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PRELIMINARY STUDY OF CARDIOVASCULAR ASSESSMENT USING VARIOUS FIELD TESTS AMONG HEMIPLEGIC STROKE PATIENTS IN EARLY STAGE OF REHABILITATION.

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Abstract

Objective: To identify an appropriate field test with which to assess the physical fitness of a population of hemiplegic patients during early stage of rehabilitation.
Methods: The study population comprised 16 patients: nine men (65 ± 2 years) and seven women (74 ± 6 years) diagnosed with ischemic stroke. Each subject completed three tests with at least 1 day's interval between them (PCI short, Up & Go, and the 20/20 Intermittent Test). The experimental conditions were: 3 min rest followed by exercise and then 3 min of recovery. Heart rate and blood pressure were measured throughout.
Results: Peak and average heart rate were significantly higher with 20/20IT than PCI and Up & GO, and the peak alone differed significantly between PCI and 20/20IT. A very good correlation was observed between 20/20IT and the other two tests.
Conclusion: This study shows that intermittent short exercise could be adapted to evaluate stroke patients in the initial phase of rehabilitation. Such a test would provide functional information and help guide rehabilitation training.

1. Introduction

It is reported that 60% of patients who have a cerebrovascular accident (CVA) exhibit a permanent functional deficit (Katz-Leurer et al., 2003, p.1609). In France, 150,000 people a year are affected by stroke. Many studies have confirmed that rehabilitation is a high priority to not only maximize their functional skills but also improve their quality of life (Devillard et al., 2007,p.490; Ramas et al., 2007, p.438). However, Ramas et al (Ramas et al., 2007, p.438) noted that it is possible to go beyond "classical" physiotherapy and recently proposed rehabilitation training based on another technique. Several studies and meta-analyses (Kuys et al., 2006, p.219;

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Kwakkel et al., 2004, p. 2529; Macko et al., 2005, p.2206) show clearly that conventional rehabilitation facilitates improvement in functional autonomy. However, it seems that it is not sufficient to stimulate the cardiovascular system.

A literature review by Devillard et al. (Devillard et al., 2007, p.490) provided a fairly comprehensive summary of work assessing the effects of rehabilitation training on the cardiovascular system. Although positive effects are reported in most hemiplegic patients, the vast majority of subjects participating in studies were evaluated one year or more after discharge from hospital, but it seems appropriate to intervene earlier than that in order to limit dependence and optimize quality of life (Kwakkel et al., 2004, p.2529 ; Stroud et al., 2009, p.1019). To achieve appropriate rehabilitation training, it is necessary to evaluate the patient. Because it is very difficult to conduct a metabolic test within 30 days post-stroke (Eng et al., 2002, p.756) field tests are often used:

- The Timed Up & Go (Podsiadlo and Richardson, 1991, p.142) and the 10-meters test (MacGregor, 1979, p.159), particularly the latter, determine the Physiological Cost Index (PCI)(Nene, 1993, p .319). These measures provide good information about the functional performance of the patient but say little about his or her cardiovascular status (Baer and Smith, 2001, p.135; Podsiadlo and Richardson, 1991, p.142).

- The 6-minute walk test (Butland et al., 1982, p.1607). Pang et al. (Pang et al., 2005, p.495) clearly showed that this test, though sometimes a little long, can be used as an indicator of physical fitness in stroke patients. Unlike in many other disorders (Riley et al., 1992, p.789; Roul et al., 1998, p.449), no correlation was found between the distance walked and the peak oxygen consumption among these patients. Weak performance correlates primarily with neuromuscular deficit and poor balance. Moreover, Pang et al evaluated patients over a year after the stroke occurred, and when Liu et al. (Liu et al., 2008, p.1686) conducted the 6-minute walk test in patients between 6 and 12 months post-stroke. They found it of little value as an indicator of function.

A major limiting factor in patients with stroke is undoubtedly time- and effort-determined fatigability (Mackay-Lyons and Makrides, 2002, p.1697). To our knowledge, no study has tried to establish a system of evaluation on the basis of short intermittent exercise.

Against that background, the objective of our work was to conduct a preliminary study on the identification of an appropriate functional test with which to assess the physical fitness of a population of hemiplegic patients undergoing early stage of rehabilitation. It should be usable in the context of conventional rehabilitation training

2. Material and methods

Study Population:

The study population consisted of 16 patients admitted to the Physical Medicine and Rehabilitation Department of Limoges University Hospital. The nine men (age, 65 ± 2 years) and seven women (74 ± 6 years), all diagnosed with ischemic hemiplegia, were volunteers and provided written informed consent.

Inclusion criteria:

Patients were selected by a physician on the basis of a comprehensive review of relevant information. Precise details varied from patient to patient, but they were all:

- able to walk independently with or without crutch
- able to understand instructions
- in a stable clinical condition (particularly cardiovascular and pulmonary)

Exclusion criteria:

- Problems with understanding
- A cardio-respiratory contra-indicating for physical activity.

Subjects were not excluded on the basis of: spasticity of the lower and/or upper limb; expressive aphasia in the absence of impaired understanding; stable, treated epilepsy; treated hypertension; diabetes; non-decompensated arteritis of the lower limb; or CHD (depending on appropriate assessment, treatment and stabilization).

Experimental Protocol:

General organization: to minimize the effects of fatigue on exercise tolerance, all testing was conducted over 3 days with at least one day's interval between the completion of each test and initiation of the next.

Testing sessions:

Each subject performed three tests: the Up & Go, the Physical Cost Index (PCI) and the 20/20 intermittent test. All were conducted in the hospital hallway with subjects wearing their normal shoes and using their usual walking aids. Throughout the evaluation, heart rate (HR) was recorded using a Polar S810i monitor (Electro Oy - Finland). The recording included: a resting phase of 3 minutes with the patient lying on his bed; a test phase; a 3-minute recovery phase with the patient lying on his bed. Systolic and diastolic blood pressures were determined during the rest phase and immediately after exercise.

Description of the three tests:

Physiological cost index (PCI): the long version of the PCI as originally described(Dean et al., 2000, p .409) takes 6 minutes and patients often find it difficult to achieve. It has therefore been adapted such that, after a 3-minute rest, subjects are asked to take two or three initial steps to gain momentum followed by a walk of 10 meters at a comfortable speed (MacGregor, 1979, p.159), thereby reducing the risk of a fall and optimizing walking technique.

Up & Go test (Podsiadlo and Richardson, 1991, p.142): this test assesses transfers between sitting, standing, and walking, and changes in direction. It has been validated by comparison of results with those of posturographic investigation of static balance using a platform dynamometer (Podsiadlo and Richardson, 1991, p.142). The subject is seated in a wheelchair equipped with armrests. At the signal, he gets up, walks 3 meters at a comfortable pace, makes a U-turn, and returns to the chair and turns to sit down again. Results are assessed in terms of travel time. Each patient performs this test three times with 5 minutes recovery sitting in the chair between each run. The best time is retained.

20/20 intermittent test (20/20 IT): This corresponds to intermittent exercise

with alternating 20-second periods of walking and rest. The total length of 5 minutes therefore comprises 2 minutes 30 seconds of effort and the same amount of rest, each at 20-second intervals. After measurement at rest, the subject is led to the start line for the test (indicated by a strip of tape). At the sound of a buzzer, he or she walks as fast as possible for 20 seconds, stops, makes a half turn and rests for 20 seconds, then sets off again in the opposite direction for a further 20 seconds. Each patient is required to make four round trips. The total distance traveled is measured at the end of the test.

Statistical analysis:

Statistical analysis was performed with Statview 5.0 software. Values given are mean and standard deviation (SD). All variables were studied by using a two-way analysis of variance (Test vs Exercise) with repeated measures. Post-hoc tests were applied when appropriate. Finally, a simple regression analysis was performed to determine the relationship between maximum HR during 20-20IT and the other two tests. Statistical significance was set at the 0.05% level

3. Results and Discussions

Characteristics of the population are presented in Table I. The HR during testing is presented in Table II.

Table 1 *Characteristics of stroke patients*

Age (years)	68 ± 9
Bodyweight (Kg)	76 ± 16
Barthel index (/100)	68 ± 18
Days post stroke	36 ± 20

Table 2 *Heart rate before, during and after effort. HR, heart rate; PCI, Physiological*

Cost Index; * p<0.05, ** p<0.01

				p		
	Up&Go	PCI	20/20	Effect of test	Effect of exercise	Test and exercise interaction
HR at rest before effort (bpm)	78.6 ± 14.7	81 ± 18.2	77 ± 12.3	*0.362*	*0.393*	*0.410*
HR at rest after effort (bpm)	82.7 ± 13.9	83 ± 18.1	82 ± 10.1	*0.949*	*0.501*	*0.958*
Median HR on effort (bpm)	84.7 ± 13.3	90 ± 18.9	91 ± 12.6	*0.126*	*0.005***	*0.233*
Peak HR on effort (bpm)	96.1 ± 16.1	98 ± 21.8	109 ± 21.3	*0.588*	*0.005***	*0.011**

No significant difference in HR at rest was observed before or after any test. A significant difference was observed in mean and peak HR between Up & GO, PCI and 20/20IT, and in peak HR alone between PCI and 20/20IT. Arterial blood pressure before and after exercise is shown in Table III. No statistically significant differences were seen between tests. However, systolic blood pressure increased significantly after exercise, regardless of the test.

Table 3 *Arterial BP at rest and after effort. DBP: Diastolic Blood Pressure, SBP: Systolic Blood Pressure*

***** p<0.001**

				p		
	Up&Go	PCI	20/20	Effect of test	Effect of exercise	Test and exercise interaction
DBP at rest	78 ± 12	75 ± 22	75 ± 16			
DBP on effort	85 ± 16	75 ± 20	72 ± 21	*0.820*	*0.311*	*0.328*
SBP at rest	125 ± 13	129 ± 12	126 ± 13			
SBP on effort	138 ± 12	139 ± 16	138 ± 15	*0.724*	*<0.001****	*0 .837*

Regarding the mean time taken by patients to conduct different tests, the 20/20IT had a fixed duration of 240 seconds, which was significantly longer than the other two tests. Figure 1 shows a clear and significant difference between the time and effort expended in 20/20IT and the other two tests. A very good correlation was noted between 20/20IT and the other two tests (r = 0.69 and p <0.01 for both correlations, Figure 1).

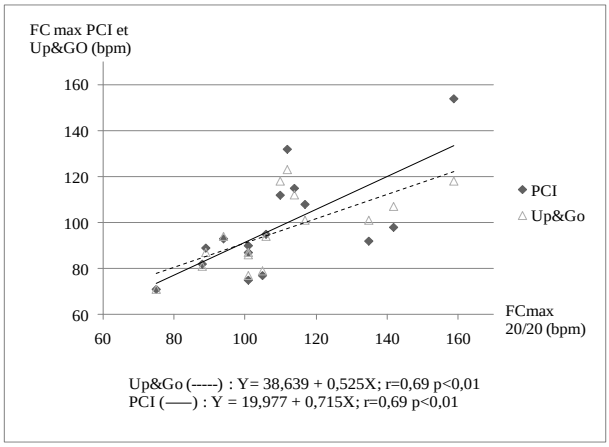

Figure 1 *Correlation between the 20/20IT and the two others tests (PCI and Up&Go). HRmax : Maximum HR recorded during the test.*

Figure 2 includes three graphs representing: 1 - a comparison of average walking speeds between the three tests, 2 -a comparison of average speed between PCI, Up & Go and the first four 20/20IT round trips, 3 a comparison of average speed between PCI, Up & Go and the last four 20/20IT round trips. The first two

graphs show no difference in speed. However, graph 3 records a significantly higher speed over the last four 20/20IT trips.

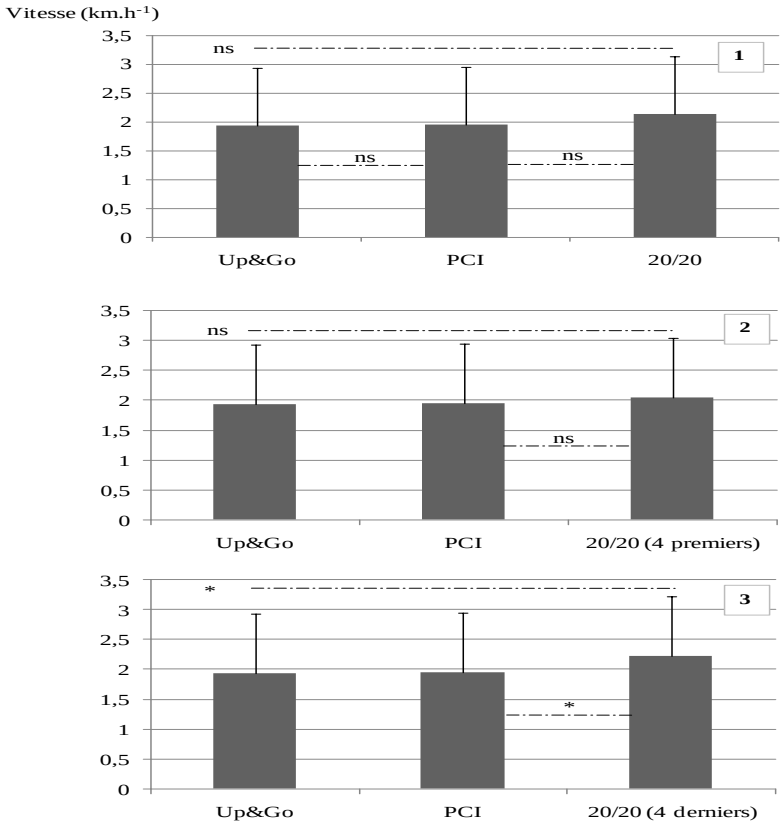

Figure 2: *Comparison of median speeds achieved in the three tests (1). PCI versus Up&Go and the first four return trips in 20/20IT 20/20 (2). PCI versus Up & Go and the last four return trips in 20/2IT 20/20 (3).** p<0,05 ; ns :Non-significant.

Analysis of the literature shows the value of physical training to hemiplegic patients (Ramas et al., 2007 p .430), but despite the evidence of obvious benefit it is very difficult to establish definitive conclusions about possible standardization of such programs, because of the factors that may cause results to differ (De Wit et al., 2006, p.1483), including variations in: evaluation criteria, measurement conditions, type of population studied (age, type of stroke), time since stroke, and rehabilitation technology and/or technique used.

The objective of this preliminary study was to assess simple evaluations among hemiplegic patients in the early stage of rehabilitation, techniques that would both provide functional information and promote rehabilitation. We compared the performance of patients during three field tests: Up & Go (Podsiadlo and Richardson, 1991, p .142), which is validated; PCI short, which is not validated but used regularly in hospitals; and the 20/20IT.

The 20/20IT seems to be best suited to meet this objective. Indeed, maximum and average HR and average walking speed during the eight 20-second sequences were significantly higher than in the other two tests. We also showed that the

walking speed during the first four 20-second sequences did not differ from the speed attained during the 10-meters PCI and Up & Go. Thus, 20/20IT may provide both functional and physical information whereas the others offer a more functional approach to the capacity of the patient.

To our knowledge, the literature contains no other findings of this kind. Some studies have focused on problems associated with field assessment of hemiplegic patients. A number used the simple 6-minute walk. Eng et al (Eng et al., 2002, p.756) found it preferable to the 12-minute test because of the difficulties patients have with moving. Furthermore, they also argued the relevance of measuring both the intensity of effort and the distance traveled during the test. This amounts to calculating the energy cost of walking, or the Physiological Cost Index. Thompson et al. (Thompson et al., 2008, p.370) showed the 6-minute test to have excellent reproducibility in hemiplegic individuals, and it appeared to be a good indicator of a patient's general physical status. However, these results were mainly reported in populations a year post-stroke. Pang et al. (Pang et al., 2005, p.495) consider this test to often be too long for patients to physically manage during the first year after stroke. Indeed, as emphasized by MacKay-Lyons and Makrides (Mackay-Lyons & Makrides, 2002, p.1967; Mackay-Lyons & Makrides, 2004, p .1608) the majority of patients find difficulty maintaining effort for 6 minutes during the first month after hospitalization, due in particular to significant cardiovascular adjustment problems.

Recent studies, such as that by Tang et al. (Tang A, 2006, p.1) among patients in the early stages of rehabilitation, show low ($r = 0.56$, $p < 0.01$) correlation between the 6-minute walk and VO2, a measure of metabolic stress. It seems that this test does not sufficiently reflect the physical fitness of the patient. The best predictor of distance walked in 6 minutes appears to be the maximum speed achieved during a 5-meter fast walk (65% of the variance). Peak VO2 could be a good indicator of physical fitness among hemiplegic patients. However, MacKay-Lyons and Makrides (Mackay-Lyons & Makrides, 2002, p .1697) point to the difficulties associated with interpretation of exercise test results in early phase of rehabilitation. Metabolic stress testing is expensive and in the case of a stroke patient in early phase of rehabilitation, the results would be warped (Mackay-Lyons & Makrides, 2002, p .1697) and would not provide information of value for rehabilitation training. Finally, calculation of the PCI during a 10-meter test walk could be a good indicator of physical fitness, but patients maintain what is described as a comfortable speed and therefore experience relatively little cardiovascular stress.

Ijzerman et Nene (Ijzerman & Nene, 2002, p .1777) showed that PCI is not the most reliable criterion in stroke patients in the initial stage of rehabilitation, particularly compared to the measurement of actual energy cost. In this context, 20/20IT appears to address the various problems mentioned above.

Intermittent exercise and rehabilitation training

Several studies have shown the value of starting rehabilitation training as soon as possible post-hospitalization (Kelly et al., 2003, p.1780; Mackay-Lyons & Makrides, 2004, p.1608; Stroud et al., 2009, p.1019). Nevertheless, these patients

are usually unable to maintain prolonged activity (at least 10 minutes). The 20/20IT can give us early information. Indeed, our results show that intermittent short exercise has a cardiovascular effect after 5 minutes. In comparison, MacKay-Lyons et Makrides (Mackay-Lyons & Makrides, 2004, p.1608) use continuous 2-minutes exercises in a population essentially identical to ours. We can therefore assume from our results that very short intermittent periods of exercise (10-20 seconds of maximum effort) could be a good solution in terms of enabling patients to achieve greater and more prolonged work than is possible with continuous intense exercise.

Limitations

Undoubtedly, the number of subjects limits the conclusions that can be drawn from our results, but it is a preliminary study, and we did not look at validity or reproducibility. We wanted to conduct an initial evaluation of intermittent exercise in stroke patients. Despite the small numbers our results were significant in the 16 cases.

4. Conclusions

This study shows that short intermittent exercise could be adapted to evaluate early rehabilitation in stroke patients. Such a test would not only help functionally but also provide information relevant to the organization of rehabilitation training. It seems that intermittent activity offers a better reflection of cardiovascular status than does continuous exercise. The next step is to study the validity and reproducibility of this test, despite the difficulty of undertaking this work in stroke patients in the early rehabilitation phase. It is also of interest to evaluate the energy cost of walking during the test. This parameter appears more representative and more accurate than the PCI in the setting of rehabilitation training.

Conflict of interest: None

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