European Journal of Cancer 80 (2017) 63–72

Available online at www.sciencedirect.com

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journal homepage: www.ejcancer.com

Original Research

Exercise training improves physical function and fitness in long-term paediatric brain tumour survivors treated with cranial irradiation

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Received 11 January 2017; received in revised form 24 February 2017; accepted 20 April 2017
Available online 25 May 2017

KEYWORDS
Paediatric;
Brain tumour;
Survivorship;
Exercise training;
Radiation;
Physical function;
Fitness

Abstract ***Aims:*** We examined the efficacy of exercise training for improving physical functioning and cardiopulmonary fitness in survivors of paediatric brain tumours (BTs) treated with cranial irradiation.
Methods: We conducted a controlled clinical trial with crossover of exercise training versus no training in the community in either a group or combined group/home setting. A volunteer sample of 28 children treated with cranial irradiation for brain tumours completed training (mean age = 11.53 years; mean time since diagnosis = 5.25 years). end-points were physical functioning assessed by four subtests from the Bruininks–Oseretsky Test of motor performance (BOT-2) and pro-rated work rate from a cycle ergometer. Linear mixed modelling was used to evaluate time, training, training setting, and carryover effects.
Results: Adherence to training was 84%. Performance on the BOT-2 was below average for all assessments. However, training resulted in improvement in bilateral coordination ($F(1, 30) = 6.59$, $p = 0.02$), irrespective of training setting and improved performance was maintained even approximately 12°weeks after training had ended ($F(1, 24) = 9.60$, $p = 0.005$).

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http://dx.doi.org/10.1016/j.ejca.2017.04.020

Training resulted in increased pro-rated work rate for participants in the group training setting only (F (1, 25) = 4.57, p = 0.04) and these participants maintained their improved work rate approximately 12°weeks after training had ended (F (1, 20) = 8.38, p = 0.01).
Conclusion: Exercise training improves physical functioning and fitness in paediatric BT survivors. Exercise interventions that ameliorate adverse physical effects and promote health in long-term survivors are highly recommended in this vulnerable population. (ClinicalTrials.gov, NCT01944761).

1. Introduction

Survival rates for children diagnosed with malignant brain tumours (BTs) such as medulloblastoma and ependymoma are now greater than 70% [1]. Unfortunately, the disease, subsequent treatment and the impact of prolonged hospitalisation often results in decreased activity levels, impairment of physical functioning, and neurological deficits that compromise quality of life [2–10].

Survivors of childhood BTs exhibit decreased physical functioning [10], impaired fitness [9], and poor functional mobility [11]. Deficits persist into adulthood [6,9,12], including decreased bone mineral density [2], restrictions in personal care/routine activities [13] and low activity levels [7,8]. Young adult survivors of paediatric BTs have demonstrated fitness levels similar to adults in their 7th decade of life [12]. Paediatric cancer survivors, and in particular paediatric BT survivors who have been treated with radiation, show reduced levels of daily physical activity [6], and cranial irradiation has been shown to be a predictor of poor health-related quality of life [5]. Considering the long-term health burden these children experience, therapies that reduce functional and physical disabilities are urgently required. Currently, no such intervention is part of clinical practice for long-term survivors of paediatric BTs treated with cranial irradiation. Likewise, school/community based sports programmes target healthy children and do not have the expertise in modifying exercise for children with physical disabilities [10].

There is evidence of the positive impact of exercise on cancer outcomes in adults [14–16]. However, there is a paucity of literature examining therapies targeted at improving physical functioning and increasing physical activity in paediatric BT survivors. The effects of exercise programmes have been examined primarily in leukaemia patients or survivors [17,18]. There are many barriers limiting BT survivors' participation in community and school-based physical activities, including neurological and motor deficits [10], greater rates of sedentary behaviour [19], decreased competence and confidence in cognitive and physical capabilities [20], and parental behaviours restricting activities in order to protect survivors from perceived physical or emotional harm [21]. Therefore, structured intervention is considered an optimal way to engage inactive young survivors in physical activity [22].

We conducted a clinical trial of exercise training in long-term survivors of paediatric BTs treated with cranial irradiation with a primary focus on neural and cognitive recovery reported elsewhere [23]. A secondary aim of this trial was to examine the efficacy of training for improving physical functioning and fitness levels, and we report these outcomes here. We hypothesised that exercise training would improve physical functioning and fitness.

2. Methods

2.1. Study design and participants

We previously presented the methods and procedures of the trial [23]. The study was a controlled clinical trial with crossover where participants either: (1) started the training without delay or (2) waited a 12-week period and then started the training. Full crossover occurred whereby participants completed a second period of 12°weeks in the opposite condition. Eligible participants were identified via database review. Each participant took part in one of seven different training blocks conducted over 2.5°years. Measures of physical function and fitness were obtained at study entry (Baseline), at approximately 12°weeks immediately prior to crossover (Period 1 assessment), and at approximately 24°weeks completion of the study (Period 2 assessment).

Participants were recruited at the Hospital for Sick Children (Toronto, Canada) and McMaster Children's Hospital (Hamilton, Canada). Inclusion criteria: English-speaking children aged 6–17°years of age (or had received°>°2°years of English schooling at the time of first assessment), a minimum of 1°year (and not > 10°years) from diagnosis of a hemispheric or posterior fossa tumour and treated with craniospinal or focal irradiation (with or without chemotherapy). Exclusion Criteria: Severe neurological/motor dysfunction based on clinical judgment precluding safe