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Reliability of Treadmill Exercise Testing in Adults With Chronic Hemiplegia and Elderly People

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Abstract

The purpose of this study was to assess the test-retest reliability of heart rate (HR) and velocity measurements during peak effort and free treadmill walking tests in older patients with gait-impaired chronic hemiparetic stroke and control group. Twenty-two adults (13 men, 9 women; mean age, 73.7±5.2 yrs) with chronic hemiparetic stroke are the experimental group. Nineteen elderly people (5 men, 14 women; mean age, 72.3±3.5 yrs) were recruited as control group. Patients had mild to moderate chronic hemiparetic gait deficits, making handrail support necessary during treadmill walking. Free and peak effort treadmill walking tests were measured and then repeated at least two days later. Reliability was calculated from HR and walking velocity during free and peak effort treadmill walking test. Among the people who had strokes, HR [ICC(2,1)=.85, r=.86] and velocity [ICC(2,1)=.93, r=.93] were good parameters during free testing. Maximal testing generated good results for HR [ICC(2,1)=.81, r=.82] and velocity [ICC(2,1)=.96, r=.96] with the chronic hemiparetic stroke. In elderly people, HR [ICC(2,1)=.59, r=.62] and velocity [ICC(2,1)=.77, r=.76] were moderately reliable during free testing. Maximal testing produced moderate parameters for HR [ICC(2,1)=.74, r=.74] and velocity [ICC(2,1)=.66, r=.66] in the elderly. This study provides that free and maximal treadmill testing produce highly reliable HR and velocity measurements in adults with chronic hemiplegia using minimal handrail support.

Key Words: Reliability; Stroke; Treadmill exercise.

Introduction

Cardiovascular disease is the leading prospective cause of death in chronic stroke victims (Roth, 1993; Sacco et al, 1982). Inactivity and low cardiovascular fitness activity, which are common in victims of stroke, are among the modifiable risk factors associated with cardiovascular disease. Given the deeply poor cardiovascular fitness of victims of stroke (Ryan et al, 2000), it would be ideal to develop reliable methods that relate to levels of cardiovascular fitness for these individuals (Franklin, 2001).

Two thirds are left with chronic neurologic deficits, which persistently impair function (Gresham et al, 1975; Gresham et al, 1979; Jorgensen et al, 1995). Specifically, stroke-induced hemiparetic gaits impair mobility, create poor balance, and increase the risk of falls (Franklin, 2001; Gresham et al, 1979). Increasing amounts of research suggests that aerobic exercise training using a variety of modalities can improve cardiovascular fitness in chronic hemiparetic stroke patients (Macko et al, 1997; Potempa et al, 1995; Rimmer et al, 2000). Furthermore, treadmill training in chronic stroke patients decreases hamstring spasticity, increases quadricep strength (Smith et al, 1999), and dynamic balance performance (Smith et al, 2000), and improves ambulatory ability (Silver et al, 2000). Accordingly, there is a strong rationale for

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using treadmill training in older hemiparetic stroke patients, given that it improves mobility and facilitates locomotor relearning (Forrester et al, 2002; Silver et al, 2000). And the symptom-limited graded exercise test is a protocol that serves two purposes: it can screen for cardiac disease and can determines maximal oxygen consumption (VO_{2max}). VO_{2max} is the criterion measure of cardiovascular fitness and reflects the functional capacity of the heart (Eng et al, 2004; Franklin, 2001). Only one study has determined the reliability of maximal VO_2 responses to cycle ergometry in the stroke patients (Potempa et al, 1995), finding cycle testing reliable, but the reliability of these measures on the treadmill have not been reported in this stroke patients (Dobrovolny et al, 2003; Potempa et al, 1995). Dobrovolny et al (2003) determined to find the test-retest reliability of cardiopulmonary measures of maximal and submaximal exercise treadmill testing in older, chronic stroke patients. The results showed that the measurement of peak functional capacity by graded treadmill exercise testing in stroke patients was very reliable for the measures of heart rate (HR) and VO_2 (Dobrovolny et al, 2003). But the test-retest reliability of HR and velocity was not measured during maximal and free treadmill walking tests in older patients with gait-impaired chronic hemiparetic stroke. This study is important to establish the test-retest reliability of maximal and free on treadmill testing with handrail support, and will help determine the utility of cardiac variables as performance outcome measures in exercise intervention studies. The test-retest reliability of maximal and free testing is relevant to the ability to measure and, interpret HR with treadmill velocity of gait in the chronic stroke population.

As already discussed, the purpose of this study was to determine the test-retest reliability of HR and treadmill velocity for simple test measures of maximal and free exercise treadmill testing in older men with gait-impaired chronic hemiparetic stroke using minimal handrail support. This study is hypothesized that although stroke patients would display a broad range of exercise capacities, based on their neurologic deficit and capable profiles, key HR and treadmill velocity measures for both maximal and free exercise treadmill tests would demonstrate high test-retest reliability.

Methods

Participants

Patients were recruited through direct contact at an H Welfare Center and gathered stroke and residual unilateral weakness on a volunteer basis with elderly people. Initial screening to determine in our study if prospective participants: (1) were able to walk independently (with or without assistive device) (2) were at least 6 months post stroke (3) were medically stable (That is, exclusion criteria were uncontrolled hypertension, arrhythmia, or unstable cardiovascular status, peripheral arterial disease with claudication, cancer, pulmonary or renal failure, unstable angina), (4) had no previous myocardial infarction, and (5) had no significant musculoskeletal disease, (6) Mini-Mental State Examination score, <22. Patients with medically stable hypertension, and diabetes mellitus were included. and informed consent and approval for the study was obtained with written permission to participate from a primary care physician.

Exercise Testing

An initial state of treadmill walking at 0 incline was first performed to assess gait safety and to select the free and maximal walking velocity for subsequent treadmill testing (Macko et al, 1997). Patients were instructed to minimize handrail support to that necessary for stabilizing balance as a safety measure but no assistance was provided unless gait difficulties were observed. Free and Maximal walking tests were performed using a treadmill[1] with at-

1) Health Trac S990 AIRFLEX SYSTEM, Gymtech Korea, Gyeonggi-do, Korea.

tached POLAR[2] on chest for HR measurement. Walking velocity was reported subsequently with HR. Polar Precision Performance Program was used for analysis of HR.

We measured resting HR of all subjects in bed for 5 minutes before each test. Patients and elderly people successfully completing at least 3 consecutive minutes of treadmill walking at greater than .8 ㎞/h (.5 mile/h) then proceeded to graded treadmill stress testing for 3 minutes (Dobrovolny et al, 2003). The way of graded velocity was advanced by .1 ㎞/h increments according to the patient's tolerance following each test and observer-rated gait stability. In the pilot study, the HR was increased constantly for 8 minutes. However, after 8 minutes, it did not increase any more. Therefore we set for 8 minutes to a maximum exercise time.

Generaly treadmill exercise on stroke patients within the control group was given according to the formula of Karvonen HR for gait velocity and balance (Macko et al, 1997). HR reserve (HRR) of age-predicted HR maximum (HR_{max}) on free testing was approximated 30% and on maximal testing was approximated 60% accompanied at stroke. Free and peak effort treadmill walking tests were measured as the way and then repeated at least two days later. And HRR of age-predicted HR_{max} on free testing was approximated 27% and on maximal testing was approximated 56% accompanied at elderly group. Free and peak effort treadmill walking tests were measured as the way and then repeated at least two days later. Both free and maximal treadmill walking tests were repeated on two separate days at the same time of day. Time of between each task divided at least 30 minutes as rest period. The same testers were used for the repeated tests.

Statistical Analysis

Descriptive statistics were performed for all variables measured. To assess the relative reliability between the 2 repeated test sessions, intraclass correlation coefficients ($ICC_{2,1}$) were calculated and provide a measure of the relative position of the measurements within a group on repeated measurements. Independent t-test of the measurement quantified the means ± standard deviations in the specific variable of each group and was used to examine the differences between control and stroke. Statistical analyses were performed using SPSS 12.0 for windows. Statistical significance was used for all tests at a p value level of <.05.

Results

A total of 41 patients with a history of cerebral infarction or hemorrhage stroke (at least 6 months post stroke) and mild to moderate chronic hemiparetic gait deficits with elderly people, were gathered from the H Welfare Center and underwent screening evaluations (Table 1). Twenty-two adults (13 men, 9 women with a mean age of 73.7±5.2 yrs) with chronic hemiparetic stroke were the experimental group. Nineteen elderly people (5 men, 14 women with a mean age of 72.3±3.5 yrs) were recruited as the control group. The location of stroke was distributed between 12 patients having right hemiparesis, and 10 patients having left hemiparesis. Further details related to characteristic of the subjects can be seen in Table 1.

Table 1. Physical characteristics of subjects (N=41)

Section	Chronic hemiplegia	Elderly
Age (yrs)	73.16±5.30[a]	73.04±4.06
Weight (㎏)	61.00±9.85	57.11±9.04
Height (㎝)	165.30±7.65	163.18±5.72
Systolic BP[b]	125.59±4.78	119.32±3.40
Diastolic BP	74.36±6.04	67.89±3.73

[a]Mean±SD.
[b]BP: blood pressure.

2) Polar Electro Inc., NY, U.S.A.

Table 2. Characteristics of each group (N=41)

Section	Chronic hemiplegia (n_1=22)	Elderly (n_2=19)
Maximum HR	146.84±5.30[a]	146.96±4.06
Resting HR	67.60±10.72	66.17±6.67
Free treadmill HR 1[b]	91.76±10.41	88.78±5.76
Free treadmill Vel. 1[c]*	2.19±.96	2.86±.81
Free treadmill HR 2[d]	91.04±9.62	87.70±6.64
Free treadmill Vel. 2[e]*	2.20±.95	2.94±.76
Maximal treadmill HR 1	113.04±8.87	109.74±7.81
Maximal treadmill Vel. 1*	3.96±1.04	4.85±.79
Maximal treadmill HR 2	114.96±8.77	112.48±6.35
Maximal treadmill Vel. 2*	4.26±1.10	5.24±.90

[a]Mean±SD.
[b]HR 1: heart rate in first treadmill test.
[c]Vel. 1: velocity in first treadmill test.
[d]HR 2: heart rate in second treadmill test.
[e]Vel. 2: nelocity in second treadmill test.
*p<.05.

Table 3. Reliability of the exercise test (N=41)

Test	Variables	Chronic hemiplegia (n_1=22)	Elderly (n_2=19)
Free testing	HR	ICC(2,1)=.85, r=.86	ICC(2,1)=.59, r=.62
	Treadmill velocity	ICC(2,1)=.93, r=.93	ICC(2,1)=.76, r=.77
Maximal testing	HR	ICC(2,1)=.81, r=.82	ICC(2,1)=.74, r=.74
	Treadmill velocity	ICC(2,1)=.96, r=.96	ICC(2,1)=.66, r=.66

Characteristics of Each Group

Strokes and older men were measured age predicted HR_{max} for HRR and resting HR. These value were no differential for compare with groups. Comparison of the two free and maximal treadmill tests performed two days apart allowed for the determination of the reliability coefficient for a number of HR and velocity parameters. Free HR and velocity parameters of subjects reported as shown in Table 2. We were able to confirm differential walking velocity according to free and maximal HR between patients and control.

Reliability of the Exercise Test

Reliability was calculated from HR and walking velocity during free and peak effort treadmill walking test. Among the people who had strokes, HR [ICC(2,1)=.85, r=.86] and velocity [ICC(2,1)=.93, r=.93] were good parameters during free testing. Maximal testing generated good results for HR [ICC(2,1)=.81, r=.82] and velocity [ICC(2,1)=.96, r=.96] with those who suffered from chronic hemiparetic stroke. In elderly people, HR [ICC(2,1)=.59, r=.62] and velocity [ICC(2,1)=.77, r=.76] were moderately reliable during free testing. Maximal testing produced moderate parameters for HR [ICC(2,1)=.74, r=.74] and velocity [ICC(2,1)=.66, r=.66] in the elderly (Table 3).

Discussion

The presentation and severity of impairments vary widely in stroke patients and there is a need to develop valid exercise tests for monitoring levels of

cardiopulmonary intensity by using a variety of exercise modalities. It would be useful also to validate treadmill tests for people who have gait impairments and normal people. Our study design required that the subjects who suffered strokes be able to complete the treadmill walking tests. We excluded 4 subjects who could not walk without human assistance during the first test or who we could not measure because they were fatigued. A major limitation of this study was its small sample size in each group and the limited ability to generalize the sample.

Our study demonstrate that free and peak treadmill walking testing is highly reproducible in older chronic hemiparetic stroke patients and older. A high reliability coefficient associated with HR and velocity provides evidence that free and peak walking testing is reliable in this population.

Bruce et al (1973) and Taylor (1955) proved that the test-retest reliability of maximal exercise testing is high [ICC(2,1)=.95～.99] in healthy young people. It is that some studies have evaluated the reliability of maximal VO_2 testing in older individuals (Fielding et al, 1997; Foster et al, 1986; Sidney and Shephard, 1977; Tonino and Driscoll, 1988). The relative test-retest reliability of the maximal and submaximal exercise measures was very high [ICC(2,1)=.90], except for the submaximal treadmill test, which was categorized as high [ICC(2,1)=.75] in stroke patients (Jancie et al, 2004).

VO_{2max} data and submaximal measures of fitness were measured reliability in 8 healthy 80-year-old sedentary women (Foster et al, 1986). The subjects performed three graded maximal treadmill tests, with 5 to 10 days between each test. VO_{2max} between trials proved to have no significant differences, and measured either in VO_2 (ℓ/min) [ICC(2,1)=.77～.79]. Especially, there were no differences in HR_{max} between the three tests. The use of ventilation as submaximal measures of fitness was determined not to be applicable for women in the eighth decade of life, because thresholds were not definable (Dobrovolny et al, 2003). But the reliability of cardiopulmonary parameters associated with maximal and submaximal treadmill testing in nine men aged 62 to 79 years (Tonino and Driscoll, 1988). The reliability of the VO_{2peak} effort measurements in the older stroke patients was the same as the reliability in VO_{2max} assessments in cardiac patients [ICC(2,1)=.95] and in healthy older men and women [ICC(2,1)=.86～.96] (Bruce et al, 1973; Sidney and Shephard, 1977). The correlation of HR_{max} and two VO_{2max} (㎖·㎏−1·min−1) were reported that no significant differences were noted between the trials, which repeated tests 1 week apart (Dobrovolny et al, 2003). However, this study found that submaximal data from treadmill testing was reliable for two VO_2 (ℓ/min) [ICC(2,1)=.84] in our population of chronic stroke patients.

Dobrovolny et al (2003) proved that the reliability of the peak test responses was high, with intraclass correlation coefficients of .94 for VO_{2peak}, .97 for HR, .99 for work rate, and .83 for systolic blood pressure. Thus, maximal-effort exercise testing in younger stroke patients was found to be reliable using a cycle ergometer. These figures are comparable with our present findings for VO_{2peak} [ICC(2,1)=.92] and HR [ICC(2,1)=.87]. Ryan et al (2000) reported that VO_{2peak} acquired from a treadmill protocol correlated moderately with self-paced walking speed (r=.53). Thus, Our study showed that the test-retest reliability of HR and velocity measurements during peak effort and free treadmill walking tests in older patients with gait-impaired chronic hemiparetic stroke and control group. It is that HR and velocity were good parameters during free testing, and maximal testing generated good results for HR and velocity with the chronic hemiparetic stroke. In addition, HR and velocity were moderately reliable during free testing, and maximal testing produced moderate parameters for HR and velocity in the elderly.

This study provides that free and maximal treadmill testing produce highly reliable HR and velocity measurements in adults with chronic hemiplegia using minimal handrail support. This study also support previous findings in healthy elderly populations,

which suggest that free and maximal treadmill testing is reliable. Some studies in the future may use a treadmill exercise program with the base data.

Conclusion

This study was a preliminary attempt to establish reliability and concurrent validity of free and maximal treadmill exercise measures in elderly persons with stroke. The measurement of free and peak functional capacity by graded treadmill exercise testing in stroke patients was very reliable for the measures of HR. Our results also support previous findings in healthy elderly populations, which suggest that free and maximal treadmill testing is reliable. Specifically, our method of free and maximal testing proved to be reliable for HR in the older chronic hemiparetic stroke population.

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