Physical Medicine and Rehabilitation - International

Open Access

Austin Publishing Group

Special Article - Stroke Rehabilitation

Test-retest Reliability of Cardiorespiratory Variables Measured with the Metamax 3b During the Six-minute Walking Test after Stroke

Polese JC[1,2]*, Ada L[2], Parreira VF[1], Faria GS[1], Avelino P[1], Teixeira-Salmela LF[1]

[1]Department of Physical Therapy, Universidade Federal de Minas Gerais, Brazil

[2]Discipline of Physiotherapy, The University of Sydney, Australia

***Corresponding author:** Polese JC, Department of Physical Therapy, Universidad Federal de Minas Gerais, Brazil, Discipline of Physiotherapy, The University of Sydney, Australia

Received: December 12, 2014; **Accepted:** February 01, 2015; **Published:** February 03, 2015

Abstract

Introduction: Subjects after stroke expend more energy, when performing the same activity as healthy controls, but it is not known whether subjects after stroke expend the same amount of energy during daily life activities. However, to allow the measurement during daily activities is necessary to use portable equipment. Thus, the aim of this study was determine the test-retest reliability of cardiorespiratory variables measured with the Metamax 3B and polar heart rate monitor during the 6-minute Walking Test (6MWT) after stroke.

Methods: Twenty-one individuals with chronic stroke (13 men, mean age of 59 years, mean time since the onset of stroke of 30 months) underwent two 6MWT within an interval of 7 days wearing a Metamax 3B and a polar heart rate monitor. Intra-class correlations coefficients ($ICC_{2,1}$), within-participant t-tests, standard errors of measurement and Bland-Altman plots were calculated for cardiorespiratory variables (relative and absolute oxygen consumption, carbon dioxide production, respiratory exchange ratio, minute ventilation and heart rate) during the 6MWT. Results: The $ICC_{2,1}$ values ranged from 0.76-0.97. Mean differences between test 1 and 2 ranged from 0-4%.The SEM% ranged from 1-12%.

Conclusions: The present findings support the test-retest reliability of the Metamax 3B during overground walking after stroke.

Keywords: Stroke; Walking; Portable gas analysis; Oxygen consumption; Measurement; Reliability

Introduction

Stroke is the leading cause of disability worldwide, which lead to serious disabilities [1]. According to the latest statement by the American Heart Association, the central goal for the current decade is a sufficient level of physical activity, with the aim of improving cardiovascular health and reducing deaths caused by stroke [2]. This goal is based on the finding that physical activity has a neuro protective effect against recurrent stroke [3] and decreasing recurrent stroke will decrease the incidence of stroke [4,5]. However, subjects after stroke have low levels of physical activity, compared with healthy individuals and very rarely meet the American Guidelines for Stroke which recommend at least 150 minutes of moderate-intensity physical activity per week [2,3]. A recent systematic review on physical activity after stroke found that subjects with stroke took 53% steps/day of healthy controls [6]. On the other hand, the findings from two studies [7,8] suggested that although there is a decrease in frequency of activity, subjects after stroke spend much the same amount of time being active as normal. Given that subjects after stroke expend more energy when performing the same *standardised* activity as healthy controls [9], the question raised as to whether subjects after stroke would expend the same amount of energy during everyday life as healthy controls, in spite of their reduced frequency of activity.

Gas analysis is the gold standard measure to investigate energy expenditure [10]. However, most gas analysis in subjects with stroke has been done during incremental tests on a treadmill or cycle ergometer in order to measure *maximum* oxygen consumption [10]. To investigate energy consumption during everyday life, it is necessary to use portable monitoring equipment, which allows the person to move freely around the environment.

The aim of this study was, therefore, to investigate the test-retest reliability of portable monitor's equipment during an everyday activity – overground walking. The Metamax 3B (Cortex, Germany) is a portable, gas analysis system which is light (1.4 kg) and allows the transmission "online" of respiratory variables for a distance of up to 800 meters. With the addition of a heart rate monitor, this allows the collection of both cardiac and respiratory variables during everyday activities such as walking. The cardiorespiratory variables are adjusted in real time, according to the environmental conditions, by means of temperature sensors, internal pressure sensors and an electronic barometer. The Metamax 3B is valid and reliable when used to measure cardio respiratory variables during everyday activities in healthy individuals [11]. However, no studies have thus been conducted to assess cardiorespiratory variables during overground walking in stroke individuals using the Metamax 3B. To investigate test-retest reliability, subjects with chronic stroke (time since stroke >1 year) were studied. The specific research question for this study was:

Citation: Polese JC, Ada L, Parreira VF, Faria GS, Avelino P, Teixeira-Salmela LF. Test-retest Reliability of Cardiorespiratory Variables Measured with the Metamax 3b During the Six-minute Walking Test after Stroke. Phys Med Rehabil Int. 2015;2(1): 1028.

What is the test-retest reliability of cardiorespiratory variables measured with a Metamax 3B and a polar heart rate monitor during the 6-minute Walk Test (6MWT)?

The establishment of reliability of portable monitoring equipment under stable conditions (i.e., in chronic stroke) is the first step in investigating energy expenditure during everyday activities after stroke.

Methods

Design

Subjects with chronic stroke were recruited from the general community in a metropolitan city in Brazil. Individuals came to a University laboratory twice within 7 days. On each occasion, they performed a 6MWT while metabolic monitoring equipment collected their cardiorespiratory variables. The 6MWT was performed at the same time of day and at least 500 ml of water was provided prior to each test, to guarantee normal hydration. First, the participants walked the course of 30 meters without monitoring equipment to familiarise themselves with the 6MWT. Then, after familiarisation, they rested for 3 minutes to stabilise the Metamax 3B. After, they performed the 6MWT, following the procedures and recommendations of the American Thoracic Society [12,13]. This study was approved by the Research Review Board of the Universidad Federal de Minas Gerais and all participants provided written consent prior to data collection.

Participants

Volunteers were eligible if they: were ≥ 20 years old; had a mean time since the onset of a unilateral stroke between one and five years; were able to walk independently with or without assistive devices; had no cognitive deficits, as determined by the Mini-Mental State Examination Brazilian cut-off scores, which were adjusted for levels of education [14]; were not undergoing rehabilitation, and had no other neurological or orthopaedic disorders.

Characteristics, such as age, gender, body mass index, side of hemiparesis, time since onset of stroke, number of medications and co-morbidities, levels of physical activity (adjusted activity scores of the Human Activity Profile) [15], levels of independence (Barthel Index) [16], walking speed (10-m Walk Test) [17] and walking capacity (distance covered during the 6MWT) [17] were collected for characterization purposes.

Measurement of cardiorespiratory variables

Participants wore a Metamax 3B for the collection of the following respiratory variables: Relative and absolute oxygen consumption [Vo_2] in ml/min/kg and L/min), carbon dioxide production [VCo_2] in L/min, respiratory exchange ratio [RER], minute ventilation [VE] in L/min). In addition, the polar heart rate monitor provided the cardiac variables (heart rate [HR], in bpm). The Metamax 3B was calibrated in three ways before each test: barometric, gas, and volume calibration. The means of the final three minutes of the 6MWT (steady state condition) were used for analyses [18].

Analysis of test-retest reliability

Test-retest reliability was assessed in four ways. Firstly, intra-class correlation coefficients ($ICC_{2,1}$) and 95% confidence intervals (CI) were calculated for all cardiorespiratory variables obtained at Tests 1 and 2. An ICC value < 0.4 was considered poor, 0.4 to 0.75 as fair to good, and > 0.75 as excellent [19]. Secondly, within-participant t-tests (mean and 95% CI) were calculated between the tests 1 and 2. Third, the standard errors of measurement (SEM) were calculated, as follows: SEM= $s\sqrt{(1.00 - r)}$, where s is the standard deviation and r is the test-retest ICC [20,21]. The SEM was expressed as a percentage of the average values of tests 1 and 2. SEM values < 15% were considered acceptable [21]. Lastly, Bland & Altman plots were generated for relative Vo_2 to assess the agreement between the tests 1 and 2 [22]. All analyses were carried out with the SPSS for Windows software (release 17.0) with a significance level of 5%.

Table 1: Characteristics of participants.

Characteristic		n=21
Age (years), mean (SD)		59 (15)
Gender, n male (%)		13 (62)
Body mass index (kg/m2), mean (SD)		26 (4)
Paretic side, n right (%)		10 (48)
Time since the onset of stroke (months), mean (SD)		30 (17)
Medications (number), mean (SD)		5 (2)
Associated pathologies (number), mean (SD)		2 (1)
Human Activity Profile (0-94), mean (SD)		58 (16)
Barthel Index (0-20), mean (SD)		19 (1)
Walking speed (m/s), mean (SD)		0.89 (0.30)
Walking distance (m), mean (SD)	Test 1	359 (140)
	Test 2	366 (139)

SD: standard deviation, AAS: adjusted activity scores.

Results

Twenty-one individuals with stroke (13 men), with a mean age of 59 (SD 15) years, a mean time since the onset of stroke of 30 (SD 17) months participated. All participants were taking oral medications, primarily anti-hypertensive drugs. Eight individuals required assistive devices (cane = 4 individuals; walker = 4 individuals) to walk during the 6MWT. The distance covered during the 6MWT was very similar between the tests, illustrating that the participants' walking was stable. Their characteristics are summarized in Table 1.

The cardiorespiratory variables for both tests along with the correlation coefficients are given in Table 2. The $ICC_{2,1}$ values ranged from 0.76 to 0.97 the mean differences between the tests 1 and 2 ranged from 0-3%.The SEM% ranged from 1 to 12%.

The Bland and Altman plot in Figure 1 showed the within-participant change across tests 1 and 2 in relative Vo_2 as a function of the individual mean on tests 1 and 2 relative to the Vo_2. The mean difference between tests 1 and 2 was approximately 1%. Second, the SD (2.3) was also small compared with the relative Vo_2 (11.0). Third, there appeared to be no relations between the differences in the two tests and the mean of the two tests.

Discussion

This study investigated the test-retest reliability of cardiorespiratory variables measured with a Metamax 3B and polar heart rate monitor during overground walking after stroke. All ICCs were greater than 0.76, demonstrating excellent reliability. In addition, the mean difference between the tests was small (0-4%) and the

Table 2: Cardiorespiratory variables for each 6-min Walk Test and the relation between tests (n=21).

Cardiorespiratory variables	Test 1	Test 2	Average of Tests		Test-retest reliability		
	Mean (SD)	Mean (SD)	Mean (SD)		ICC2,1 (95% CI)	MD (95%IC)	SEM (%)
Relative VO2 (ml/min/kg)	11.0 (2.4)	10.9 (3.1)	10.9 (2.5)		0.80 (0.51 to 0.92)	-0.1 (-1.1 to 1.0)	1.1 (10)
Absolut VO2 (L/min)	0.76 (0.18)	0.78 (0.18)	0.77 (0.17)		0.85 (0.62 to 0.94)	0.01 (-0.04 to 0.07)	0.07 (9)
VCO2 (L/min)	0.70 (0.18)	0.76 (0.18)	0.73 (0.16)		0.76 (0.42 to 0.90)	0.06 (-0.01 to 0.12)	0.09 (12)
RER	0.91 (0.04)	0.91 (0.04)	0.91 (0.04)		0.97 (0.92 to 0.99)	0.00 (-0.01 to 0.00)	0.01 (1)
VE (L/min)	27 (6)	28 (9)	28 (7)		0.81 (0.52 to 0.92)	1 (-2 to 3)	3 (9)
HR (bpm)	101 (18)	104 (20)	103 (18)		0.92 (0.80 to 0.97)	3 (-2 to 7)	5 (5)

ICC = Intraclass Correlation Coefficient; CI = Confidence Interval; VO_2 =, Oxygen Consumption; VCO_2 = carbon dioxide production; RER = *Respiratory Exchange* Ratio; VE = Ventilation; HR = Heart Rate; MD = Mean Difference; SEM = Standard Error of Measurement.

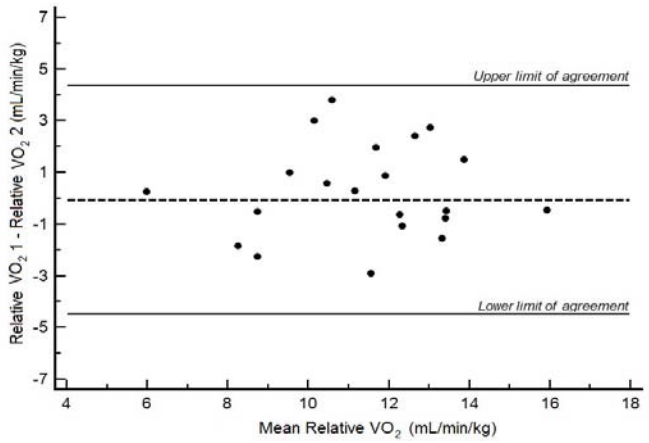

Figure 1: Bland and Altman plot. Individual difference in relative VO_2 (mL/kg/min) between Test 1 and 2, plotted against individual mean (Test 1 and 2) relative VO_2 (mL/kg/min). Dashed line shows the group mean relative Vo_2 between Test 1 and 2 (-0.1 mL/kg/min). The 95% upper and lower limits of agreement represent 2 standard deviations above and below the group mean difference in relative VO_2 between Test 1 and 2 (-4.5 to 4.4).

SEM% was below 15%. The Bland Altman plot of the relative Vo_2 also indicated high agreement between the tests. Since all four methods of investigating test-retest reliability produced similar results, it can be concluded the Metamax 3B is stable during overground walking in subjects with stroke.

The investigation of test-retest reliability was carried-out, following rigorous methods. The sample of subjects with stroke had a time after stroke (mean 30 months, SD 17) and was not undergoing rehabilitation. This sample was chosen to ensure stability of their walking patterns across the tests. The similarity in distance covered during the 6MWT between tests 1 and 2 illustrates that walking capacity contributed little to the error in test-retest reliability. In addition, the sample reflects a broad range of walking ability, contributing to generalization of the results. While on average they walked at 66% of normal speed according to their ages [23], and covered 67% of the normal distance during 6MWT [23], their walking speeds ranged from 0.4 to 1.1 m/s and walking distances from 115 to 618 m.

The reliability and use of the Metamax 3B has been firmly established for healthy individuals during everyday activities and incremental tests [11,24,25]. In subjects with stroke, the reliability of another portable monitoring equipment – K4b2 (COSMED USA; Chicago, IL) has been recently established [26]. The ICCs of the cardiorespiratory variables between the two 6MWT with 23 chronic stroke individuals ranged from 0.66 to 0.95. The ICC values from the K4b2 plus polar the heart rate monitor were similar to the findings of the present study with the Metamax 3B plus polar heart rate monitor and both reflected excellent reliability (> 0.75) [19] for relative Vo_2 (0.90 vs 0.80), absolute Vo_2 (0.93 vs 0.85), VCO_2 (0.93 vs 0.76), VE (0.95 vs 0.81) and HR (0.76 vs 0.92). Only RER was not excellent from the K4b2 (0.66 vs 0.97). The combination of these findings suggests that portable monitoring equipment is reliable for the assessment of cardiorespiratory variables during an everyday activity – overground walking – after stroke. This is important for the investigation of energy expenditure of subjects after stroke during everyday activity within community settings.

Conclusions

The results of the present study reinforce the reliability of the Metamax 3B, since excellent ICCs were found for all cardiorespiratory variables during the 6MWT. Therefore, the Metamax 3B can provide stable measurement during overground walking by subjects with stroke.

References

1. Lauretani F, Saccavini M, Zaccaria B, Agosti M, Zampolini M, Franceschini M; et al. Rehabilitation in patients affected by different types of stroke. A one-year follow-up study. Eur J Phys Rehabil Med. 2010; 46: 511-516.

2. Kernan WN, Ovbiagele B, Black HR, Bravata DM, Chimowitz MI, Ezekowitz MD, et al. Guidelines for the prevention of stroke in patients with stroke and transient ischemic attack: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke 2014; 45: 2160-2236.

3. Gordon NF, Gulanick M, Costa F, Fletcher G, Franklin BA, Roth EJ, et al. Physical activity and exercise recommendations for stroke survivors: an American Heart Association scientific statement from the Council on Clinical Cardiology, Subcommittee on Exercise, Cardiac Rehabilitation, and Prevention; the Council on Cardiovascular Nursing; the Council on Nutrition, Physical Activity, and Metabolism; and the Stroke Council. Circulation 2004; 16: 2031-2041.

4. Wendel-Vos GC, Schuit AJ, Feskens EJ, Boshuizen HC, Verschuren WM, Saris WH, et al. Physical activity and stroke. A meta-analysis of observational data. Int J Epidemiol. 2004; 33: 787-798.

5. Lee CD, Folsom AR, Blair SN. Physical activity and stroke risk: a meta-analysis. Stroke. 2003; 34: 2475-2481.

6. English C, Manns PJ, Tucak C, Bernhardt J. Physical activity and sedentary behaviors in people with stroke living in the community: a systematic review. Phys Ther. 2014; 94: 185-196.

7. Alzahrani MA, Ada L, Dean CM. Duration of physical activity is normal but frequency is reduced after stroke: an observational study. J Physiother. 2011; 57: 47-51.

8. Sakamoto K, Nakamura T, Sajima Y, Miyake T, Yamanaka M, Tajima F. Physical activities and steps in daily living after stroke. Journal of the Wakayama Medical Society 2008; 59: 67–72.

9. Galea SL, Lee MJ, English C, Ada L. Sedentary versus active behaviour in people after stroke: a systematic review. Phys Ther Rev [in press].

10. Smith AC, Saunders DH, Mead G. Cardiorespiratory fitness after stroke: a systematic review. Int J Stroke. 2012; 7: 499-510.

11. Macfarlane DJ, Wong P. Validity, reliability and stability of the portable Cortex Metamax 3B gas analysis system. Eur J Appl Physiol. 2012; 112: 2539-2547.

12. ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories. ATS statement: guidelines for the six-minute walk test. Am J Respir Crit Care Med. 2002; 166: 111-117.

13. Britto RR, Probst VS, de Andrade AF, Samora GA, Hernandes NA, Marinho PE, et al. Reference equations for the six-minute walk distance based on a Brazilian multicenter study. Braz J Phys Ther. 2013; 17: 556-563.

14. Bertolucci PH, Brucki SM, Campacci SR, Juliano Y. [The Mini-Mental State Examination in a general population: impact of educational status]. Arq Neuropsiquiatr. 1994; 52: 1-7.

15. Souza AC, Magalhaes LC, Teixeira-Salmela LF. Adaptação transcultural e Análise das propriedades psicométricas da versão brasileira do Perfil de Atividade Humana. Cad Saude Publica 2006; 22: 2623-2636. [article in Portuguese] .

16. Quinn TJ, Langhorne P, Stott DJ. Barthel index for stroke trials: development, properties, and application. Stroke. 2011; 42: 1146-1151.

17. Flansbjer UB, Holmbäck AM, Downham D, Patten C, Lexell J. Reliability of gait performance tests in men and women with hemiparesis after stroke. J Rehabil Med. 2005; 37: 75-82.

18. Wasserman K, Hansen JE, Sue DY, Stringer W, Whipp B. Clinical Exercise Testing. In: Weinberg A, ed. Principles of Exercise Testing and Interpretation, 4th edition. Philadelphia: Lippincott, Williams and Wilkins, 2005:133-159.

19. Shrout PE, Fleiss JL. Intraclass correlations: uses in assessing rater reliability. Psychol Bull. 1979; 86: 420-428.

20. de Vet HC, Terwee CB, Knol DL, Bouter LM. When to use agreement versus reliability measures. J Clin Epidemiol. 2006; 59: 1033-1039.

21. Beckerman H, Roebroeck ME, Lankhorst GJ, Becher JG, Bezemer PD, Verbeek AL. Smallest real difference, a link between reproducibility and responsiveness. Qual Life Res. 2001; 10: 571-578.

22. Euser AM, Dekker FW, le Cessie S. A practical approach to Bland-Altman plots and variation coefficients for log transformed variables. J Clin Epidemiol. 2008; 61: 978-982.

23. Bohannon RW, Williams Andrews A. Normal walking speed: a descriptive meta-analysis. Physiotherapy. 2011; 97: 182-189.

24. Brandes M, VAN Hees VT, Hannöver V, Brage S. Estimating energy expenditure from raw accelerometry in three types of locomotion. Med Sci Sports Exerc. 2012; 44: 2235-2242.

25. Vogler AJ, Rice AJ, Gore CJ. Validity and reliability of the Cortex MetaMax3B portable metabolic system. J Sports Sci. 2010; 28: 733-742.

26. Stookey AD, McCusker MG, Sorkin JD, Katzel LI, Shaughnessy M, Macko RF, et al. Test-retest reliability of portable metabolic monitoring after disabling stroke. Neurorehabil Neural Repair 2013; 27: 872-877.

Phys Med Rehabil Int - Volume 2 Issue 1 - 2015
ISSN : 2471-0377 | www.austinpublishinggroup.com

Citation: Polese JC, Ada L, Parreira VF, Faria GS, Avelino P, Teixeira-Salmela LF. Test-retest Reliability of Cardiorespiratory Variables Measured with the Metamax 3b During the Six-minute Walking Test after Stroke. Phys Med Rehabil Int. 2015;2(1): 1028.