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Two Minutes Step Test Versus Six Minutes' Walk Test on Physical Capacity in Diabetic Neuropathy

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ABSTRACT

Background: Given that diabetes mellitus can cause physical tiredness, fatigue, muscle weakness, and decreased plantar sensitivity all of which are linked to normal aging changes. Functional capacity serves as a crucial indicator of the health of the patient, particularly in older adults.

Purpose: This study aimed to look at how the 2 minute' step test and the 6 minute' walk test affect a diabetic neuropathy patient's physical capabilities.

Martial and Method: The study was conducted on 60 paints suffering from diabetes mellitus with neuropathy. The following parameters were measured before and after the six-minute' walking test and the two-minute' step test: Heart rate, blood glucose level, O_2 saturation, systolic and diastolic blood pressure, Borg scale, and walking distance.

Results: There were no significance differences between the groups before the study. There were positive correlation between the 6 minute walking test and 2 min step test regarding heart rat, blood pressured O_2 saturation and Borg scale measurement when were asked to assess functional capacity.

Conclusion: The 2 minute' step test and 6 minute walking test were used to measure functional capacity in diabetic neuropathy patients and 2 minute step test could be used when there were difficulties to use 6 minute walking test.

Keywords: 2 Minutes' step, Six minutes' walk, Diabetic neuropathy

INTRODUCTION

Since diabetes mellitus (DM) is a public health issue with a rising incidence rate, it poses one of the worst challenges to global health. Diabetic peripheral neuropathy (DPN), nephropathy, and retinopathy are among the frequent side effects of type II diabetes. Peripheral neuropathy is characterized by a decrease in nociception, reduced positional perception, loss of distal strength, ataxia, and muscular atrophy [(1)].

Disorders associated with diabetic peripheral neuropathy (DPN) limit a patient's capacity for functional exercise and impair their ability to engage in physical activity [(2)].

Diabetes mellitus (DM) is a chronic metabolic disease marked by abnormally high blood glucose levels. It is caused by defects in the secretion of insulin, its action, or both. DM is frequently linked to microvascular and macrovascular complications, as well as a number of other disorders, including disturbances in blood coagulation, metabolism, and cells. These complications can affect a variety of organs, including the kidney, retina, peripheral nerves, and microvascular and macrovascular components [(3)].

Considering that diabetes mellitus can result in physical exhaustion, fatigue, muscle weakness, and decreased plantar sensitivity all of which are linked to normal aging changes. Functional capacity serves as a crucial indicator of the health of the patient [(4)]. Various methods, including laboratory or field testing, can be used to objectively measure the exercise ability of people with diabetes mellitus. Clinicians frequently employ the 6-minutes' walk test (6MWT) to assess DM patients' ability to engage in functional activity **(5)**.

Because the 6MWT requires a broad area to be done reliably, this may limit its application in diabetes clinics, where time and space are typically more limited and a large population is screened **(6)**. Less time and space are needed for the minute' step test (MST). Therefore, as MST requires less physical space than 6MWT, it has been employed recently as an easy and effective alternative **(7)**.

Clinicians can evaluate submaximal exercise capacity using the 6MWT, a straightforward clinical instrument. This is a helpful instrument to record baseline function and the efficiency of therapy interventions, such as exercise regimens **(8)**. The loss of strength and muscle mass seen in Type II diabetes is associated with numerous causes. Specifically, one of the underlying causes for decreased muscular strength in DM is motor neuron-related neuropathic processes. It has been shown that a valid way to assess lower extremity muscular strength and functionality in type II diabetic patients is by the walking test **(9)**.

The American Thoracic Society recommendations provided a defined methodology that was followed when doing the 6MWT. Prior to and following the test, measurements were made of blood pressure, heart rate, oxygen saturation (SpO_2), dyspnea, and impression of leg weariness. For the assessment of leg fatigue and dyspnea, a modified Borg scale was employed. A Finger Pulse Oximeter (Germany) was used to assess heart rate and oxygen saturation (SpO_2). At the conclusion of the test, the greatest distance traveled was noted. Cardiorespiratory fitness determines

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functional exercise capacity, which is a powerful predictor of survival in type II diabetes [10].

The 6MWT is frequently utilized in the literature to assess individuals with type II DM's cardiopulmonary function [11]. This physical fitness test gives a quick overview of a person's ability to engage in physical activity by counting the number of complete steps they can accomplish in a two-minute period. It is a predictor of the ability to remain physically independent. It is a valid substitute for other physical fitness tests, such as the six-minute walk test, and provides a rapid and effective assessment of an individual's lower body functional capacity [12].

It is crucial to bear in mind that the 2-minutes' step test is merely one fitness assessment tool. For a more thorough evaluation of physical fitness in older persons, one may also consult the Senior Fitness Test. Additionally, it's important to consider other factors such as medical history, current health status, issues like cognitive impairment, and individual goals when assessing overall fitness [13].

PATIENT AND METHOD

Patients: Sixty individuals with diabetes mellitus, ranging in age from forty to seventy, participated in this study. Patients from King Khaled Hospital were chosen, and they were divided into two groups at random.

We used G-power software to estimate the sample size. We used the two-way MANOVA test and specified a statistical power of 0.95 along with an alpha error of 0.05. Based on the estimated 10% attrition, the effective size of 0.56 indicated that 60 individuals are required. Ultimately, 60 participants were used in the sample size computation. Figure (1) showed the procedure's flow chart.

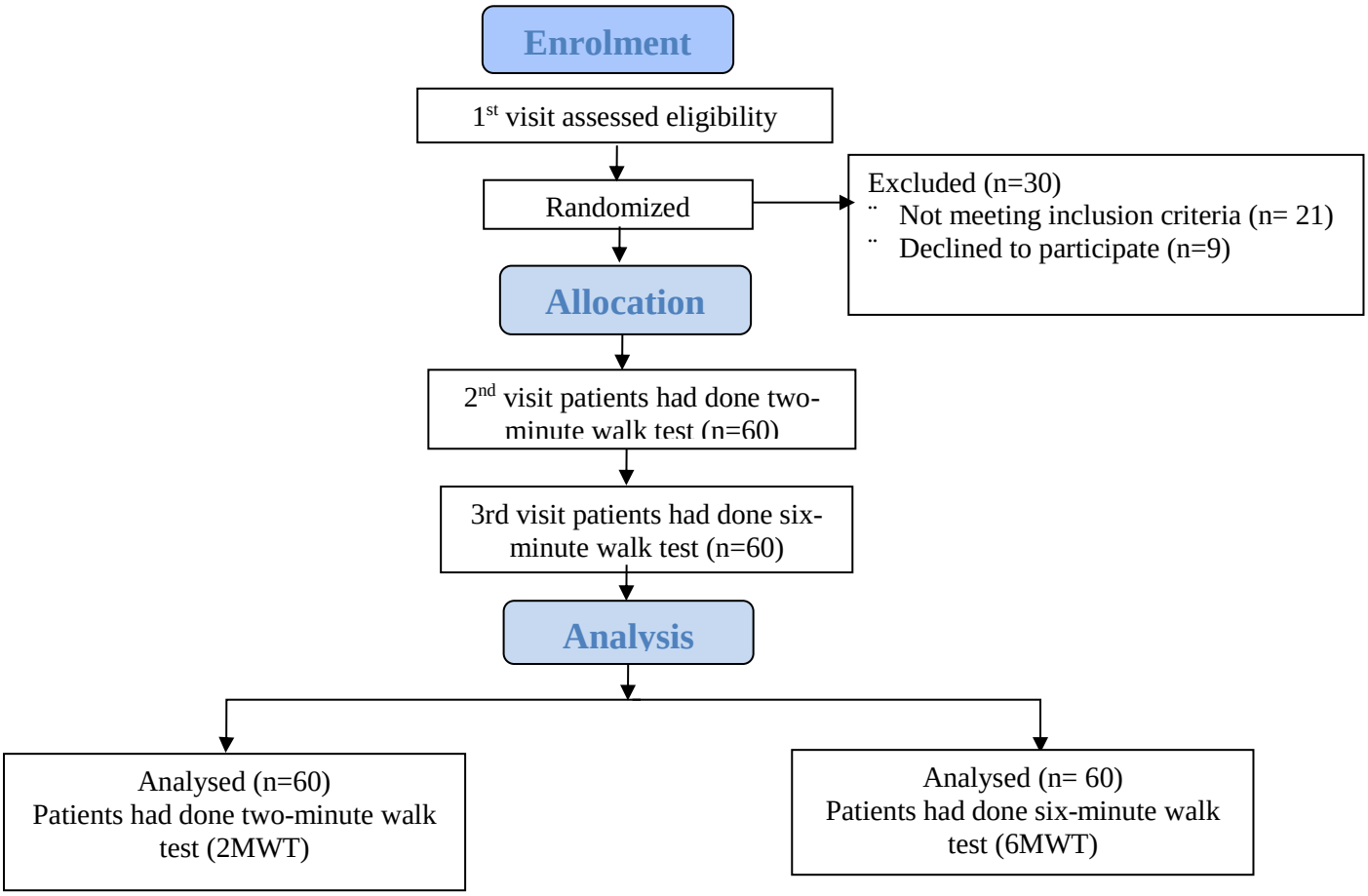

Figure (1): The procedure's flow chart.

Inclusion Criteria: 60 individuals suffering from type II diabetes. A fasting blood glucose reading between 115 and 126. HbA1c < 9. DM lasting more than five years. The goal of the medical regimen was reached at least three months before the trial began. The patients' ages varied from 40 - 70 years old. Prior to the trial, none of the patients had taken part in any rehabilitation initiatives. Based on the Neuropathy Disability Score (NDS), every patient in the study had moderate neuropathy. Neuropathy score is the foundation of the NDS system.

Exclusion criteria: Three months prior to study enrollment, symptoms of severe arrhythmia, unstable angina, or abrupt heart failure. Pacesetters. Chronic pulmonary obstructive illness. Additional conditions (burns, fractures, etc.) that counteract exercise testing factors that impede lower limb mobility. Pre-existing neuromuscular diseases (for example Myasthenia Gravis). Chronic inflammatory autoimmune disease. Anemic patient. Patient with liver disease. Heavy smokers patient.

Evaluation:

Primary outcome: Walking distance – Blood pressure, heart rate, oxygen saturation in 6 minutes' walking test and step number, oxygen saturation, heart rate and blood pressure.

Secondary outcome: Any signs of fatigue and claudication pain and blood glucose measurement.

Procedure: Three visits from patients were made to the laboratory. To determine their eligibility, clinical data were gathered during the initial appointment.

After completing 2MST, every patient saw a second time. Ultimately, all patients had completed 6MWT by the third visit.

Based on the Neuropathy Disability Score (NDS), every patient in the study had moderate neuropathy.

Score for Neuropathy Disability (NDS): The neuropathy score system (NDS) has a range of 0 to 10, which can also be used to determine the severity of peripheral neuropathy. The neuropathy disability was categorized into three severity levels: mild (scoring 3-5), moderate (scoring 6-8), and severe (scoring 9–10).

1. Six-minutes' walk test

It assesses the overall and combined reactions of all the systems that are engaged in physical activity (blood, neuromuscular units, muscle metabolisms, systemic and peripheral circulation, pulmonary and cardiovascular systems, etc.).

Pre-Testing

- The procedure was explained to the subject.
- VO_2 max, blood pressure, heart rate, dyspnea, and fatigue (as defined by the modified Borg scale) were measured at the start of the 6-minute walking test.
- Measurements were made of baseline walking distance, heart rate, blood pressure, oxygen saturation, dyspnea and tiredness (as judged by the modified Borg scale).
- The patient was asked to wear appropriate clothing and shoes.
- At least ten minutes before to the test's start, the patient was instructed to sit on a chair close to the starting position.
- The warm-up period before to the test is prohibited.
- The exclusions were examined
- The patient was asked to fill out the first part of the worksheet.

Testing

- The patient was asked to walk alone in accorder about 300 meters, not with other patients.
- The standardized phrases were used to encourage the patient during the test.
- The patient was watched carefully.
- The patient was asked to keep silence and don't speak talk to anyone during the walk.
- The patient was asked not to count the laps (e.g. mark the lap on the worksheet).

Post test

- Take note of the patient's walking distance, heart rate, blood pressure, oxygen saturation, VO_2 max, post-walk dyspnea, and overall weariness (measured on the Borg scale).

2- Minutes' step test

Pre-test:

- The baseline, blood pressure heart rate, dyspnea, fatigue (modified Borg scale) and oxygen saturation were measured.
- The subject was given an explanation of the methods. Assess potential health concerns and acquire informed consent.

Procedure:

Placing a mark on the wall at the midpoint between the iliac crest (top of the hip bone) and patella (knee cap), the individual was instructed to stand straight up next to the wall. Next, for two minutes, the subject was to march in place, while raising their knees to the wall's mark. Holding onto the wall or a sturdy chair was acceptable, as was sleeping. When two minutes have passed, stop.

Post-test:

- The patient's heart rate, blood pressure, oxygen saturation, VO_2 max, number of steps, post-walk dyspnea, and general weariness (measured on the Borg scale) were all noted.

Ethical approval:
The study was approved by the Ethics Board of King Khaled Hospital.

Statistical analysis:
Data were screened, for normality assumption test and homogeneity of variance. Normality test of data using Shapiro-Wilk test was used, that reflect the data was normally distributed (P>0.05) after removal outliers that detected by box and whiskers plots. Additionally, Levene's test for testing the homogeneity of variance revealed that there was no significant difference (P>0.05). All these findings allowed to conducted parametric and non-parametric analysis. The data is normally distributed and parametric analysis is done.

RESULTS

This study conducted to investigate the effect of 2 minute step test versus 6 minute walk test on physical capacity in diabetic neuropathy. Sixty patients with type II diabetes mellitus (DM) with an age range from 40 to 70 years old with duration of DM more than 5 years. All 20 patients visited the laboratory on three occasions. In the 1st visit, clinical information was obtained to assess their eligibility. On the 2nd visit, all patients had done six-minute walk test (2MST). Finally, on the 3rd visit, all patients had done six-minute walk test (6MWT).

The current study examined the relationship between 6MWT and 2MST and explored the relationship diabetic neuropathy. Our results show that, although there is a positive relationship between the two tests, so the 2MST should still be considered as a complement to the 6MWT. However, in cases where the 6MWT cannot be performed, the 2MST seems to emerge as a valid option due to its high level of concordance.

A. Normality test

The table revealed that no significant difference (P>0.05) (Table 1).

Table (1): Test of normality for all measured variable outcomes

Items	Shapiro-Wilk test		
	Statistic value	P-value	Significance
Heart rate	0.930	0.142	NS
Systolic blood pressure	0.966	0.090	NS
Diastolic blood pressure	0.960	0.625	NS
Borg scale	0.932	0.056	NS
O2 saturation	0.966	0.438	NS
Blood glucose response	0.865	0.189	NS

P-value: probability value, NS: non-significant (P>0.05).

B. Clinical general characteristics of diabetic neuropathy patients

The statistical analysis revealed that no significant differences in fasting blood glucose level , Hb A1C between six-minute walk test group vs. two-minute step test group. (Table 2).

Table (2): Comparison mean values of patients general characteristics between both groups

Items	Clinical general characteristics of patients			
	Age Years)	FBG (mg/dl)	Hb A1c (%)	Duration of DM (years)
Six-minute walk test (n=30)	54.73 ±3.19	119.27 ±4.71	6.50 ±0.70	6.20 ±1.08
Two-minute step test (n=30)	55.20 ±2.80	119.00 ±4.88	6.36 ±0.89	6.33 ±1.04
t-value	0.425	0.452	0.343	0.152
P-value	0.674	0.645	0.734	0.880
Significance	NS	NS	NS	NS

DM: diabetes mellitus; FBG: fasting blood glucose level; Hb A1C%; Uncontrolled Diabetes Mellitus
Data are expressed as mean ±standard deviation (SD)
P-value: probability value, NS: non-significant.

C. Mixed design (2×2) multivariate analysis of variance (MANOVA)

1. Heart rate

Multiple pairwise comparisons test revealed that there was significantly increased in heart rate at post-treatment compared to pre-treatment. Multiple pairwise comparisons test revealed that there was significantly (P<0.05) increased in heart rate at post-treatment compared to pre-treatment (Table 3).

Table (3): Mixed MANOVA for the effect of treatment on heart rate

Heart rate (Mean ±SD) (Beat/min)		
Items	Six-minute walk test (n=20)	Two-minute step test (n=20)
Pre-treatment	73.80 ±5.68	72.40 ±6.05
Post-treatment	101.67 ±9.89	99.47 ±8.71

Data are expressed as mean ±standard deviation P-value: probability value S: significant *
Significant (P<0.05) NS: non-significant.

2. Systolic blood pressure

Considering the effect of the tested group on systolic blood pressure, the pairwise comparisons test revealed no significant difference (Table 4)

Table (4): Mixed MANOVA for the effect of treatment on systolic blood pressure

Systolic blood pressure (Mean ± SD) (mmHg)		
Items	Six-minute walk test (n=20)	Two-minute step test (n=20)
Pre-treatment	126.33 ±8.77	123.87 ±9.14
Post-treatment	145.20 ±7.11	141.07 ±10.72

Data are expressed as mean ±standard deviation.
P-value: probability value, S: significant
* Significant (P<0.05) , NS: non-significant.

3. Diastolic blood pressure

Considering the effect of the tested group on diastolic blood pressure (Table 5), the pairwise comparisons test revealed no significant difference (Table 5)

Table (5): Mixed MANOVA for the effect of treatment on diastolic blood pressure

Diastolic blood pressure (Mean ±SD) (mmHg)		
Items	Six-minute walk test (n=20)	Two-minute step test (n=20)
Pre-treatment	74.87 ±6.41	74.67 ±6.52
Post-treatment	79.60 ±6.30	77.27 ±6.12

Data are expressed as mean ±standard deviation.
P-value: probability value. S: significant *
Significant (P<0.05). NS: non-significant.

4. Borg scale

Considering the effect of the tested group on Borg scale (Table 6), the pairwise comparisons test revealed no significant difference (Table 6)

Table (6): Mixed MANOVA for the effect of treatment on Borg scale

Borg scale (Mean ±SD)		
Items	Six-minute walk test (n=20)	Two-minute step test (n=20)
Pre-treatment	7.73 ±2.01	7.00 ±1.69
Post-treatment	11.80 ±2.27	12.87 ±1.72

Data are expressed as mean ±standard deviation.
P-value: probability value. S: significant *
Significant (P<0.05). NS: non-significant.

5. O_2 saturation

Considering the effect of the tested group on O2 saturation (Table 7), the pairwise comparisons test revealed no significant difference (Table 7)

Table (7): Mixed MANOVA for the effect of treatment on O_2 saturation

O_2 saturation (Mean ±SD) (%)		
Items	Six-minute wa test (n=20)	Two-minute step (n=20)
Pre-treatment	96.47 ±0.30	96.29 ±0.30
Post-treatment	96.02 ±0.33	95.92 ±0.45

Data are expressed as mean ±standard deviation.
P-value: probability value. S: significant *
Significant (P<0.05). NS: non-significant.

6. Blood glucose response

Considering the effect of the tested group on blood glucose response (Table 8), the pairwise comparisons test revealed no significant difference (Table 8).

Table (8): Mixed MANOVA for the effect of treatment on blood glucose response

Blood glucose response (Mean ±SD) (mg/dl)		
Items	Six-minute walk test (n=20)	Two-minute step test (n=20)
Pre-treatment	128.73 ±7.51	129.07 ±6.98
Post-treatment	115.40 ±5.877	115.13 ±4.30

Data are expressed as mean ±standard deviation.
P-value: probability value. S: significant. *
Significant (P<0.05). NS: non-significant.

7. Distance and number of steps

The mean distance for six-minutes' walk test and the mean steps number for two-minutes' step test ahowed in Table 9.

Table (9): Mean, minimum, and maximum values of distance and number of steps

Items	Mean	Minimum	Maximum
Distance for six-minutes' walk test (n=20)	446.93 ±29.40	410.00	490.00
Steps number for two-minutes' step test (n=20)	71.57 ± 5.90	60.00	81.00

Data are expressed as mean ± standard deviation (SD)

DISCUSSION

In order to compare the effects of the 2-minutes' step test and the 6-minutes' walk test on physical capacity in diabetic neuropathic pain, this study was conducted. Between the ages of 40 and 70, 60 patients with diabetes mellitus were included in this study. The patients were divided into two groups at random.

In this study, the association between diabetic neuropathy and 6MWT and 2MST was investigated.

Despite the positive correlation between the two tests, our findings indicate that the 2MST should be viewed as a supplement to the 6MWT. Due to its high degree of concordance, the 2MST appears to be a viable alternative in situations where the 6MWT cannot be completed.

Our findings regarding the hemodynamic response to the effort of each test indicated that, while both tests required physical effort, the heart rate increased more at the conclusion of the 6MWT and the perception of effort increased more at the conclusion of the 2MST. These findings are in line with previous research conducted on other populations [(14)]. This could be mostly due to the fact that although being a habitual activity, walking involves displacement, balance, and global movement, whereas stair climbing is lower limb-intensive despite being a stationary activity [(15)].

Contradictory results have been recorded in similar encounters with various populations. In patients with symptomatic peripheral vascular disease, **Amaral *et al.*** [(16)] found that there was a link with the number of steps in the 6MWT ($r = 0.55$, $p < 0.01$) but not between the steps achieved in the 2MST and the meters walked in the 6MWT ($r = 0.26$; $p = 0.23$). However, in patients undergoing cardiac rehabilitation, **Haas *et al.*** [(17)] found a good association ($r = 0.93$) between the steps completed in the 2MST and the meters run in the 6MWT. According to **Wegrzynowska-Teodorczyk *et al.*** [(14)] study on people with heart failure, there was a somewhat positive connection ($r = 0.44$; $p = 0.0001$) between the two tests.

Exercise prescriptions must be given to diabetic patients before any encouragement to exercise is offered. An appropriate exercise prescription is carried out by methodically organizing potential physical activities based on an individual's abilities as well as their unique traits. The typical components of an exercise prescription are frequency, intensity, type, and time. Determining the appropriate level of exercise intensity is the most significant and challenging issue in exercise prescription. Exercise effects cannot be anticipated at too low intensity; at too high intensity, patients will not be able to exercise consistently. Consequently, exercise needs to be done for a specific length of time and at the right intensity in order to have the desired results [(18)].

Although, the connection between the two tests was not as high as that observed in other populations, our results nevertheless indicated the positive link between them. This may be explained by the fact that in contrast to the 6MST, the 2MST was seen as a novel assessment. Additionally, it has been demonstrated that time constraints and submaximal nature of the tests affect the association with maximal oxygen consumption when compared to maximal tests in heart failure patients [(19)]. These factors may possibly account for the heterogeneity in the strength of the connection between tests.

Our findings also revealed that there was a stronger correlation between the two tests among the participants in the 6MWT who walked a longer distance. This finding may be explained by the fact that the 6MWT, which measures a patient's capacity for performing submaximal activities of daily living, has a strong predictive power for peak oxygen consumption in participants who walk a longer distance [(20)].

Even though our research revealed a correlation between the steps taken in the 2MST and the distance walked in the 6MWT, as well as a relationship between both tests and muscle strength, age, weight, height, and muscle strength, we can still draw the conclusion that, in patients with diabetic neuropathy, it is generally advisable to substitute 2MST for the 6MWT when it is feasible. The 2MST is helpful in this population and may also offer further information for the fitness assessment [(21)].

But, the 6-MWT and step test are easy to use, affordable, and reliable. This is the reason why the step test is not utilized in clinical practice, although the 6-MWT has already been used as an exercise test. There has been minimal research on the application of the step test, with the majority of research on the step test being done on the general population. The 20 cm height and reduced exercise intensity of the step test make it suitable for the elderly and ill. Furthermore, it does not require measuring with sophisticated technologies [(20)]. However, we took into account the value of the 2MST in terms of the clinical applicability of these findings, particularly in situations where the 6MWT cannot be carried out [(21)].

CONCLUSION

Since the purpose of our study was to investigate the link between the two tests in a population with diabetic neuropathy, we think that the findings added to our understanding of the value of both tests and provided a foundation for subsequent research. However, we took into account the value of the 2MST particularly in situations where the 6MWT cannot be carried out. Future research could expect to see greater findings from the validity of the 6-MWT and step test, both of which were statistically significant. This is because additional participants in the tests should improve the results.

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