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Assessment of Fundamental Movement Skills in Childhood Cancer Patients

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Background. The improved treatment protocols and subsequent improved survival rates among childhood cancer patients have shifted the focus toward the long-term consequences arising from cancer treatment. Children who have completed cancer treatment are at a greater risk of delayed development, diminished functioning, disability, compromised fundamental movement skill (FMS) attainment, and long-term chronic health conditions. The aim of the study was to compare FMS of childhood cancer patients with an aged matched healthy reference group. ***Methods.*** Pediatric cancer patients aged 5–8 years (n = 26; median age 6.91 years), who completed cancer treatment (<5 years) at the Sydney Children's Hospital, were assessed performing seven key FMS: sprint, side gallop, vertical jump, catch, over-arm throw, kick, and leap. Results were compared to the reference group (n = 430; 6.56 years). ***Results.*** Childhood cancer patients scored significantly lower on three out of seven FMS tests when compared to the reference group. These results equated to a significantly lower overall score for FMS. ***Conclusions.*** This study highlighted the significant deficits in FMS within pediatric patients having completed cancer treatment. In order to reduce the occurrence of significant FMS deficits in this population, FMS interventions may be warranted to assist in recovery from childhood cancer, prevent late effects, and improve the quality of life in survivors of childhood cancer. Pediatr Blood Cancer 2015; 62:2211–2215. © 2015 Wiley Periodicals, Inc.

Key words: assessment; cancer treatment; childhood cancer patient; fundamental movement skills; oncology; pediatrics

INTRODUCTION

Over the last 50 years, research and scientific advances have played a pivotal role in transforming childhood cancer from a virtually incurable disease to achieving a 5-year survival rate of approximately 80%.[1] However, improved survival rates for childhood cancer survivors (CCS) present an ongoing challenge of how to effectively manage subsequent complications resulting from treatment.[2] Oeffinger et al.[3] indicated that nearly two-thirds of CCS report at least one severe or life-threatening chronic health condition at and beyond the 5-year survival mark. Despite efforts to decrease the toxicity of cancer treatment, present therapy produces a range of short-term side effects and late effects.[4] These include cardiovascular deficits;[5] metabolic syndrome;[3] cognitive, endocrine, and pulmonary dysfunction;[6] obesity;[7] osteoporosis;[8] acute peripheral neuropathy;[9] musculoskeletal and neurological deficits; and physical disability,[6] all of which can decrease function and the ability to perform regular daily tasks.[10] Such side effects can also reduce potential participation in physical activity and exercise, further exacerbating the short-term and late effects.[11–13]

Childhood is also an important time for the development of rudimentary fundamental movement skills (FMS). FMS form the building blocks or attributes that are the prerequisites of physical activity and sport.[14] There is also evidence to suggest that after 13–14 years of age, it is difficult to correct and reverse FMS deficits, indicating that FMS deficits need to be identified early and corrected if possible.[15] Additional research among school-aged children indicates an important correlation between high levels of FMS and higher levels of physical activity,[16–18] cardiorespiratory fitness,[19,20] and lower levels of obesity.[21] Unfortunately, FMS are thought to be adversely affected both during and post-cancer treatment due to excessively sedentary behaviour throughout cancer treatments[22] and the toxic effects of the chemotherapeutic drugs used, particularly vincristine.[23] This is particularly concerning as physical activity levels in CCSs are already reported to decline during and after treatment completion[24] and be lower than their "healthy" peers or sibling equivalents.[10,15,25] If FMS deficits are then added to the mix, the ongoing physical activity levels in CCS could be at risk.

The aim of this study was, therefore, to examine the impact of cancer treatment upon FMS in pediatric cancer patients aged 5–8 years. Specifically, the aim was to characterize and compare the FMS among pediatric cancer patients who were less than 5 years from completion of cancer treatment with healthy children to determine whether diagnosis and treatment outcomes were associated with lower FMS performance scores.

METHODS

A cross-sectional study was implemented that incorporated the sampling of children aged 5–8 years. The study recruited both pediatric cancer patients at the Sydney Children's Hospital (SCH) and a healthy reference group from four Catholic schools in Sydney. Clinical nursing consultants and treating oncology staff identified eligible participants from the hospital clinic registers. Oncology patients were eligible if they had completed cancer treatment within the past 5 years. Children were not eligible to participate if they

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were outside the ages of 5–8 years or parents/guardians did not speak English to a sufficient level to assist the child with the completion of the questionnaires and provide informed consent. Participants' families were provided with a study brochure, which outlined the scope of the study and invited them to participate. Informed consents were obtained from parent/guardians.

Recruitment of the healthy reference group was from four primary schools within the Eastern Suburbs of Sydney. Four hundred thirty children (male n = 236; female n = 194) met the eligibility criteria. Of the 430 children, 300 children (approximately 70%) consented to participate in the study. Pediatric oncology patient recruitment occurred from July to October 2014. Initially, 325 children were identified from pediatric oncology follow-up clinic lists. Of the 325 patients, 288 children were not eligible as they did not meet the age criterion or were presently undergoing cancer treatment. Thirty-seven children met the eligibility criteria of whom contact was made with 31 families. From the 31 families, 26 provided consent; 11 males and 15 females. The five families who did not provide consent cited limited time prior to, or post medical appointments.

A baseline pre-participation interview and fundamental movement skill assessment battery were conducted by an Accredited Exercise Physiologist (AEP) on-site at the Sydney Children's Hospital or at the school venue. Demographic and medical variables were obtained by self-report, parent report, and from hospital records. These included age at time of testing, initial diagnosis, cancer type, relapses, treatment modality, such as chemotherapy, radiation therapy, surgery, bone marrow transplant, and any noted side effects of treatment.

The FMS test battery assessed seven key fundamental physical movements split for examination[27] into: locomotor skills: sprint run, vertical jump, side gallop and leaping; and object control (or manipulative) skills: throwing, catching, and kicking. Prior to testing, the assessors were trained on the administration to the FMS assessment. Children were tested individually in the hospital setting and in small groups within the physical education class at their school. Each skill was demonstrated by the assessor and the children were allowed to practice the skill. Each participant was filmed performing the seven skills and the performance analyzed by the senior research AEP. The FMS test battery was scored according to the process-oriented checklists developed by the NSW Department of Education and Training Get Skilled: Get Active. [27] All skills had six components except the side gallop, which had five components. The components are incorporated elements of the movement which are required for the execution of the skill. For each skill, a score was given based on the number of components correctly executed by the participant. The scores across the seven skills were summed to produce a total proficiency score out of 41 for each participant (Table I). Validity and reliability of the FMS capacity tests used in this study have been cited by Hardy et al.[27]

All statistical procedures were performed using SPSS package (IBM, Armonk, NY, version 22.0). Non-parametric univariate statistics were performed on all FMS scores and presented as medians and interquartile ranges (25th–75th) to provide an indication of both the middle of the distribution, as well as the upper and lower ranges. Based on an independent means sample size power calculation, the total number of participants should be 25 per group in order to detect a large effect size of 0.8 for an $\alpha = 0.05$. Independent sample nonparametric tests were used to identify differences between FMS scores. Significance was set at $P \leq 0.05$.

TABLE I. Rating Scale for Fundamental Movement Skills

Skill	Components
Sprint run	Run as fast as you can from one end to another 0: Not attempted, 1: Lands on ball of foot, 2: Non-support knee bent at least 90° during the recovery phase, 3: High knee lift, thigh almost parallel to the ground, 4: Head and trunk stable, eyes focused forward, 5: Elbows bent at 90°, 6: Arms drive forward and back in opposition to legs
Vertical jump	Jump as high as you can 0: Not attempted, 1: Eyes focused forward or upward throughout the jump, 2: Crouch with knees bent and arms behind the body, 3: Forceful forward and upward swing of the arms, 4: Legs straighten in the air, 5:Lands on balls of the feet and bends knees to absorb landing, 6: Controlled landing with no more than one step in any direction
Side gallop	Side gallop from one end to the other and return 0: Not attempted, 1: Smooth rhythmical movement, 2: Brief period where both feet are off the ground, 3: Weight on the balls of the feet, 4: Hips and shoulders point to the front, 5: Head stable, eyes focused forward or in the direction of travel
Leap	Run up to the marker and leap as far as you can 0: Not attempted, 1: Eyes focused forward throughout the leap, 2: Knee of take-off leg bends, 3: Legs straighten during flight, 4: Arms held in opposition to the legs, 5: Trunk leans slightly forward, 6: Lands on ball of the foot and bends knee to absorb landing
Catch	Catch the object with two hands 0: Not attempted, 1: Eyes focused on the object throughout the catch, 2: Feet move to place the body in line with the object, 3: Hands move to meet the object, 4: Hands and fingers relaxed and slightly cupped to catch the object, 5: Catch and control object with hands only (well-timed closure), 6: Elbows bend to absorb the force of the object
Kick	Run up to the ball and kick it as hard as you can 0: Not attempted, 1: Eyes focused on the ball throughout the kick, 2: Forward and sideward swing of arm opposite kicking, 3: Non-kicking foot placed beside the ball, 4: Bend knee of kicking leg at least 90° during the back swing, 5: Contact ball with top of the foot (a "shoelace" kick) or instep, 6: Kicking leg follows through high toward the target area
Overarm throw	Throw the object as far as you can 0: Not attempted, 1: Eyes are focussed on the ball throughout the kick, 2: Forward and sideward swing of arm opposite kicking leg, 3: Step forward with non-kicking foot placed near the ball, 4: Hip extension and knee flexion of at least 90 degrees during preliminary kicking movement, 5: Contact the ball with the top of the foot (a "shoelace" or instep kick), 6: Kicking leg follows through high towards the target after ball contact

Study approval was obtained through the University of New South Wales (UNSW) Human Research Ethics Committee (HREC/HC13221) and the Sydney Children's Hospital Human Research Ethics Committee (HREC/13/SCHN/361).

RESULTS

Demographics for age, height, weight, and treatment factors are illustrated in Table II. Age was significantly different (*P*-value 0.022) with the oncology group having a median age of 6.91 years and the reference groups a median age of 6.56 years. The types of cancers varied in the pediatric cancer patient group, with the majority being diagnosed with acute lymphoblastic leukemia (n = 17, 65%). The median age at diagnosis for the childhood cancer patients was 3.86 years, with a median treatment time of 715 days.

Three of the seven FMS tests presented a significant difference between the oncology and reference groups ($P < 0.05$) (Table III). When each of the seven FMS scores were added together (total of 41), the total scores were significantly different ($P = 0.009$) with the childhood cancer patients achieving a 61% mastery versus a 76% mastery for the healthy reference group. This difference between groups indicated that the children who had completed cancer treatment had significantly lower FMS scores when compared with the healthy reference group. This lower score was found despite the childhood cancer patient being significantly older than their healthy peers.

DISCUSSION

The major outcome of this study was the identification of a global deficit in FMS within pediatric cancer patients when compared to healthy peers, suggesting cancer treatment does not come without consequences. There has been minimal research conducted in children aged 5–8 years, characterizing FMS in children who are within 5 years from completion of cancer treatment. The reduced FMS competency was prominent in the childhood cancer patients' running ability, side gallop, and overarm throwing capacity. This deficit in global FMS is made even more prominent when one considers that the childhood cancer patients were significantly older than their health peers, with some children delaying their start date at school in response to treatment demands.

The assessment of FMS during childhood provides information about the normal growth and development trajectory within children. The delay in FMS development could have been attributed to the young age at diagnosis (3.86 years) and the long time spent in treatment (715 days). Early stages of schooling (5–8 years of age) are critical to a child's development of FMS.[26] The acquisition of FMS is known to be developmentally sequenced and learnt through a range of play and structured programs both internal and external to school programs.[27] By the time children complete cancer treatment, the long periods of sedentary behavior and the reduced opportunity for active play experiences diminish FMS development. This is particularly concerning as there is evidence to suggest that after 13–14 years of age, it becomes increasingly difficult to correct and reverse deficits related to FMS.[15]

The challenge facing childhood cancer survivors is to have them establish a healthy lifestyle that will reduce the risk of developing late effects in the time after treatment completion. Conducting a FMS assessment on childhood cancer patients post-treatment could provide valuable information regarding the developmental progress of patients and enable early identification of deficits. Our deficit findings across FMS are similar those of Leone et al.,[14] who reported deficits for 10 out of 11 FMS tests in males and females, aged 9–11 years, who were 4 years post-treatment. With nearly 50% of childhood cancer patients demonstrating developmental delays in gross motor skills, Leone et al.[14] concluded that acute lymphoblastic leukemia survivors would benefit from early skill intervention training both during and after treatment. Currently, no such screening or exercise intervention exists. The findings of Leone et al., along with the current results for the younger population, provide justification for the systematic assessment of FMS in all children completing treatment and for the development of an exercise intervention that focuses on the skill development for pediatric patients. Although children develop skill mastery at their own rates, research has suggested that early childhood, from 3–8 years, represents the greatest window of opportunity for FMS

TABLE II. Age, Diagnosis, and Treatment Demographics for the Study Participants

	Oncology (n = 26) Median (25th–75th percentile)	Reference (n = 300) Median (25th–75th percentile)	*P*-value
Median age (years)	6.91 (6.15–7.72)	6.56 (5.86–6.57)	0.022*
Median age at diagnosis (years)	3.86 (2.26–4.95)	N/A	N/A
Mean age at treatment completion (years)	5.77 (4.41–6.79)	N/A	N/A
Total time between diagnosis and treatment completion (days)	715 (280–770)	N/A	N/A
Time since treatment completion (days)	298 (110–842)	N/A	N/A
Oncology diagnostics	N (%)	N/A	N/A
ALL	17 (65%)	N/A	N/A
BMT	4	N/A	N/A
Wilms tumor	3 (11.5)	N/A	N/A
Brain tumor	3 (11.5)	N/A	N/A
Lymphoma	1 (3.8%)	N/A	N/A
Sarcoma	1 (3.8%)	N/A	N/A
Spinal cord glioma	1 (3.8%)	N/A	N/A

ALL, acute lymphoblastic leukemia; BMT, bone marrow transplant. *P*-value was calculated using a nonparametric *t*-test between groups. *Statistical significance.

TABLE III. Comparison of Fundamental Movement Skills Between Groups

	Oncology (n = 26)	Reference (n = 300)	*P*-values
Sprint run	4.0 (3.0–5.0)	5.0 (4.0–5.0)	0.039*
Vertical jump	4.0 (3.0–5.0)	5.0 (4.0–6.0)	0.119
Side gallop	3.5 (1.0–5.0)	4.0 (3.0–5.0)	0.045*
Catch	4.0 (1.0–5.2)	5.0 (3.0–6.0)	0.784
Kick	4.0 (3.0–5.0)	5.0 (4.0–5.0)	0.182
Overarm throw	3.0 (1.0–4.0)	5.0 (3.0–6.0)	0.000*
Leap	5.0 (3.0–5.2)	5.0 (4.0–6.0)	0.492
Total out of 41	25.5 (20.0–30.0)	32.0 (29.0–35.0)	0.009*

Median FMS scores (25th–75th percentile). *P*-values calculated from nonparametric independent sample tests comparing the median scores between groups. A higher score denotes more advanced skill mastery. *Statistical significance.

development.[27] Research also indicates children would benefit from repeated opportunities to practice and gain skill mastery during this time. Children gain skill competency both during free play and during teacher-directed activities, such as those at school, with research indicating teacher-directed activities lead to greater improvements in children's FMS proficiency.[28]

The delays identified in this study could become more problematic for the child if an intervention is not made before the end of childhood as correction of FMS deficits becomes very challenging after the ages of 13–14 years.[15] Evidence also associates low level of motor proficiency with a decline in overall participation in physical activities.[18,29] Importantly, low levels of physical activity in childhood are often carried into adulthood, which can increase the risk of cardiovascular and other chronic diseases later in life.[30]

The findings of this study reinforce the need for childhood cancer patients to participate in an exercise and physical activity program both during and after cancer therapy treatment to reduce the deficits in FMS development. These exercise programs should be individually tailored to improve and reverse FMS developmental delays. By improving FMS deficits within pediatric patients, physical activity and exercise participation should increase, providing an opportunity to decrease the prevalence of long-term chronic health conditions.[3]

The limitations of the current study include the small number of childhood cancer patients recruited for the study. Although 70% of eligible patients consented to the study, a longer recruitment period would have enabled larger numbers to be assessed. A second limitation was that the results were a single "snapshot" of FMS proficiency. Future studies should look to complete longitudinal research which tracks fundamental movement skill development from an individual's diagnosis into survivorship. This would provide medical professionals with information on the trajectory of childhood cancer patients.

CONCLUSIONS

This study has highlighted FMS deficits in pediatric oncology patients, showing treatment does not come without consequences. A recommendation from the study would be to systematically assess FMS in children aged 5–12, in order to identify any children with delayed or impaired development. A second recommendation would then be to develop and deliver a skill-based exercise intervention which can assist the children recover from treatment. These exercise programs should be tailored individually to address the specific deficiencies in FMS of each child.

A longitudinal study is also needed to assess FMS among pediatric survivors over time. The addition of treatment information (i.e., chemotherapy and radiation exposure) may have allowed a better understanding about the impact of these treatments on the motor skills delay observed in this research.

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