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A Review of the Effectiveness of Aerobic Training in Increasing Endurance in Subacute Stroke Patients

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Abstract

Purpose: The purpose of this study was to review the effectiveness of aerobic training in increasing endurance in subacute stroke patients.

Methods: A review of available research was selected. Electronic databases searched online were Medline-Pubmed, Cumulative Index in Nursing and Allied Health Literature (CINAHL) and Excerpta Medica Database (EMBASE).

Results: Aerobic training appears to have a positive effect on endurance and oxygen consumption.

Conclusion: Further research studying the effect of endurance training in subacute stroke patients, is required in order to reach a clearer image of the effect of aerobic training in stroke patients in the subacute phase.

Keywords: Cardiac rehabilitation; Subacute stroke; Endurance trainining; Stroke rehabilitation

Introduction

Stroke is one of the most important causes of disability and rehabilitation services are widely prescribed for stroke patients [1]. An important aspect of rehabilitation is reeducation of movement, balance, strength, and gait. Moreover endurance is another important component of rehabilitation.

In the acute phase of stroke, endurance, as measured by peak oxygen consumption, can decrease to even the 60% of the capacity of healthy individuals matched in age and sex [2-4]. It has been supported that low peak oxygen consumption indicates that perhaps low levels existed before the stroke took place [2].

Stroke patients demonstrate low endurance and low aerobic exercise capacity, which can be attributed to stroke itself as a pathological manifestation having secondary effects to the function of the body. Furthermore, inactivity and immobilization resulting from the movement limitations that are commonly met at least in the acute phase may also result in low endurance and exercise capacity [5].

Low aerobic capacity can be attributed to a reduction in the oxidative capacity of the affected muscles and the decrease in active motor units [6]. Reduced exercise capacity is also supported to result from unilateral dysfunction of the paretic limb [7-10]. Adaptations that have been reported are reduction of femoral artery diameter [8,9], blood flow reduction [7,9,10], change in tissue composition [11-13], and vasomotor reactivity [9,10].

Spasticity may be a factor contributing to increased levels of energy required for movement, as supported in studies focusing on multiple sclerosis or cerebral palsy [14,15]. Another factor may be age related. Co-contraction is a result of reduced muscle co-ordination which we propose may lead to increased levels of required energy. With advancing age, co-contraction of the muscles in joints is introduced and increased [16]. There is thus evidence that following stroke, low aerobic capacity is demonstrated due to spasticity or possibly incoordination of muscle contraction around the joint.

The purpose of this review was to investigate the effectiveness of aerobic training to increase endurance in subacute stroke patients. The subacute phase was selected since it was aimed to evaluate inpatient or early outpatient stroke patients in rehabilitation centers, and this is the phase that patients are commonly treated in rehabilitation centers.

Methods

A review of the literature took place, regarding the effects of aerobic training in stroke patients in the subacute stage. Electronic databases searched online were Medline-Pubmed, Cumulative Index in Nursing and Allied Health Literature (CINAHL) and Excerpta Medica Database (EMBASE). The inclusion criteria were clinical studies that took place within the last 15 years. Clinical trials were included with an emphasis placed in Randomized Controlled Trials (RCT), so as to include research with the highest quality of evidence. The keywords "subacute stroke" and "endurance" or "aerobic" were selected, rendering 14 and 29 results respectively. Of the 7 studies initially selected only 3 RCTs (Tables 1 and 2) [1,6,17] and one RCT study protocol [18] met the inclusion criteria.

Author/Year	N	Therapeutic Intervention	Exercise Duration
Dunkan et al. [17]	92	Exercise program designed to improve strength, balance, and endurance.	Three 90-min sessions/week /for 12 weeks.
Katz-Leurer et al. [6]	92	Aerobic training with a leg cycle ergometer.	8 weeks.
Billinger et al. [1]	9	Aerobic training with a recumbent stepper.	Three up to 40-min sessions/week/for 8 weeks.
N: Number of Participants			

Table 1: RCTs: therapeutic interventions-exercise duration.

Author/Year	N	Outcome Measures	Results
Dunkan et al. [17]	92	Stroke Severity, Motor Recovery and Strength, Gait and Balance, Exercise Stress Test, Assessment of Medical Comorbidities.	Balance, Endurance, Peak aerobic capacity, Mobility, statistically significantly improved.
Katz-Leurer et al. [6]	92	Workload Exercise Time, Resting Blood Pressure and Heart Rate, Submaximal Blood Pressure and Heart Rate, Functional Abilities.	Workload, work time (P<0.01) and Heart Rate at rest (P<0.02) statistically significant improvement.
			Functional activities improved. Stair climbing statistically significantly improved (P<0.01).
Billinger et al. [1]	9	Flow Mediated Dilation (FMD),Six-minute Walk Test (6-MWT),Cardiovascular Health and Peak Exercise Test.	Flow Mediated Dilation (FMD) in both arms (P<0.01),Resting Systolic Blood Pressure (SBP), Six-minute Walk Test (6-MWT) (P<0.002) statistically significantly improved.
			Diastolic Blood Pressure, Heart Rate and VO2 peak values improved.
N: Number of Participants			

Table 2: RCTs: outcome measures-results.

Results

A randomized, single blinded, controlled trial, regarding the effectiveness of a structured, supervised home program for patients with subacute stroke, was conducted in 17 health care institutions [17]. A large sample of 92 patients was selected. Treatment consisted of a general program designed to increase strength, flexibility, balance, endurance, each session lasted 90 minutes. Endurance training included riding a stationary bike. Intervention took place 3 times per week for 12 weeks.

Outcome measures included peak aerobic activity measurement and exercise duration, scales such as Fugl Meyer, Berg balance test, wolf motor function test, the 10 and 6 min walk test. Improvement was observed in endurance and peak aerobic activity after intervention and 3 months after the end of the treatment. Of note, endurance was rarely included in the treatment program and when included it was rarely continued to the end of treatment, unlike balance, upper extremity function, ROM etc. [17].

In another study conducted by Katz-Leurel et al. [6] in 2003 the effect of submaximal aerobic exercise in 92 patients with subacute stroke was investigated [6]. The duration of the RCT trial was 8 weeks during which patients received aerobic exercise using a leg cycle ergometer. The treatment protocol was divided in two parts. In the first part, training 5 days per week for 2 weeks was introduced during which duration was gradually increased up to 20 min. In the second part that lasted the remaining 6 weeks, training took place 3 times per week and exercise duration was 30 min with a limitation of heart rate not reaching levels more that 60% of maximal heart rate, for the patients' age. Improvement was found in workload, work time (P<0.01) and heart rate at rest to a statistically significant level. It is suggested that this finding may indicate an effect of aerobic exercise on the exercise response or it may reveal an influence on "movement efficiency". Furthermore a significant relation of age and aerobic exercise was found in the distance covered walking unassisted. An increase in functional activities was noted, but only stair climbing reached a statistically significant level of improvement (P<0. 01) [6].

Finally Billinger et al. [1] conducted a research study where the effect of an aerobic exercise program was studied in subacute stroke patients, in a small sample of 9 patients. There was a preparation time, which included stretching and a post training part. The exercise program took place for 8 weeks, three sessions per week, each session lasting 40 min. In the first two weeks a limitation of exercise not surpassing 50-59% of maximal heart rate was selected, whereas in the following 4 weeks an increase was introduced to 60-69% of maximal heart rate [1]. A peak Vo2 exercise test was used for testing exercise capacity, which revealed no statistically significant in VO2 peak values. Significant improvement was found in flow mediated dilation in both arms after the intervention, in systolic blood pressure and the 6 min walk test [1].

Discussion

Primary research retrieved through the literature review was obviously scarce. Aerobic exercise appears to enhance exercise capacity in subacute stroke patients as shown in the presented studies, though there are significant differences among the studies in research design, program selection and inclusion criteria.

As mentioned by Duncan et al. [17] endurance was rarely incorporated and if it was present, was rarely progressed. This finding brings up thoughts that enough emphasis is not placed on endurance by health care professionals or/and motivation to patients is not satisfactory. The literature review did not reveal further information to elucidate this suggestion; still it is important to keep in mind as worth investigating, when considering endurance.

The provision of sufficient endurance training is underlined by the fact that a standard rehabilitation program in stroke patients is largely static, and a large part of the day, the patient is practically left inactive. Therefore, it is important not to overlook the endurance training component since; there is an inherent tendency to immobility [2].

A methodological difficulty outlined by Billinger et al. [1] was that research on stroke rehabilitation entails the basic function of gait. Endurance is dependent on the workload produced by the pattern of walking and its reeducation. Therefore, different patients may exhibit different workload spent, depending on the pattern and biomechanics of walking, and the energy spent during movement.

Inclusion criteria are of critical importance, and it is essential to correctly establish a common period that a patient is considered to be in the subacute phase. Billinger et al. [1] recorded patients that suffered a stroke in less than 6 months prior to the initiation of the study [1]. Duncan et al. [17] included patients from 30-150 days after the stroke, which means that patients in the acute phase were also included partially in the trial as it may be suggested for the previous study as well. Katz-Leurer et al. [6] studied patients 48 h after initiation of symptoms with an average of 15.4 days after the stroke. In this study a narrower range of time after the event was selected which might have restricted the results to a smaller portion of the available subacute patient population; still it has surely not included acute or chronic patients due to the narrow time frame [6].

Regarding the content of the exercise program in the studies presented, it can be easily observed that aerobic exercise was the main exercise intervention except the study by Duncan et al. [17] which investigated the effect of endurance in subacute stroke patients as well as strength, balance, and flexibility. The endurance parameter was less specified and targeted than other studies. In the other studies shorter training periods were selected [1,6].

The Meta-analysis by Pang et al. [19], outlined that endurance training was mainly trained through cycle ergometer or treadmill gait training, which still stands up to this date, as shown in the research studies presented in this study.

Of note in a recent study protocol for a randomised controlled trial by Floel et al. [18] a short training period was proposed, which indicates a much more comprehensive and rigorous program. More specifically a treatment period of 4 weeks instead of 8 weeks in the other studies presented whilst exercise frequency of 5 times per week instead of 3 times per week as in other trials [1,17] has been proposed. In the present study an interesting intervention variable that is suggested to be further explored is the addition of overhead weight support on a treadmill. The percentage of body weight support reached no more than 15% and a much more comprehensive aerobic exercise program was utilized [18]. The aim was to achieve sufficient cardiovascular stress to produce significant outcomes in terms of endurance. This parameter may be incorporated in future studies. This may have several interpretations and possible utilizations and results. For instance to enable patients with greater movement limitations to reach the cardiovascular stress reached by patients with less movement limitations.

Future research in stroke rehabilitation is encouraged to specify a basic structure of the treatment program, leading to general guidelines at first. Exercise duration, intervention selected, Heart rate maximum percentage, treatment period, use of body weight support, are basic parameters that need to be narrowed down, so that research studies may reach a clinically relevant assumption for treatment planning.

Conclusion

Since research regarding the effect of aerobic training to subacute patients is scarce, no safe conclusions can be reached. Multiple methodological difficulties also support this statement. Furthermore, there is not an up to date particular protocol used by researchers. A clear common element in the studies though is the selection a percentage of heart rate maximum up to 60-70% as the limit for exercise, as it was expected.

It seems that there is a large variability in the selection of time after the stroke, thus the stage of recuperation of the patient. Future research is encouraged to reach a common ground on this important inclusion criterion. Other inclusion criteria can also be established such as a standardized measure of stroke severity or walking or activities of daily living (ADL) limitation to define the severity of stroke.

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