

Relation between Cardiorespiratory Fitness Measured with Six-Minute Walk Test and Walking Speed Measured with 1—Meter Walk Test in Patients of Post-Subacute and Chronic Ischemic Stroke

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Abstract

Background: Cardiorespiratory fitness measurement using 6MWT (Six Minute Walking Test) and walking speed measurement using 10MWT (Ten Minute Walking Test) in post-stroke patients are measurement to assess post-ischemic stroke patients in subacute or chronic phase. This study is to assess cardiorespiratory fitness and to measure walking speed of post-stroke patients in subacute and chronic. We also aim to observe the relation between cardiorespiratory fitness and walking speed in post-stroke patients.

Method: This study involved 38 subjects as samples. 6MWT assessment was conducted by measuring the mileage in six minutes. Walking speed was conducted afterwards with self-speed and fast-speed which were respectively assessed through three repetitions.

Results: We found strong correlation in 6MWT assessment results with mileage in meter and VO₂ max ($r = 0.680$ and $p = 0.000$). The result of 6MWT measured with VO₂ max (ml/kg/minute) indicated strong correlation with 10MWT both with self-speed ($r = 0.715$, $p = 0.000$) and fast-speed ($r = 0.687$ $p = 0.000$).

Conclusions: We concluded that there was a relation between cardiorespiratory fitness and walking speed in post-subacute and chronic ischemic stroke patients.

Keyword: *cardiorespiratory fitness, stroke, walk test.*

Introduction

In post-stroke, continuous aerobic capacity usually occur in acute phase which reduce cardiorespiratory fitness reserve¹. In addition, the high amount of energy required for walking as well as comorbidities lead to functional limitations for this population². Cardiorespiratory fitness in post-stroke decreases from 50% to 70% depends on certain ages and genders. In elderly, the decrease occurs more rapidly. Cardiorespiratory fitness also decreases faster in female than in male. The sharpest decline is up

to seven weeks post-stroke. The energy level required by stroke patients for routine ambulation is 1.5-2 times higher than in healthy individuals which indicates 76% of their physiological capacity³.

This is due to post-stroke muscle fatigue and low level of cardiorespiratory fitness related to declining functional activity performance. Many studies suggested that it is associated with low peak oxygen consumption (VO₂peak)³. The average peak oxygen (VO₂peak) consumption in post-stroke patients is around 11.4-17.3 mL/minute. This is 50-60% of VO₂peak in healthy individuals in accordance with age and gender⁴. Maximal oxygen uptake (VO₂pMax) decreases to 10-17 mL/kg/minute during 0-30 days post-stroke⁵.

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Patterson et al. found that short-distance walking in chronic stroke patients is related to balance, cardiorespiratory fitness and weak side limb strength. The difference of ability in long-distance walking is caused by severe sensory fatigue and deficit which lead to poor gait. Balance also becomes an important factor for those who walk slower, while cardiorespiratory fitness plays bigger role in those who walk faster ⁶.

Janice et al. also conducted a study in chronic stroke patients and reported that stroke specific impairment was the main obstacle for chronic stroke patients to take longer distance. In the study, they found that the subjects' heart rate in the study reached steady state after six minutes of walking. This indicates that six-minute walk test (6MWT) may depict cardiorespiratory fitness. Six-minute walk test (6MWT) also strongly correlates with self-paced walking speed ⁷.

There is a study on subacute stroke patients conducted by Kelly et al. suggesting that 6MWT is strongly related to peak cardiorespiratory fitness and also strongly correlated with self-paced walking speed ⁸.

Walking speed assessment can also be conducted using 10 meter walk test (10MWT), a time measurement required to do 10-meter walking with patients' maximum walking speed. The test began with three minutes of warming up ⁷. Walking speed is the parameter of disability in walking fast and easily which is recommended as a measuring instrument in stroke rehabilitation ⁹.

It is still debatable whether or not there is a correlation between walking speed, walking distance taken by the subjects, functional walking test (including 6MWT) and aerobic capacity in post-stroke patients. For instance is a conclusion from a study conducted by Tang et al. stating that even though 6MWT might be able to spur cardiorespiratory system, the results seem to be more affected by walking ability limitations than by cardiorespiratory capacity ².

In this research, the authors aim to find out if there is a relation between cardiorespiratory fitness level using 6MWT measuring instrument and walking speed in post-ischemic stroke patients and if walking speed in all ischemic stroke phase is related to cardiorespiratory fitness level. Such study has never been conducted before in Dr. Soetomo General Hospital Surabaya.

Methods

This was an observational analytic study with cross-sectional design. It was conducted from July to October 2014 in Medical Rehabilitation Installation of Dr. Soetomo General Hospital Surabaya. The samples of this study were post-ischemic stroke that met the inclusion criteria (post-hemiparesis ischemic stroke patients, more than 2 weeks until 1 year post-ischemic stroke, adult age of 30 to 65 years old), able to independently walk the distance of 60 meters for six minutes with or without aids, no complains of pain, asphyxiate, heart-pounding and cold sweat, able to conform with simple commands such as "start", "stop" and "you may rest if you are tired") and exclusion criteria (uncontrolled hypertension, cardiorespiratory impairment, cognition impairment with MMSE score less than 24, apraxia, severe hemi spatial neglect, musculoskeletal abnormalities, neurology impairment aside of stroke, visual impairment, hearing impairment, ataxia, severe sensory impairment, and involuntary movements) and had signed informed consent. The samples were chosen using consecutive sampling technique.

We found 38 subjects stroke patients that met the inclusion criteria and did not belong to exclusion criteria. We measured cardiorespiratory fitness using 6MWT and walking speed in Dr. Soetomo General Hospital Surabaya. Data analysis then was conducted using SPSS software. The study protocol was approved by the Ethics Committee of Dr. Soetomo General Hospital

Results

Table 1. Walking speed measured using 10MWT (m/s)

10-mWT	N	Rerata (m/dt)	Minimum	Maximum
Self-speed	38	0.534 ±0.310m/s	0.085	1.127
Fast speed	38	0.629 ±0.385 m/s	0.083	1.3

Table 2. 10MWT assessment with self-speed and fast speed in male and female subjects, subjects with stroke onset of 4-48 weeks as well as unilateral and bilateral hemiparesis

Variable	N	Self-speed (m/s)			Fast speed(m/s)		
		Mean	Minimum	Maximum	Mean	Minimum	Maximum
Gender							
Male	22	0.641±0.356	0.085	1.127	0.769±0.442	0.083	1.3
Female	16	0.389±0.141	0.094	0.599	0.438±0.160	0.1	0.710
Onset							
4 <24weeks	22	0.541±0.334	0.085	1.127	0.635±0.431	0.083	1.493
24-48 weeks	16	0.526±0.282	0.094	1.105	0.623±0.327	0.100	1.316
Paresis							
Unilateral hemi	32	0.577±0.315	0.085	1.170	0.690±0.389	0.083	1.205
Bilateral hemi	6	0.308±0.140	0.094	1.105	0.310±0.138	0.100	1.493

Table 3. Relation between 6MWT (VO₂max and mileage) and 10MWT (self-speed and fast speed)

Variable	6MWT		10-mWT (m/dt)	
	VO ₂ max (ml/kg/minute)	mileage (m)	Self-speed	Fast speed
VO ₂ max (ml/kg/minute)	r= 1.000 p= 0.000 .	r= 0.680 p= 0.000	r= 0.715 p= 0.000	r=0.687 p= 0.000
Mileage (m)	r= 0.680 p= 0.000	r= 1.000 p= 0.000	r= 0.756 p=0.000	r= 0.770 p=0.000
10-mWT Self-speed(m/s)	r=0.704 p=0.000	r= 0.756 p= 0.000	r= 1.000 p=0.000	r=.966 p=0.000
10-mWT Fast speed (m/s)	r=0.687 p= 0.000	r=0.770 p=0.000	r=0.966 p=0.000	r= 1.000 p=0.000

*Annotation r = 0.6 medium correlation, r= >0.7 Strong correlation. Significant if (p= 0.05)

There were 32 subjects (84.21%) with unilateral hemiparesis and six subjects (15.79%) with bilateral hemiparesis. The number of subjects using walking aids was 20, while the other 18 subjects did not use walking aids.

Walking speed assessment in 38 subjects in this study using 10MWT indicated the results of mean time required to take 10 meters with self-speed was

0.534±0.0310 m/s. The shortest time to take 10 meters was 0.085 m/s and the longest time was 1.127 m/s. Walking speed with fast speed was 0.629±0.385 m/s with the shortest time of 0.083 m/s and the longest time of 0.083 m/s (Table 7). The mean of walking speed measurement results using 10MWT in 22 male subjects with self-speed was 0.641±0.356 m/s with minimum speed of 0.085 m/s and maximum speed of 1.127 m/s. As for fast speed, the mean was 0.769±0.442 m/s with

minimum speed of 0.083 m/s and maximum speed of 1.3 m/s. The mean of walking speed measurement results using 10MWT in 16 female subjects with self-speed was 0.389 ± 0.141 m/s with minimum speed of 0.094 m/s and maximum speed of 0.599 m/s. As for fast speed, the mean was 0.438 ± 0.160 m/s with minimum speed of 0.1 m/s and maximum speed of 0.710 m/s. The mean of walking speed measurement results using 10MWT in 22 subacute stroke patients with self-speed was 0.541 ± 0.334 m/s with fastest speed of 0.085 m/s and the slowest speed of 1.127 m/s. As for fast speed, the mean was 0.635 ± 0.431 m/s with the fastest speed of 0.083 m/s and the slowest speed of 1.493 m/s. The mean of walking speed measurement results using 10MWT in 16 chronic stroke patients with self-speed was 0.526 ± 0.282 m/s with the fastest speed of 0.094 m/s and the slowest speed of 1.105 m/s. As for fast speed, the mean was 0.623 ± 0.327 m/s with the fastest speed of 0.1 m/s and the slowest speed of 1.3 m/s.

The mean of walking speed measurement results using 10MWT in 32 hemiparesis unilateral stroke patients with self-speed was 0.577 ± 0.315 m/s with the fastest speed of 0.85 m/s and the slowest speed of 1.170 m/s. As for fast speed, the mean was 0.690 ± 0.389 m/s with fastest speed of 0.083 m/s and the slowest speed of 1.205 m/s. The mean of walking speed measurement results using 10MWT in six hemiparesis bilateral stroke patients with self-speed was 0.308 ± 0.140 m/s with the fastest speed of 0.094 m/s and the slowest speed of 1.105 m/s. As for fast speed, the mean was 0.310 ± 0.138 m/s with fastest speed of 0.1 m/s and the slowest speed of 1.493 m/s.

The relation between 6MWT (VO₂max and mileage) and 10MWT (self-speed and fast speed)

The result of 6MWT measurement with mileage in meter indicated a strong correlation with 10MWT both self-speed ($r = 0.756$ $p = 0.000$) and fast speed ($r = 0.770$ $p = 0.000$). 6MWT measured with VOX₂max (ml/kg/minute) indicated strong correlation with 10MWT both with self-speed ($r = 0.715$ $p = 0.000$) and fast speed ($r = 0.687$ $p = 0.000$) (Table 9).

Discussion

The age of this study's subjects vary between 30-65 years old with various Body Mass Index (BMI). Subjects were allowed to use walking aids during walking test.

Six-minute walk test was a simple, practical test that

was easy to conduct, well-tolerated, and reflecting daily activity better than other walking tests. This test was conducted in a 10 feet (33m) hall. This test was designed to be an objective measurement for functional status and to represent cardiorespiratory fitness measurement in several individuals by converting the results of 6MWT walking test in VO₂max. This test could also be used for measuring distances in meter taken by patients in six minutes. This test was able to make global and integrated evaluation from all involved system during practice including pulmonary and cardiovascular system, circulation system, peripheral circulation, blood, neuromuscular units and muscle metabolism¹⁰.

Our study showed the same result in which we found VO₂max decline in all samples, both subacute and chronic. This was in accordance with the result from Kelly et al. (2005) who reported cardiorespiratory fitness decline stroke onset of 4-7 weeks. Cardiorespiratory decline was significant physical impairment in post-stroke patients, regardless their genders, within approximately 30 days after stroke onset. Their findings also indicated that gait performance might be affected by cardiorespiratory fitness decline⁸.

Our findings implied a relation between VO₂max and mileage (Table 5.8). This corresponded with the statement from Kelly et al. (2005) that cardiorespiratory fitness measure was well-associated with gait performance where VO₂max showed positive correlation with mileage in measurement using 6MWT in subacute stroke patients. Walking test was designed as an objective measurement for functional status and reflected cardiorespiratory measurement in several individuals. Correlation between 6MWT mileage (meter) and VO₂max was within the range of 0.51-0.9².

Walking speed was a parameter of disability in walking fast and easily which was recommended as a output measuring instrument in stroke rehabilitation. Currently, there are several methods of walking speed measurement.

This study measured 10MWT walking speed in stroke patients with subacute and chronic onset where 20 subjects used walking aids and 18 others did not. The average of walking speed observation result in 22 male subjects with fast-speed was slower than with self-speed (see Table 8). This might occur when patients who had walking spasticity with fast speed would have stronger spasticity which inhibited patients in walking¹¹.

Calf muscle spasticity showed deviation of muscle tendon length pattern. The deviation pattern was more obvious in walking speed increase. In swing phase, spastic calf muscle was extracted one-third times faster than in normal state. The more deviation in muscle tendon length pattern led to the more rapid dependent velocity in spasticity. This inhibited patients' walking process, especially in those with fast speed and therefore led to walking speed limitation in patients¹¹.

Observation result for correlation between 6MWT (by measuring mileage in meter) with 10MWT showed no significance ($p=0.000$) with correlation coefficient $r=0.756$. This is also in line with a study conducted by Scivoletto (2011) implying that both tests had inter and intra rater reliabilities and showed positive correlation with lower limb muscle strength¹⁶.

The findings of this study suggesting a relation between upper and lower limb spasticity and 6MWT can be seen in Table 5.5 as stated by Ivey (2005). Mileage and walking speed were strongly related to spasticity. Skeletal muscle consisted of fibers expressing myosin heavy chain (MHC) isoform. MHC protein had higher oxidative function, resistant to fatigue and more sensitive for insulin-mediated glucose absorbance in paretic side thigh muscles. Fast and slow MHC fiber shift in thigh muscles occurred in post-stroke and it caused muscle fibers easier to get tired and there would be more insulin resistance. Low fast MHC fiber immunity led to dependency toward anaerobic or glycolytic energy production. In paretic side extremity, fast MHC fiber proportion showed strong negative relation with self-speed walking speed. This indicated that walking pattern neurological deficit walking pattern severity was correlated with 61% variants in fast MHC isoform⁸. Aerobic capacity in individuals was correlated with cardiorespiratory fitness which was strongly associated with age, walking endurance and walking speed, and also associated with knee extensor muscle weakness during walking¹⁷.

Cardiorespiratory fitness decline in post-subacute and chronic stroke patients caused difficulty in daily activities, particularly in walking. Walking was an indicator of independence in an individual. The findings in this study were expected to be able to increase awareness of the importance of cardiorespiratory fitness in daily activities and therefore it was important to conduct walking speed test and mileage in stroke patients that could independently walk or use walking aids.

The use of 6MWT and 10MWT was expected to be conducted with the proper standard and not only limited in patients in outpatient units, but also patients discharged from inpatient unit in order for us to be able to monitor patients' fitness development objectively.

Conclusion

We found a relation between cardiorespiratory fitness and walking speed in post-subacute and chronic ischemic stroke.

Conflict of Interest : There is no conflict interest

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Ethical of Clearence: This study was approved by Ethical Commission of Health Research Faculty of Medicine University of Airlangga

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