

Correlation of Cardiorespiratory Fitness Levels with Functional Mobility Ability in Post Thrombotic Infarction Stroke Patient

Eny Susilowati¹, Reni Hendrarati Kusharyaningsih², Dewi Poerwandari²

¹Department of Physical Medicine and Rehabilitation, Faculty of Medicine, Universitas Airlangga, Dr. Soetomo Teaching Hospital, Universitas Airlangga, Surabaya 60285, Indonesia

Abstract

Background: Stroke patients often experience functional ambulation difficulties and lack ability to walk independently due to the reduction cardiorespiratory fitness so that an understanding of the relationship between fitness levels cardiorespiratory with functional mobility ability is needed, especially for thrombotic infarction stroke patients..

Objectives: This study aims to assess the relationship between cardiorespiratory fitness levels with functional mobility ability in the first three months after thrombotic infarction stroke.

Method: Subjects are 38 post trombotic infarction stroke. Functional mobility is measured by the Timed Up and Go test. Subjects were asked to stand up from a chair whose seat is \pm 46cm and the height of its back is 65cm, walk as far as 3 m, turn 1800, walk back and sit back. Data were analyzed and performed statistical test using SPSS 17.

Results: The study showed the average TUG test was 15.56-7.79 seconds with the longest travel time was 37.38 seconds and the fastest travel time was 8.16 seconds. The average of VO_{2max} was 10.62 ± 2.31 mL / kg / min, with the lowest VO_{2max} yield of 5.78mL / kg / min and the highest was 14.54mL / kg / minute. The TUG test had a negative correlation with VO_{2max} the 6 minute walk test result.

Conclusion: There is a significant relationship between cardiorespiratory fitness level and functional mobility abilities in post thrombotic infarction stroke patient.

Keywords: *Thrombotic Infarction Stroke, TUG, Cardiorespiratory fitness level, Functional Mobility Ability, VO_{2max}*

Introduction

Stroke incidence approximately occurs in 15 million population per year worldwide, 5 million people died and 5 million people experiencing sequelae and permanent disability¹⁻⁴. Stroke prevalence in Indonesia is 12.1 per

1,000 population⁵. The number of stroke incidences continues to increase along with rising risk factors and elderly population and can affect quality of life⁶ that leads to appropriate treatment^{7,8}. Motor impairment is the main cause of disability and limited mobility in individual with stroke⁹. Mobility recovery is the main purpose of stroke patient during rehabilitation since it serves as the key factor to be independent in daily activities¹⁰.

Stroke patient commonly has functional ambulation difficulties and reduced ability to walk independently due to decreased cardiorespiratory fitness, changes in neuromotor control and increased energy required

Corresponding Author:

Reni Hendrarati Kusharyaningsih

Departement of Physical Medicine and Rehabilitation,
Faculty of Medicine, Universitas Airlangga, Dr.
Soetomo Teaching Hospital, Universitas Airlangga,
Surabaya 60285, Indonesia,
Email: rmasduchi@gmail.com

for daily activities¹¹. Other research pointed out that improved Timed Up and Go (TUG) score was obtained in the first week until 3 months after stroke, while there was no significant change after those periods, and the patterns of mobility recovery differed by age groups. The age group above 80 suffer from decreased mobility in the third until the twelfth month after stroke, while mobility in other age groups tends to be stable¹².

Cardiorespiratory fitness decreases significantly in post-stroke patients. It brings negative effects to walking speed, endurance and performance in daily activities and stroke patient independence. Other study obtained minimum VO_{2max} (peak oxygen consumption) for age group of 85 to live independently was 17.7 mL/kg/minute for male and 15.4 mL/kg/minute for female¹². Minimum VO_{2max} in order to perform daily activities is 15 mL/kg/minute¹³. MacKay-Lyons and Makrides, in their study on assessing VO_{2max} in post-stroke patients after 1 month with body weight supported female, found average VO_{2max} was 14.4±5.1mL/kg/minute or around 60% of prediction value based on age and sex¹⁴.

Stroke patient has low cardiorespiratory fitness. Average VO_{2max} is an indicator of average aerobic capacity from 11.7±3.7 mL/kg/minute to 17.3±7.0 mL/kg/minute or around 50-60% of normal value based on age and sex. Low training capacity is a result of increased energy usage to walk due to paretic deficits. These deficits also cause low social participation and life quality¹⁵. The study is then aimed to investigate the correlation between cardiorespiratory fitness level and functional mobility ability in the first three months after thrombotic infarct stroke, factors affecting functional mobility ability and cardiorespiratory fitness level. Previous study found a correlation between TUG score and distance achieved in 6-minute walking test¹⁶.

Method

An observational analytic study was carried out at Medical Rehabilitation Unit of Dr. Soetomo Teaching Hospital, Surabaya, Indonesia from June 2015 using cross sectional study design. The samples were taken using consecutive sampling after fulfilling the inclusion criteria: post-thrombotic infarct stroke patients aged 21-70 (first stroke attack or recurrent attack) with unilateral or bilateral hemiparesis (leg muscle strength ≥ 3), onset ≥ 2 weeks until 3 months after thrombotic infarct stroke, subjects could walk 10 meters without aid, non-assistant, could comply with simple orders and signed

informed consent. The study protocol was approved by the ethics committees of Dr. Soetomo Teaching Hospital (Surabaya, Indonesia). 38 eligible subjects' functional mobility ability were measured using TUG test and 6-minute cardiorespiratory fitness test. The data were analyzed using SPSS 17.0 (SPSS, Inc., Chicago, IL)

Results

Subjects' characteristics

There were 38 subjects, consisting of 26 males and 12 females. The youngest and oldest subjects were 39 and 69 years old, respectively, with subjects' average age was 55.13±8.29. The subjects' average body mass index (BMI) was 24.25±4.05 kg/m². The subjects' average stroke onset was 6.60±3.20 weeks. There were 32 subjects (84.2%) with first stroke attack, 16 subjects with right right-sided hemiparesis and 22 subjects with left-side hemiparesis. There were 2 subjects used walking aids. There were 16 subjects with diabetes mellitus history, 36 with hypertension history, 11 with smoking history and 1 with alcoholic history. All subjects had lower extremity muscle strength ≥ 3 . Male subjects' muscle motor strength of paretic lower limb was better than female subjects after enhancement. 33 subjects (86.8%) were post-stroke patients who had first visitation to Medical Rehabilitation Unit of Dr. Soetomo Teaching Hospital, Surabaya, Indonesia and had not received rehabilitation therapy, while the rest 5 subjects (13.1%) had more than one visitations and received rehabilitation therapy.

Results of TUG and 6-minute walking tests

The results of functional mobility test using TUG test in 38 subjects showed average TUG time was 15.56±7.69 seconds, with longest and shortest TUG time were 37.38 seconds and 8.16 seconds, respectively (Table 1).

Table 1. Results of TUG test and VO_{2max}

Variabel	n	Mean	SD	Range value
TUG	38	15.56	7.69	8.16-37.38
VO2max	38	10.62	2.31	5.78-14.54

Table 2 showed mean rank of TUG time of all variables (sex, diabetes mellitus, smoking history,

hypertension history and hemiparesis).

Table 2. TUG test on variables

Variable		n	Mean rank TUG	P
Sex	M	26	16.96	p = 0.038
	F	12	25.00	
Diabetes mellitus	Yes	16	17.63	p = 0.375
	No	22	20.86	
Smoking	Yes	11	18.55	p = 0.735
	No	27	19.89	
Hypertension	Yes	36	20.14	p = 0.133
	No	2	8.00	
Hemiparesis	Right	16	14.5	p = 0.906
	Left	22	16.3	

The results of cardiorespiratory fitness assessment using 6-minute walking test showed the VO_{2max} were 14.54mL/kg/minute and 5.78mL/kg/minute, respectively. Table 3 showed average VO_{2max} of all variables (sex, diabetes mellitus, smoking history, hypertension history and hemiparesis).

Table 3. VO_{2max} of all variables

VO2max variables		n	Mean±SD	SD	P
Sex	M	26	11.32	1.91	p = 0.004
	F	12	9.10	2.42	
DM	Yes	16	10.64	2.73	p = 0.975
	No	22	10.61	2.01	
Smoking	Yes	11	10.64	2.42	p = 0.970
	No	27	10.61	2.31	
Hypertension	Yes	36	10.54	2.34	p = 0.343
	No	2	12.15	0.74	
Hemiparesis	Right	16	10.79	2.16	p = 0.702
	Left	22	10.50	2.45	

Association between cardiorespiratory fitness and functional mobility ability

Spearman’s correlation test showed a negative correlation between TUG time and VO_{2max} . TUG time

correlated with age ($r = 0.387$, $p = 0.016$), while it had no correlation with onset ($r = 0.106$, $p = 0.525$) and BMI ($r = 0.183$, $p = 0.270$). VO_{2max} did not correlate with age ($r = -0.168$, $p = 0.313$), onset ($r = -0.277$, $p = 0.092$) and BMI ($r = 0.158$, $p = 0.343$; Table 5).

Table 4. Correlation between TUG test and VO_{2max}

		TUG
VO _{2max}	r p	-0,803 0.0001*

r: correlation coefficient; *significant correlation in p <0.01 (2-tailed)

Table 5. Correlation between TUG test and age, onset and BMI

Variable	TUG		VO _{2max}	
	R	P	r	P
Age	0.387	0.016**	-0.168	0.313
Onset	0.106	0.525	-0.277	0.092
BMI	-0.183	0.270	0.158	0.343

r: correlation coefficient; **significant correlation in p <0.05 (2-tailed)

Discussion

The study found that there is a correlation between cardiorespiratory fitness level and functional mobility ability in post-thrombotic infarct stroke patients. The higher the VO_{2max} in 6-minute walking test, the lower the TUG score. Cardiorespiratory fitness decreased, VO_{2max} <25.2 ml/kg/minute is associated with increased stroke risk and ischemic stroke, and this is a modifiable risk factor that requires training intervention for increased cardiorespiratory fitness¹⁷. The average TUG time in subjects with average stroke onset of 6.60±3.20 weeks was 15.56±7.69 seconds, faster than the finding of Persson et al. They found TUG score of 17.0±11.0 seconds in the first-week test, slower than three-month evaluation (14.5±10.0 seconds)¹². It was due to improving process of post-stroke impairment, non-optimal lower limb muscle strength improvement and greatest mobility improvement in the first three month after stroke¹². There were 36 subjects (94.7%) with hypertension risk factor, 16 DM subjects (42.1%) and 11 active smokers (28.9%). Hypertension risk factor has been known to increase stroke risk five times, DM and smoking increase stroke risk twice¹⁸.

VO_{2max} in stroke patients ranged from 11.4±3.7 to 17.3±7.0 ml/kg/minute or around 50-60% compared to normal subjects with same age and sex. Lower training capacity can be exacerbated by increased energy used in each movement associated with functional deficit and decrease social participation that result in poor quality of life¹⁹. The VO_{2max} was measured using training test as a gold standard to assess cardiorespiratory fitness. Stroke patients have limitations in performing training test due to decreased strength and sensory impairment¹¹. Six-minute walking test is a submaximal test since patients determine their own walking speed. The test is performed in 100-foot track or around 30 meters in accordance with American Thoracic Society (ATS) guidelines²⁰. The study used 10-meter track since subjects in the study were subacute post-stroke patients who had not performed stress test. Therefore, emergency condition could be easily detected, and patients could be immediately treated. Pohl et al. in their study used 10-meter track for initial screening before conducting 6-minute walking test²¹.

The average VO_{2max} was 10.62±2.31 ml/kg/minute, a little bit lower than the finding of Tang et al. (12.3±3.1 ml/kg/minute)¹¹. Pohl et al. in their study in 72 subjects found average distance obtained in 6-minute walking test was 215.8±91.6 meters in 73.3±26.8 days of onset²¹, a little bit higher than the result found in the study (206±78.6 meters). Normal distance obtained in the 6-minute walking test was 593±57 meters for female and 638±44 meters for male²². The study found a slightly lower distance than Pohl et al. since subjects in their study had received training program, either strength, balance or endurance in lower and upper limbs for 12 weeks¹⁶. On the other hand, 86.8% of our subjects were post-stroke patients who first visited medical rehabilitation unit. Pohl et al. used 30-meter track, while we used 10-meter track that required a lot of time for turning.

Cardiorespiratory fitness varies from age, sex, physical activity level, body composition and chronic or disability presence¹⁴. In this study, VO_{2max} obtained from 6-minute walking test was not significantly affected by age, stroke onset, hemiparesis and BMI. Subjects were relatively young (55.13±8.29), hence there was no decreased muscle mass and strength that subsequently shortened the distance. All subjects were in subacute phase. Our findings were not affected by BMI since 47.4% of all subjects had normal BMI. Subjects with obesity had a shorter distance. Nevertheless, VO_{2max} was

significantly different by sex since male had a longer distance compared to female. Male was higher than female, therefore they had a wider stride length when walking²². VO_{2max} was significantly difference due to hypertension risk factor, DM and smoking habit. In this study, blood pressure in subjects with hypertension history was controlled by drugs. Subjects in this study were dominated by non-DM patients (57.9%) and non-smokers (71.1%). Dourado et al. found arterial hypertension and smoking significantly affected distance during 6-minute walking test²³. The study found around 40% of post-stroke cardiorespiratory fitness decreased compared to normal people.

The study found significant TUG time and age differences between male and female subjects ($p = 0.038$ and $p = 0.016$, respectively). It might be due to male subjects (68.4%) were more than female subjects (31.6%), and male's lower limb motoric improvement was better than female's. Subjects aged <60 were 24 (63.2%). There was no decreased muscle mass, muscle strength and coordination in this age group. The study found no significant TUG time difference based on onset, BMI, hemiparesis side, DM history, hypertension and smoking. TUG score in the previous studies were affected by muscle strength, balance, coordination, spasticity and postural control anticipation^{9,16,24}. Ng et al. found a negative correlation between walking speed and TUG score at a comfortable pace, even though TUG test is a series of movements and commands requiring balance control of muscle strength and coordination¹⁶.

In this study, post-stroke patient's TUG time was longer than healthy subject. It indicated decreased functional mobility ability in post-stroke patients, in which subjects are still independently capable of main transfer with or without aids, but are at risk of failing. Distance in 6-minute walking test is used to calculate VO_{2max} as it reflects a person's cardiorespiratory fitness level. In this study, VO_{2max} was negatively correlated with TUG time. The longer the distance, the larger the VO_{2max} , and it shows better cardiorespiratory fitness. The shorter the TUG time, the better the mobility status. Therefore, the higher the VO_{2max} , the shorter the TUG time. It indicates that subject with better cardiorespiratory fitness level has better functional mobility¹⁶

Conclusion

The study showed a significant correlation between cardiorespiratory fitness level and functional mobility

ability in post-thrombotic infarct stroke patients. The higher the VO_{2max} in 6-minute walking test, the lower the TUG score.

Ethical Clearance: The study has been approved by ethical committee in Dr. Soetomo Teaching Hospital Surabaya, Indonesia.

Conflict of Interest: The author reports no conflict of interest of this work.

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References

1. Imanda A, Martini S, Artanti KD. Post Hypertension and Stroke: A Case Control Study. *Kesmas Natl Public Heal J*. 2019;13(4):164–8.
2. Santosa W, Kalanjati VP, Machin A. Are there any correlations between embolic stroke and previous post-traumatic epilepsy?—Study from a case report. In: *IOP Conference Series: Materials Science and Engineering*. IOP Publishing; 2018. p. 12326.
3. Stoller O, de Bruin ED, Schuster-Amft C, Schindelholz M, de Bie RA, Hunt KJ. Cardiovascular rehabilitation soon after stroke using feedback-controlled robotics-assisted treadmill exercise: study protocol of a randomised controlled pilot trial. *Trials*. 2013;14(1):304.
4. Pramudita K, Notobroto HB. Analisis Survival Kecepatan Kekambuhan Stroke. *J Biometrika dan Kependud*. 2018;6(1):62–9.
5. Dasar RK. Laporan Hasil Riset Kesehatan Dasar (Riskesdas) Nasional 2007. Jakarta Badan Litbangkes, Depkes RI. 2007;
6. Sawab S, Bahrudin M, Daulima NHC. Hopelessness Experience among Stroke Survivor in Semarang. *J Ners*. 2015;10(1):125–32.
7. Maharani A, Praveen D, Oceandy D, Tampubolon G, Patel A. Cardiovascular disease risk factor prevalence and estimated 10-year cardiovascular risk scores in Indonesia: The SMARThealth Extend study. *PLoS One*. 2019;14(4):e0215219.
8. Fadilah N, Kusnanto K, Nursalam N, Rahariyani LD. Analysis of influencing factors of burden of caregiver among stroke patients at home. *J Public Health Africa*. 2019;
9. Faria CD, Teixeira-Salmela LF, Silva EB, Nadeau S. Expanded timed up and go test with subjects

- with stroke: reliability and comparisons with matched healthy controls. *Arch Phys Med Rehabil.* 2012;93(6):1034–8.
10. van Wijk I, Algra A, van de Port IG, Bevaart B, Lindeman E. Change in mobility activity in the second year after stroke in a rehabilitation population: who is at risk for decline? *Arch Phys Med Rehabil.* 2006;87(1):45–50.
 11. Tang A, Sibley KM, Bayley MT, McIlroy WE, Brooks D. Do functional walk tests reflect cardiorespiratory fitness in sub-acute stroke? *J Neuroeng Rehabil.* 2006;3(1):23.
 12. Persson CU, Danielsson A, Sunnerhagen KS, Grimby-Ekman A, Hansson P-O. Timed Up & Go as a measure for longitudinal change in mobility after stroke—Postural Stroke Study in Gothenburg (POSTGOT). *J Neuroeng Rehabil.* 2014;11(1):83.
 13. Shephard RJ. *Gender, physical activity, and aging.* CRC Press; 2001.
 14. MacKay-Lyons MJ, Makrides L. Exercise capacity early after stroke. *Arch Phys Med Rehabil.* 2002;83(12):1697–702.
 15. Baert I, Daly D, Dejaeger E, Vanroy C, Vanlandewijck Y, Feys H. Evolution of cardiorespiratory fitness after stroke: a 1-year follow-up study. Influence of prestroke patients' characteristics and stroke-related factors. *Arch Phys Med Rehabil.* 2012;93(4):669–76.
 16. Ng SS, Hui-Chan CW. The timed up & go test: its reliability and association with lower-limb impairments and locomotor capacities in people with chronic stroke. *Arch Phys Med Rehabil.* 2005;86(8):1641–7.
 17. Kurl S, Laukkanen JA, Tuomainen T-P, Rauramaa R, Lakka TA, Salonen R, et al. Association of exercise-induced, silent ST-segment depression with the risk of stroke and cardiovascular diseases in men. *Stroke.* 2003;34(7):1760–5.
 18. Cuccurullo SJ. *Physical medicine and rehabilitation board review.* Demos Medical Publishing; 2014.
 19. Mattlage AE, Ashenden AL, Lentz AA, Rippee MA, Billinger SA. Submaximal and peak cardiorespiratory response after moderate-high intensity exercise training in subacute stroke. *Cardiopulm Phys Ther J.* 2013;24(3):14.
 20. Laboratories ATSC on PS for CPF. *ATS statement: guidelines for the six-minute walk test.* *Am J Respir Crit Care Med.* 2002;166:111–7.
 21. Pohl PS, Duncan PW, Perera S, Liu W, Lai SM, Studenski S, et al. Influence of stroke-related impairments on performance in 6-minute walk test. *J Rehabil Res Dev.* 2002;39(4):439–44.
 22. Chetta A, Zanini A, Pisi G, Aiello M, Tzani P, Neri M, et al. Reference values for the 6-min walk test in healthy subjects 20–50 years old. *Respir Med.* 2006;100(9):1573–8.
 23. Dourado VZ. Reference equations for the 6-minute walk test in healthy individuals. *Arq Bras Cardiol.* 2011;96(6):e128–38.
 24. Shumway-Cook A, Brauer S, Woollacott M. Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go Test. *Phys Ther.* 2000;80(9):896–903.