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Effect of boxing therapy on upper-limb function, balance, and quality of life in stroke patients: A randomized controlled trial

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Abstract

Background: Active engagement of stroke patients in rehabilitation is directly linked with better functional performance. Boxing therapy is one of the innovative approaches that have been used to improve the active patient participation. *Objective:* To determine the additional effects of boxing therapy along with task-oriented training on upper limb function, balance, and quality of life in stroke patients. *Methods:* This randomized control trial was conducted on thirty stroke patients - of either gender, age (40 to 60 year) and able to sit for at least 2 minutes - recruited through non-probability convenience sampling and randomly assigned into two equal groups: Boxing Therapy (BT) and Task-Oriented (TO) through sealed envelope method. Both groups received task-oriented training while BT group received additional concurrent boxing therapy for 8 weeks, 3 times per week. Fugl-Meyer-Upper Extremity, Wolf Motor Function Test, Berg Balance Scale, and Stroke Specific Quality of Life Questionnaire were used for assessment at baseline and after 4 and 8 weeks of intervention. Data was analyzed using SPSS. *Results:* The between-group analysis showed the statistically significant difference in both group in terms of Fugl-meyer assessment for upper extremity, Wolf motor function test, Berg balance scale, and Stroke specific quality of life questionnaire ($p<0.05$). Within group analysis of all the variables are statistically significant for both groups ($p<0.05$).
Conclusion: The study found that boxing therapy has additional beneficial effects on upper limb function, balance and quality of life as compared to only task-oriented training in stroke patients.

Keywords: Balance, boxing therapy, quality of life, stroke, task-oriented, upper limb function.

INTRODUCTION

The social and economic costs of stroke continue to put a strain on health-care resources and rehabilitation programs and amounts to roughly $68.9 billion USD every year in the United States alone.[1,2] This economic burden will continue to climb as the population grows older, death rates decline, and stroke incidence rises.[3] Pakistan has a stroke prevalence of 250 persons per 100,000.[4] Functional impairment continues in approximately 40% of individuals after stroke, while serious dysfunction persists in 15-30 percent of cases.[5,6] Hemiplegia develops in more than 85 percent of stroke patients shortly after the commencement of the stroke, and 55–75 percent of stroke survivors have ongoing impairments, such as lack of physical activity and poor sense of wellbeing.[7]

Stroke can alter emotion and cognitive capacity, further limiting functional capacities, and arm motor disability can decrease overall well-being.[8] Upper-limb weakness is common in both early and late stages of stroke, with up to 40% of people never regaining functional upper-limb usage in everyday tasks.[9] Further, stroke patients have uneven posture, irregular bodily balance, and a reduced capacity to transfer weight, among other issues.[10] As a result of such chronic conditions, the majority of stroke patients suffer from mental health issues, difficulties in mutual association and social life, and a general diminished life satisfaction.[11] Problematic movement and

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coordinating the arms, hands, and fingers is a typical presentation of upper limb deficits, which makes daily tasks difficult. Upper limb movement disability is linked to depression and a lower assessment of health-related quality of life and subjective well-being one year after stroke.[8]

Patients who have had a stroke and have small or no physical impairment may also have a poor quality of life.[12] There is a decreased upper-extremity function and several socio-demographic characteristics were linked to a lower health-related quality of life.[13] The ability to maintain postural control is hampered by body dissymmetry and difficulties in weight shifting to the paralyzed side, which impedes the orientation and stability required for normal trunk and limb movement.[14] About 3 out of 4 stroke survivors fall within six months after their stroke, 21% fell after six months, and over half of all reported falls happened while walking.[15] Recent stroke studies have reported interventions such as more traditional general and passive treatment[16], training based on reality[17], treatment encompassing encouragement and active participation, forced induction exercise[18], visual practice feedback[19], task-specific training[20], and goal-directed training.[21] Both acute/subacute and chronic stroke patients benefit from task-oriented training therapies to improve muscular strength and gait-related tasks.[23]

Combs *et al*. conducted the first study involving boxing therapy in Parkinson's disease patients and found that boxing therapy was viable and dependable.. High-intensity boxing workouts conducted four times a week for 50 minutes increased fitness, health, and well-being in able-bodied person.[23] The seated boxing program had a favorable influence on arm function, balance, gait, and quality of life in stroke patients.[6] In addition to neurodevelopmental therapy, virtual and actual boxing training approaches were found to be useful in enhancing upper limb, stability, and cognition in individuals with hemiparetic stroke.[1] However, trials of boxing therapy for stroke patients using actual boxing regimen are sparse with more studies focusing on virtual boxing training instead.

In majority of the past studies, the number of outcome measures used was very limited. Another shortcoming was the use of boxing training only in the sitting position and without progression. Furthermore, the past studies reported the findings based on data collected only before and after the regimen. The primary objective of the current study was to determine the effect of additional boxing therapy on upper-limb function, balance, and quality of life as compared to task oriented training alone in stroke patients.

METHODS

This single-blind randomized control trial involved thirty patients recruited via non-probability convenience sampling technique. The patients were randomly assigned into two equal groups (Boxing Therapy: BT and Task-oriented: TO) through sealed envelope method (Figure 1). Opaque envelopes were created and sealed by a person not familiar or related to the current trial. The envelopes were securely kept until provided to the therapist during recruitment. The research was conducted at a private rehabilitation center from June 2021 to July 2022. The inclusion criteria include either gender, age bracket 40-60 years, Fugyl-Meyer score limit for upper limb of 30, Sub-acute and chronic and able to sit for 2 minutes independently. The exclusion criteria included cognitive impairment (MOCA score: <26), abnormal synergic pattern, and visual Impairment. The sample size was calculated using online sample size calculator (epitools) using Wolf Motor Function Test as the primary outcome measure. The study was approved by the Research Ethical Committee of Riphah International University, and all participants gave their written informed consent to participate.

Patient information

The mean±SD age of the patients in BT and TO groups was 54.7±4.7 years and 50.1±6.2 respectively. The number of females in BT and TO groups was 6 and 11 while number of males was 9 and 4 respectively.

Data collection procedure

Both groups performed 30 minutes of identical task-oriented training. This was followed by 15 minutes of boxing therapy (sitting and standing) for BT group and 15 minutes of additional task-oriented training for TO group. Overall duration of each session for either group was 45 minutes. The treatment was provided 3 days/week for 8 weeks (Table 1). Data was collected at baseline, after 4, and 8 weeks of intervention by using the following instruments. The upper limb section of the Fugl-Meyer Assessment is widely used in stroke interventional studies. The Wolf Motor Function Test (WMFT) assesses upper - limb motion control through timed single- and multiple-joint motions as well as functional tasks. The

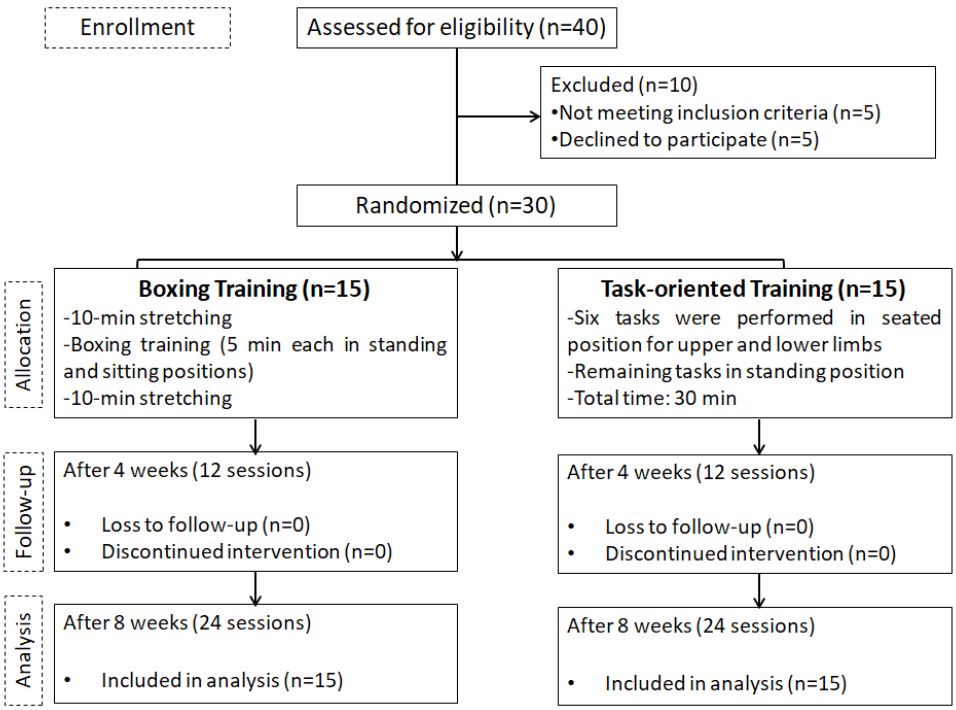


Figure 1. CONSORT diagram

Berg Balance Scale is used in stroke patients to evaluate balance. The Berg balance scale analyses functional balance performance using 14 everyday items. The Stroke Specific Quality of life Questionnaire was used to assess quality of life in stroke patients.

Intervention

BT Group (Boxing Therapy)

Instructed to sit in gloves and strike mitts and a sandbag in multiple directions (up, down, left, and right) using verbal cues such as punch, straight, one two, and a pairing of these. There were four levels of boxing therapy. Level 1 consisted of a unilateral jab/direct hit (high and low). Both sided punch/direct and hook/hook punches were included in Level 2. (high and low). Both sided direct punches/jab combinations (right jab + left jab) were included in Level 3. (High and low). Level 4 punch combinations involve either different punching styles (i.e. jab + cross) or different sides (right + left) (high and low). There are four ranges in boxing training first one is long range (outside of range) second 3 feet away range just outside of range next is the arms distance (in range) and the last one is close range (inside fighting). Arms distance range was applied with all the four levels of boxing therapy. During the first four weeks, the therapist provided help and support to the injured limb while hitting with a light weight. In the following four weeks, adhesion was introduced as the strength and function of the impacted upper limb enhanced. The physical therapist accelerated the tolerance and frequency range between the levels. From the first to the fourth week, the training was done while sitting (Table 1). Following that, from the fifth to the eighth week, the subjects were instructed to hit the target while seated and standing. Three of them were bilateral direct punches/jab combinations (right jab + left jab) (high and low). Level 4 punch combinations involve either different punching styles (i.e. jab + cross) or opposing sides (right + left) (high and low).

TO Group (Task-oriented Training)

Following tasks were performed for 5 minutes each from seated position in very session:

- Open and close the lid of bottles and boxes of different sizes.
- Picking the stones from the table and put it in the box. Flip the cards that are placed on the table.
- Hold the pencil and write or draw anything on the paper.

Table 1: Detailed intervention protocol

Weeks	Boxing Therapy group (BT)	Task-oriented training group (TO)
Duration of a session	45 minutes	45 minutes
Frequency of sessions	3 times a week	3 times a week
Week 0 (Baseline)	Pre-assessment	Pre-assessment
Weeks 1,2,3,4	Boxing therapy: warm up. Mitt Punching, sandbag punching, in sitting and standing position (3 sets of 10 punches of each upper limb with 2 mins of rest) per day. (sitting 5 mins and standing 5mins) (therapist assist the affected upper limb while punching, with low weight) in sitting. Cool down Assessment was performed after 4 weeks	Task oriented training: Six tasks were performed in seated position and other in standing posture for both upper and lower extremity Assessment was performed after 4 weeks
Weeks 5,6 7,8	Boxing therapy: warm up. Mitt Punching, sandbag punching, both in sitting and standing, (3 sets of 10 punches of each upper limb with 2 mins of rest) per day. (Sitting 5 mins and standing 5mins) (Progress by adding more weight). Cool down Post assessment	Task oriented training: Six tasks were performed in seated position and other in standing posture for both upper and lower extremity Post assessment

- Pick a lock key and from the table and open and close the lock. Transfer different sizes objects from one box to another.
- Transfer different sizes bottles, cups and cans from one table to another. Also transfer the juice from one glass to another.
- Reach forward to grab the balls and throw toward the therapist and catch with both hands.

All exercises were carried out with bilateral upper extremities. Excess time spent on tasks was not permitted, even if a participant had a more complicated activity to complete. Modification was only done if a patient was unable to complete the task. When necessary, the clinician facilitated the participant in completing the task.

- Chair features: back support chair, no hand rest, seat 42 cm diameter. The chair size was modified to match the subject's leg length.
- Step spec2ifications: a height limit of 11 cm and a length of 70 cm.

Data analysis procedure

The assessor (ANM) was unaware of which group each participant belonged to. To ensure that the assessor remained blinded, any information linking participants to their study group was concealed. Data analysis was done by using SPSS version 21. For categorical variables, descriptive statistics were used to calculate frequency and percentages while, for continuous variables, mean and standard deviation were calculated. Between group analyses, for continuous variables, mixed ANOVA test was applied. Within group analyses were done by repeated measures ANOVA. Post-hoc analyses were carried out with Bonferroni test for pairwise comparison of means. Statistical significance was defined as a p-value below 0.05.

RESULTS

There were statistically significant interactions between the intervention (groups) and time (assessment time) assessed by Berg balance scale. All assumptions were filled for Mixed ANOVA and all variables have shown the significant interaction between interventions (groups) and time (assessment). (Table 2)

Table 2: Mixed ANOVA showing the interaction of intervention (Groups) and Time (assessment)

	BT group			TO group			F value	P value		Partial
	Baseline	Week 4	Week 8	Baseline	Week 4	Week 8		Within group	Between groups	eta square
BBS	32.3±5.0	41.5±5.3	46.7±4.2	34.1±7.6	39.1±6.7	40.9±6.5	198.3	P≤0.05	P≤0.05	0.98
FMA-UE	32.6±1.5	45.1±4.2	55.7±5.5	33.4±2.2	38.9±3.9	40.6±4.4	196.6	P≤0.05	P≤0.05	0.93
WMFT	32.6±8.4	43.2±8.7	52.8±6.5	34.8±11.4	41.3±8.5	42.5±8.1	72.3	P≤0.05	P≤0.05	0.84
SSQoL	139.3±22.5	152.5±23.6	167.1±20.8	123.9±15.0	127.9±15.9	129.3±15.5	37.4	P≤0.05	P≤0.05	0.73

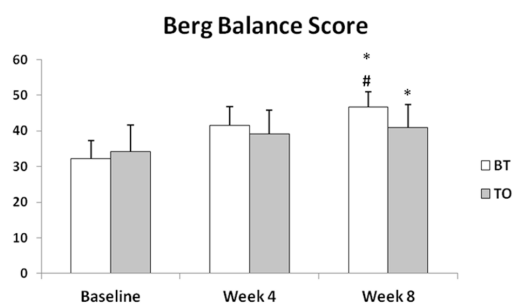
BT: Boxing Therapy, TO: Task-oriented, BBS: Berg Balance Score, FMA-UE: Fugl-Meyer Assessment-Upper Extremity, WMFT: Wolf Motor Function Test, SSQoL: Stroke Specific Quality of life

The between group analysis of BBS and FMA-UE shows that significant difference at 4th and 8th week and it shows that BT group was more effective as compared to TO group. (Fig. 2 and 3) The between-group analysis of WMFT and QOL analysis showed that there was no significant difference at 4th week while BT group score was significantly better after 8 weeks of intervention. (Table 2)

DISCUSSION

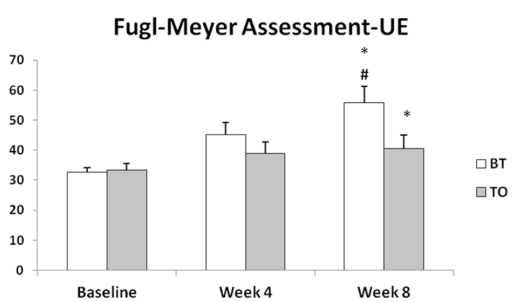
The present study aimed to determine the impact of boxing therapy with task- oriented training on upper-limb function, balance, and quality of life in stroke patients. Boxing therapy, when adapted for stroke patients, offers a unique blend of physical and cognitive challenges that can contribute to significant rehabilitation outcomes. There was a significant improvement in FMA and WMFT score in boxing therapy group after 8 weeks of intervention as compared to task-oriented alone group. A similar randomized control trial conducted by Park *et al*. 2017 reported that there was improvement in upper-limb function as they use Manual Function Test which showed higher scores after 6 weeks. They reported improvement in the control group as well since both interventions were provided to the control group too.[6] Erosy *et al*. 2020 compared the effects of real Boxing and virtual Boxing in which both groups showed significant improvement in WMFT and manual dexterity test scores without group differences. The reason was that they applied boxing therapy with addition to neurodevelopmental intervention in both groups, and mean age of participants was 58 year, and ratio of male to female was 15:5 and they recruited only chronic patients (>30 months).[1] The current study has one boxing therapy group and other task-oriented training and the mean age of the participants was 52 year, and there was 17 male and 13 female participants, this study considered only sub-acute and chronic not more than 16 months of onset. Boxing exercises can stimulate the brain to form new neural connections, particularly in areas affected by stroke. This neuroplasticity can help relearn motor functions and improve coordination. Park *et al*. 2016 conducted a study for two weeks - 5 days per week - and each session lasting 30 min. A significant improvement in upper-limb function was reported. [24]

Boxing requires precise body awareness and proprioception, which can be impaired after a



(BT: Boxing Therapy, TO: Task-oriented, * Significant difference with baseline
Significant between-group difference

Figure 2. Changes in Berg Balance Score in both groups (BT: Boxing therapy, TO: task-oriented)



* Significant difference with baseline
# Significant between-group difference

Figure 3. Changes in Fugl-Meyer Assessment score in both groups (UE: Upper Extremity) BT: Boxing therapy, TO: task-oriented)

stroke. Boxing exercises can help retrain these senses. The present study showed improvement in balance function in the Boxing group as compared to task-oriented group. Similar results have been shown previously in terms of decreased fall risk and better BBS scores by boxing therapy.[6] Fullerton Advance Balance scale scores showed significant improvement in balance in both study groups.[1] Martins *et al*. 2017 concluded that task-specific training improved balance function and mobility in post-stroke patients. Randomized control trial comprised of program involving task-specific training and a control group of global stretching, memory exercise, and educational sessions to determine the level of functional tasks, risk of fall, ambulation and, life satisfaction, in stroke population.[25] Another study based on exer-gaming reported reduced fall risk and improved walking in patients with stroke in which experimental group receives exer-gaming and control group received traditional training for 6 weeks. Berg balance scale showed significant improvement in balance in exer-gaming group after complete intervention.[26] Malik and Masood (2017) conducted a randomized control trial to explore the effect of exer-gaming and task-oriented training on ability to move in post-stroke and reported improvement in balance and mobility in exer-gaming group after completing the 8 weeks of interventions. They used 45 mins of task-oriented training for both group and with addition of 20 minutes of exer-gaming in experimental group and used Berg balance scale as outcome measure.[27] The present study revealed that the participants in the boxing therapy group experienced substantially more significant improvements in quality of life compared to those in the the TO group which also showed significant improvement. Similar results were also reported by a pervious trial conducted on boxing therapy.[6] The goal-oriented nature of boxing can boost motivation and self-confidence, which are crucial for rehabilitation. Quality of life improved in task-oriented group as compared to control group that receive global stretching technique. Quality of life in stroke patients was enhanced by changes in physical activity levels.[25]

One of the limitations of current study is lack of objective data to measure the study variables. Furthermore, the average duration of stroke was not documented in either study group.

In conclusion, the boxing therapy improves upper limb function, balance and quality of life in stroke patients treated with task-oriented training. and such training should be incorporated in the stroke rehabilitation protocols. Further studies are needed to understand the detailed effects and mechanism of boxing therapy.

DISCLOSURE

Trial registry: This trial has been registered at the clinicaltrials.gov (U.S National Library of Medicine) under the identifier number NCT0526099.

Financial support: None

Conflict of interest: None

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