ORIGINAL ARTICLE

Benefits of Exercise Maintenance After Traumatic Brain Injury

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ABSTRACT. Wise EK, Hoffman JM, Powell JM, Bombardier CH, Bell KR. Benefits of exercise maintenance after traumatic brain injury. Arch Phys Med Rehabil 2012;93: 1319-23.

Objective: To examine the effect of exercise intervention on exercise maintenance, depression, quality of life, and mental health at 6 months for people with traumatic brain injury (TBI) with at least mild depression.

Design: Treatment group participants were assessed at baseline, after a 10-week exercise intervention, and 6 months after completion of the intervention.

Setting: Community.

Participants: Participants (N=40) with self-reported TBI from 6 months to 5 years prior to study enrollment and a score of 5 or greater on the Patient Health Questionnaire-9.

Interventions: Ten-week exercise intervention program consisting of supervised weekly 60-minute sessions and unsupervised 30 minutes of aerobic exercises 4 times each week. Telephone follow-up was conducted every 2 weeks for an additional 6 months to promote exercise maintenance for individuals randomized to the intervention group.

Main Outcome Measure: Beck Depression Inventory (BDI) comparing participant outcomes over time. Post hoc analyses included comparison among those who exercised more or less than 90 minutes per week.

Results: Participants reduced their scores on the BDI from baseline to 10 weeks and maintained improvement over time. Many participants (48%) demonstrated increased physical activity at 6 months compared with baseline. Those who exercised more than 90 minutes had lower scores on the BDI at the 10-week and 6-month assessments and reported higher perceived quality of life and mental health.

Conclusions: Exercise may contribute to improvement in mood and quality of life for people with TBI and should be considered as part of the approach to depression treatment.

Key Words: Brain injuries; Depression; Exercise; Rehabilitation; Treatment outcome.

PEOPLE WITH TRAUMATIC brain injury (TBI) report high rates of depression,[1] anxiety,[2] and diminished quality of life.[3] There is growing evidence that physical activity interventions are effective ways to improve quality of life, depression, and other symptoms.[4] Physical activity interventions have been studied in people with conditions such as primary depression,[4] anxiety,[5] arthritis,[6] and dementia.[7] Nevertheless, thus far there has been little research examining the potential long-term benefits of physical activity or maintenance of gains from exercise interventions in people with TBI.

There is preliminary evidence that people with TBI who exercise regularly experience many of these same health benefits, such as improved aerobic fitness and cardiovascular capacity.[8-10] One community-based retrospective study found that 64 individuals with TBI who exercised reported less depression, fewer other symptoms, and better health status than 176 participants with TBI who did not exercise.[11] A prospective study of 13 adults with moderate TBI used a virtual reality cycling task for single bouts and a prolonged 4-week intervention. Participants were found to have improved learning ability and decreased reaction times.[12] A qualitative study of 27 participants with TBI found that exercise intervention focused on balance retraining improved balance, self-esteem, and social participation.[13] A pilot study demonstrated improved mood among 10 subjects who participated in weekly hour long sessions of Tai Chi Qigong over 2 months compared with 10 subjects performing nonphysically-based activities.[14] Finally, 2 prospective randomized controlled trials showed no differences between the 2 groups studied. In the first study, Hassett et al[15] randomized individuals with severe TBI to either an exercise center-based group with 3 visits per week for 12 weeks or to a home-based group with similar exercises. Our group conducted a second study,[16] where individuals with a broad severity of TBI were randomized to the intervention group, including 1 supervised exercise session per week for 10 weeks and recommended additional community-based exercise 4 times per week, or to a waitlist follow-up group. Both groups in each trial demonstrated similar increases in physical activity and psychosocial outcomes at the end of the treatment phase. In the second study, post hoc analyses showed that those who exercised 90 minutes per week or more reported less depression, as well as better sleep, community participation, and overall quality of life compared with those who exercised less than 90 minutes per week.

Despite some positive findings for exercise interventions, maintenance of exercise without a structured treatment has

List of Abbreviations

BDI	Beck Depression Inventory
PQOL	Perceived Quality of Life Scale
SF-12	Medical Outcomes Study 12-Item Short-Form Health Survey
TBI	traumatic brain injury

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been typically unsuccessful in other populations.[17,18] Exercise maintenance has not been studied in individuals with TBI. Hassett et al[19] attempted to look at factors that increased the engagement of individuals with TBI in their home-based treatment arm, but did not follow individuals after the initial treatment period. In our study, we followed the treatment group for 6 months after the end of the structured intervention period to determine whether our focus on community-based exercise and education would extend any potentially positive benefits. To evaluate whether exercise was maintained for this subsample of the initial randomized controlled trial, we sought to examine the following questions: (1) To what extent were any positive effects of the intervention on exercise, depression, quality of life, and mental health maintained at 6 months? (2) Was there a statistically significant relationship between exercise frequency or duration and participant outcomes, such as depression, quality of life, and mental health? We also examined whether there was any change in activity level from the end of the treatment phase (10wk) to 6 months later.

METHODS

Participants

Participants were individuals randomized to the treatment group in the study investigating the effect of a structured aerobic exercise program on the severity of depressive symptoms in people with TBI, which has been published.[16] Recruitment for the full study took place through posted and online advertisements in the community. Eligibility criteria included a TBI 6 months to 5 years prior to enrollment that was severe enough to have required medical evaluation or hospital admission immediately after injury, based on subject self-report. In addition, participants were required to be between the ages of 18 and 55, have a score of 5 or greater on the Patient Health Questionnaire-9,[20] indicate at least a mild level of depressive symptoms, and have sufficient cognitive ability to maintain an exercise log and participate in the study either independently or with the assistance of an involved support person. A reasonable threshold of cognitive ability was deemed sufficient if participants were able to contact the study coordinator, arrange transportation, attend study appointments, and participate in the exercise program. Individuals who required assistance from a caregiver were asked to include the caregiver in all sessions to assist as needed. Exclusion criteria included a medical condition that would limit or preclude exercise, current suicidal ideation with intent or plan, current pregnancy, current regular exercise program 3 times a week or more, any physical barrier to the use of standard aerobic exercise equipment, and non-English speakers. If there were concerns about a potential participant's physical abilities, the participant was further screened for eligibility with a physical examination by the study physician (K.R.B.). For the original 10-week randomized controlled trial, eligible participants were randomized to the exercise intervention or to a waitlist control group.[16] This article examines only those who received the exercise intervention and were followed at 6 months. Informed consent was obtained with approval of the University of Washington Human Subjects Division.

Procedures

The initial exercise intervention is described in Hoffman et al.[16] Briefly, the treatment group received 10 weeks of once per week exercise training sessions, conducted by a research educational trainer and a certified athletic trainer at a local community college gymnasium. Each supervised exercise session included education on exercise, home exercise log review, warm-up exercises, 30 minutes of aerobic exercise, and a cool-down period with planning for future exercise activities. Participants were trained to monitor their heart rate and perceived exertion[21] during the aerobic exercise portion of the sessions to be moderately intense. The exercise intensity was adjusted until their heart rate goal was met.

The treatment group was then asked to perform 30 minutes of moderately intense aerobic exercise of their choice 4 times each week outside of the weekly supervised exercise sessions and to keep an exercise log. Participants were given information on free or low-cost exercise groups and facilities, with encouragement to walk, bicycle, or engage in other physical activity if they did not have access to these resources.

Telephone follow-up phase. After the 10-week intervention, an outcome evaluation was conducted to compare the treatment and control group for the randomized controlled trial. The treatment group was then followed to provide support and assistance with maintaining their exercise programs via phone every 2 weeks for 6 months by the 2 trainers from the treatment phase. These contacts were individualized to each person's situation and included encouraging ongoing self-monitoring of exercise, discussing strategies to maintain social and environmental support for exercise or how to cope with relapse into nonexercise, and providing general support for positive lifestyle change.

Several strategies were employed during the phone calls to promote maintenance of exercise beyond the intervention period. First, the educational trainer reviewed specific topics covered in the intervention based on principles of social cognitive theory[22] and the transtheoretical stages of change model.[23] These included general information oriented toward motivating change (eg, self-efficacy), as well as information specific to facilitating change related to exercise (eg, identifying exercise-related benefits, reducing exercise barriers, and building social support for exercise). Participants were encouraged to review goals they had set, as well as continue to use self-monitoring, self-reinforcement, and problem-solving to facilitate maintenance of exercise in their daily lives. Finally, the trainer might engage a participant in a cost/benefit analysis to prevent relapse or reduced exercise.

Measures

Basic demographics were collected including age, sex, marital status, and education. We assessed each participant at baseline, 10 weeks after enrollment into the study, and at 6 months after enrollment.

Measures relating to mood included the Beck Depression Inventory (BDI),[24] which measures intensity, severity, and depth of depression, and the Medical Outcomes Study 12-Item Short-Form Health Survey (SF-12) mental component summary,[25] which includes items relating to vitality, social functioning, role-emotional, and mental health. Additionally, we used the Perceived Quality of Life Scale (PQOL),[26] a measure of satisfaction with 12 different aspects of life, including an individual's contact with family or friends, contribution to the community, meaning and purpose in life, and happiness. Data on type and amount of exercise were collected using the 7-day physical activity recall.[27] The following measures were given to all participants at the 3 time points, but are not presented, because there was no change found over time: Analog Pain Scale,[28] Brief Pain Inventory,[28] Traumatic Brain Injury Symptom Checklist, Pittsburgh Sleep Quality Index,[29] Craig Handicap Assessment and Reporting Technique Short-Form,[30] Repeatable Battery for the Assessment of Neuropsychological Status,[31] Trail Making Test parts A and B,[32] weight, blood

Table 1: Comparison of Exercise Group Performance Over Time

Measure	Exercise Group			Change Over Time			
	Baseline*	10wk*	6mo*	Baseline to 10wk†	10wk to 6mo†	Baseline to 6mo†	3-Way Comparison‡
BDI	–21.7±9.2 (40)	–16.5±10.3 (37)	–16.0±11.9 (32)	4.72 (.009)§	–0.23 (.901)	5.04 (.014)§	.033§
Minutes of exercise per week	65.5±76.9 (40)	252.0±278.1 (37)	146.6±184.6 (29)	188 (.000)§	−105 (.036)§	80 (.024)§	.000§
Days of exercise per week	1.28±1.47 (40)	3.68±2.53 (37)	2.31±2.55 (29)	2.41 (.000)§	−1.66 (.005)§	1.17 (.023)§	.000§
PQOL	53.9±19.0 (40)	58.4±20.3 (37)	59.4±20.4 (32)	5.30 (.070)	0.87 (.742)	6.25 (.025)§	.442
SF-12 physical	41.6±12.5 (40)	42.0±12.1 (37)	42.3±12.2 (32)	−0.12 (.937)	0.32 (.842)	−0.86 (.663)	.976
SF-12 mental	31.8±10.7 (40)	38.3±11.2 (37)	37.6±14.4 (32)	6.49 (.002)§	−2.31 (.290)	5.75 (.031)§	.040§

*Values are mean ± SD (sample size).
†Values are the change in group means (corrected such that a positive value indicates improvement) and *P* value of a paired *t* test or Mann-Whitney *U* test in parentheses.
‡Values are either analysis of variance (parametric) or Kruskal-Wallis (nonparametric) comparisons of the 3 time periods.
§Statistically significant data.

pressure and heart rate in sitting, and distance walking in 6 minutes.

Data Analysis

The primary analysis examined differences on all outcome variables across the 3 time points: baseline, 10 weeks, and 6 months. Paired *t* tests and analysis of variance were used for all continuous outcome measures, and Mann-Whitney *U* tests and Kruskal-Wallis tests were used for nonparametric measures. In addition, a post hoc analysis was performed among individuals who exercised more or less than 90 minutes per week at each time period using the Wilcoxon rank-sum test on measures of depression, quality of life, and general mental health.

RESULTS

Demographics

Initially, 42 individuals were randomized into the exercise group. However, despite meeting initial screening criteria, 2 subjects reported engaging in more than 400 minutes of exercise (meeting exclusion criteria) at the baseline assessment and were dropped from all analyses. Therefore, a total of 40 individuals, who were randomized to the exercise group and then followed for 6 months after the intervention, were included in the analyses. Participants of the initial sample were 38% men, 35% married (vs any other status), 68% white, 95% with high school or higher education, had been injured an average ± SD of 2.1±1.4 years, and had an average age ± SD of 39.7±12.6 years. Of the 40 individuals who completed the baseline assessment several were lost to follow-up, with 37 being assessed after the 10-week exercise intervention and 32 assessed after the 6-month maintenance phase. There were significantly fewer women who completed the 6-month assessment. All other demographic variables were the same for those who did and did not complete the 6-month assessment.

Table 1 displays the change in outcome variables over time. Individuals who participated in the exercise intervention reduced their scores on the BDI from baseline to 10 weeks and were able to maintain their improvement over time. There was no significant change in level of depression from 10 weeks to 6 months after baseline assessment. This same pattern of findings held for scores on the SF-12 mental component. Quality of life did not significantly change during the intervention, but the trend suggested improvement.

There was a large increase in minutes of exercise per week after engaging in the exercise intervention. However, some individuals were not able to maintain the level of increased exercise achieved at 10 weeks over the 6-month follow-up period. At baseline, 36% of subjects reported more than 90 minutes of exercise per week. At 10 weeks, 77% of individuals were exercising at least 90 minutes per week. However, the proportion who continued to exercise more than 90 minutes per week decreased to 52% by the 6-month follow-up assessment. For those subjects who completed all 3 assessments (n=29), 48% increased or maintained their level of exercise over time, 41% experienced a relapse, 2 individuals did not improve, and 1 person reported exercising less after being enrolled in the intervention. While overall exercise minutes did decrease for these participants, at 6 months they were still exercising significantly more minutes compared with baseline. This same finding held true for days per week of exercise.

Table 2 compares those who exercised more than 90 minutes per week with those who exercised less than 90 minutes on the BDI, PQOL, and SF-12 mental component. Results suggest that those who exercised more than 90 minutes had lower scores on the BDI at both the 10-week and 6-month assess-

Table 2: Comparison Among Participants Who Exercised More or Less Than 90 Minutes Per Week

Measure	Baseline				10wk				6mo			
	<90min (n=27)	≥90min (n=13)	*t* Test	WRS	<90min (n=9)	≥90min (n=28)	*t* Test	WRS	<90min (n=15)	≥90min (n=14)	*t* Test	WRS
BDI	22.5	20.1	.444	.497	24.9	13.9	.003*	.006*	18.8	11.8	.046*	.037*
PQOL	50.9	60.1	.152	.236	47.6	61.9	.065	.137	53.3	67.2	.031*	.014*
SF-12 mental	31.0	33.5	.483	.497	33.0	40.0	.104	.083	32.0	43.6	.017*	.014*

Abbreviation: WRS, Wilcoxon rank-sum test.
*Statistically significant data.

ment. In addition, at 6 months, those who continued to exercise more than 90 minutes per week also reported higher perceived quality of life and mental health.

DISCUSSION

The results presented in this article provide an initial look at maintenance of exercise after a structured exercise intervention. Results suggest the duration and frequency of exercise substantially exceeded baseline reports for those individuals who received both the exercise intervention and follow-up telephone calls. Nearly half of the subjects (48%) were able to achieve and sustain increases in physical activity over the 6-month period, and 52% were exercising more than 90 minutes per week at 6 months.

Depression, perceived quality of life, and mental health were all better at 6 months compared with baseline and either continued to improve (BDI and PQOL) or did not decline significantly from 10 weeks to 6 months. The indicators of psychological benefits of the intervention remained stable, despite the decreasing trend in days and minutes of physical activity from 10 weeks to 6 months. We cannot determine whether any maintenance or improvement was because of the receipt of telephone follow-up or because of unmeasured factors. However, these patterns may suggest that time and frequency of exercise do not mediate the effect of the intervention on depression, quality of life, and mental health or that, at 6 months, participants remained above the physical activity threshold needed to maintain these psychological benefits. Our post hoc comparison of subgroups with higher versus lower levels of physical activity supports the latter notion. Those who exercised at least 90 minutes per week reported significantly higher mood, better quality of life, and improved mental health. Taken together, these data support the potential benefit of exercise on depression, quality of life, and mental health in people with TBI.

While level of depression declined, at 6 months the average scores on the BDI remained in the mildly depressed range. The exercise group reported an average of 146.6 minutes of exercise per week, which is just under the minimum recommended minutes of exercise recommended by the American College of Sports Medicine.[33] Previous research has shown that physical activity at this level was associated with greater improvement in depression severity than a lower dose of physical activity.[34] Higher doses of exercise either in terms of greater exercise intensity or more minutes per week may be needed to achieve more clinically significant improvement in depression severity. In addition, depression after TBI may also be more complex or difficult to treat than primary depression.[35] If this is the case, then exercise should be included in a multimodal treatment approach to depression, which may also include counseling and medication.

There is a dearth of research on effective treatments for depression after TBI. The data in this study are correlational, and more experimental research is needed to verify the relationship between exercise and depression for this population. Future research on exercise interventions regarding the amount of exercise and the optimal methods for initiating[36] and maintaining exercise behavior,[37] including telephone support, for those with TBI, is needed. In addition, future research should be informed by multimodal, stepped care approaches to improving depression treatment effectiveness.[38]

Study Limitations

Without a control group for comparison at 6 months, it is difficult to judge the efficacy of the exercise maintenance and telephone call support aspects of the intervention. The results of this study may not generalize to the larger TBI population given the higher percentage of participants who were women and the overall high level of education. In addition, severity of injury was based on self-report rather than medical record review because of the community-based strategy for enrollment. Exercise dose was also based on self-report, which may have been impacted by participant difficulties with cognition or memory. The data are correlational, and we cannot determine whether exercise led to an improvement in mood and quality of life or whether mood and quality of life led to an increase in exercise. Telephone contact and counseling may also have affected depression directly rather than through maintenance of exercise.[39] Physical parameters, such as aerobic capacity and body mass index, were not available and should be included in future research. In addition, the literature in relation to the maintenance of exercise effects does not provide precise benchmarks. However, the maintenance effects of this study are generally consistent with what would be expected from formal exercise programs emphasizing sustained physical activity with other populations.[37]

CONCLUSIONS

The results of the current study add to the literature, suggesting that exercise can contribute to improvement in mood and quality of life for those with TBI. While there was a decline in minutes exercised after the specific treatment program, the positive effects were maintained. In addition, exercising a minimum of 90 minutes per week was associated with improved mood, quality of life, and mental health. Additional research to determine whether higher levels of exercise can lead to even larger improvements in mood would be beneficial. What means of support are most effective in achieving exercise maintenance for those with TBI is still not determined. However, exercise should be included as part of an approach to depression treatment for individuals with TBI.

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