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ORIGINAL ARTICLE

The effect of aerobic exercise on stroke rehabilitation

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Abstract

Background and aims To compare the effects of aerobic exercise and conventional exercise that were applied during the rehabilitation process on the aerobic capacity, motor function, activity limitation, quality of life, depression level, and sleep quality in subacute stroke patients.

Methods The patients were divided into two groups; aerobic exercise group ($n = 22$) or conventional exercise group ($n = 20$). Both groups participated in a conventional stroke rehabilitation program; however, aerobic exercise program was applied only for the patients in group 1. Exercise tolerance test (ETT), respiratory function tests, 6-min walking test (6-MWT), functional independence measure (FIM), Nottingham health profile (NHP), Beck depression scale (BDS), and Pittsburgh sleep quality index (PSQI) were evaluated on admission and discharge.

Results The 6-MWT, FIM, some subgroups of NHP, BDS, and PSQI results demonstrated statistical differences in both groups after rehabilitation programs. Significant differences were recorded in terms of changes between admission and discharge values of ETT and BDS in favor of aerobic exercise group.

Conclusions Incorporation of aerobic exercises into conventional rehabilitation programs of early stroke patients may provide positive contributions, particularly to mood and aerobic capacity.

Keywords Aerobic capacity · Exercise · Rehabilitation · Stroke

Introduction

Disabilities resulting from stroke cause significant problems in physical, psychological, and social aspects of life, and impair quality of life [1, 2]. Because rehabilitation programs have become critical, investigators focused on aerobic exercise programs besides classical rehabilitation methods.

Metabolic equivalent (MET) calculations of different daily living activities (DLA) revealed that light DLA required an oxygen consumption of approximately 3 MET while heavier ones required approximately 5 MET, or 17.5 ml/kg/min oxygen consumption. The peak fitness level of the individuals who had stroke is approximately the half of the level of age-matched sedentary controls. This shows a significant functional aerobic impairment, and that low aerobic capacity causes a decrease in the capacity of the stroke patients due to increased energy need for hemiparetic walking [3, 4], it limits the capacity of basic DLA, and contributes to fatigue and intolerance to activity [5].

Aerobic exercise incorporated in the rehabilitation programs after stroke aims to improve functions after stroke and prevent recurrent strokes. It is recognized as part of comprehensive stroke rehabilitation in best-practice and clinical guidelines, yet many individuals remain physically inactive during hospitalization. Although, aerobic exercises have been mostly studied in patients with chronic stroke, there are relatively few sufficient data for the effects of cardiovascular exercise programs on the patients with subacute stroke. Therefore, we aimed to investigate the effect of aerobic exercise in conjunction with conventional exercise and conventional exercise during rehabilitation process on aerobic capacity, ambulation, activity limitation, quality of life, depression level, and sleep quality of the patients with subacute stroke.

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Methods

Patients

A total of 50 patients who were hospitalized in Physical Therapy and Rehabilitation clinic, and diagnosed with subacute stroke in relation with WHO (World Health Organization) criteria were included in the study. Unconscious patients, the ones with bilateral or previous hemiplegia, sensory aphasia or communication problems that could cause problems to complete the tests used in the study, comorbid neurological diseases (multiple sclerosis, Parkinson's disease, spinal cord injury, traumatic brain injury, brain tumor, etc.), and the ones who had any contraindication for maximum exercise test in relation with American College of Sports Medicine were excluded. The patients between the ages of 18–80 years who had a balanced sitting or could be ambulated were included in the study. The local ethics committee of the hospital approved the study protocol. Patients accepted to participate the study were informed about the study, and their written consents were obtained at the beginning of the study. Patients were assigned to either the aerobic exercise group (group 1) or conventional exercise group (group 2). Both groups participated in a conventional stroke rehabilitation program; however, aerobic exercise program was applied only to patients in group 1.

Assessment of the patients

A questionnaire was used to record age, gender, duration of stroke, affected side, premorbid exercise habits, and smoking status of the patients.

Data collection was carried out at both admission and discharge. Functional independence state, quality of life, depression level, and sleep quality were evaluated with Functional Independence Measurement (FIM) [6, 7], Nottingham Health Profile (NHP) [8], Beck depression scale (BDS) [9], and Pittsburgh sleep quality index (PSQI) [10, 11], respectively.

The patients walked in a 30-m corridor at the walking speed they preferred, and the distance they walked in 6 min was recorded by 6-min walking test (6-MWT).

Respiratory function test and then exercise tolerance test (ETT) on bicycle ergometry were performed to analyze exercise capacities of the patients. The patients did not eat anything for at least 3 h prior to the test, and they did not smoke or consume caffeine. Before the test, 12-derivation electrocardiography (ECG) and blood pressure were recorded. Bicycle ergometry was performed with Care Fusion Type Master Screen-CPX device. In the first 3 min, 50 rpm without load was employed, then the load was increased by 5 W every minute. The patients used a mask with a gas-meter to measure oxygen inspiration and carbon dioxide exhalation during the test. After spirometric analysis, oxygen uptake volume (VO_2 ml/kg/min), forced vital capacity (FVC), forced vital capacity in 1 s (FEV1), and FEV1/FVC were recorded. ECG, blood pressure, and heart rate (HR) were followed throughout the test. The exercise test was stopped when the patient expressed that he could not continue the test, or if the indications for stopping the test appeared. The patients were analyzed with Borg scale for degree of stress where they were given a score between 0 and 20. ETT duration, max VO_2, MET, peak work load, and peak heart rate were noted.

Exercise program

Both groups received 1 h/day of conventional rehabilitation program (with range of motion (ROM), muscle strengthening, and mobilization exercises), 5 days a week for 6 weeks. Aerobic exercise program was planned for 30 min/day and 5 days/week with a value corresponding to 60–80% of the peak heart rate determined according to the ETT with cycling ergometer. The patients performed warming-up and respiration exercises for 10 min before aerobic exercise. The bicycle exercise started with a 5-min warming up, and ended with a 5-min cooling period. In warming up phase, the exercise started with a low watt that was increased gradually to the desired watt in 5 min. The watt was decreased gradually in the cooling phase, and the exercise was stopped.

Statistical method

Statistical analyses were performed using SPSS 20.0 for Windows (SPSS Inc., Chicago, IL, USA). Normality of distribution was assessed by Shapiro Wilk test. Descriptive statistics are given as mean ± standard deviation for continuous variables, and as percentage for categorical variables. The paired t test or Wilcoxon test was used to reveal whether there was a significant difference within the groups. The Fisher exact test was used to assess the qualitative differences between the groups. Numerical variables were compared using the Student t test or Mann–Whitney U test as appropriate. Statistical significance was set at $p < 0.05$.

Results

A total of 50 patients were enrolled in this study. There were 27 patients in aerobic exercise group and 23 patients in conventional exercise group. Five patients in group 1 and 3 patients in group 2 could not complete the physical exercise program due to their comorbid diseases. Demographic and clinical data of the patients are presented in Table 1.

A total of 6 patients were exercising regularly prior to stroke and 13 patients were smoking in both groups. Groups were similar for the rates of regular exercise and smoking.

Comparison of admission and discharge values of the groups for ETT, respiratory function test, 6-MWT, FIM,

Table 1 Clinical and demographic characteristics of the patients

		Group 1 ($n = 22$)	Group 2 ($n = 20$)	p
Age (year), mean ± (SD)		52.6 ± 2.9	56.3 ± 3.3	0.420
Duration of stroke (day), mean ± SD		56.5 ± 10.3	65.9 ± 8.3	0.490
Gender *n* (%)	Female	7 (%31.8)	8 (%40)	0.585
	Male	15 (% 68.2)	12 (%60)	
Affected side *n* (%)	Right	11 (%50)	6 (%30)	0.193
	Left	11 (%50)	14 (%70)	
Brunnstrom stage (upper) median (min–max)		5 (1/6)	4.5 (1/6)	0.886
Brunnstrom stage (lower) median (min–max)		5 (1/6)	5 (1/6)	0.556

SD, standard deviation

BDS, and PSQI results are revealed in Tables 2, 3, 4, 5. When intergroup analyses of the abovementioned tests were done, it was noted that only the BDS showed significant differences in admission and discharge changes ($p = 0.038$).

Subgroups of NHP including energy, emotional reactions, sleep, and physical activity scores in aerobic exercise group, pain, sleep, and physical activity scores in conventional exercise group revealed significant differences ($p < 0.05$). No difference was noted for changes of admission and discharge NHP values between groups.

Discussion

Stroke takes the first place for frequency and importance among the neurological disorders of adulthood. It has been reported that the mean aerobic capacity of the stroke patients decreases by 60% in the first month after stroke compared to age- and sex-matched healthy controls. Therefore, aerobic exercise programs are essential in this group of patients [12]. Significant differences were recorded in terms of changes between admission and discharge values of ETT and BDS in favor of aerobic exercise group in this study.

Max VO_2 represents the maximum oxygen amount used during maximum dynamic exercise, and it is the best indicator of aerobic capacity. A significant decrease starts in the early period in stroke patients, and this decrease continues if necessary programs are not employed. Studies reported that max VO_2 decreased to 10–17 ml/kg/min 0–30 days after stroke [13]. In accordance with the literature, our data showed that max VO_2 capacity of the patients was 10.7 ml/kg/min after a mean period of 61 days after stroke. In our aerobic exercise group, the mean admission max VO_2 was 10.0 ml/kg/min while this value increased to 12.6 ml/kg/min after rehabilitation program, and the difference between two values was statistically significant. Aerobic exercise in conjunction with conventional exercise demonstrated superior improvement than conventional exercise.

Table 2 Comparison of admission and discharge values of ETT results

		Admission mean ± SD	Discharge mean ± SD	p
Group 1	ETT duration (min)	6.3 ± 3.59	8.8 ± 4.02	0.07
	Max VO_2 (l/min)	10.0 ± 2.69	12.6 ± 3.25	*< 0.001*
	MET (kcal/kg)	2.8 ± 0.76	3.6 ± 0.92	*< 0001*
	Peak work load (watt)	18.9 ± 14.27	38.0 ± 21.28	*< 0.001*
	Borg scale	16 ± 1.19	14.3 ± 1.56	*< 0.001*
	Peak heart rate (beats/min)	109.9 ± 18.01	118.2 ± 21.51	*0.042*
Group 2	ETT duration (min)	5.8 ± 3.34	5.5 ± 3.06	0.513
	Max VO_2 (l/min)	11.4 ± 4.29	10.5 ± 3.24	0.241
	MET (kcal/kg)	3.2 ± 1.22	2.9 ± 0.92	0.244
	Peak work load (watt)	23.4 ± 22.30	18 ± 13.86	0.177
	Borg scale	15.7 ± 1.83	15.5 ± 1.98	0.465
	Peak heart rate (beats/min)	113.8 ± 21.50	114.2 ± 21.72	0.925

A value of $p < 0.05$ was considered to be statistically significant

ETT, exercise tolerance test; *MET*, metabolic equivalent; *SD*, standard deviation

Table 3 Comparison of admission and discharge values of respiratory function test results

		Admission mean ± SD	Discharge mean ± SD	*p*
Group 1	FEV1 (l)	2.29 ± 1.12	2.4 ± 0.97	0.480
	FVC (l)	2.94 ± 1.26	3.2 ± 1.14	*0.033*
	FEV1/FVC (%)	77.1 ± 9.38	78.2 ± 9.41	0.516
Group 2	FEV1 (l)	2.0 ± 0.67	2.1 ± 0.81	0.962
	FVC (l)	2.5 ± 0.82	2.5 ± 1.12	0.835
	FEV1/FVC (%)	81.6 ± 11.22	84.8 ± 8.46	0.962

A value of $p < 0.05$ was considered to be statistically significant

FEV1, forced expiratory volume in 1 s; *FVC*, forced vital capacity

Table 5 Comparisons of admission and discharge values of BDS and PSQI results

		Admission mean ± SD	Discharge mean ± SD	*p*
Group 1	BDS	13.9 ± 8.28	7.64 ± 7.07	*< 0.01*
	PSQI	5.6 ± 4.63	3.55 ± 3.09	*0.034*
Group 2	BDS	14.5 ± 7.13	12.20 ± 9.31	*0.04*
	PSQI	9.1 ± 5.74	5.75 ± 5.05	*0.002*

A value of $p < 0.05$ was considered to be statistically significant

BDS, Beck depression scale; *PSQI*, Pittsburgh sleep quality index; *SD*, standard deviation

Billinger et al. examined the patients with subacute stroke with ETT. The mean pre-treatment test duration was 654 s while this value increased to 700 s after treatment, however the difference was not statistically significant [14]. In our study, ETT time was 6.39 min before treatment, and increased to 8.89 min after treatment in aerobic exercise group. In conventional exercise group, pretreatment ETT time was 5.87 min and posttreatment ETT time was 5.56 min. The changes in ETT time were not significant in either group; however, comparison of two groups revealed that ETT time was significantly longer in aerobic exercise group when compared to conventional exercise group.

For an efficient aerobic exercise, the exercise must be performed at the 60–80% of the peak heart rate calculated according to the age of the patient. However, most of the stroke patients end the test before they reach target heart rate. Tang et al. found 5% difference in peak heart rate between pre- and post-treatment periods in the exercise group while this difference was 11% in the control group; however, the change in the heart rate was not found significant [15]. In our study, although no significant difference was obtained in the conventional exercise, significant results were noted for peak heart rate in aerobic exercise group after rehabilitation program.

An important issue in aerobic exercise programs is the pulmonary capacity of the patient. Lennon et al. studied efficiency of a 10-week aerobic exercise program, and did not find any significant differences in intragroup and intergroup analyses of exercise and control groups [16]. Similar to the literature, we only found a significant increase in FVC in aerobic exercise group; however, there were no differences for FEV1 and FEV1/FVC.

Recent studies analyzed smoking and physical activity in stroke patients, and reported rates of 30% for smoking [15] and 40% for regular exercise before stroke [14]. In our study, 18% of the patients were exercising regularly in aerobic exercise group, and 31.8% of them were smoking. Those rates were 10 and 30%, respectively, in the conventional exercise group.

Katz-Leurer et al. studied 92 patients with subacute stroke, and did not find any significant difference for pre- and post-treatment total FIM scale scores of aerobic exercise group, and the control group [17]. Although we found significant increase in admission and discharge FIM motor and total scores in both groups, intergroup analysis did not reach a significant result.

Depression revealed a statistically significant improvement after rehabilitation process in both aerobic and conventional exercise scores. Comparison of two groups showed better improvement in aerobic exercise group than the conventional exercise group. Similarly, Smith et al. reported that a 4-week aerobic exercise program applied to patients with chronic

Table 4 Comparisons of admission and discharge values of 6-MWT and FIM score results

		Admission mean ± SD	Discharge mean ± SD	*p*
Group 1	6-MWT	173.6 ± 81.84	239.4 ± 120.15	*< 0.001*
	FIM motor	66.9 ± 17.94	77.7 ± 14.77	*< 0.01*
	FIM cognitive	32.5 ± 5.40	32.7 ± 5.28	0.131
	FIM total	99.8 ± 17.62	110.5 ± 14.71	*< 0.01*
Group 2	6-MWT	172.7 ± 107.03	222.3 ± 99.76	*0.044*
	FIM motor	64.4 ± 18.90	77.2 ± 15.71	*< 0.01*
	FIM cognitive	31.9 ± 4.62	33.1 ± 3.44	*0.018*
	FIM total	96.3 ± 21.39	110.2 ± 17.75	*< 0.01*

A value of $p < 0.05$ was considered to be statistically significant

6-MWT, 6-min walking test; *FIM*, Functional Independence Measurement, *SD*, standard deviation

stroke resulted in a better improvement in BDS scores compared to the control group [18].

Sleep disorders such as hypersomnia, insomnia, and sleep apnea are frequently seen complications in stroke patients. Although a number of studies in the literature investigated sleep disorders, no studies have investigated the effect of an aerobic exercise program on sleep quality [19]. In our study, PSQI scores were improved in both groups after rehabilitation phase.

Gordon et al. compared the group given 3 days/week aerobic exercise plus classical physical therapy for 12 weeks with classical physical therapy alone in patients with subacute stroke, and measured the quality of life with short form-36 (SF-36). Significant difference in physical health component between pre- and post-treatment scores was found. The difference between the groups was also significant [20]. In our study, sleep and physical activity scores were improved in both groups. The addition of an aerobic exercise enabled the patients to feel more energetic and emotionally better.

The main limitation of our study is the small number of patients to document strong results. The reasons for that are the study population only consists of patients who are hospitalized and the difficulty to find patients who are compliant for ETT. Another limitation is the lack of long-term follow-up after discharging the patients. On the other hand, the most important differences of our study from the similar ones are inclusion of early period stroke patients, analysis of functionality, depression level, sleep quality, and quality of life of the patients in addition to their aerobic capacities.

In conclusion, we found better results for ambulation, functionality, mood, sleep, and life qualities after both aerobic and conventional exercise programs. However, conventional therapy alone may not be sufficient for stroke rehabilitation. It was stated that the inclusion of aerobic exercises in conventional rehabilitation programs for patients with early stroke may provide positive effects, particularly to mood and aerobic capacity.

Compliance with ethical standards

The local ethics committee of the hospital approved the study protocol. Patients accepted to participate the study were informed about the study, and their written consents were obtained at the beginning of the study.

Conflict of interest The authors declare that there is no conflict of interest.

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