Original Article

The Correlation Between the 2-Minute Step Test and Body Mass Index in Thai Community-Dwelling Older Adults

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Objective: To determine and compare the 2-minute step test (2MST) scores among different body mass index (BMI) of elderly subjects and to predict the cardiorespiratory performance in community-dwelling older adults.

Materials and Methods: Ninety subjects, aged 60 or older were assigned for cardiorespiratory performance using the 2MST.

Results: There were significant differences in the 2MST scores among normal weight, overweight, and obese elders. The lowest score of the 2MST was found in obese elders when compared with normal weight and overweight elders. Moreover, BMI was negatively correlated with the 2MST ($r=-0.83$, $p<0.05$).

Conclusion: Community-dwelling obese elders had decreased cardiorespiratory performance, and BMI was negatively correlated with cardiorespiratory performance in obese elders.

Keywords: 2-minute step test; Body mass index; Elderly; Cardiorespiratory performance; Physical therapy

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Cardiovascular disease is one of the most common health problems among the elderly people, and it can lead to higher death rate[1]. The elderly people have higher incidence of cardiovascular diseases including hypertension, coronary artery disease, and diabetes mellitus resulting in decreased cardiorespiratory performance due to increased artery wall thickness, decrease blood vessel flexibility, and impaired blood vessel structure[1]. The commonly used cardiorespiratory performance assessment test in elderly people is 6-minute walk test (6MWT)[2]. The 6MWT is a simple field test that assess the submaximal level of functional capacity in individual during walking on a flat, hard surface for six minutes[3,4]. Several studies have used 6MWT to evaluate the cardiorespiratory performance in elders[5,6]. However, the 6MWT has several limitations, including the fact that the test was conducted on 30 meters course with motivation words, and the walking speed was reduced over a long period of time[7]. These factors could lead to the variation of the results in the 6MWT[7]. An alternative cardiorespiratory performance test that is appropriate for the elderly people is the 2-minute step test (2MST)[8]. The 2MST is a simple test to evaluate cardiorespiratory performance in elderly, takes only a few minutes, and requires only a square meter of space. It has been used internationally in people with both healthy and diseased cardiorespiratory system[9]. The 2MST is regarded as one of the reliable tests to assess the cardiorespiratory performance with an intraclass correlation coefficient (ICC) of 0.90[9]. The tested subjects need to march in place as fast as possible for two minutes while lifting the knees to a height midway between their patella and iliac crest while standing. The cardiorespiratory performance on the test is determined as the number of right-side steps of the criterion height completed in two minutes[9]. A 2MST score of less than 65 times indicates low cardiorespiratory endurance in elders[9].

Currently, Thai elders have increased incidence of

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obesity[10], and obese elderly condition leads to the risk of many cardiovascular and respiratory diseases[11]. However, there is no report regarding the evaluation of cardiorespiratory performance in community-dwelling elders. Furthermore, the cardiorespiratory performance of community-dwelling elders in different body mass index (BMI) has not been investigated. Therefore, in the present study, the authors tested hypothesis that cardiorespiratory performance had a negative correlation with BMI, and then, cardiorespiratory performance declined with the increase of BMI.

Materials and Methods

Study design and subjects

The present study was a cross sectional study design. Ninety subjects aged 60 or older were recruited, and divided into three groups, based on BMI as normal weight with a BMI of 18.5 to 24.9 kg/m², overweight with a BMI of 25.0 to 29.9 kg/m², and obese with a BMI of 30 kg/m² or greater. If the elders could walk at least six meters without assistive walking devices, they were recruited as the subjects. Subjects who had problems of visual, hearing, communication and musculoskeletal diseases that affect to lifting the knees such as arthritis, osteoarthritis, hip or knee replacement, and pain scale of lower extremities more than 5 over 10, neurological diseases with imbalance problem, and unstable cardiorespiratory disease were excluded. The present study was approved by the Clinical Research Ethics Committee of the University of Phayao, Phayao, Thailand (1.3/021/63).

Procedures

All subjects were interviewed and evaluated the baseline demographic data including underlying disease, heart rate, and blood pressure. After that, cardiopulmonary performance was assessed using the 2MST. The heart rate and blood pressure were measured at the end of the procedure.

For the 2MST, each subject was directed to stand against the wall and measured the height of patella and anterior superior iliac crest, which were marked it on the wall. Then, a piece of tape marked half of the distance between the two points was placed on the wall. All subjects were instructed and encouraged to tread in place as fast as possible for two minutes by lifting the knees to the height marked midway between their patella and iliac crest while standing. The number of right-side steps of the criterion height completed in two minutes were counted for the test record in each subject.

Statistical analysis

Descriptive statistics were used to report the demographic data. We used relative frequency distribution for categorical underlying diseases. The one-way ANOVA test followed by an LSD post hoc test was used to compare the 2MST, heart rate, and blood pressure in different BMI groups. Pearson's correlation test was used to investigate the correlation between the 2MST and the BMI. All statistical analyses were conducted using IBM SPSS Statistics, version 22.0 (IBM Corp., Armonk, NY, USA). A p-value of less than 0.05 was set to denote significance.

Results

The characteristics of subjects are shown in Table 1. The data revealed that most of the subjects were female. The average age was not different among the tested groups, but BMI was different between the groups. The underlying diseases were hypertension, dyslipidemia, and diabetes mellitus. In addition, the heart rate, systolic blood pressure, and diastolic blood pressure were not significantly different between the groups. The 2MST was measured to assess the cardiorespiratory performance. Regarding the 2MST, a significant difference was found between the groups ($p<0.05$). The overweight subjects showed a significantly decreased score of 2MST when compared with the normal weight subjects ($p<0.05$). Moreover, the lowest score of 2MST was found in obese subjects.

The correlation between variables and the 2MST are shown in Table 2. There was no correlation between age and height with the 2MST ($r=0.08$ and $r=–0.05$, respectively). In contrast, weight was correlated with the 2MST ($r=–0.80$, $p<0.05$). The BMI was negatively correlated with the 2MST ($r=–0.83$, $p<0.001$). These results are shown in Figure 1.

Discussion

The major finding of the present study indicated that an increase in BMI causes a decrease cardiorespiratory performance in community-dwelling older adults, exemplified by low score of the 2MST in obese subjects. In addition, the present study results also found that cardiorespiratory performance decreased with increased in BMI among the elders.

It is known that cardiorespiratory performance can be assessed by using the 2MST, which is a good alternative test for those who have limited amount of

Table 1. Characteristics of the subjects

Variables	Normal weight (n=30; F=21, M=9); mean±SD	Overweight (n=30; F=21, M=9); mean±SD	Obese (n=30; F=21, M=9); mean±SD	p-value
Age (years)	71.13±5.38	69.56±5.46	69.60±6.17	0.48
Weight (kg)	50.26±5.79	63.47±6.74[a]	75.30±5.72[a,b]	<0.01
Hight (cm)	155.00±6.90	154.57±8.40	154.27±6.41	0.93
BMI (kg/m^2)	20.90±1.83	26.52±1.03[a]	31.64±1.43[a,b]	<0.01
Underlying disease; n (%)				
Hypertension	11 (36.67)	19 (63.33)	24 (80.00)	<0.01
Dyslipidemia	4 (13.33)	7 (23.33)	13 (43.33)	<0.01
Diabetes mellitus	2 (6.67)	5 (16.67)	9 (30.00)	<0.01
Heart rate (bpm)				
Before 2MST	81.30±10.51	81.73±9.49	81.27±10.56	0.98
After 2MST	92.73±11.90	88.80±11.62	86.90±12.64	0.87
Systolic blood pressure (mmHg)				
Before 2MST	132.50±14.63	133.30±13.29	133.77±11.46	0.71
After 2MST	140.97±16.45	138.60±14.60	136.97±12.76	0.68
Diastolic blood pressure (mmHg)				
Before 2MST	71.56±8.26	74.50±9.18	74.07±9.66	0.40
After 2MST	78.03±8.56	76.83±9.58	76.03±9.35	0.46
2MST (score)	91.90±9.22	68.87±10.19[a]	50.87±6.07[a,b]	<0.01

F=female; M=male; BMI=body mass index; 2MST=2-minute step test;SD=standard deviation

[a] p<0.05 vs. normal weight, [b] p<0.05 vs. overweight

Table 2. The correlation between variables and 2MST

Variables	2MST
Age (years)	r=0.08
Weight (kg)	r=–0.80*
Hight (cm)	r=–0.05
BMI (kg/m^2)	r=–0.83*

BMI=body mass index; 2MST=2-minute step test

* p<0.05 from Pearson correlation coefficient

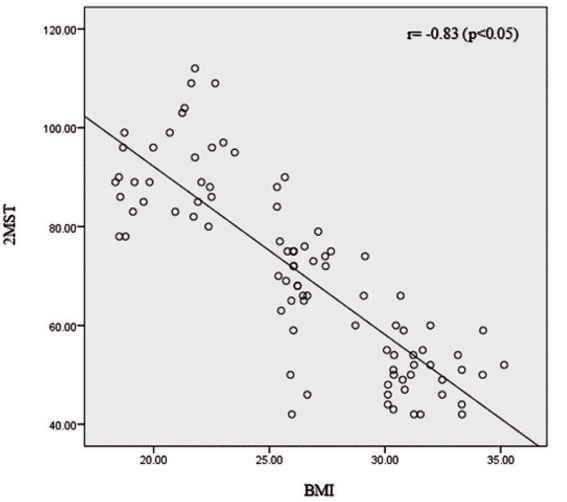

Figure 1. The correlation between BMI and 2MST.

space, time, and lack of equipment[12]. The 2MST had a good correlation with measures of cardiorespiratory fitness, which is 1-mile walk times, treadmill time to 85% of predicted maximum heart rate using a modified Balke protocol (r=0.62 to 0.74)[9]. Moreover, the 2MST can evaluates cardiorespiratory fitness in older adults with heart failure, hypertension, chronic kidney disease, Parkinson's disease, Alzheimer's disease, stroke, osteoporosis, and depression[8]. In addition, the 2MST was highly correlated with the 6MWT, a commonly used test to evaluate the cardiorespiratory performance[13]. Moreover, a previous study has reported that the 2MST was valid to determine the functional capacity in obese patients with comorbidities and, the result indicated that the 2MST was strongly correlated with cardiopulmonary exercise test (CPX)[14]. The CPX is a gold standard test to assess the cardiorespiratory performance[14]. These findings suggested that the 2MST was valid to assess the cardiorespiratory performance.

The present study results showed that obese

elders had the lowest score in the cardiorespiratory performance, compared to normal weight and overweight elders. These findings were consistent with several previous studies in which the results indicated that BMI was correlated with functional capacity when determined by using the 6MWT[15,16]. Furthermore, the previous studies found that obese patients had reduced functional capacity as indicated by fatigue, dyspnea, and decreased oxygen uptake (VO_2)[17,18]. Moreover, the reduction in functional capacity of obese patients was because obesity caused increase in fat mass and decrease in muscle mass, which lead to reduced metabolic rate[19]. In addition, a reduction of muscle mass can affect the functional capacity[20]. Therefore, the present study indicated that obese elders had reduced cardiorespiratory performance.

The obese elder group had a lower score of the 2MST than normal weight and overweight elder group. The score of the 2MST in obese elder group is 50.87 times. A previous study has reported that lower cardiorespiratory performance was found in elders as indicated by the score of the 2MST of less than 65 times[9]. Therefore, the present study results indicated that obese elders had a decreased cardiorespiratory performance. In addition, the previous studies have revealed that an increase in body weight and BMI were associated with decreased lower limb muscle strength and cardiovascular endurance. This was leading to functional capacity impairment in the obese individual with less physical activity[21,22]. In contrast, the increase in functional capacity were found in normal weight individuals[23]. Moreover, elders with high BMI had lower physical function than elders with low BMI, which lead to increased health problems resulting in decreased quality of life in the obese elders[24]. All these findings could be beneficial to find the intervention for improving the cardiorespiratory performance in obese elders.

Conclusion

The present study is the first study to determine the correlation between BMI and cardiorespiratory performance in community-dwelling elders. The findings indicated that cardiorespiratory performance was decreased in obese elders in community-dwelling. The BMI was negatively correlated with cardiorespiratory performance using the 2MST.

What is already known on this topic?

The 2MST can evaluate the cardiorespiratory performance. This test is one of the reliable tests to assess cardiorespiratory performance (ICC 0.90). The cardiorespiratory performance is indicated by the number of right-side steps of the criterion height completed in two minutes. The number of 2MST less than 65 times indicate low cardiorespiratory endurance in elders.

What this study adds?

This study supports that BMI was correlated with cardiorespiratory performance in community-dwelling elders, and the cardiorespiratory performance can be evaluated by using the 2MST.

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Conflicts of interest

The authors declare that they have no competing interests.

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