

Assessment of Cardiorespiratory Fitness in Post-Stroke Patients in Cotonou: A Case-Control Study

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Abstract

Objective: This study compares the cardiorespiratory fitness of stroke patients with that of healthy control subjects matched by age and gender. It was a descriptive, analytical and comparative case-control study that aims to assess the aerobic capacity of stroke survivors in Cotonou. **Methods:** Data were collected during the Six-Minute Walk Test from 91 patients affected by stroke at least (03) three months ago and from 91 healthy subjects, who are at least 18 years old. **Results:** The average age was 53.16 ± 10.13 years with a sex ratio equal to 2.5. 45.05% of patients had ischemic strokes and 31.87% had strokes of unspecified origin. 59.34% of patients were right side affected, and almost all had a low level of physical activity. The average distance covered in relation to VO_2 max was 276.39 ± 175.27 meters with an estimated VO_2 max of 11.3 ± 4.03 ml/min/kg in patients and 464.14 ± 128.4 meters for an estimated VO_2 max of 15.62 ± 8.72 ml/min/kg. These values were highly significantly influenced by age, post-stroke duration and level of exercise. **Conclusion:** The study revealed a low cardiorespiratory fitness in the study population, and suggests that post-stroke patients should be monitored by improving their aerobic endurance through an adapted physical activity program aimed at preventing recurrence.

Keywords

Post-Stroke Patients, Cardiorespiratory Fitness, Benin

1. Introduction

Long described as a pathology specific to the elderly, strokes are now a major

public health problem worldwide and in sub-Saharan Africa. It affects middle-aged adults, especially women under 55, who are physically inactive and sedentary [1]. Its prevalence in Benin is estimated at 460 per 100,000 inhabitants in Cotonou [2]. These people, generally left to their own devices after a period of hospitalization, inevitably find it difficult to establish the optimal effort dose (dose-response relationship) to achieve a reduction in recurrence risk factors, morbidity and mortality [3]. This exposes them to low aerobic capacity and poor body composition, which are associated with cardiovascular disease and diabetes [4]. Although the benefit of PA for the health of post-stroke patients and for controlling the risk of recurrence is well established [5] [6], very little research in Benin has focused on the aerobic fitness of these stroke survivors. It is therefore important, for better control of these risk factors, to assess aerobic fitness, recognized by several authors as one of the main components to be measured [7] [8]. It is considered to be the best health index in relation to physical fitness [9]. The measurements taken help to determine the subject's strengths and weaknesses, or to identify factors requiring improvement, in order to adjust the type of treatment [4] [10]. Thus, in this study, the focus is on the component directly related to patients' health, and on the tests used to assess it. In particular, it aims to assess the cardiorespiratory fitness of stroke survivors, in order to fill the information gap that is essential for the proper treatment of post-stroke patients in Cotonou and the surrounding area.

2. Methods

Descriptive, analytical and comparative case-control study carried out at the Centre National Hospitalier et Universitaire Hubert Koutoukou MAGA (CNHU-HKM) in Cotonou, Republic of Benin, specifically in the University Medical Clinic for Physical Medicine and Rehabilitation (CUMPR). The results of the search for the records of stroke patients at the clinic identified 91 patients who met the following criteria: they must be at least 18 years old, have had a stroke at least three months previously and have given informed consent. A total of 182 people, comprising 65 male patients and 26 female patients, were equitably matched for age and sex with healthy subjects who had never suffered from a stroke (control group) and live in Cotonou or the surrounding area.

Exclusion criteria: Subjects with a history of recurrent stroke or cognitive impairment (MMSE < 20) were excluded from the study due to their severely deteriorated physical condition. Similarly, patients with a history of congestive heart failure and dyspnea were excluded from the study due to abnormal hemoglobin levels that could adversely affect O₂ transport to active muscles.

2.1. Collected Data

These data involve height and body mass, measured respectively using a SECA wall scale (France) and a KAMTHRON scale (China), on which the subject stands wearing a light garment, looking forward with the arms hanging at the side of the

body. This led to the calculation of the Body Mass Index (BMI), determined by the ratio of the patient's body mass to his or her height squared (Kg/m^2), in order to provide better information on weight status, which is a modifiable factor in the subjects' aerobic fitness. In addition, a standardized survey form containing general information and assessment tools, notably the 6MWT and the IPAQ questionnaire, was used to collect data on the distance covered and the maximum oxygen consumption of study participants. The latter was assessed using a standardized test of a person's functional capacity: the 6MWT. This consisted in having each subject walk for 6 minutes on a straight, 20-meter-long route delimited at each end by a cone and marked every three meters [11]. Each subject tried to cover as much distance as possible in six minutes [10], and the following formula was used to calculate the average maximum oxygen consumption of each group: $\text{VO}_2 \text{ max (ml/kg/min)} = 4.948 + 0.023 \times 6\text{MWT (meter)}$ [12]. During the test, participants could stop at any time if they felt tired. This in no way detracts from the 6MWT's excellent test-retest reliability ($\text{ICC} = 0.99$) [13] [14].

2.2. Independent Variables

In addition to socio-demographic characteristics grouped by category, clinical characteristics were related to: type of stroke (hemorrhagic, ischemic and unknown for patients whose CT scan results were unavailable); post-stroke duration; affected side (right or left motor deficit); medical history (diabetes, hypertension); length of hospital stay and, finally, level of physical activity assessed by the IPAQ, recognized as the most widely used tool for studies in adults and in particular by the "Health barometer" [15].

2.3. Statistical Analysis

The data collected using the survey form were entered and coded in Microsoft "Excel 2013" and processed using "Sigma plot version 15.0" and "SPSS version 32" software. Statistical analysis consisted of calculating the mean, median, maximum and minimum for quantitative variables. For qualitative variables, proportions and frequencies were determined. The relationship between the dependent variable and the independent variables was determined using ANOVA, Kruskal Wallis, Student's t, Mann-Whitney tests, depending on whether the variable was quantitative or qualitative with normality verified or not. ANOVA was chosen for its ability to compare the means of several groups when the data follow a normal distribution and the variances are homogeneous. In our case, the criteria of normality and homogeneity of variances were checked using appropriate tests (such as the Shapiro-Wilk test for normality and the Levene test for homogeneity of variances). As a non-parametric alternative to ANOVA, the Kruskal-Wallis test was chosen and applied to data which did not meet the conditions for normal distribution. It was particularly useful on our unevenly distributed sample size. It helped us to identify the existence or absence of significant differences without making assumptions about the data. Data were compared between subject types

using the Mann-Whitney test or the Pearson's chi-squared test. The significance level was 5%.

3. Results

3.1. Socio-Demographics

The age of stroke patients ranged from 24 to 72 years, with an average of 53.16 ± 10.13 years, and a sex ratio (M/F) of 2.5. On average, 89% of patients are between 40 and 72 years of age, with the highest prevalence of stroke at or slightly below 55 (**Table 1**).

Table 1. Age comparison of patients and control subjects.

| | Patients (%) | Control subjects (%) | Total (%) | Statistical hypothesis test |
|-----------------|--------------|----------------------|------------|-----------------------------|
| [24; 40[| 10 (10.99) | 10 (10.99) | 20 (10.99) | $X^2 = 2.308$ |
| [40; 55[| 40 (43.96) | 40 (43.96) | 80 (43.96) | ddl = 4 |
| ≥ 55 years | 41 (45.05) | 41 (45.05) | 82 (45.05) | p = 0.679 |
| Total | 91 (100) | 91 (100) | 182 (100) | |

A very high rate (84%) of stroke victims is found among married people, in contrast to divorced or widowed where the rate of stroke victims is very insignificant (**Table 2**).

Table 2. Marital status comparison of patients and control subjects.

| | Patients (%) | Control subjects (%) | Total (%) | Statistical hypothesis test |
|------------|--------------|----------------------|-------------|-----------------------------|
| Single | 06 (6.6) | 12 (13.2) | 18 (9.89) | RV = 11.863 |
| Married | 77 (84.6) | 66 (72.5) | 143 (78.57) | ddl = 9 |
| Divorced | 04 (4.4) | 06 (6.6) | 10 (5.5) | p = 0.221 |
| Widow (er) | 04 (4.4) | 07 (7.7) | 11 (6.04) | |
| Total | 91 (100) | 91 (100) | 182 (100) | |

3.2. Clinical Features of Patients

45% of patients had an ischemic stroke and 31.87%, a stroke of unknown origin (**Table 3**). A total of 54 patients (59.34%) suffered from right hemiplegia and 37 (40.66%) from left hemiplegia.

The mean IPAQ score was 830.48 ± 1021.83 MET-minutes/week in the patients, for whom 57% were recognized as having a low level of physical activity, versus 1430.21 ± 1734.74 MET-minutes/week in the control subjects, for whom almost 50% were recognized as having a moderate level of physical activity (**Figure 1**). However, weight status remained the same in both groups, with 49.5% normal weight and 34% overweight (**Figure 2**), with mean a BMI relatively equal at 25.837

± 5.009 in patients and 24.353 ± 4.295 in control subjects.

Table 3. Stroke type.

| Stroke type | Quantity (n) | Frequency (%) |
|--------------------|--------------|---------------|
| Ischemic stroke | 41 | 45.05 |
| Hemorrhagic stroke | 21 | 23.08 |
| Unknown | 29 | 31.87 |
| Total | 91 | 100 |

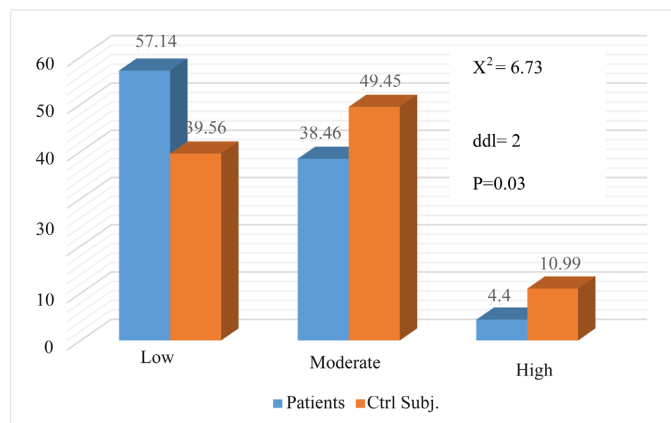


Figure 1. Classification of subjects by level of physical activity.

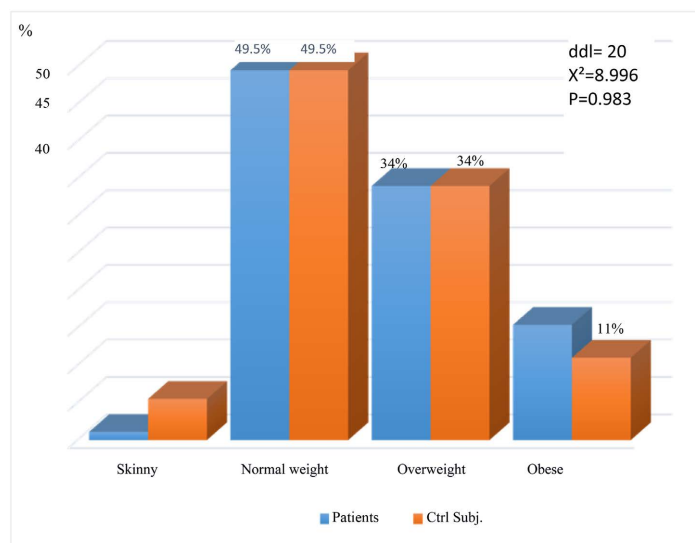


Figure 2. Comparison of body mass index between patients and control subjects.

3.3. Cardiorespiratory Fitness

Comparison of the mean distances covered (m) by patients and control subjects, and their average VO_2 max (ml/kg/min) during the 6MWT shows a highly significant difference between the two groups (**Table 4**).

Table 4. Comparison of mean distances covered (m) and VO₂ max (ml/kg/min) by patients and control subjects.

| 6MWT | Average | Standard deviation | Test statistics |
|---------------------------------|---------|--------------------|-----------------|
| Distance (m) | | | |
| Patients | 276.39 | 175.27 | U = 67.954 |
| Control subjects | 464.14 | 128.4 | p < 0.0001 |
| VO ₂ max (ml/kg/min) | | | |
| Patients | 11.3 | 4.03 | U = 67.96 |
| Control subjects | 15.62 | 8.72 | p < 0.0001 |

Patients' average oxygen consumption over the average distance covered is more or less influenced by several factors, including gender, age, hypertension history, stroke type, body part affected by the stroke, physical activity level and post-stroke time (**Table 5**).

Table 5. Factors influencing patients' walking ability and maximal oxygen consumption.

| | Distance | Test statistic | VO ₂ max | Test statistics |
|----------------------------|------------------------------|----------------------|------------------------------|----------------------|
| | Average ± Standard deviation | | Average ± Standard deviation | |
| Gender | | | | |
| Male | 298.89 ± 186.08 | F = 3.87 | 11.82 ± 4.27 | F = 3.87 |
| Female | 220.13 ± 131.65 | p = 0.04 | 10.01 ± 3.02 | p = 0.04 |
| Age (year) | | | | |
| [24 - 40[| 367.64 ± 212.93 | F = 2.05 p = 0.13 | 13.4 ± 4.89 | F = 2.05 p = 0.13 |
| [40 - 55[| 284.62 ± 174.56 | | 11.49 ± 4.01 | |
| ≥ 55 | 246.11 ± 161.61 | | 10.6 ± 3.71 | |
| History of HBP | | | | |
| No | 321.41 ± 177.42 | F = 1.28 | 12.34 ± 4.08 | F = 1.28 |
| Yes | 266.79 ± 174.43 | p = 0.26 | 11.08 ± 4.01 | p = 0.26 |
| History of Diabetes | | | | |
| No | 284.94 ± 179.47 | F = 1.19 | 11.5 ± 4.12 | F = 1.19 |
| Yes | 229.35 ± 146.77 | p = 0.27 | 10.22 ± 3.37 | p = 0.27 |
| History of Stroke | | | | |
| No | 286.02 ± 178.92 | F = 2.25 | 11.52 ± 4.11 | U = 2.52 |
| Yes | 198.4 ± 122.67 | p = 0.13 | 9.51 ± 2.82 | p = 0.14 |

Continued

| Stroke type | | | | |
|---------------------------------|-----------------|----------------------|--------------|-----------|
| Unknown | 312.31 ± 148 | F = 1.93 | 12.13 ± 3.4 | |
| Ischemic | 223.26 ± 154.07 | p = 0.15 | 10.08 ± 3.54 | F = 1.93 |
| Hemorrhagic | 264.08 ± 215.24 | | 11.02 ± 4.94 | p = 0.15 |
| Affected side | | | | |
| Right side | 295.08 ± 176.49 | F = 1.09 | 11.73 ± 4.05 | F = 1.09 |
| Left side | 256.04 ± 171.16 | p = 0.29 | 10.83 ± 3.93 | p = 0.29 |
| IPAQ | | | | |
| Low | 230.62 ± 144.82 | F = 8.2 p = 0.001 | 10.25 ± 3.33 | |
| Average | 267.61 ± 145.04 | | 11.1 ± 3.33 | F = 8.02 |
| High | 403.72 ± 215.43 | | 14.23 ± 4.95 | p = 0.001 |
| Post-stroke time (month) | | | | |
| <6 | 174.82 ± 174.03 | F = 4.35 p = 0.01 | 8.97 ± 4 | |
| 6 - 12 | 296.02 ± 186.05 | | 11.75 ± 4.27 | F = 4.35 |
| >12 | 305 ± 160.03 | | 11.98 ± 3.7 | F = 0.01 |

4. Discussion

4.1. Socio-Demographics

The average age of the stroke patients was 53.16 ± 10.13 years. These patients are adults. There was no significant difference between the age of the patients and the control subjects ($p = 0.679$).

Similar results regarding the age of stroke patients have been reported in the work of Ndayishimiye [16] in Benin in 2015 where the average age was 52.61 ± 11.64 years, Gnonlonfoun *et al.* [17] in Benin in 2017 where the average age was 54.5 ± 9.3 years and Ossou-Nguet *et al.* in 2013 in Brazzaville [18] where the median age of stroke patients was 51.5 years. In comparison with our result, the average age of stroke survivors in a German population was much higher, at 69 years [19].

This disparity in results could be explained by the relatively longer life expectancy in the Western world and the fact that the incidence of age-specific stroke is relatively higher in younger age groups in sub-Saharan Africa. In addition, in Benin, compared with European countries, preventive measures are not widely promoted, and the population remains more exposed to risk factors (poor diet, sedentary lifestyle and regular physical inactivity), making stroke a possibility at any age. It should also be noted that our patients were selected from a referral clinic in Benin called University Medical Clinic for Physical Medicine and Rehabilitation of the CNHU-HKM. The predominance of males among the stroke patients (71.4%), with no significant difference between the gender of control

subjects and patients ($p = 0.212$), is a classic feature of the documentation available on the stroke [20]-[22].

These results can be explained, on the one hand, by the protective role of female hormones and, on the other, by the prevalence of vascular risk factors, which are higher in men, notably smoking and alcohol abuse [23] [24], not to mention the psychological factors inherent in the marital status of the majority of married adult patients (84.9%).

4.2. Clinical Features of Patients

In the study, ischemic strokes accounted for 45.05% of the population, hemorrhagic strokes for 23.08%, and 31.87% of patients had unclear diagnoses as to the type of stroke. Our results are comparable to those of Adoukonou *et al.* in their study of the incidence of epilepsy after a stroke in 2014 in Parakou (Benin), who found 45.8% of ischemic strokes, 31% of hemorrhagic stroke and 23.2% to be determined [25]. The same applies in the 2016 study by Gnonlonfoun *et al.* entitled "Study of ischemic stroke in sub-Saharan Africa, the case of Benin", who found a predominance of ischemic stroke of 41.6% of the study population [26]. These results can be explained by the fact that ischemia is the first and most frequent cause of strokes (87%) [27].

The most affected side in the study was the right side, *i.e.* 59.34%. These results are in line with studies carried out by Razafindrasata *et al.* on the evolutionary profile of motor deficits in stroke patients in 2015 in Madagascar, who showed a right-sided predominance of 50.22% [28], and Gallien *et al.* in 2005 [29] in France, who found 64% of subjects affected by right hemiplegia. It is the same thing with the study of Edouard *et al.* in 2008 [30] carried out in Belgium, with a rate of 56%.

However, it should be noted that 79.10% of patients were in a chronic phase of stroke, *i.e.* a post-stroke time ≥ 6 months, despite the fact that almost all of them had benefited from follow-up rehabilitation sessions. This did not protect patients from the risk factors most frequently encountered with stroke [31]-[33], especially hypertension (82.42%) and diabetes (18.38%).

This condition can be explained, on the one hand, by their low level of physical activity revealed through their mean IPAQ score, 830.48 ± 1021.83 MET-minutes/week, very significantly different ($p = 0.005$) from that of the control group who achieved 1430.21 ± 1734.74 MET-minutes/week and, on the other hand, by the onset of impairments (motor and orthopedic) that occur after a stroke [34]. In addition, patients suffering from fatigue may have to avoid certain physical activities in order to rest; which will lead to cardiorespiratory deconditioning in these patients [35] [36] despite a normal average weight in almost 50% of patients and control subjects recruited under the same living and working conditions. Such a high proportion of overweight and obese subjects is thought to be linked to the sedentary lifestyle and poor diet of these two groups [37]-[39].

4.3. Assessment of Aerobic Capacity

Walking endurance was assessed by the mean distance covered by both groups of

subjects during the 6MWT. It was 276.81 ± 174.73 meters in patients and 463.27 ± 126.09 meters in control subjects. These data revealed a significant difference ($p = 0.001$). It was more difficult for the patients to complete a six (6)-minute walk than the control subjects. This could be due to changes in the dynamic (step length, width and height) and kinetic (higher energy cost) parameters of walking in these subjects.

Dunn *et al.* found a similar result in their review based on 127 studies ($n = 6012$). In this review stroke survivors (chronic and acute stages combined) walked an average of 284 ± 107 m during the 6MWT, which is significantly less than that of age-matched individuals [40]. Fabiana *et al.* found in their study that the 6MWT distance in hemiparetic subjects was lower (274.6 ± 163.7 m) than in healthy subjects (565.5 ± 64.9 m) [41].

Muren *et al.* found in thirty (30) stroke subjects (who were tested 60 ± 27 months after the stroke), a distance of 353 ± 137 m, or 63% of the distance predicted for healthy subjects [42]. Eng *et al.* found a mean distance of 378 ± 123 m in 12 hemiplegic patients in chronic phase [14]. By comparison, Kervio *et al.* [43] found a mean distance of 535 ± 20 m for the same exercise and a similar group of people. There is therefore a difference in walking ability between a hemiplegic group and a healthy group of similar age.

Furthermore, cardiorespiratory endurance, considered to be the best index of functional capacity, [44] [45] is estimated during the 6MWT using the formula $VO_2 \text{ max (ml/kg/min)} = 4.948 + 0.023 \times 6MWT \text{ (meter)}$ [12]. As a matter of fact, very low mean estimates of $VO_2 \text{ max}$ were found in patients, 11.3 ± 4.03 (ml/kg/min) and 15.62 ± 8.72 (ml/kg/min) in control subjects. There was a significant difference between patients and control subjects $VO_2 \text{ max}$ ($P < 0.0001$). Patients have a very low $VO_2 \text{ max}$ compared with healthy subjects. Our results are similar to those of Eng *et al.* who found a mean oxygen consumption ($VO_2 \text{ max avg}$) equal to $12.0 \pm 1.3 \text{ ml} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$ in 12 hemiplegic patients in chronic phase [14]. For comparison, Kervio *et al.* found an average $VO_2 \text{ max}$ of $21.8 \pm 1.3 \text{ ml} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$ on a similar group of individuals [43]. Authors such as Bar-Or [44] and Krahenbuhl *et al.* [45] have also highlighted these aspects in the healthy subjects. This observation of consistently lower values of aerobic performance in patients and control subjects should be taken into account in exercise training or rehabilitation programs.

4.4. Factors Influencing Post-Stroke Walking and Aerobic Capacity

In this study, the BMI of the patients was not influenced by any of the socio-demographic or clinical aspects.

However, at $p = 0.04$, patients' walking and aerobic capacity were significantly influenced by gender. They were also influenced by the level of physical activity ($p = 0.001$) and post-stroke time ($p = 0.01$).

Distance covered and the $VO_2 \text{ max}$ were significantly higher in male patients.

As post-stroke time increased, so did the distance covered by patients, with a

subsequent improvement in the VO₂ max. Similarly, the higher the level of physical activity, the greater the distance covered and the greater the patients' maximum oxygen consumption.

5. Conclusions

The aim of this case-control study was to assess the aerobic endurance of patients who had suffered from a stroke in Cotonou and the surrounding area. The results showed that 45.05% of patients had suffered from an ischemic stroke, and the time to post-stroke evolution was more than 12 months for the majority of patients. Patients had a low functional capacity inherent during poor walking endurance, highlighted by the very low maximum oxygen consumption (VO₂ max) observed in patients and control subjects. These two factors were also significantly influenced by gender, post-stroke time and level of physical activity in all study subjects.

After all is said and done, in the care of post-stroke patients, particular attention must be paid to improve their cardiorespiratory fitness by acting on their aerobic endurance through adapted physical activity programs, particularly walking, in order to prevent stroke recurrence.

Conflicts of Interest

The authors do not declare any conflict of interest regarding of the publishing of this article.

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