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REHABILITATION AND PRACTICE

An enriched environment increases activity in stroke patients undergoing rehabilitation in a mixed rehabilitation unit: a pilot non-randomized controlled trial

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Abstract

Purpose: An enriched environment (EE) facilitates physical, cognitive and social activity in animal models of stroke. The aim of this pilot study was to determine whether enriching the environment of a mixed rehabilitation unit increased stroke patient activity. *Methods*: A non-randomized controlled trial was conducted. Direct observation was used to determine the difference in change in physical, cognitive, social or any activity over 2 weeks in patients exposed to an enriched versus non-enriched environment. *Results*: Stroke patients in the EE ($n = 15$) were 1.2 (95% CI 1.0–1.4) times more likely to be engaged in any activity compared with those in a non-enriched environment ($n = 14$). They were 1.7 (95% CI 1.1–2.5) times more likely to be engaged in cognitive activities, 1.2 (95% CI 1.0–1.5) times more likely to be engaged in social activities, 0.7 (95% CI 0.6–0.9) times as likely to be inactive and alone and 0.5 (95% CI 0.4–0.7) times as likely to be asleep than patients without enrichment. *Conclusions*: This preliminary trial suggests that the comprehensive model of enrichment developed for use in a rehabilitation unit was effective in increasing activity in stroke patients and reducing time spent inactive and alone.

Keywords

Environmental enrichment, physical activity leisure activities, social activity, stroke

History

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➤ Implications for Rehabilitation

- Stroke patients within a mixed rehabilitation unit who are exposed to an enriched environment (EE) are more likely to be engaged in activity than those not exposed to the enriched environment.
- Patients in enriched conditions are less likely to be "inactive and alone" or asleep during waking hours.
- These results suggest a comprehensive model of enrichment is effective in increasing activity levels.

In animal models of stroke, exposure to an enriched environment improves neurobehavioural function and learning [1] and is an appealing and potentially applicable intervention for the clinical setting. An enriched environment refers to conditions in which the provision of equipment and organization of the environment facilitates physical, cognitive and social activity [2]. It enables voluntary exploration and ''challenge-free'' interaction of the animals with each other and with a stimulating environment [3] ie. animals are not ''forced to do any particular task'' [4]. Such stimulating conditions are thought to enhance post-stroke brain recovery by triggering structural changes within the brain which are instrumental in the process of neuroplasticity [5]. These cellular alterations include: an increased number of dendritic spines [6], normalized astrocyte-neuron ratios [7] and advantageous levels of one of the most important neurotrophic factors associated with plasticity, brain derived neurotrophic factor (BDNF) [8].

Stroke patients undergoing inpatient rehabilitation do so in conditions which do not appear to facilitate activity. Observational research conducted over the last thirty years has consistently shown that stroke patients in multiple different rehabilitation units and countries spend the majority of their waking hours physically inactive [9–12]. Post stroke motor impairments cause significant disability, rendering the majority of survivors dependent on others to engage in activity [13]. Engaging in higher levels of therapeutically based physical activity after stroke is associated with achieving better physical function [14] and greater independence [15]. Hence, improving

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sensorimotor function through greater physical activity is an important focus of stroke rehabilitation. There is evidence emerging that the other two components of environmental enrichment – cognitive and social activity – may also be important in maximizing stroke recovery.

Being more cognitively or socially active may reduce the burden associated with stroke related mood disorders and cognitive dysfunction. Cognitive stimulation (listening to music or audio books) for as little as one hour a day for eight weeks early following stroke, has been shown to enhance cognitive recovery and improve mood [16]. Playing challenging board games (ie. Mahjong) has been found to impede cognitive decline and reduce depressive symptoms in elderly people with dementia [17]. Clinical data regarding the efficacy of social activity is scarce but research in experimental stroke indicates that certain aspects of socialisation such as physical contact [18] and being surrounding by others [19], may augment recovery. Simply talking to people or engaging in structured leisure activities, both early (<2 months) [20] and much later (>2–7+years) [21] following stroke, is associated with better health related quality of life (HRQoL).

It is important to investigate the role cognitive and social activity plays in stroke recovery because a significant number of survivors experience cognitive and emotional problems. For example, approximately 20% of stroke survivors experience depression [22] and one in four suffer anxiety [23]. One in five have persisting cognitive impairments [24] and 30–40% develop dementia after their stroke [25]. These, in conjunction with motor impairments, can restrict activity and participation. It is not surprising then that the majority of stroke survivors report a poor quality of life [26].

There is potential to improve the cognitive and social activity levels of stroke survivors undergoing inpatient rehabilitation. Despite the high value they place on personal interactions, both with their fellow patients and their therapists [27], stroke patients spend the majority of the day socially isolated [9,12,28,29]. Work recently completed by our team confirms trends found in previous observational studies [12,30] that less than 5% of a stroke patient's day is spent engaging in cognitively stimulating leisure activities [28]. The aim of this trial, therefore, was to determine whether a human equivalent model of environmental enrichment is effective for stroke survivors undergoing rehabilitation. While the conduct of a multi-unit trial powered to determine the effect of an enriched environment on functional outcomes in patients is our ultimate goal, we first sought to establish whether enriching the environment increases activity levels in humans affected by stroke. To date, there is no data to indicate whether patients exposed to an enriched environment do increase their activity. Without an increase in activity, there is little hope for a functional improvement as a result of this intervention. Given that the mechanism of benefit of EE in animal studies is thought to be through increasing physical, cognitive and social activity, this study examined all three domains. The specific research questions were:

(1) Does exposure to an enriched environment increase the activity levels of stroke patients undergoing rehabilitation?
(2) How do physical, cognitive and social activity levels change with exposure? and
(3) Does an enriched environment reduce the amount of time stroke patients spend sleeping or ''inactive and alone'' during waking hours?

Method

Design

A prospective, non-randomized controlled trial was conducted (Figure 1) [31]. Using intention-to-treat analysis, the activity levels of stroke patients treated in the absence of enrichment (control) were compared with those treated in the same unit immersed in an enriched environment (experimental). All patients admitted to the unit for rehabilitation following stroke during April to August 2010 were screened and recruited to the control group, and those admitted during April to July 2011 were screened and recruited to the experimental group. The intervention period for individual participants was 13 days. Activity levels were collected at baseline (Week 0) on one week day (Thursday, Day 0) and one weekend day (Saturday, Day 2), and then collected again on the same days two weeks later (Days 14 and 16, Week 2). Activity was measured by trained researchers every ten minutes from 8 am until 8 pm on each observation day, making a total of 48 hours of direct observations for each participant. The trial was approved by the Hunter New England Human Research Ethics Committee (HNE HREC 09/09/16/5.08) and registered with the Australian New Zealand Clinical Trials Registry (ACTRN12611000629932).

Setting

The trial was conducted in the 20-bed mixed rehabilitation unit of a stand-alone rehabilitation hospital. This unit receives referrals to rehabilitate patients with both medical and neurological conditions from two large tertiary hospitals, both of which have acute stroke units and teams involved in stroke research. Within this rehabilitation unit there were 4 x four-bed, 1 x two-bed and 2 x single-bed rooms. There were two main communal areas: the dining room, located in the centre of the unit opposite the nurses' station, and the ''solarium'', a multipurpose area located at the end of a hallway. Activities of daily living rooms (kitchen and bathroom) and the Independent Living Unit were located on the same floor. All other allied health areas including the physiotherapy and occupational therapy gyms were located on the floor above. Access to these therapy areas were via stairs or a lift. Staff:patient ratios on the weekday were: nurses 1:4, physiotherapists 1:10, occupational therapists 1:8, speech therapists 1:10, social workers 1:12, physiotherapy aides 1:18 and occupational therapy aides 1:20. These were unchanged over the two time periods.

Participants

Stroke patients were eligible for the trial if they had an estimated length of stay $\geq$16 days, had a pre-morbid modified Rankin Score [32] of $\leq$2 (indicating no or little pre-morbid disability), were able to follow at least one-step commands, and were able to stand with the assistance of two people or less. Patients were excluded if there were behavioural, medical, or other factors which prevented their safe participation in standard rehabilitation.

In order to describe patient characteristics, stroke severity, pre-morbid engagement in activity and post stroke cognition were collected. Characteristics of patients including: age, gender, language spoken at home, years of education, main occupation, type, date and side of stroke were obtained from medical records by an investigator (HJ). Severity of stroke was determined by the same investigator using the National Institute of Health Stroke Scale (NIHSS) , which is a neurological examination scale grading motor, sensory and cognitive impairments, speech, language, visual deficits and ataxia [33]. Stroke severity was categorized as mild (NIHSS <8), moderate (NIHSS, 8 to 16), or severe (NIHSS >16) [34]. Frequency of engagement in physical, cognitive and social activities prior to stroke was determined using the self-report Variety of Activity Questionnaire [35]. This comprises four categories, cognitive, social and physical activity, and exercise, where a higher score reflects greater participation in activity (range 0–152). Cognition was determined by research students (NB and RH) using the Montreal Cognitive Assessment

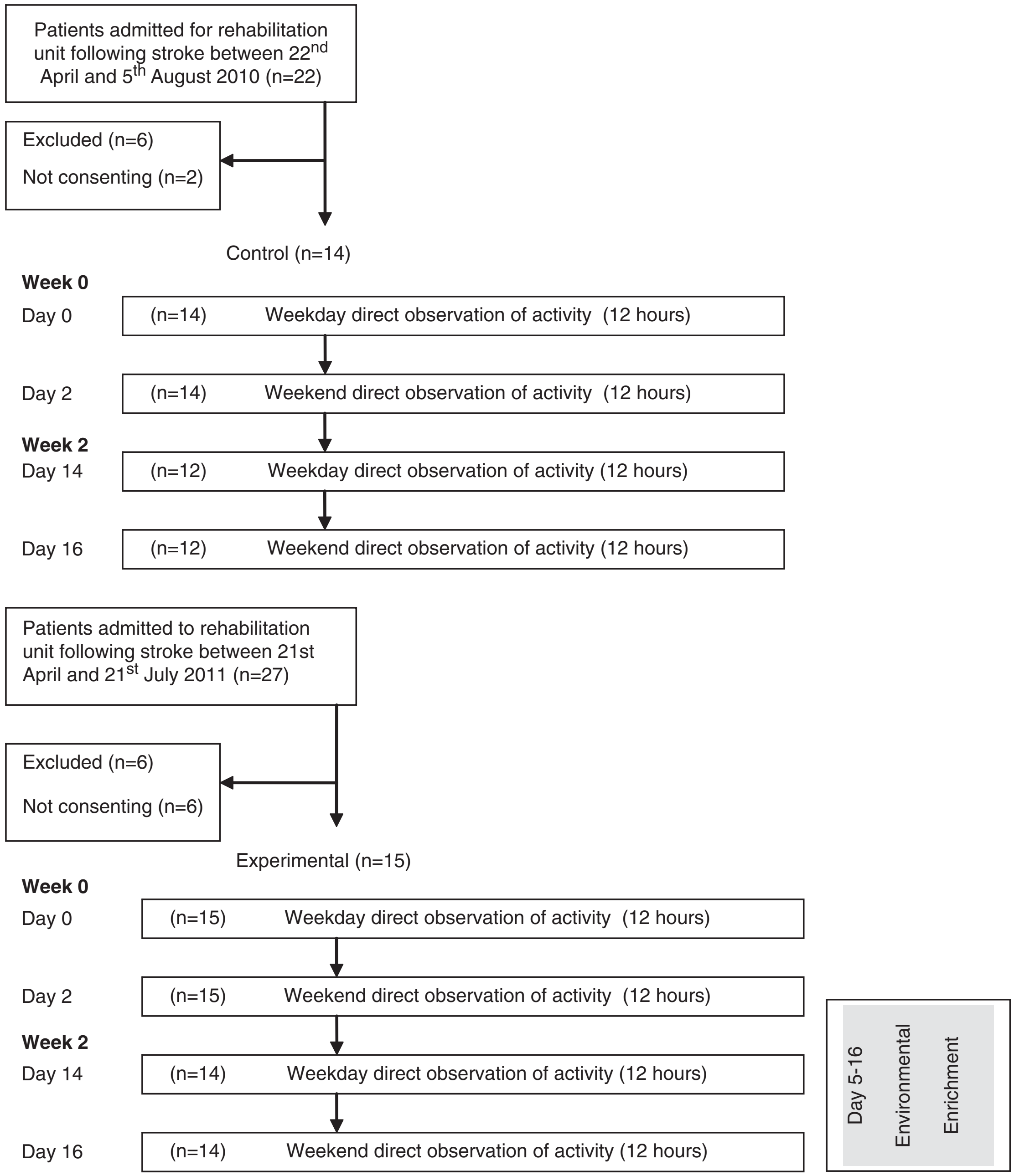


Figure 1. Study design and flow of participants through the study.

(MoCA) (0 to 30). A score ≥26 indicates normal cognition [36]. Level of independence was measured by nurses on the unit accredited in the use of the Functional Independence Measure (FIM) [37]. Mood was determined using the Patient Health Questionnaire (PHQ)-9, a 9-item self-report questionnaire used to screen for depression [38] where scores range from 0 (no symptoms) to 27 (severe depression, symptoms occurring daily) [39]. Both measurement tools have been found to be valid and reliable for use in the stroke population [40,41].

Intervention

The experimental group was exposed to an enriched environment from Day 5 until Day 16 of the observation period (Figure 1). During this 12-day period, participants were given access to both communal and individual environmental enrichment equipment and activities. Communal enrichment involved provision of an area (the dining room) in which participants had easy access to a computer with internet connection, reading material (ie, books, newspapers), games, and an area for eating meals. Nintendo Wii gaming and recreational activities (ie, bingo) were made available (with assistance from a member of the rehabilitation team) throughout the intervention period. Individual enrichment involved the provision of activities of the participant's choice including music, audio books, books, word and number puzzles, and board games. Family members were encouraged to bring in hobbies and activities that participants enjoyed prior to their stroke. Individual enrichment activities and equipment were stored in a satchel by the participant's bedside. This meant that the individual enrichment was mobile which enabled access and use at places other than the participant's bedside. To promote patient-driven activity, rehabilitation team members were advised to encourage, but not coerce, the participants to utilize either communal or individual forms of enrichment (ie, use of environmental enrichment was at the discretion of the participants). For example, nursing staff were advised to remind the participants of the activities available in their satchel and to help them with equipment they may have had difficulty setting up themselves.

The control group received standard care, with no additional therapies, equipment or activities other than that which was usual within the rehabilitation unit. Both groups received standard rehabilitation therapies. Participants were informed that the purpose of the trial was to gather information to improve understanding of how the rehabilitation surroundings of a stroke survivor influence their stay in hospital, their activity levels and their recovery. The experimental group was unaware that access to the enrichment activities was not ''standard care''.

Outcome measures

The primary outcome was the level of ''any activity'' reported as the percentage of observations. Secondary outcomes included the percentage of observations spent sleeping, or ''inactive and alone''. ''Any activity'' was defined as behaviours or tasks which involved any one, or a combination, of physical, cognitive or social activity. Physical activity included virtually all purposeful physical movement, including activities such as eating, drinking or using utensils, all personal activities of daily living and active physical participation in transfers, ambulation and physical, occupational and speech therapies. Cognitive activity was defined as any non-physical leisure activity that involved active engagement in a mental task including activities such as reading a book or newspaper, listening to the radio, crosswords, puzzles, games, speech therapist-prescribed language exercises, occupational therapist-prescribed cognitive exercises, video games, writing, computer use and playing a musical instrument. Social activity was defined as any interaction that involved verbal or non-verbal communication such as talking, laughing, touching, kissing, telephone/mobile phone/email/internet forum use and being present engaged in ''group therapy''. ''Inactive and alone'' was defined as not being within a two-meter radius of a person conducive to interaction and not performing physical, cognitive and or social activity. Sleeping was defined as sitting or lying with eyes closed.

Behavioural mapping was used to collect outcomes, according to an established approach [42] which was a modification of the approach used in previous observational research involving stroke patients in similar settings [11,43]. In brief, every ten minutes researchers observed the participants, recording a yes or no response on spreadsheets regarding activity (physical, cognitive, social, ''inactive and alone'' and/or sleeping). Performance of physical, cognitive and social activity was not mutually exclusive. Observations were made inconspicuously for less than two seconds, with participants first sought by their bedside and then elsewhere within the unit, hospital and then outside. When participants were not able to be directly observed (ie, due to curtains being drawn or whilst in showers and toilets), activity was recorded after conferring with nursing staff or others nearby. In circumstances where activity was not able to be estimated, participants were classified as unobserved and these episodes did not contribute to the total number of observations made for that participant.

Behavioural mapping was conducted on each participant on four separate 12-hour days. Five randomly selected 15 minute breaks were taken each day, making for a total of 260 observations per participant. The research assistants who conducted the behaviour mapping had no knowledge of the specific purpose of the study. They received a minimum of three hours of training which involved explanation of the category definitions, working through examples and practice observations. Training was provided by two investigators (HJ and LA) until $\geq$90% consensus was reached across the categories.

Statistical analysis

Using data of ''any activity'' from the first eight participants, sample size calculation determined that with an alpha level of 0.05, 11 participants per group were required to give the trial 80% power to detect a one standard deviation between groups in the mean level of ''any activity'' as a result of the intervention. Activity levels were averaged across the week and weekend day. Poisson regression within a Generalized Estimating Equation framework to adjust for the repeat measurements on individuals was used to determine the between-group difference. The unit of time for observations in the model was day, with outcome being the number of times the individual was observed carrying out the activity on that day. The p-value associated with the coefficient of the interaction term was used to determine whether there was a statistically significant difference in change in the experimental group compared with the control group. Between-group differences for each type of activity are presented as incidence rate ratios (IRR). An IRR provides a way to compare the rate at which an activity is more likely to be observed in the experimental group than the control group. All statistical analyses were performed using STATA 11.0 [44].

Results

Flow of participants through the trial

Patients admitted to the unit for rehabilitation following stroke between April and August 2010 were recruited to the control group, and those admitted between April and July 2011 recruited to the experimental group. The flow of participants through the trial is summarized in Figure 1. Two participants from the control group and one from the experimental group were discharged early. However, data available for these participants was used in the analysis. The characteristics of participants are summarized in Table 1. There were 31% fewer participants with right hemiplegia and 31% fewer males in the experimental group than in the control group. Participants in the experimental group had more severe stroke and were more dependent than those in the control group. Overall, the majority of participants in this trial had impaired cognitive function (median Montreal Cognitive Assessment (MoCA) was 16 in both groups). They also had low levels of educational attainment – seventy nine percent did not receive education beyond the age of 16.

The median time from admission to the rehabilitation unit to initial observation (Week 0) in both groups was similar. Because of occasions when participants were unobserved or were discharged prior to completion of collection of activity data and for breaks taken by observers, the mean number of valid observations of behaviour made each day were 59 (SD 9) for the experimental and 63 (SD 5) for the control group out of a possible 65 observations, equating to 94% complete data.

Effect of intervention

Group data are presented in Table 2 with IRR graphed in Figure 2. The experimental group were 1.2 (95% CI 1.0 to 1.4, $p = 0.02$) times more likely to be engaged in any activity than the control group. Specifically, they were 1.7 (95% CI 1.1 to 2.5, $p = 0.02$) times more likely to be engaged in cognitive activity, 1.2 (95% CI 1.0 to 1.5, $p = 0.04$) times more likely to be engaged in social activity, 0.7 (95% CI 0.6 to 0.9, $p < 0.001$) times as likely to be inactive and alone and 0.5 (95% CI 0.4 to 0.7, $p = < 0.001$) times as likely to be asleep. The between-group difference in physical activity was not significant (IRR $= 1.1$, 95% CI 0.9 to 1.4, $p = 0.21$).

Table 1. Baseline characteristics of participants.

Characteristic	Experimental group ($n = 15$)	Control group ($n = 14$)
Age (yr), median (IQR)	76 (66–83)	78 (68–81)
Gender, *n* males (%)	5 (33)	9 (64)
English second language, *n* (%)	2 (13)	3 (21)
Education after 16 yr, *n* (%)	2 (13)	4 (29)
Infarct, *n* (%)	12 (80)	12 (86)
Side of hemiparesis, n right (%)	6 (40)	10 (71)
Severity of stroke (NIHSS) *(0–21)*, median (IQR)	8 (6–11)	3 (2–8)
Mild <8, *n* (%)	6 (40)	10 (71)
Moderate 8 to 16, *n* (%)	7 (47)	3 (21)
Severe >16, *n* (%)	2 (13)	1 (7)
First ever stroke, *n* (%)	11 (73)	9 (64)
Time from admission to stroke rehabilitation unit to first observation (days), median (IQR)	3 (1–6)	5 (2–8)
Time from stroke to first observation (days), median (IQR)	14 (11–16)	17 (10–28)
Variety of Activity Questionnaire *(0–152)*, median (IQR), $n = 14/12$	44 (39–55)	49 (41–57)
Physical activity *(0–36)*	17 (14–21)	18 (16–19)
Cognitive activity *(0–36)*	14 (10–15)	17 (12–20)
Social activity *(0–36)*	12 (9–12)	11 (7–15)
Exercise *(0–44)*	7 (2–8)	4 (1.5–7)
Function (FIM) *(18–126)*, median (IQR)	56 (45–72)	77 (57–81)
Mood (PHQ–9) *(0–27)*, median (IQR)	8 (7–14)	11 (5–15)
Cognition (MoCA) *(0–30)*, median (IQR)	16 (10–22)	16 (12–19)

IQR, inter quartile range; NIHSS, National Institute of Health Stroke scale; FIM, functional independence measure; PHQ-9, patient health questionnaire 9; MoCA, Montreal cognitive assessment.

Table 2. Mean (SD) activity* expressed as % of observations and between-group difference expressed as incidence rate ratio (IRR) (95% CI).

	Groups				
	Week 0		Week 2		Incidence rate ratio
Activity	Exp ($n = 15$)	Con ($n = 14$)	Exp ($n = 14$)	Con ($n = 12$)	Exp relative to control
Any activity	45 (13)	49 (18)	58 (15)	51 (15)	1.2 (1.0–1.4)
Physical activity	23 (8)	23 (10)	31 (13)	28 (9)	1.1 (0.9–1.4)
Cognitive activity	6 (7)	4 (4)	13 (10)	5 (7)	1.7 (1.1–2.5)
Social activity	24 (12)	32 (18)	27 (14)	27 (16)	1.2 (1.0–1.5)
Inactive and alone	25 (13)	40 (17)	17 (12)	36 (17)	0.7 (0.6–0.9)
Sleeping	12 (12)	16 (13)	5 (8)	15 (14)	0.5 (0.4–0.7)

*Activity averaged over weekday and weekend.

Discussion

This is the first trial to investigate the introduction of comprehensive model of environmental enrichment into the clinical setting. In this pilot trial, we showed that stroke patients exposed to an enriched environment were significantly more likely to be engaged in activity than those in non-enriched conditions. Specifically, patients undertaking rehabilitation in the enriched environment were more likely to be engaged in cognitive and social activity, and less likely to spend their waking hours inactive and alone. Importantly, with a median age of 76 and 78 years and admission FIM scores of 56 and 77 (out of 126), the stroke patients in the cohorts of this trial are representative of patients recovering from stroke in mixed rehabilitation units across Australia [45]. Furthermore, the group exposed to the enriched environment had more severe strokes and were more dependent at baseline than the control group, which would have been expected to favor controls in the analysis. These encouraging results were achieved through a relatively simple intervention applied over a short period of time.

Previous attempts to increase activity levels of patients undergoing rehabilitation have done so through predominantly staff-driven strategies such as group physiotherapy [46], scheduled recreational sessions [47,48], staff-supervised individualized therapy programs [47] and or a change in hospital processes aimed at increasing social interaction [48] (ie. moving patients to communal areas for morning and afternoon tea). These strategies are labor intensive, with success reliant on the availability, attitude and enthusiasm of staff [47,49]. In animal models of stroke, enrichment models rely on the environment driving behaviour. We aimed to replicate this approach with enrichment primarily achieved through alteration of the surrounds and/or the addition of equipment with which patients voluntarily engage. As the aim was to replicate the model successfully used in animal studies, cognitive and social stimulation were key components. To date there is very little data available on whether these factors are important in recovery of stroke patients, unlike the case for physical activity. Perhaps future trials will help address this issue.

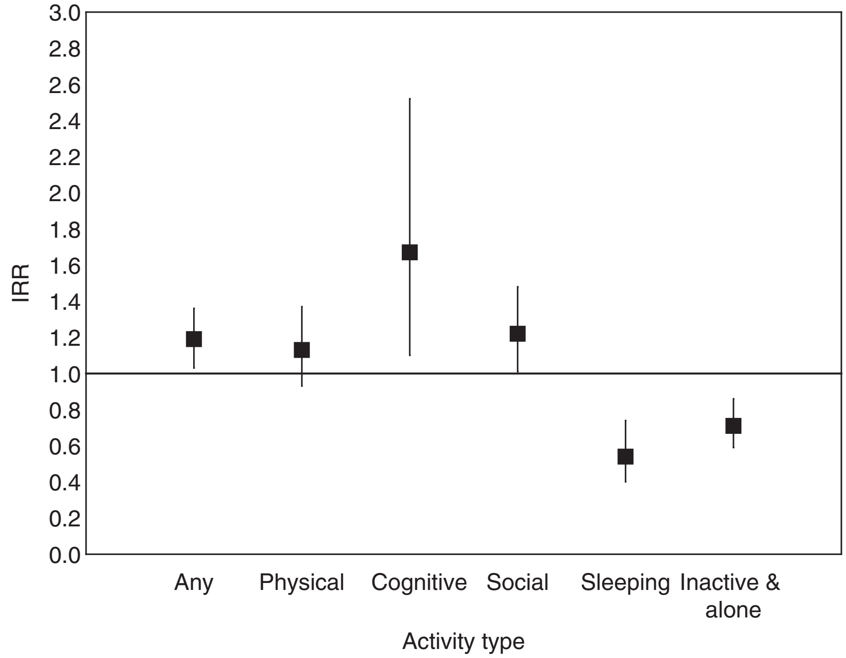
The incidence rate ratios (IRR, 95% CI) were similar for any-, physical- and social activity. In contrast, the wide CI for cognitive activity indicates that the effect of an enriched environment varied between individuals. This large variability in response may be due to the low level of cognitive activity at baseline (4% of the day). Furthermore, the large mean effect on levels of cognitive activity may reflect the nature of the environmental enrichment, since a key feature of the intervention involved better access to cognitive activities.

Throughout the trial, numerous barriers to activity were observed. Most of these barriers related to the ease with which patients were able to engage in physical activity. For example, a large number of patients relied on help to mobilize beyond their bedside. At certain times of the day, hospital processes and routines discouraged physical activity in order to compensate for low staff numbers. Furthermore, the occupational and physiotherapy gyms were off limit during non-therapy hours and inaccessible on weekends.

Nevertheless, we have shown that our model of environmental enrichment is feasible and led to an increase in the activity levels of stroke patients during two weeks of rehabilitation in a mixed rehabilitation unit. Whether this increase in activity translates into better outcomes is yet to be determined. Previous research demonstrates that when used in isolation, components of the enrichment used in this pilot trial (ie. music [50,51] and Nintendo Wii [52–54] are associated with better mood [50,51], physical activity [52–54], cognition [50,51], and greater participation in activities of daily living [54]. We believe the multi-component approach used here is more likely to result in measurable gains in patient outcomes.

Several aspects of the design of this trial support the validity of the findings. As with the model of enrichment employed in animal models of stroke, patients were not forced or coerced to engage in activity and had easy access (individually and communally) to equipment which was designed to be stimulating and novel. Activity levels were measured across usual waking hours for patients in this unit. The large number of observations per patient (~260) overcomes some of the limitation imposed by the small number of participants in both groups. Additionally, participants

Figure 2. IRR (95% CI) between experimental and control group (where control group served as reference group) for activity type. Horizontal line at 1.0 represents line of no difference.



in both groups were observed during the same months of the year preventing any seasonal variation in activity (such as spending more time inactive and or sleeping during colder months) [48]. The definitions of activity – physical, cognitive and social – were broad in order to ensure that all forms of purposeful activity were captured. Observations were as unobtrusive as possible, supported by the fact that the majority of participants reported that they were unaware of being observed.

Limitations

There are some limitations to this trial. First, this preliminary trial, conducted at one site and involving change at the ward level, prevented the use of a parallel study design. To avoid contamination, groups were collected at different times. Second, our trial sample size was small, and is likely to have contributed to an imbalance in groups in favor of the control group in terms of stroke severity and level of independence. With such an imbalance, one would expect the experimental group (ie. which had more severe strokes and were more dependent) to be less active. It is unclear whether the higher proportion of women and those with left hemiplegia in the experimental group would have influenced outcomes. Third, to minimize potential further contamination of the trial, very little time or labor was allocated to embedding the model of environmental enrichment into ‘‘normal practice’’. The rehabilitation team was aware of the trial, but their role was simply to remind patients of the enrichment activities and equipment available and assist with set up if required. An even greater increase in activity may have been achieved had more time and resources been allocated to implementing the intervention. Lastly, this trial was not adequately powered to explore the influence that an individual's personality traits, interests and or stroke-related impairments (physical and or cognitive) may have had on their desire or ability to interact with either the non-enriched or enriched rehabilitation environment.

Conclusions

Exposure to an enriched environment is associated with a significant increase in the activity levels of stroke patients undergoing rehabilitation in a mixed rehabilitation unit. This increase in activity included increases in cognitive and social activity, and a decrease in time spent ‘‘inactive and alone’’ and sleeping. These results are encouraging and suggest that a randomized trial is warranted to determine whether the higher activity levels in the enriched environment improves function, mood and quality of life of stroke survivors in a cost-effective manner.

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Declaration of interest

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