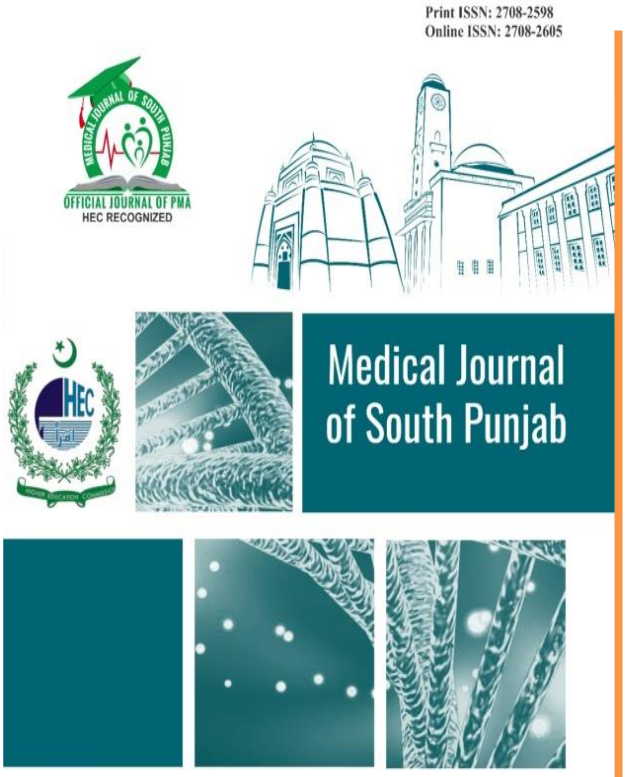
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Original Article

Impact of high intensity interval training versus moderate intensity continuous training on upper limb motor function among subacute stroke patients: a randomized controlled trial

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ABSTRACT

Objective: To compare the effects of high intensity interval training (HIIT) and moderate intensity continuous training (MICT) on upper limb motor function in subacute stroke patients.

Methods: Randomized controlled trial was conducted at department of Physical Therapy, Bahawal Victoria Hospital, Bahawalpur, Pakistan, over four months. Sixty patients aged 43 to 75 years with subacute ischemic stroke (1 to 6 months after onset) were randomly allocated by computer generated random numbers to Group A (HIIT, n = 30) or Group B (MICT, n = 30). Group A performed ten 60 second bouts of arm ergometer cycling at 80 to 90% of heart rate reserve (HRR), each followed by 60 seconds of active recovery. Group B performed continuous arm ergometer cycling at 50 to 60% HRR. Both groups also received 30 minutes of conventional physiotherapy per session, four sessions per week for six weeks.

Results: Fifty seven participants completed the trial. Group A improved from 35.41 ± 4.55 to 50.69 ± 2.55 ($Z = -4.708$, $p < 0.001$), and Group B improved from 34.00 ± 4.43 to 43.89 ± 2.64 ($t = -11.173$, $p < 0.001$). The mean change was significantly greater in Group A (15.28 ± 5.18) than in Group B (9.89 ± 4.69), with $t = 4.112$, $p < 0.001$ and $d = 1.09$.

Conclusion: Both HIIT and MICT improved upper limb motor function in subacute stroke patients, but HIIT produced a significantly greater improvement.

Keywords: High Intensity Interval Training, Moderate Intensity Continuous Training, Motor Function, Randomized Controlled Trial, Stroke, Upper Extremity

1. INTRODUCTION

Stroke is one of the major causes of long-term disability in adults globally, and the number of survivors requiring a long-term rehabilitation after stroke is increasing with the improvement in acute care and increasing population age.[1] It is one of the most common and long-term effects on the upper limbs. At onset about 77% of patients are weak in the arm and only about 12% return to normal arm function by 6 months with standard care.[2] The arm and hand are used in nearly all activities of daily living, including feeding, dressing, grooming and household activities. This continued upper limb dysfunction consequently results in a reliance on care takers and low quality of life.[3] The earliest first few months after stroke is the time for the fastest recovery. The subacute period (1-6 months) is considered a critical window of increased brain plasticity when intensive rehab is most effective and when more effective training strategies are needed.[4]

Aerobic exercise is being used more and more to activate the brain for motor recovery, since it increases the levels of brain derived neurotrophic factor (BDNF), a major factor in regulating synaptic plasticity and motor learning of stroke survivors.[5] The response seems to be intensity-dependent: In stroke patients, serum BDNF levels were up to 2 fold higher after the HI sessions than the moderate continuous sessions.[6] The aerobic prescription following stroke has long been moderate intensity continuous training (MICT) for 20–60 minutes with exercise intensity between 40 and 60% heart rate reserve (HRR). High intensity interval training (HIIT), which involves short periods of high intensity (80 to 90% HRR) followed by periods of rest, has been found to lead to greater improvements in peak oxygen uptake (15 to 22% versus 8 to 12%).[7] In patients with post stroke gait dysfunction, HIIT has additionally created more enhancements in gait speed, walking ability, and cerebral blood flow contrasted to MICT.[8] Meta analysis showed no adverse event rate after stroke with HIIT compared with conventional exercise, and highlighted the need for investigation of HIIT effect on motor upper limb recovery.[9] However, nearly all of the HIIT vs. MICT trials have assessed the effects on cardiorespiratory fitness, gait or balance. Upper limb motor function has rarely served as the main outcome measure, there is very limited evidence from the subacute phase, and from populations that are not from the South Asian region; the Wolf Motor Function Test (WMFT) is a reliable, valid and responsive test of upper limb function, but has not been used to compare the two training modes.[10]

The purpose of this study was to assess and compare the effects of high intensity interval training and moderate intensity continuous training on wolf motor function test in subacute stroke patients. The hypothesis was that while moderate intensity continuous training would improve upper limb motor function, high intensity interval training would achieve a significantly greater improvement.

2. METHODOLOGY

This study was a two arm, parallel group randomized controlled trial conducted for four months in the Department of Physical therapy, Bahawal Victoria Hospital, Bahawalpur, Pakistan. This was determined using G*Power for a two tailed independent samples t test. This comparison was the first to take place between HIIT and MICT with the WMFT, and a medium effect size (d = 0.5) was hypothesized. An α of 0.10 with a power of 0.60 resulted in a sample size of 30 participants per group, or a total sample size of 60.

The sampling technique employed was nonprobability consecutive sampling, which involved the selection of eligible patients. The participants in these two groups were then randomly assigned (random number generator) to the computer-generated sequence

of numbers for Group A (HIIT) and Group B (MICT) in a 1:1 ratio.

Adults (aged 43–75 years) with a confirmed diagnosis of ischemic stroke were included. They were required to be in the subacute phase (1-6 months from onset). They also needed to be medically stable, have written informed consent from the treating physician to exercise and be willing.

Patients were excluded if had had a recurrent stroke or transient ischemic attack. They also were not included if a previous upper limb musculoskeletal condition (e.g. frozen shoulder, fracture, or a high degree of arthritis) would make it impossible for them to perform the arm ergometer exercise. Any patient included in another structured exercise or rehabilitation program during the study period was excluded. So too were those who had any other psychiatric or neurological condition that might affect the outcome.

This data collection included taking a baseline measurement of demographic and clinical information on a structured proforma after obtaining ethical approval and informed consent. These were age, gender, affected side, time since stroke, comorbidities (hypertension, diabetes mellitus and cardiac disease) and blood pressure.

The Major Outcome was the WMFT. It includes 15 functional tasks (from simple proximal to complex distal hand tasks) timed and 2 strength tasks. There are 120 seconds per functional task and each task is scored on the Functional Ability Scale (FAS) from 0 to 5. The maximum attainable mark is 75 for the tested limb and a higher score reflects a better function. The WMFT has high internal consistency ($\alpha \geq 0.88$), excellent intra rater reliability (ICC ≥ 0.97), excellent inter rater reliability (ICC $\geq$ 0.92) and good responsiveness in stroke survivors.[10] The more affected limb was assessed at baseline and again within 48 hours after the final session. All the assessments were conducted by the same assessor who was blinded to group allocation.

The two groups were trained on an upper extremity arm ergometer. All HIIT and MICT sessions were supervised and intensities and session durations were based on published protocols for stroke recovery. Medical clearance prior to participation and monitoring during training of participants with cardiac disease.

Group A (HIIT) began each session with a 5 min low intensity warm up. This was then followed by 10 intervals, high intensity (80–90% HRR) followed by low intensity active recovery (LIA) for 60 seconds each to give 20 minutes of interval work. After that, there was a five minute cool down ending the session, which is about 30 minutes.

Group B (MICT) also had a 5 min warm up. Then there was continuous moderate intensity cycling (50-60% HRR) and a 5 minute cool down for a total of 30 minutes.

Both groups did 30 minutes of conventional physiotherapy after the aerobic training. This consisted of passive and active range of motion exercises, stretching and task oriented upper limb exercises. A total of 24 sessions of training were provided four times a week for six weeks.

SPSS version 26.0 was used to analyse the data. Data are presented as mean ± standard deviation (and medians as appropriate) for continuous variables, and as frequencies and percentages for categorical variables. The Shapiro Wilk test was used to analyse normality. Independent samples t test and chi square test for continuous and categorical data respectively were used to test baseline equivalence.The WMFT FAS scores at baseline were not normally distributed in Group A (Wilcoxon test, W = 0.916, p = 0.024) and therefore the Wilcoxon signed rank test was used for within group changes. The Group B data were normally distributed (p = 0.485) and therefore the paired samples t test was used.

3. RESULTS

Sixty patients were randomized, with 30 allocated to each group. The six-week

programme was completed by 57 participants (29 in Group A and 28 in Group B), with three participants dropping out for personal reasons unrelated to the training programme. Both groups reported no cardiac or other serious adverse events during intervention.The continuous baseline characteristics between the two groups. Mean age was 59.50 ± 8.96 years in Group A and 57.23 ± 8.71 years in Group B (p = 0.324). Time since stroke was similar in both groups, at 3.61 and 3.68 months (p = 0.856).Baseline systolic and diastolic blood pressure were also similar between groups (p = 0.480 and p = 0.899). The groups were found to be comparable with regard to each of the continuous baseline variables, with no significant differences.

Table-1: Comparison of continuous baseline variables between groups

Variable	Group A (HIIT) n = 30, Mean ± SD	Group B (MICT) n = 30, Mean ± SD	p value
Age (years)	59.50 ± 8.96	57.23 ± 8.71	0.324
Time since stroke (months)	3.61 ± 1.53	3.68 ± 1.42	0.856
Systolic BP (mmHg)	138.43 ± 9.01	140.17 ± 9.86	0.480
Diastolic BP (mmHg)	85.37 ± 6.95	85.60 ± 7.12	0.899

Table 2: Within group comparison of WMFT FAS scores before and after intervention

Group	Pre Mean ± SD (Median)	Post Mean ± SD (Median)	p value
Group A (HIIT), n = 29	35.41 ± 4.55 (36.00)	50.69 ± 2.55 (51.00)	< 0.001
Group B (MICT), n = 28	34.00 ± 4.43 (34.00)	43.89 ± 2.64 (44.00)	< 0.001

Table 4: Between group comparison of change in WMFT FAS scores

Group	n	Mean change ± SD	Median (range)	p value
Group A (HIIT)	29	15.28 ± 5.18	14.0 (5 to 26)	< 0.001
Group B (MICT)	28	9.89 ± 4.69	9.0 (1 to 21)	

4. DISCUSSION

In this trial, 6 weeks of arm ergometer HIIT and MICT in addition to standard physiotherapy were both effective in improving upper limb motor function in sub-acute stroke patients. HIIT resulted in a significantly greater improvement (large effect size, d = 1.09) on the WMFT FAS (5.4 additional points). To the best of our knowledge this is the first randomized trial that compared these two modes of aerobic exercise with respect to functional outcome of the upper limbs in the subacute phase in Pakistan. It is responsive to recent reviews that have requested that HIIT be evaluated in other areas beyond the cardiorespiratory and gait outcomes.

Both groups exhibited a large improvement, which aligns with evidence that structured, high dose, upper limb practice is associated with motor recovery. Task oriented training with aerobic activity was more effective in improving arm function and fitness than just task training alone.[11] The dose response was greatest in the subacute phase and higher doses of upper limb rehab resulted in 40-60% larger improvements.[12]A Cochrane review also found that spending more time in rehabilitation was associated with improved activity and impairment outcomes after stroke.[13] In the present study, both groups engaged in about an hour of use in each session in the subacute period which represents the time when spontaneous and training induced recovery can be expected to be greatest.[14] This is the reason why even the MICT group improved by nearly 10 points, a figure which is well comparable to the median improvements of 8–15 points reported in the usual care group.[15]

The superiority of HIIT agrees with previous trials that compared the two modes on other outcomes. HIIT (80-90% HRR) resulted in greater improvement in VO_2peak, six minute walk distance and gait speed as compared to MICT.[16] Their HIIT group also had more improvements in motor region cerebral blood flow. The 18.3% greater rise in VO_2peak and a 0.12 m/s greater improvement in gait speed after eight weeks of HIIT in higher functioning stroke survivors.[17] HIIT led to greater improvements in cardiorespiratory fitness than MICT. At the level of pooled evidence, HIIT has been demonstrated to have benefits on functioning and HRQoL, aerobic capacity,balance and walking ability,

compared to moderate intensity training.[18] This strength based benefit appears to be transferable to the upper limb when training is provided on an arm ergometer as found in the present study.

There are a number of reasons for the increased benefits of HIIT. Hsu et al. demonstrated that the serum BDNF following HIIT sessions was up to twice as high as following MICT in stroke patients and resting BDNF level was also higher after four weeks of HIIT. A validated aerobic exercise's ability to increase BDNF in subacute stroke according to the intensity of the exercise.[18] In addition, an increase in BDNF has been confirmed in stroke survivors by a meta-analysis. BDNF stimulates synaptogenesis, cortical remapping and consolidation of motor learning. There are reports of positive alterations in markers of neuroplasticity following HIIT after stroke even low intensity exercise has shown to increase plasticity in the contralesional hemisphere.[19]

Results may have been affected by the use of an arm ergometer. The aerobic exercise was also repeated and challenging for use of the affected limb. The power and speed of arm movements in the work intervals of HIIT were greater when compared to moderate steady cycling performed at 80-90% HRR. This gives a task-specific strength and endurance stimulus to build on the cardiovascular stimulus. Follows the rule of higher intensity and dosage of upper limb training for better result.[18]HIIT was clinically well tolerated. Although over a third of Group A suffered from cardiac disease, no serious adverse events were reported. This aligns with the safety of HIIT following stroke as demonstrated by a meta-analysis.[20] Concurrently, the MICT still made a substantial and clinically significant improvement. It is therefore a useful treatment in patients who cannot endure the high intensity exercise. It is suggested that a risk stratified approach be used, where HIIT is given to medically cleared patients, and MICT is used as an effective alternative for the medically higher risk patients.

5. CONCLUSION

In subacute stroke patients, both HIIT and MICT, when combined with the traditional physiotherapy, showed significant improvement in motor function of the upper limbs. For medically stable patients, HIIT resulted in a significantly greater improvement and should be utilized during the subacute recovery window.

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