Evaluation of a Physical Activity Intervention for Adults with Brain Impairment: A Controlled Clinical Trial

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Abstract

**Background:** Individuals with brain impairment (BI) are less active than the general population and have increased risk of chronic disease. **Objective:** This controlled trial evaluated the efficacy of a physical activity (PA) intervention for community-dwelling adults with BI. **Methods:** Forty-three adults with BI (27 males, 16 females; age 38.1±11.9 years; Stage of Change 1-3) who walked as their primary means of locomotion were allocated to an intervention (n=23) or control (n=20) condition. The intervention comprised 10 face-to-face home visits over 12-weeks including a tailored combination of stage-matched behaviour change activities, exercise prescription, community access facilitation and relapse prevention strategies. The control group received 10 face-to-face visits over 12-weeks to promote sun safety, healthy sleep and oral health. Primary outcomes were daily activity counts and minutes of moderate-to-vigorous PA (MVPA) measured with the ActiGraph GT1M at baseline (0-weeks), post intervention (12-weeks) and follow-up (24-weeks). Between-group differences were evaluated for statistical significance using repeated measures ANOVA.

**Results:** MVPA for the intervention group increased significantly from baseline to 12-weeks (20.8±3.1 min.day⁻¹ to 31.2±3.1 min.day⁻¹; p=.01) but differences between baseline and 24-weeks were non-significant (20.8±3.1 min.day⁻¹ to 25.3±3.2 min.day⁻¹; p=.28). MVPA changes for the control group were negligible and non-significant. Between-group differences for change in MVPA were significant at 12-weeks (p=.03) but not at 24-weeks (p=.49).

**Conclusion:** The 12-week intervention effectively increased adoption of PA in a sample of community-dwelling adults with BI immediately after the intervention but not at follow-up. Future studies should explore strategies to foster maintenance of PA participation.

**KEYWORDS:** acquired brain injury; cerebral palsy; exercise; health promotion; stroke.
Introduction

There is unequivocal evidence that physical activity (PA) is essential for good health. Physical inactivity is the fourth leading cause of death due to non-communicable disease worldwide and is estimated to contribute to over three million preventable deaths each year including deaths due to coronary heart disease, hypertension, colon cancer and diabetes mellitus.\textsuperscript{1,2} Based on this evidence, it is recommend that adults should accumulate 30 minutes of moderate-to-vigorous intensity PA (MVPA) per day.\textsuperscript{3-5}

Brain impairment (BI) is defined as a significant loss or abnormality in the brain structure.\textsuperscript{6} A range of health conditions may lead to BI, including: cerebral palsy, a disorder of movement or posture resulting from a non-progressive lesion in the developing brain\textsuperscript{7}; traumatic brain injury, which is an injury resulting from an external force and causing altered brain function\textsuperscript{8}; and stroke, a focal disturbance of cerebral function of vascular origin.\textsuperscript{9} These 3 conditions are particularly important because of their high incidence – cerebral palsy affects 1 per 500 live births\textsuperscript{10}, traumatic brain injury affects 200 per 100,000 people per year\textsuperscript{11} and stroke affects 94 per 100,000 people per year.\textsuperscript{12} Regardless of aetiology, BI results in abnormal brain function including impaired cognitive, social/behavioural and/or sensorimotor function. Additionally, people with BI participate in significantly less PA than the general population.\textsuperscript{13-15} Evidence indicates that the benefits accrued by people with BI who increase their PA includes improved cardiorespiratory fitness, muscle strength and functional independence.\textsuperscript{16-20} In order to increase PA participation and improve health, fitness and functioning in people with BI, it is critical to develop interventions which effectively promote free-living PA participation in this population.
To date, interventions to increase PA in adults with BI have largely been ineffective.\textsuperscript{21-25} These programs have primarily been conducted in dedicated, fixed facilities including hospital-based or outpatient-based facilities and consisted of structured exercise prescription with limited use of tailored evidence-based behaviour change strategies.\textsuperscript{21-25} There is preliminary evidence to indicate that tailored exercise counselling alone, or in combination with supervised exercise, improves PA participation in community-dwelling stroke survivors.\textsuperscript{26} However, this approach has not been tested in more general samples of adults with brain impairment. Additionally, evidence indicates that key contextual factors such as lack of transportation and/or finances are significant barriers to attending exercise programs at fixed facilities for individuals with a disability, including brain impairment.\textsuperscript{27} Physical activity interventions delivered in an individual’s home or local community help to reduce these barriers and increase the prospect of sustained participation, particularly for individuals who have PA preferences beyond structured exercise in a fixed facility. Therefore studies evaluating the efficacy of lifestyle PA interventions delivered in the home or local community are required.

Community-based rehabilitation is a theory-driven model of service delivery that has been successfully applied to the provision of a range of rehabilitation services for individuals with BI including physiotherapy, occupational therapy and community reintegration services.\textsuperscript{28} Community-based rehabilitation refers to services delivered in an individual’s home or community (i.e., physical surrounds which they typically inhabit or could easily access).\textsuperscript{28} An advantage of the community-based rehabilitation model of service delivery is that infrastructure costs are negligible when compared to establishing and maintaining a purpose-built, fixed facility. Community-based rehabilitation aims to enhance the natural
support systems within an individual’s home and community and may be a potentially effective service delivery model for promoting PA in people with BI.29

Lifestyle PA interventions are an effective means of promoting PA\textsuperscript{30} and could be delivered using a community-based rehabilitation service delivery model. Lifestyle interventions utilise a range of evidence-based PA promotion strategies (e.g., goal setting, self-monitoring, self-reward and social support) to assist individuals increase their physically active behaviour.\textsuperscript{28,30} The strategies increase PA because of their effect on theory-based mediators of PA including self-efficacy\textsuperscript{31-33}, social support\textsuperscript{34,35} and decisional balance.\textsuperscript{35} The effectiveness of lifestyle interventions can be enhanced by using a stage of change algorithm to categorise each participant into 1 of 5 stages of motivational readiness for change\textsuperscript{36} – thereby permitting selection of PA promotion strategies which best suit an individual’s motivational readiness for change. This process is known as stage matching an intervention. Delivering a lifestyle PA intervention using a community-based service delivery model allows for PA promotion strategies to be discussed, designed and evaluated in the same setting in which PA will be adopted and maintained. Lifestyle interventions have the potential to be seamlessly integrated into already established community-based rehabilitation services for individuals with BI. To date, studies evaluating the effectiveness of community-based lifestyle PA interventions for adults with BI have not been conducted.

The purpose of this controlled clinical trial was to evaluate the efficacy of a PA intervention for community-dwelling adults with BI. The intervention adopted a community-based rehabilitation approach to deliver a stage-matched lifestyle PA intervention and the primary outcome was objectively measured PA. Secondary outcome measures were decisional balance, self-efficacy and social support.
Methods

Participants

People meeting the following inclusion criteria were eligible to participate: males or females, aged 18-60 years with a BI resulting from cerebral palsy, traumatic brain injury or stroke; living in a community setting within a 150km radius of the University of Queensland; walking as their primary means of locomotion (with or without aids); medically safe to participate in moderate intensity PA\textsuperscript{37}; currently insufficiently active for health; and cognitive ability to participate in the behaviour change activities integral to the intervention. Exclusion criteria were: lower limb surgery in the past six months or scheduled during the intervention; lower limb botox in the past three months or scheduled during the intervention; serious, regular or uncontrolled substance abuse; documented violent or aggressive behaviour; or suicidal ideation.

Ethical approval for this study was received from The University of Queensland Medical Research Ethic Committee (HMS10/0410) and the Cerebral Palsy League of Queensland Research Ethics Committee (CPL-2011-003). The study was registered through the Australian New Zealand Clinical Trials Registry (ANZCTR) ACTRN: 12610000864022.

Recruitment

Participants were recruited through gatekeeper referral agencies including community-based service providers for people with BI, and outpatient rehabilitation services in Brisbane from January 2011- May 2012. Referral agencies were provided with an overview of the intervention and the inclusion and exclusion criteria and asked to identify participants who met the criteria and who would be interested in taking part in a healthy lifestyle program.
addressing the following health behaviours: physical activity, sun safety, oral health and sleep. Potential participants were subsequently contacted by a member of the research team who formally assessed study eligibility and provided details of the study in terms commensurate with their level of understanding. Following an opportunity for questions, people who were eligible and interested in participating provided written informed consent. Eligibility assessment included the administration of the Marcus et al. staging algorithm.35 People in the first three stages of change were, by definition, insufficiently active for health and therefore eligible to participate, these stages being: Stage 1 (Precontemplation - not currently physically active and have no intention of increasing their activity in the next 6 months); Stage 2 (Contemplation – not currently physically active, but intend to become physically active in the next 6 months); and Stage 3 (Preparation - completing some PA however not a volume sufficient to meet the PA guidelines for health).38

Study Design

A stratified systematic allocation protocol was used to assign participants to either a PA intervention or a control condition. As participants were enrolled in the study, they were first stratified by Stage of Change, ensuring that both study arms had equal numbers of inactive or insufficiently active participants. Within each stratum, the first participant recruited was allocated to the intervention or control group by flipping a coin. The second participant assigned to the cell was allocated to the alternative condition (e.g., if the first participant assigned to the cell was allocated to the control group, the second participant assigned to the cell was automatically allocated to intervention group). This process was conducted by a researcher external to the study.
Participants allocated to the intervention group were informed that they would be receiving two health behaviour interventions, the PA intervention first, then an intervention addressing sun safety, oral health and sleep. Participants allocated to the control intervention were told the reverse.

The participant flow diagram is shown in Figure 1. Fifty-four referrals were received from gatekeeper agencies and participants with BI were assessed for eligibility. Eleven were excluded as they did not meet the inclusion criteria (n=5), suffered an unrelated illness or injury (n=5) or declined to participate (n=1). Forty-three participants were stratified by Stage of Change (n=19 Stage of Change 1 and 2; n=24 Stage of Change 3) and allocated into the PA intervention (n=23) or the control condition (n=20). One participant from the intervention group and one participant from the control group were unable to complete the post-intervention measures due to medical issues not associated with their participation in the program.

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*Physical Activity Intervention*

Table 1 provides an overview of the PA intervention. All participants transitioned through Steps 1, 2 and 3 during 10 face-to-face sessions over 12-weeks. Each session was 1 hour in duration and the inter-session time varied depending on the needs of the participant and the stage of the program, with typically more sessions in the first 6 weeks as community access was arranged, skills learned and habits were established. Session frequency diminished in the second 6 weeks, with more emphasis on fostering independence and self-management.
Step 1 was a standardised preparticipation assessment conducted in order to permit each participant’s PA intervention to be individually tailored. This step had 3 main components, the first being a series of questions and activities based on the domains of the International Classification of Functioning, Disability and Health (ICF)\(^6\) which aimed to identify key factors that would impede or enhance PA participation for a particular individual. Domains assessed included each participant’s impairments, activity limitations and participation restrictions, as well as personal and environmental factors likely to affect PA participation.\(^39\) An information sharing exercise, conducted through a short video discussing the definition and benefits of PA, was also completed in order to establish a shared understanding of the concept of PA.\(^40\) The motivational readiness of each participant, previously evaluated using a Stage of Change algorithm, was used in order to permit stage-matching of the intervention.\(^36\)

Step 2, the intervention implementation, entailed the application of stage-matched behaviour changes strategies (Step 2a), exercise prescription (Step 2b), and strategies to promote community access (Step 2c). For the purposes of this program, participants who were originally classified as Stage of Change 1 and 2 were pooled because the information sharing exercise conducted in Step 1 explicitly required participants to consider the benefits they may accrue by becoming physically active, so any genuine Stage 1 participants who remained in the program would have become Stage 2. For participants in Stage 1 and 2, emphasis was placed on developing a discrepancy between the participant’s current PA behaviour and their broader goals and values, evaluating the benefits and barriers and eliciting change talk for increasing PA. For Stage 3 participants, emphasis was placed on strategies that would assist them to increase their activity from insufficient levels to sufficient levels (e.g., goal setting, reward systems, and self-monitoring).\(^36\) The specific strategies used for each participant were
selected from those presented in Table 1 (Step 2a), all of which have been described elsewhere.\textsuperscript{41-43} The selection of the strategies used was based on the outcomes of Step 1 and any subsequent session.

The behaviour change strategies implemented as part of Step 2a led to a broad array of PA which usually included a mixture of structured, graduated exercise prescription (Step 2b) as well as sports, outdoor activities, practical activities or cultural activities facilitated by Step 2c. Exercise prescription and recommendations for the type of activity were individually tailored using the information gained during the preparticipation assessment. The structured exercise prescribed in Step 2b aimed to assist participants achieve personally relevant goals (e.g., to be physically stronger, to be able to walk further or to “get back into the garden”). Community access facilitation included activities such as liaising with community-based PA providers, equipment modification and/or the identification of financial assistance programs and transportation.\textsuperscript{44}

Step 3 entailed the delivery of individually tailored relapse prevention strategies designed to help participants identify potential situations in which their PA routine may be disrupted or stopped and to formulate appropriate strategies to restart or continue with their PA program.\textsuperscript{45}

During Steps 2 and 3 the face-to-face sessions were supplemented by reminder calls, email messages or electronic notifications in order to reinforce the session outcomes and provide a prompt for additional action where required (e.g., completing an activity log or completing a daily walk). The extent to which these methods were utilised depended on
individual participant preferences, availability and utilisation of the various communication methods, as well as the individual’s impairment profile (especially impaired memory).

--- Insert Table 1 near here---

**Control Condition**

Like the PA intervention, the control condition comprised 10 x 1 hour face-to-face counselling sessions delivered over 12 weeks. The distribution of face-to-face sessions was similar to the PA intervention and control participants received an equivalent number of reminder calls and electronic notifications. By controlling for an equivalent amount of contact, this group acted as an attention-control, thereby reducing the potential confounding influence of the effect that therapist contact can have on the response of the participants. The control intervention aimed to promote oral health, sun safety and healthy sleep. Sun safety, oral health and sleep were chosen because, they are health behaviours that can significantly reduce disease risk in the target population, and because they can be influenced using behaviour change strategies similar to those employed for promoting PA. The face-to-face sessions for the control condition followed a sequence similar to the PA intervention outline presented in Table 1, aiming to: 1) develop a shared understanding of the target health behaviours, including their importance and the recommended guidelines for good health; 2) discuss the participant’s thoughts and feelings regarding the behaviour; 3) discuss the perceived importance of- and their current engagement in- the health behaviours; and 4) use evidence-based behaviour change strategies to increase engagement in the target behaviours.

After participants had completed 12 weeks of either the PA intervention or the control condition, there was a 12 week follow-up period (week 13 to week 24) during which there was no contact – either face-to-face or electronic – between the research team and
participants. At the conclusion of the follow-up period (24-weeks) participants received an abridged version of the program they had not already received - participants who initially completed the PA intervention received the control intervention, and participants who initially received the control intervention received the PA intervention. Both the PA and control interventions were delivered by the same accredited exercise physiologist (AEP), who had experience in exercise prescription for individuals with BI and behaviour change strategies for increasing PA as well as the principles of promoting oral health, sun safety and sleep. Delivery of both interventions by the same person ensured that inter-practitioner factors did not influence results.

*Primary Outcome Measure- Physical Activity*

Both primary and secondary outcome measures were taken at three time points – baseline (0-weeks), immediately post intervention (12-weeks) and follow-up (24-weeks) and were performed in the participant’s home by one assessor who was blinded to the allocation of the participants.

Physical activity was measured using an ActiGraph GT1M accelerometer-based motion sensor (ActiGraph, Pensacola, FL). Using portable indirect calorimetry as a criterion measure, Tweedy and Trost\(^46\) established that the ActiGraph could validly differentiate between MVPA and activity that was light or sedentary in adults with brain injury.

Participants wore the ActiGraph for seven consecutive days at baseline (0-weeks), post intervention (12-weeks) and follow-up (24-weeks). The ActiGraph was positioned on the midaxilla line at the level of the iliac crest on the side of the body least affected by neurological impairment. Where there was no obvious difference between sides the
ActiGraph was worn on the participant’s dominant side. Participants were provided with a log book with pictures showing how to position the monitor correctly. During these data collection periods, participants received a reminder card, phone calls or text messages to ensure they wore the ActiGraph for the full seven day period. A user-defined time sampling interval (epoch) of 1 minute was used in this study. On completion of the seven day monitoring period, the accelerometer data were downloaded and a customised Visual Basic Excel Macro was used to determine daily wear time, daily average counts per minute (cpm) and daily time spent in MVPA. Counts were classified as either MVPA or light/ sedentary using the cut-point validated by Tweedy and Trost.

In order for a monitoring day to be considered valid and included for analysis, 600 minutes of wear time was required. Non-wear time was classified as consecutive zero counts for at least 60 consecutive minutes, allowing for up to two consecutive 1-minute epochs with non-zero counts less than or equal to 100 counts. Daily wear time was calculated by subtracting the estimated non-wear time from the total monitoring time. Participants with 4 or more valid monitoring days were included in the analyses.

Secondary Outcome Measures

Self-efficacy was measured using the 5-item scale developed by Marcus et al. A 5-point likert type scale was used to rate each item, with one indicating “not at all confident,” and five “very confident.” In this sample Cronbach’s alpha was acceptable at 0.68. Social support was measured using the 13-item scale developed by Sallis et al. A 5-point likert type scale was used to rate the frequency of support received from family and friends in the 3-months prior, with one indicating “none” and five indicating “very often.” Social support scores were calculated for family and friends separately by computing the sum of the items on
the measure. In this sample Cronbach’s alpha for the friends and family subscales was 0.83 and 0.86 respectively. Decisional balance was measured using the 16-item scale developed by Marcus et al which included 6-items representing the avoidance of exercise (cons) and 10-items representing the positive perceptions of exercise (pros). A 5-point likert type scale was used to rate how important each statement was with one indicating “not at all important” and five indicating “extremely important.” The average of the 10 pro-items and the 6 con-items was computed. The difference in the averages (i.e., the average pro score - the average con score) was taken as the decisional balance score. In this sample Cronbach’s alpha was 0.86 for the positive items and 0.62 for the negative items.

Statistical Analysis

Descriptive statistics including means and standard deviations were calculated for the primary and secondary outcomes. Differences between the groups at baseline were tested using independent t-tests for continuous variables and chi-square tests for categorical variables. For the chi-square analysis, Fisher Exact Tests were used when cell counts were less than five. Differences between the intervention and control group changes in PA from baseline to post intervention, and baseline to follow-up, were evaluated for statistical significance using repeated measures ANOVA. Because daily MVPA and wear time were positively correlated, accelerometer wear time was included as a covariate. All participants (n=43) enrolled in the study were included the final analysis. Assuming a two-tailed alpha level of .05, a SD of 25 cpm for change in daily cpm, and a SD of 5 minutes for change in daily minutes of MVPA, the sample size of 23 intervention and 20 control participants (n=43) provided 80% power to detect change scores of 22 cpm and 4.4 mins of MVPA respectively. All analyses were conducted on an intention-to-treat basis; with missing follow-up data conservatively imputed using the last observation carried forward method. General
linear models were implemented in SAS (Version 9.3) using the MIXED procedure, which allows for the specification of the covariance structure for repeated observations. Statistical significance was set at an alpha level of .05.

Results

Participants

Participant characteristics are presented in Table 2. Forty-three participants (27 males and 16 females), mean age 38.1±11.9 years participated in the study (n=23 intervention and n=20 control). Aetiology included traumatic brain injury (n=21), stroke (n=20) and cerebral palsy (n=2). Forty participants were unemployed and 3 worked part time (≤ 20 hours/week) at the time of the intervention. All participants had completed junior high school with 42% of participants having completed a trade, vocational certificate or university degree prior to their injury. All but two participants were classified as community ambulators as per the Hoffer Functional Ambulation Scale.51 There were no significant differences between participants in the intervention and control group for the participant characteristics and outcome variables, with the exception of height. Although participants in the control group were significantly taller than participants in the intervention group (p=.034), the 7cm difference was considered to be of little practical significance. All participants in both the PA and control interventions completed all ten face-to-face sessions. Although there was some variability in the mean time for each contact session, there was no significant difference between the mean session length for the intervention and control groups – the average session time for the intervention group and control group was 55.0 ± 3.8 minutes and 56.9 ± 3.9 minutes respectively.

--- Insert Table 2 near here ---
Primary Outcome Measure – Physical Activity

Between- and within- group differences in the changes in accelerometer cpm and MVPA are presented in Table 3. Mean cpm in the intervention group increased significantly from baseline to post intervention (mean change 60.9±20.7 cpm, p=.004) but changes from baseline to follow-up were non-significant (mean change 34.5±21.0 cpm, p=.11). Changes in cpm over time were small and non-significant for participants in the control group. The increase in daily cpm from baseline to post intervention among intervention participants was significantly greater than that observed among the control participants (net difference 71.9±30.8 cpm, p=.02). However, the between-group difference for the change from baseline to follow-up was non-significant (net difference 29.3±31.0 cpm, p=.35).

Participants in the intervention group exhibited a significant increase in MVPA from baseline to post intervention (mean change 10.4±4.0 min.day\(^{-1}\), p=.01) but changes from baseline to follow-up were non-significant (mean change 4.5±4.1 min.day\(^{-1}\), p=.28). For participants in the control group, changes in MVPA were small and non-significant. After controlling for daily wear time, the increase in MVPA from baseline to post intervention among intervention participants was significantly greater than that observed among control participants (net difference 12.9±6.0 min.day\(^{-1}\), p=.03); however, the between-group difference in the change from baseline to follow-up was non-significant (net difference 4.2±6.1 min.day\(^{-1}\), p=.49).

--- Insert Table 3 near here---

Secondary Outcome Measures

Changes in the secondary outcomes are also presented in Table 3. While participants in the intervention group increased their self-efficacy, social support and decisional balance
scores, with the exception of decision balance, none of the changes were significant post intervention. Within-group changes in family social support and self-efficacy scores for the intervention group were significant at 24-weeks follow-up. There were no significant within-group changes for these variables among control participants. Net differences for changes in social support, self-efficacy, and decisional balance were non-significant from baseline to post intervention (12-weeks) and from baseline to follow-up (24-weeks).

Discussion

This is the first study to evaluate a community-based, lifestyle PA intervention for adults with BI. The findings indicate that the intervention was effective at increasing daily PA levels in adults with BI. However, there was limited maintenance of the increase, 3 months post intervention, indicating that the intervention was successful at promoting PA adoption, but was limited in its capacity to promote PA maintenance. These findings are noteworthy given the particularly low volumes of PA in this population and the significant cognitive, physical and environmental barriers that individuals with BI face. While the absolute volume of change may appear modest evidence indicates these changes are clinically important. A recent review by Powell and colleagues\textsuperscript{52} concluded that even very small increases in physically active behaviour confers significant health benefits for people who are completing less than 150 minutes of moderate intensity PA per week. Furthermore, the review suggests that interventions that prevent people from becoming more physically inactive may also be considered successful. The results of this study indicate that a community-based, lifestyle PA intervention is potentially an efficacious approach for promoting adoption of PA in adults with BI.
Previous studies evaluating interventions to promote PA in individuals with BI have been conducted predominantly in fixed facilities rather than being community-based. The shortcoming of fixed-facility PA programs is that penetration is low, being restricted to those who can travel to the facility, and the prospect of maintaining increases after the conclusion of the intervention is reduced because the facilities and staffing support typically ceases at the study conclusion. A community-based, lifestyle PA program addresses these shortcomings and was a particular strength of this study. Conducting the intervention in the participant’s home also addressed a range of common barriers for PA participation including, but not limited to, lack of transportation, lack of access to an accessible facility and the costs associated with participating in a PA programme.27 All participants in the intervention and control group completed all ten sessions of their allocated program. This high attendance rate is attributed to the intervention being conducted at both a convenient time and convenient location for the participant removing the requirements for transportation and accessibility. Additionally, the prospects of translating results from this study into practice are enhanced by the fact that a range of other health related services (e.g., physiotherapy, occupational therapy, social work) are currently delivered to people with BI using the community-based rehabilitation model of service delivery, and the intervention evaluated in this study could be seamlessly incorporated into such services.

Relative to baseline, participants in the intervention group exhibited increases in PA at 12-weeks and 24-weeks. However, during the follow-up period, activity levels in the intervention group declined marginally by approximately 10%. Compared to the PA intervention, participants in the control group exhibited a small decrease in PA from baseline (0-weeks) to post intervention (12-weeks) and a small increase in PA from post-intervention (12-weeks) to follow-up (24-weeks). The small changes in PA participation in the control
group can be attributed to the natural variance in PA participation over time. As a result of these differences, the between-group difference in the change from baseline to follow-up (24-weeks) was not statistically significant. By design, participants did not have contact with the intervention staff during the follow-up period, and it is possible that the withdrawal disrupted the routine that had been established. A more gradual reduction in the frequency and duration of home visits and the provision of relatively cheap remote support strategies (e.g., reminders via phone, text or e-mail) may be effective ways of assisting participants to maintain their positive changes in behaviour. For example, evidence indicates that follow-up phone calls can improve maintenance of PA following intervention withdrawal. Accordingly, future research should evaluate strategies to provide support beyond the intervention period.

Although the intervention resulted in significant increases in PA, there were no concomitant changes in the secondary outcome measures, indicating changes were mediated by variables not measured in the current study. This finding is consistent with the results of previous intervention studies that also reported increases in PA without concomitant changes in the theory-based mediators of PA behaviour. A possible explanation for our finding is that, because the constructs targeted and their associated measures were adapted from the non-disabled literature, the changes in PA in our sample were mediated by cognitive, social, and environmental influences specific to people with BI which were not measured (e.g., independence in living/ function, physical environment or facility access or expected benefits). Further research on the social-ecological influences of PA in adults with brain impairment is thus warranted.

The participants in this study included adults with brain impairments including cerebral palsy, traumatic brain injury and stroke. Despite the diversity in the health
conditions, from the perspective of promoting PA, the participants were sufficiently similar to
be treated as one group. Specifically, the diagnostic groups included in the study are
classified by having impairments to the brain that affect physical, cognitive or social/
behavioural functioning and low levels of PA participation. Additionally, all participants
included in this study walked as their primary means of locomotion and lived in a community
setting (i.e. non-institutional), ensuring a relatively uniform level of functioning. From the
perspective of promoting PA, these shared features mean that many of the strategies used to
promote PA are similar, addressing issues such as community access, building social support,
and improving self-efficacy for PA. Furthermore, individual tailoring of behaviour change
strategies according to the physical, cognitive and behavioural profile of each participant is a
central feature of the intervention evaluated in this study, making it appropriate for each of the
diagnostic groups included. Previously published PA promotion studies have used even more
diverse populations.24,58

This study has several limitations that warrant consideration. Firstly, participants lived
in urban settings located within a 150 km radius of a large metropolitan university.
Consequently, the findings may not be generalisable to individuals with BI residing in rural
and remote areas. Future studies should explore the viability of implementing the intervention
in rural areas, including exploring the need for adaptations such as increasing the proportion
of the intervention delivered through channels such as internet and phone delivery. Secondly,
due to the difficulties of objectively measuring PA in wheelchair users, the study excluded
individuals who used a wheelchair as their primary form of locomotion. The results of this
study are also only generalisable to individuals who have the cognitive capacity to engage in
intervention activities such as identifying values of interest, discussing behaviour patterns and
setting goals for increased physical activity participation. Thirdly, although accelerometers
are capable of assessing the pattern and intensity of activity, as well as total accumulated activity; they cannot be worn while swimming, and are unable to measure the increased energy expenditure associated with bike riding, walking up stairs, or walking while carrying a load. However, this limitation is applied to both the intervention and control participants, and participation in problematic activities was minimal. Fourthly, the last observation carried forward method was used to impute missing values. This method is limited due to the potential risk of underestimating the variance in the outcome and inflating the type I error rate. However, this approach is conservative in nature (i.e., assumes no change over time), is transparent to the reader, and allows for intention to treat analyses to be conducted. Finally, while the method for allocating participants to the intervention and control conditions could not be considered true random assignment, the systematic allocation protocol resulted in two groups with no significant differences with respect to participant characteristics or baseline outcome measures reducing the threat of confounding due to selection bias.

These limitations were offset by several strengths. The use of an objective measure of PA, in comparison with a self-report instrument, is advantageous given the cognitive impairments associated with BI. Studies evaluating validity of self-report measures in adults with BI identify difficulties in recalling the duration of activities within the monitoring period and quantifying the time spent being active in assisted activities (e.g., the time they spend independently completing housework in comparison to the time that they are provided with in home assistance). These problems may result in participants either over- or under-reporting their time spent active. The veracity of outcomes from this study is enhanced because changes in PA were measured objectively using an instrument specifically validated in this population. Secondly, the study included an attention-control condition to control for the amount of face-to-face contact with the therapist. Finally, the intervention made use of
evidence-based behaviour change strategies tailored to the participant’s PA preferences and Stage of Change.

Conclusions/Implications

In conclusion, a 12-week community-based, lifestyle intervention significantly increased PA in a sample of community-dwelling adults with BI immediately after the intervention but not at follow up. The results of this study are sufficiently positive to warrant conducting additional efficacy trials, utilising trained practitioners in a variety of clinical practice and rehabilitation settings. Future studies should explore strategies to foster maintenance of PA participation, including providing support to participants via phone or internet. Additional research for adapting the intervention for effective delivery in rural and remote settings should also be a future research priority.

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REFERENCES


Table 1: Physical Activity Intervention outline. All intervention participants received the preparticipation assessment and initial intervention strategies. Post completion of these sessions’ participants continued to receive the intervention strategies as per their classified stage of change.

**STEP 1: Pre-participation Assessment**
- Preparticipation assessment based on domains of the International Classification of Functioning, Disability and Health (ICF): health condition, impairments, activity limitations and participation restrictions, as well as environment and personal characteristics which are relevant for the development of the intervention. Includes identifying activities of interest, home and community facilities, disposable income, levels of independence and support, activity or mobility limitations, other commitments;
- Information Sharing: video presentation in order to develop a shared understanding of physical activity (definition, benefits, opportunities).

**STEP 2: Intervention Implementation**

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<thead>
<tr>
<th>2a: Individualised Behaviour Change Strategies</th>
<th>2b: Structured Exercise Prescription</th>
<th>2c: Community Access/Adaptation</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOC 1 or 2 strategies</td>
<td>Goal oriented physical activity prescribed in terms of frequency, intensity, time and type.</td>
<td>Organisational and logistical activities undertaken in order to facilitate physical activity, for example:</td>
</tr>
<tr>
<td>- Information Sharing</td>
<td></td>
<td>- Education of activity stakeholders (e.g., coaches, administrators, instructors or potential team members);</td>
</tr>
<tr>
<td>- Value Identification</td>
<td></td>
<td>- Identifying opportunities for increasing incidental activity (e.g., fostering physical independence rather than dependence on others or walking rather than using a wheelchair for long distances);</td>
</tr>
<tr>
<td>- Modelling</td>
<td></td>
<td>- Equipment modification or other specialist information;</td>
</tr>
<tr>
<td>- Decisional Balance</td>
<td></td>
<td>- Identifying potential funding sources available to the client; and</td>
</tr>
<tr>
<td>- Motivational Interview (Value Card Sort, Importance and Confidence Rulers, expressing empathy, rolling with resistance, developing discrepancy)</td>
<td></td>
<td>- Sourcing affordable, accessible transport options where necessary.</td>
</tr>
<tr>
<td>- Social Support</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Personal Time Audit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Barrier Identification and Resolution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Build Self-Efficacy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Foster Enjoyment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SOC 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Self-Monitoring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Goal Setting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Reward Systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Prompting/Reminders</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Social Support</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Personal Time Audit</td>
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<tr>
<td>- Foster Enjoyment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Support Self-Efficacy</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**STEP 3 – Tailored Relapse-Prevention Strategies**
Work with clients and their primary caregivers to teach skills and develop strategies that will ensure ongoing participation, including:
- What worked and what didn’t (past successes);
- Planning for high risk situations;
- Education on exercise progressions; and
- Community entry skills.
Table 2: Participant characteristics at baseline (n=43).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total (n=43)</th>
<th>Intervention (n=23)</th>
<th>Control (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>38.1 ± 12.0</td>
<td>39.2 ± 12.5</td>
<td>36.9 ± 11.4</td>
</tr>
<tr>
<td>Height (m)</td>
<td>171.4 ± 10.8</td>
<td>168.2 ± 11.6</td>
<td>175.1 ± 8.7*</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>81.6 ± 21.8</td>
<td>81.9 ± 22.3</td>
<td>81.3 ± 21.7</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>27.9 ± 7.9</td>
<td>29.4 ± 9.3</td>
<td>26.3 ± 5.8</td>
</tr>
<tr>
<td>Waist (cm)</td>
<td>100.7 ± 18.8</td>
<td>101.7 ± 19.9</td>
<td>99.5 ± 17.9</td>
</tr>
<tr>
<td>Hip (cm)</td>
<td>107.9 ± 14.6</td>
<td>110.4 ± 14.3</td>
<td>105.0 ± 14.7</td>
</tr>
<tr>
<td>Waist to Hip Ratio</td>
<td>0.9 ± 0.1</td>
<td>0.9 ± 0.1</td>
<td>0.9 ± 0.1</td>
</tr>
<tr>
<td>Statistical Local Area Index of Relative Socioeconomic Advantage and Disadvantage</td>
<td>1033.0 ± 70.8</td>
<td>1028.2 ± 65.4</td>
<td>1038.5 ± 77.9</td>
</tr>
</tbody>
</table>

Sex
- Male n (%) 27 (63) 12 (52) 15 (75)
- Female n (%) 16 (37) 11 (48) 5 (25)

Stage of Change
- Stage 1 and 2 n (%) 23 (53) 13 (56) 10 (50)
- Stage 3 n (%) 20 (47) 10 (44) 10 (50)

Driving Status
- No Drivers Licence / No Car to Drive n (%) 41 (95) 22 (96) 19 (95)
- Drivers Licence and Car to Drive n (%) 2 (5) 1 (4) 1 (5)

Employment
- Full Time Work / Study n (%) 0 (0) 0 (0) 0 (0)
- Part Time Work / Study n (%) 3 (7) 0 (0) 3 (15)
- Unemployed n (%) 40 (93) 23 (100) 17 (85)

Education
- ≤ Year 10 (Junior High School) n (%) 5 (12) 2 (9) 3 (15)
- Completed Year 12 (Senior High School) n (%) 20 (47) 13 (57) 7 (35)
- Trade / Apprentice / Vocational Certificate n (%) 11 (26) 4 (17) 7 (35)
- University Degree / Higher Degree n (%) 7 (16) 4 (17) 3 (15)

Marital Status
- Never Married n (%) 20 (47) 8 (35) 12 (60)
- Married / de facto n (%) 13 (30) 8 (35) 5 (25)
- Separated / Divorced n (%) 10 (23) 7 (30) 3 (15)

Hoffer Functional Ambulation Scale51
- Community Ambulator 41 (95) 22 (96) 19 (95)
- Household Ambulator 2 (5) 1 (4) 1 (5)

Values signify mean ± standard deviation unless otherwise indicated.
*denotes a significant between group (control vs. intervention) difference (p ≤ .05)
Table 3: Changes in outcome measures (from baseline to post intervention and baseline to 3-month follow-up) scores and net differences between the intervention and control group for all outcome measures.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>Baseline</th>
<th>Post Intervention</th>
<th>Follow Up</th>
<th>Change Baseline to Post Intervention</th>
<th>Change Baseline to 3-Month Follow Up</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean Change Scores ± SE</td>
<td>Net Difference (95% CI)</td>
</tr>
<tr>
<td>Counts per minute (cpm)</td>
<td>Intervention (n=23)</td>
<td>202.6 ± 15.1</td>
<td>263.4 ± 15.5</td>
<td>237.0 ± 15.8</td>
<td>60.9 ± 20.7*</td>
<td>71.9 (10.5 to 133.4)</td>
</tr>
<tr>
<td></td>
<td>Control (n=20)</td>
<td>208.4 ± 16.6</td>
<td>197.3 ± 17.1</td>
<td>213.5 ± 17.1</td>
<td>-11.1 ± 22.9</td>
<td>5.1 ± 22.8</td>
</tr>
<tr>
<td>MVPA (mins.day⁻¹)</td>
<td>Intervention (n=23)</td>
<td>20.8 ± 3.1</td>
<td>31.2 ± 3.1</td>
<td>25.3 ± 3.2</td>
<td>10.4 ± 4.0†</td>
<td>12.9</td>
</tr>
<tr>
<td></td>
<td>Control (n=20)</td>
<td>22.2 ± 3.4</td>
<td>19.6 ± 3.5</td>
<td>22.5 ± 3.5</td>
<td>-2.5 ± 4.5</td>
<td>(0.9 to 24.9)</td>
</tr>
<tr>
<td>Family Social Support</td>
<td>Intervention (n=22)</td>
<td>33.3 ± 2.3</td>
<td>35.5 ± 2.3</td>
<td>37.1 ± 2.3</td>
<td>2.2 ± 1.7</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>Control (n=19)</td>
<td>32.6 ± 2.4</td>
<td>34.1 ± 2.4</td>
<td>32.8 ± 2.4</td>
<td>1.4 ± 1.9</td>
<td>(-4.3 to 5.9)</td>
</tr>
<tr>
<td>Friend Social Support</td>
<td>Intervention (n=22)</td>
<td>27.4 ± 2.1</td>
<td>30.2 ± 2.1</td>
<td>28.2 ± 2.1</td>
<td>2.8 ± 2.1</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td>Control (n=19)</td>
<td>29.8 ± 2.3</td>
<td>30.8 ± 2.3</td>
<td>28.6 ± 2.3</td>
<td>1.1 ± 2.3</td>
<td>(-4.4 to 8.0)</td>
</tr>
<tr>
<td>Self-Efficacy</td>
<td>Intervention (n=23)</td>
<td>2.3 ± 0.2</td>
<td>2.4 ± 0.2</td>
<td>2.7 ± 0.2</td>
<td>0.1 ± 0.2</td>
<td>-0.05</td>
</tr>
<tr>
<td></td>
<td>Control (n=20)</td>
<td>2.7 ± 0.2</td>
<td>2.9 ± 0.2</td>
<td>2.7 ± 0.2</td>
<td>0.2 ± 0.2</td>
<td>(-0.7 to 0.6)</td>
</tr>
<tr>
<td>Decisional Balance</td>
<td>Intervention (n=23)</td>
<td>0.9 ± 0.2</td>
<td>1.4 ± 0.2</td>
<td>1.2 ± 0.2</td>
<td>0.5 ± 0.2†</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>Control (n=20)</td>
<td>1.4 ± 0.3</td>
<td>1.3 ± 0.3</td>
<td>1.1 ± 0.3</td>
<td>-0.1 ± 0.2</td>
<td>(-0.1 to 1.2)</td>
</tr>
</tbody>
</table>

MVPA= moderate-to-vigorous physical activity; cpm= counts per minute of monitoring time; † denotes a significant within group difference (p ≤.05); *denotes a significant between group (intervention vs. control) difference (p ≤.05); # Cohen’s d