned the amount of PA and muscle strength upon screening for LS[2]. Development of a screening tool for LS was produced in the form of the Loco-check questionnaire[3], but its correlation with PA and muscle strength has not been well known. These data could potentially serve as additional LS risk predictors.

LS is a condition characterized by decreased mobility function. This condition is caused by a disturbance in the locomotive organ. It results in limitations of independence carrying out daily activities. LS is considered equivalent to osteoarthritis and osteoporosis because it causes the highest mobility impairment in Japan[4]. There are 5.5 million individuals in Japan between the ages 40-70 years suffering from LS. The prevalence of LS is about 8.4% in individuals in their 40s and remains stable into their 60s, but increases rapidly in their 70s. The average prevalence of LS in Japan is currently 10.2%[2]. In Indonesia, there is no known data on the prevalence of LS.

Mobility disorders found in LS result in reduced PA in daily life[3]. Good overall health could be affected by doing physical activities at a minimum level per day in a correct way[5]. PA is defined by the American College of Sports Medicine and the Centers for Disease Control and Prevention as any bodily movement caused by skeletal muscle contraction that results in a substantial increase in energy output at rest[6,7]. PA could be categorized based on their type (i.e working, walking, and leisure time)[8]. PA has an important role in LS prevention[9], but its relationship with LS is still being studied. Assessment tools which are often used to assess PA

are questionnaires[10]. One commonly used questionnaire is the International Physical Activity Questionnaire – Short Form (IPAQ-SF) which is can be used to determine the amount of daily PA for the last 7 days[11], but it is still unknown at what level of PA affects the occurrence of LS conditions.

PA requires muscle activity of the whole body. Physical inactivity is the main determinant of muscle strength loss, in addition to the effects of gender, age, and body mass index (BMI). To assess individual muscle strength, various tests could be used. Measurements of lower extremity strength could indicate a person's strength for active mobilization and assess their level of PA[12]. Previous studies showed that hand grip strength (HGS) could measure lower extremity strength in addition to overall strength and predict functional status[13]. HGS was described by Wiśniowska-Szurlej *et al.*[13] correlating with lower leg strength, mobility, and dynamic balance. HGS testing could replace lower extremity strength examinations, since it could be performed more efficiently in a large population[13]. However, the correlation between HGS and PA still needs to be investigated especially in LS conditions.

Methods

An analytical observational method with a cross sectional design was performed for this study. Participants were Indonesian elderly at the community health services for the elderly (*Posyandu Lansia*) in Rungkut Barata, Surabaya, Indonesia. Participants were selected by consecutive sampling in October 2020. Inclusion criteria were Indonesian males and females aged 60 years old and above which were screened for LS using the Indonesian version of the Loco-check[14], could read and answer questionnaires in Indonesian language. Individuals were excluded if having any uncorrected eyesight disorders, hearing disorders, cognitive disorders, or hand grip disorders on dominant hand. Vital signs and base characteristics were recorded. A total of 44 participants (15 men and 29 women) with LS were identified and recruited for this study. All participants provided written informed consent and the study protocol was approved by the Health Research Ethics Committee of the Faculty of Medicine of Universitas Airlangga.

The Indonesian version of the Loco-check was used as a screening tool to assess LS, which had been previously adapted for cross-cultural adaptation to Indonesian language[14]. The Loco-check consists of a 7-item questionnaire to assess locomotive disability based on the activities of daily living. Participants if answered at least one of the seven items were considered to have LS[3]. The Indonesian version of the IPAQ-SF was used to assess PA which had been previously adapted for cross-cultural adaptation to the Indonesian language[16]. IPAQ-SF assesses the amount of PA done in the last 7 days, recording the duration of daily activities of vigorous and moderate intensity activities, walking, and sitting. Results were recorded as MET-min/week and participants were classified in three categories, low, moderate, and high PA[11].

HGS was measured with a digital dynamometer (Camry®) in kilograms. Participants were instructed to sit on a standard chair on a flat surface, with a

back rest and arm rest. The highest recorded HGS of three measurements on both hands was used.

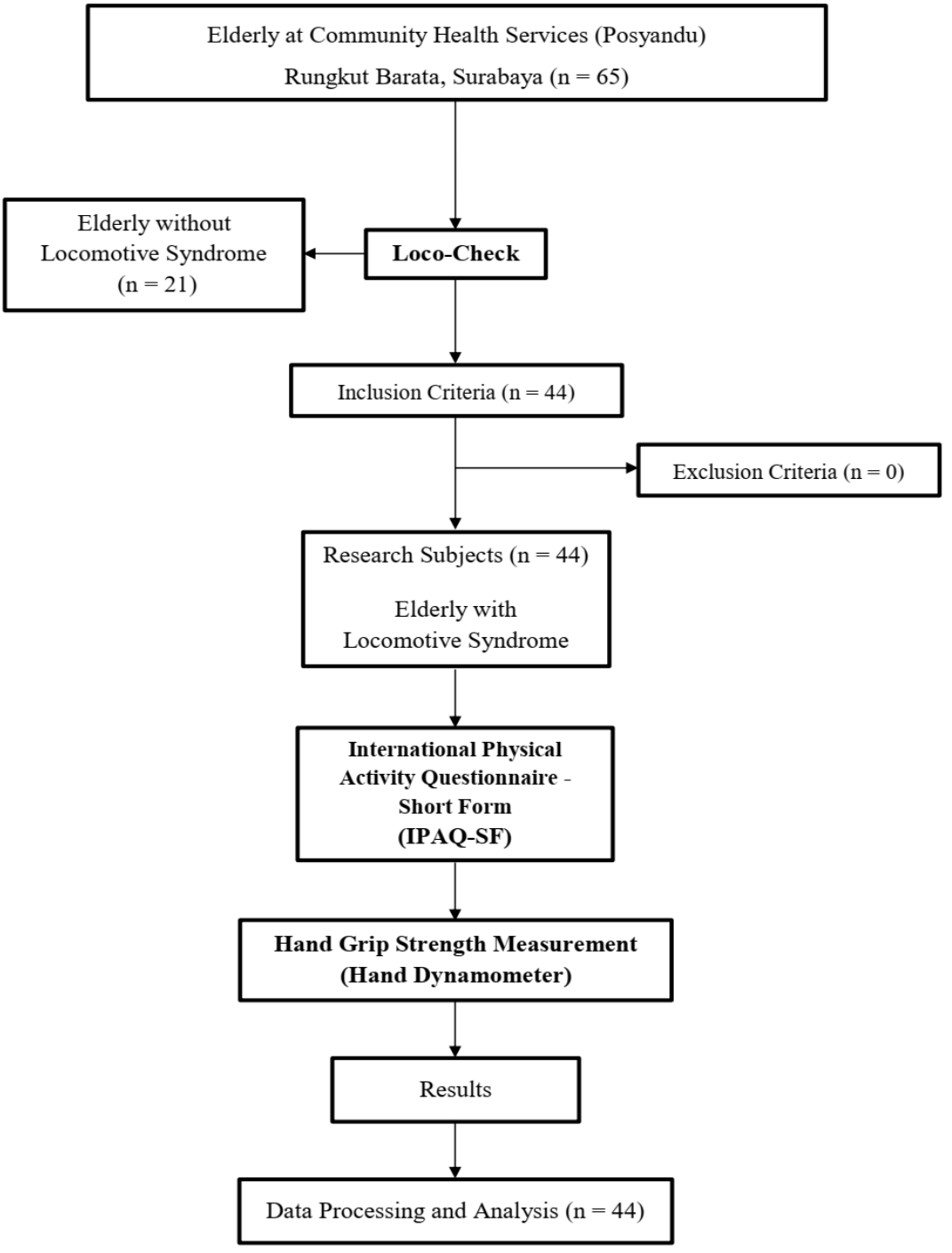

Figure 1. Research Flow

Statistical analysis

The data collected were analyzed using SPSS v26.0. Data were tested for normal distribution with the Shapiro Wilk test. Non parametric Spearman's correlation test was used to analyze correlation outcomes. Results were significant if $p < 0.05$.

Results

Total subjects who met the inclusion criteria with LS were 44 people, consisting of 15 men (34.09%) and 29 women (65.91 %). The characteristics of the research subjects assessed were age, weight, height, and BMI. Characteristics of research subjects could be seen in table 1.

Table 1: Characteristics of research subjects

	Mean (SD)	Minimum value	Maximum value
Age (years)	67.7 (4,7)	60	77
Body weight (kg)	61.7 (11,9)	33.9	87.8
Body height (cm)	1.56 (0,08)	1.38	1.80
Body Mass Index (kg/m²)	25.23 (4,41)	15.07	33.69
IPAQ-SF score (MET-min/week)	1,873 (2,011)	0	9,732
Hand Grip Strength (kg)	17.07 (3,64)	10.00	28.00

PA levels of subjects were divided into 3 categories, low, medium, and high PA, based on IPAQ-SF scores. Average PA of subjects was categorized as moderate level PA. The individual IPAQ-SF scores of majority of subjects were also categorized as moderate level of PA, while subjects categorized with low and high levels of PA were fewer and of equal amount, as seen in table 2.

Table 2: PA level of research subjects

	Total Subjects (n = 44)
Physical Activity Category (IPAQ-SF)	
Low	11 (25%)
Moderate	22 (50%)
High	11 (25%)

The normality test of the IPAQ-SF score showed values that were not normally distributed (p value < 0.05), hence non-parametric Spearman's correlation test was used to assess the correlation between the level of PA based on the IPAQ-SF with the Loco-check. Results yielded significant values for questions number six and seven of the Loco-check, with a level of correlation between PA and Loco-check on question number six is categorized as low (0.333), while question number seven as moderate (0.407). The correlation test between the level of PA based on the IPAQ-SF and the Loco-check can be seen in table 3.

Table 3: Correlation test between PA levels based on the Indonesian version IPAQ-SF with the Indonesian version Loco-check on research subjects

	IPAQ-SF (n = 44)	
	Correlation coefficient	*p* value
Loco-check		
Question 1	0.000	1.000
Question 2	- 0.148	0.336
Question 3	- 0.066	0.670
Question 4	0.223	0.146
Question 5	0.230	0.133
Question 6	0.333	0.027 *
Question 7	0.407	0.006 *
Total number of "Yes" answered in Loco-check	0.209	0.173

* Spearman's correlation test were significant if *p* value < 0.05.

HGS of men and women were categorized based on cut-off point according to the Asian Working Group for Sarcopenia (AWGS) into weak and normal HGS. Only 13 subjects were considered as having normal HGS, while based on gender, the majority of men had weak HGS than women as seen in table 4. Majority of subjects were right-handed.

Table 4: Classification of HGS and hand dominance of research subjects based on gender

	Men (n = 15)	Women (n = 29)	Total Subjects (n = 44)
Hand Grip Strength			
Weak	14 (93.33%)	17 (58.62%)	31 (70.45%)
Normal	1 (6.67%)	12 (41.38%)	13 (29.55%)
Hand Dominance			
Right	13 (86.67%)	23 (79.31%)	36 (81.82%)
Left	2 (13.33%)	6 (20.69%)	8 (18.18%)

The normality test of HGS showed values that were not normally distributed (*p* value <0.05), hence non-parametric Spearman correlation test was used to assess the correlation between HGS and each question of the Loco-check. Result of the correlation test resulted in a non-significant value for each question, as well as the total number of "yes" answered on the Loco-check. Results of the correlation test between HGS and the Loco-check can be seen in table 5.

Table 5: Correlation test between HGS with the Indonesian version Loco-check on research subjects

	HGS (n = 44)	
	Correlation coefficient	*p* value
Loco-check		

Question 1	- 0.156	0.311
Question 2	0.000	1.000
Question 3	- 0.132	0.393
Question 4	0.136	0.378
Question 5	0.115	0.457
Question 6	0.069	0.654
Question 7	- 0.034	0.827
Total number of "Yes" answered in Loco-check	- 0,058	0.711

* Spearman's correlation test were significant if p value < 0.05.

The Spearman correlation test was also implemented to assess the correlation between the IPAQ-SF scores and the HGS of subjects. The result yielded non-significant results, as seen in table 6.

Table 6: Correlation between PA levels based on the Indonesian version IPAQ-SF and HGS of research subjects

	IPAQ-SF (n = 44)	
	Correlation coefficient	*p* value
HGS	0.000	1.000

* Spearman's correlation test were significant if *p* value < 0.05.

Discussion

Data on LS in the current study are in accordance with results of the national internet survey research conducted by Kimura *et al.*[2] in Japan with subjects aged 40-79 years old. Women on average showed a higher mean score on the Geriatric Locomotive Function scale-25 (GLFS-25) than men[2]. The GLFS-25 assesses the severity of LS conditions. Ohtsuki *et al.*[16] had done research also stating results that women have a greater percentage of LS risk than men in young adults aged 18-64 years old at various companies in Japan. In Indonesia, research on LS is still very limited. Based on statistical data in 2020, Indonesia's elderly population was 26.82 million people, with percentage of elderly women higher than men[17]. Comparing data from Kimura *et al.*[2] and Ohtsuki *et al.*[16], the percentage of LS in Indonesia could reach a high number.

Nakamura *et al.*[4], explained that there was a close relationship between height and BMI with LS in the elderly female population in Japan. In that study, subjects with LS had shorter stature than subjects without LS, and revealed a higher BMI in LS subjects. They explained that BMI is one of the indicators that can detect LS and any individuals with BMI of ≥ 23.5 kg/m2 would be considered as having LS[4]. Mitani *et al.*[18] observed a higher BMI in LS group than without LS. What distinguishes that study is that subjects were aged 40-74 years old, and took account of metabolic syndrome disorders. LS subjects still showed a higher mean BMI despite the presence or absence of metabolic syndrome[18], even though the value was lower than what was proposed by Nakamura *et al.*[4] Mean BMI of current study subjects were higher than the limit value proposed by Nakamura *et*

al.[4] which indicates our study is similar in regards to BMI to both those studies, although we have not taken into account any metabolic syndrome conditions.

Average IPAQ-SF scores of subjects in the current study categorize their PA as moderate-intensity. Based on individual IPAQ-SF scores, 50% of subjects were categorized as having moderate PA, while subjects with low or high PA had the same percentage (25%). Comparing to research by Sekarsari *et al.*[19] describing levels of PA in elderly people in Bandung, results were similar. That study used the Global Physical Activity Questionnaire to determine the subject's level of PA as MET-min, and was categorized as low, moderate and high PA which was similar to the current study and resulted also with majority of subjects as having moderate PA[19]. While Otani *et al.*[20] studied the baseline characteristics and risk of LS as well as PA using the IPAQ-SF in subjects aged 40 – 80 years old in Aizu, Japan, which showed the majority of subjects aged 60 years and over fall into high PA category[20]. Differences in PA in our study and Otani *et al.*[20] may be due to geographical, cultural and physical fitness differences between the subjects in Japan and Indonesia. Physical activities are affected by both physiological and external factors, including gender-related sociocultural values, motivation, opportunities and choices[21]. In the current study, there was a seemingly wide standard deviation value from the IPAQ-SF mean score. This might be due to subjects having difficulty recalling all the physical activities carried out in the past week, and also the types of activities listed in the IPAQ-SF were not fitting to subjects' daily activities, hence its corresponding PA level could not be calculated properly and IPAQ-SF score could be lower or higher than that obtained in this study.

Correlation test between PA using IPAQ-SF and LS using the Indonesian version of Loco-check resulted in significant values on questions number six and seven of the Loco-check, while other questions had insignificant values. The 6th and 7th questions on Loco-check are respectively "You have difficulty when you have to walk home while carrying a shopping bag weighing about 2 kg" and "You have difficulty doing household chores that require physical strength". Hirano *et al.*[22] on the other hand examined the quality of life using Short Form-36 (SF-36) and its correlation to LS with Loco-check which resulted in a negative correlation, meaning that subjects with LS have greater PA limitations than those without LS. That study was in accordance to our current study that there is a correlation between PA and LS, though PA assessment was different[22]. Our current study is in line with results by Hirano *et al.*[22] Our study found significant correlation between PA using the IPAQ-SF with question 6 and 7 of the Loco-check, although correlation between PA and the total number of "yes" answered in the Loco-check resulted in an insignificant value. The 6th Loco-check question and its correlation with IPAQ-SF could possibly due to the elderly were not accustomed to carrying a load of 2 kg while walking for more than 100 meters or a long period of time, since they would be more used to carrying shopping bags on vehicles such as motorbikes or bicycles, and upon further analysis the majority of subjects who answered yes to the 6th question of the Loco-check were in the low PA category. While the 7th Loco-check question and its correlation with IPAQ-SF could be due to the activity of doing household chores considered as a moderate-high intensity PA which would be difficult for the majority of elderly population, and since only 25% of our study subjects were categorized as having high PA. Result of a

significant value in the correlation test between PA levels and the two questions from the Loco-check indicates a possible risk of LS in the low-moderate PA category based on the IPAQ-SF value, but remarks of the IPAQ-SF that have been addressed earlier should also be considered.

AWGS recommends cut off value of HGS as a diagnostic of weak muscle strength to be less than 28.0 kg and 18.0 kg for men and women respectively[23]. The current study had an average HGS value of 17.08 kg. When assessed separately in male and female subjects results were 18.01 kg and 16.60 kg respectively, which indicated weak HGS. Similar results by Akbar F and Setiati S.[24] which HGS in elderly subjects aged over 60 years was also below the cut-off value recommended by the AWGS. That study was not specific to the LS but subjects had various comorbidities such as hypertension, diabetes mellitus, dyslipidemia, and osteoarthritis[24]. Sekarsari *et al.*[19] had comparable data in elderly aged 60 - 90 years with average HGS value of men and women below the AWGS cut-off value. That study also was not specific to LS or other comorbidities but examined the level of PA, skeletal muscle mass and gait speed of the elderly[19]. Both those studies were similar regarding HGS results with the current study possibly due to the fact the participants were elderly Indonesians, though in different regions, but they did not involve LS assessment. While Yoshimura *et al.*[25] studied the severity of LS in elderly subjects above 60 years old from the Research on Osteoarthritis / Osteoporosis Against Disability study in Japan, with results of average HGS of male and female subjects above the cut-off value recommended by AWGS, which indicated normal HGS[26]. Difference in results with our current study could possibly due to geographical, or physical fitness differences of sample population. In addition both research[19,25], examined the gait speed of subjects but data from Sekarsari *et al.*[19] showed the gait speed of subjects was about half slower than in the study by Yoshimura *et al.*[25], which suggest that HGS could have a lower value in Indonesian elderly population based on findings from Sekarsari *et al.*[19] Observing the average value of HGS were equally low for elderly population in Indonesia, it would be wise to review the reference value of HGS to determine the classification of HGS and physical fitness conditions of the Indonesian elderly population.

Correlation test between HGS and LS using Loco-check on research subjects did not result in any significant correlation. The correlation between HGS with each question on the Loco-check and the total number of "yes" answered resulted in insignificant values. Comparing results by Matsui *et al.*[26], there were significant results when comparing HGS of subjects to a yes or a no answer of each Loco-check question. HGS was significantly lower if any question was answered as yes than those answered as no[26]. But subjects were 40-89 years old with and without the risk of LS[26]. Sasaki *et al.*[27] also compared HGS of subjects with LS assessed using GLFS-25 aged 21-87 years old, and results were also significant. Differences of HGS values in those two studies[26,27] were significant, possibly due to inclusion of subjects at a younger age. It is known that LS is not only experienced by elderly population, but could also occur in young adults, therefore in a population with young adults it could give a higher mean HGS result and if there is a risk of LS in that population it could show a more pronounced decrease in HGS compared in elderly population. The presence of a degenerative process and a decrease in muscle mass in the elderly may contribute an insignificant

difference in HGS result between groups with and without LS[27]. Another possibility is that LS more clearly affects the lower limbs since it is defined as a decrease of mobility function, and is not directly correlated with the upper limb and HGS, although HGS has been investigated and associated with overall strength and lower limb strength[13].

Correlation test between PA and HGS of our current subjects resulted in an insignificant value. Lenardt *et al.*[28] explained a decrease in PA and HGS in the elderly leads to a higher probability of frailty conditions, but PA was assessed with the Questionário de Nível de Atividade Física para Idoso – CuriibAtiva questionnaire which consists of 20 questions regarding the frequency and duration of PA in the past week. While that study did not assess LS, it is known that LS could overlap with frailty but the terms are not interchangeable[29]. The criteria for frailty includes weakness of HGS and low PA[30], which could explain findings by Lenardt *et al.*[28], whereas our current study, no correlation between PA of subjects with LS and HGS was found, possibly due to no correlation between HGS and LS, also most subjects had weak HGS. Macedo *et al.*[31] in another similar study examined HGS in elderly divided in three groups with different levels of activity. The result of that study stated the average HGS was higher in high PA group, which in this instance were elderly who routinely did volleyball three times a week[31]. The difference with our current study is that IPAQ-SF[11] calculates PA based on subjective answers, while Macedo *et al.*[31] categorized subjects' PA levels based on their appropriate activities, which could impact HGS values. Also another possibility previously mentioned was LS being caused by a decrease in mobility which is closely related to the lower limbs, while HGS is closely related to the upper limbs, which effectively produce an insignificant correlation value.

Conclusion

In conclusion our current study showed a significant correlation between PA based on IPAQ-SF and LS based on Loco-check, but no correlation was found between HGS and LS, neither between PA and HGS in elderly with LS. Therefore the author suggests that the IPAQ-SF could be used as a screening tool for risk of LS. Limitations of this study include that only the elderly population was assessed and did not take into account of comorbidities found on research subjects, additionally IPAQ-SF scores reflect subjectively the subjects' response on daily activities which could impact on final IPAQ-SF scores.

Recommendations for further research include the need to conduct research on other age subject groups and results could be generalized to reflect the population as a whole. Comorbidities (i.e. cardiopulmonary, metabolic and BMI problems) of subjects would be needed to be taken into account to recognize its effect on PA, HGS and LS. IPAQ-SF scores could be more objectively if integrated with other methods such as diary of daily activities with METs score, or additional objective measurements (i.e. pedometers, accelerators) on daily activities. A daily dietary nutrition diary could also be suggested to recognize any effect on PA, HGS or LS.

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Conflict of interest

The authors declare no conflict of interest.

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