Fatigue and Physical Performance in Children and Adolescents Receiving Chemotherapy

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Purpose/Objectives: To examine the relationship between physical performance and fatigue in child and adolescent cohorts during the first three cycles of chemotherapy.

Design: Prospective, observational design.

Setting: Two pediatric cancer centers in the upper Midwest region of the United States.

Sample: 16 children and 14 adolescents newly diagnosed with cancer.

Methods: Standardized instruments were administered during the first and third cycles of chemotherapy. Instruments included physical performance tests (Timed Up and Down Stairs [TUDS] and the 6-Minute Walk Test [6MWT]) and a self-report fatigue scale.

Main Research Variables: Fatigue and physical performance.

Findings: In the child cohort, physical performance appeared to improve and fatigue diminished from cycle 1 to 3 of chemotherapy. When time on TUDS decreased, fatigue tended to decrease; when 6MWT distance increased, fatigue decreased. In the adolescent cohort, fatigue seemed to decrease but physical performance measures evidenced little change. Correlations between changes in the physical performance variables and fatigue were not significant.

Conclusions: Fatigue may decrease early in treatment as disease symptoms resolve. Fatigue in the child cohort was related to physical performance, which is consistent with previous studies that defined fatigue in children as primarily a physical sensation. Findings in the adolescent cohort support research that defined adolescent fatigue as more complex with mental, emotional, and physical components.

Implications for Nursing: Knowing how fatigue relates to physical performance in children and adolescents informs the nurse in educating patients and families about symptom management.

Symptom distress in children with cancer is frequently overlooked as efforts focus on a curative approach to treatment (Docherty, 2003; Hockenberry, 2004; National Institutes of Health, 2002). Fatigue has been identified as a significant symptom that interferes with the developmental experiences of childhood (Hockenberry-Eaton & Hinds, 2000). One of the mechanisms that has been proposed as contributing to cancer-related fatigue includes loss of muscle mass and function, which can reduce physical performance (Dimeo, 2001; Dimeo et al., 2003; Lucia, Earnest, & Perez, 2003; National Comprehensive Cancer Network [NCCN], 2010). Little is known about the relationship of fatigue to physical performance in children and adolescents with cancer (Clarke-Steffen et al., 2001; Kline et al., 2000). In this study, the relationship between the changes in fatigue and physical performance was examined in a cohort of children (ages 6–12 years) and adolescents (ages 13–17 years) during the first three cycles of chemotherapy treatment.

Both children and adolescents with cancer, as well as parents and healthcare providers, have identified fatigue as one of the most distressing and prevalent treatment-related symptoms (Collins et al., 2000, 2002; Davies, Whitsee, Bruce, & McCarthy, 2002; Gibson, Garnett, Richardson, Edward, & Sepion, 2005; Hinds & Hockenberry-Eaton, 2001; Hockenberry-Eaton & Hinds, 2000). Through their focus group interviews of children, adolescents, parents, and staff, Hinds and Hockenberry-Eaton have defined fatigue as a subjective symptom with physical, mental, and emotional components characterized by a lack of energy (Hinds et al., 1999). In addition, fatigue often differs by developmental level. For example, school-age children emphasized the physical sensation of feeling weak or tired, whereas adolescents emphasized mental and emotional tiredness that alternated and sometimes merged with the physical sensation of fatigue. These physical, mental, and emotional dimensions of fatigue were confirmed by Davies et al. (2002) who found that managing energy was a core process in coping with fatigue.

Research is emerging on the role that coexisting conditions play in the symptom of fatigue in children. For children hospitalized during chemotherapy, the number of nocturnal awakenings significantly correlated with levels of hospital-related fatigue (Hinds, Hockenberry, Rai, et al., 2007). Children in the continuation phase of treatment for acute lymphocytic leukemia (ALL) reported prevalent fatigue and also experienced night awakenings (Gedaly-Duff, Lee, Nail, Nicholson, & Johnson, 2006). Hinds, Hockenberry, Gattuso, et al. (2007) found significant increases in fatigue and changes in sleep quality in response to a five-day pulse of dexamethasone during continuation therapy for ALL.

Health professionals may exacerbate patients' fatigue by counseling them to decrease their daily activities to conserve energy; this advice can cause paradoxical results (Dimeo et al., 2003). When muscles become inactive, the enzyme content in the mitochondria and the density of muscle capillaries decrease. Myofibrils become thinner, indicating muscle atrophy; muscle fibers needed for endurance activities are lost. Muscles lose their power and force and become more fatigable (Al-Majid & McCarthy, 2001). In adults with cancer, multiple systemic reviews have rated exercise as demonstrating the highest evidence as a safe intervention for reducing fatigue (Cramp & Daniel, 2008; Knols, Aaronson, Uebelhar, Fransen, & Aufdemkampe, 2005; Mitchell, Beck, Hood, Moore, & Tanner, 2007; NCCN, 2010). In children with cancer, studies are beginning to explore the efficacy of nursing interventions to decrease fatigue. In a randomized clinical trial, a week-long nursing intervention for inpatient children newly diagnosed with cancer included patient and parent education, daily physical activity, and sleep hygiene. The experimental group of patients had decreased fatigue as reported by patients and their parents (Genc & Conk, 2008).

Physical performance is conceptualized as a child's ability to do developmentally appropriate muscle movements necessary for the child to ambulate and actively participate in age-appropriate experiences that support ongoing development and health. Research on children with cancer has focused primarily on those with ALL. Children in the early months of ALL treatment have been found to be significantly weaker, with poorer mobility than healthy controls (Gocha Marchese, Chiarello, & Lange, 2003). Children with cancer are significantly less active than healthy controls during the induction and maintenance phases of ALL therapy (Winter et al., 2009). Children with ALL also demonstrate a significant decrease in daytime activity levels during the five-day dexamethasone pulse of maintenance therapy (Sanford et al., 2008). Decreases in physical performance, measured by self-report, also are evident in adolescents across cancer diagnoses (Keats, Culors-Reed, Courneya, & McBride, 2006). Deficits in performance persist following completion of treatment for cancer. A meta-analysis of studies that measured peak oxygen uptake (VO_{2peak}) in childhood ALL survivors revealed that levels in survivors were 13% lower than healthy controls. The researchers identified sedentary habits and muscle atrophy as contributors to that difference and noted that poor physical fitness contributed to fatigue experienced by survivors (van Brussel, Takken, Lucia, van der Net, & Helders, 2005). After treatment for ALL, children performed significantly worse than healthy controls in running speed and agility, balance, and strength (Wright, Halton, Martin, & Barr, 1998). Research on physical performance during and after treatment for childhood cancer shows that patients have less strength, endurance, and fitness or exercise capacity compared to healthy children. These changes are related to deconditioning from lack of activity and the toxicities of chemotherapy.

Conceptual Framework

A developmental model was used for this study (Hooke, 2009). The framework incorporates factors identified in research on fatigue in children with cancer as well as concepts from developmental science (see Figure 1). Hockenberry-Eaton and Hinds (2000) identified factors that could contribute to the symptom of fatigue

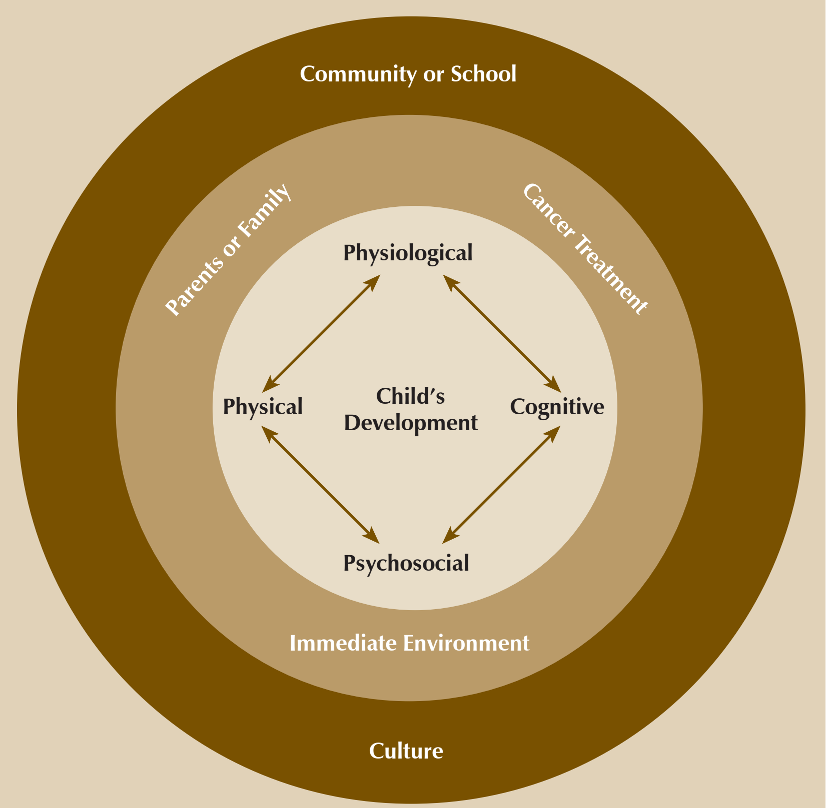

Figure 1. Developmental Model for Children and Adolescents With Cancer

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that included treatment side effects; the healthcare environment; and family, culture, and community. The developmental model also recognizes the complex interaction of four components of the child's development: cognitive, psychological, physiological, and physical. Reciprocal interactions occur among these components within a dynamic, continual process of development (Miles & Holditch-Davis, 2003). In a developmental framework, a change in one component of development will impact others. For example, if a child is physiologically impacted by illness and is unable to attend school or have peer interactions, other parts of the child's development will be impacted. Treatment influences the cancer itself (a physiologic component), but its side effects also can impact the child physically, psychologically, and cognitively over the course of treatment and during the child's ongoing development. In this study, the fatigue variable has been defined as having physical, psychological, and cognitive dimensions that are influenced by cancer and its treatment as well as the child's developmental level. The physical and physiological components of the study variable physical performance also are impacted by cancer and its treatment.

Methods

Study Design

In this exploratory study, a within-subjects design was used to examine the relationship between the change in physical performance and the change in fatigue measures between two time points in two cohorts of participants. A correlational design was selected for the study because the literature supported possible connections among the study variables, but their relationships had not been evaluated in studies of children with cancer.

Setting and Sample

The current study was conducted at two pediatric oncology treatment centers in Minneapolis and St. Paul, MN. Eligible participants included children (ages 6–12) and adolescents (ages 13–18) who (a) spoke English and were (b) newly diagnosed with cancer, (c) receiving chemotherapy for a minimum of three cycles with at least two IV or intramuscular chemotherapy agents, (d) able to give assent according to institutional guidelines, and (e) who had parental consent to participate. A three-cycle period of chemotherapy was selected as the study time interval because, during this time, intensive chemotherapy is administered to induce and consolidate a remission in the patient. The time frame of three cycles also included the shortest treatment interval for some pediatric cancers (Wilms tumor and Hodgkin disease), although treatment regimens for other diagnoses could continue for as many as three years. Receipt of two IV and/or intramuscular chemotherapy agents was selected as the criterion indicator of minimal intensity of treatment. Children and adolescents were excluded if they were receiving radiation therapy; had an antecedent neurological, developmental, or genetic disorder; displayed neurological deficits secondary to surgical intervention; or were in the intensive care unit longer than 48 hours during the first two weeks of diagnosis. As newly diagnosed patients entered the oncology programs at the two study sites, they were screened for eligibility for this study by the investigator. The study was approved by the institutional review boards at both study sites.

Initial sample size calculations for a single cohort were performed using fatigue scores from the Childhood Fatigue instrument development study (Hockenberry et al., 2003). After study enrollment began, additional research on fatigue scales was published (Hinds, Hockenberry, Tong, et al., 2007). The researchers who developed the child and adolescent scales recommended that the fatigue scores not be transformed to z scores but rather be analyzed separately as two separate cohorts (P.S. Hinds, personal communication, April 3, 2008; M.J. Hockenberry, personal communication, April 14, 2008). That approach recognizes the conceptual definition of fatigue as being distinct for each developmental group. Enrollment concluded after a 20-month enrollment period with 30 participants.

Measurements

The **Childhood Fatigue Scale (CFS)**, a 14-item, two-part questionnaire, was used for the child cohort (ages 6–12). The instrument takes about 10 minutes for the child to complete and was read to the participants. The child is asked for a "yes" or "no" (frequency) response regarding his or her experience of any fatigue-related symptoms during the past week. If the statement is true, the child is asked to rate how much the problem bothers him or her on a four-point adjectival scale ranging from "not at all" to "a lot" (intensity). If the child has not experienced the particular problem and has answered with a "no" response for the question, the score is zero for that question. Multiplying the frequency with the intensity score provides the total fatigue score, which can range from 0–70, with higher scores corresponding to greater fatigue. Internal consistency reliability testing for the total fatigue score of the CFS was 0.84 (Cronbach alpha) (Hockenberry et al., 2003). In this study, the Cronbach alpha coefficients for the CFS ranged from 0.84–0.86.

The **Fatigue Scale for Adolescents (FS-A)** is a 14-item self-report scale developed to measure the perceptions of fatigue during the previous week of treatment in adolescent patients with cancer (Hinds, Hockenberry, Tong, et al., 2007) and was used for the adolescent cohort in the current study. The adolescent circles the description of the intensity of fatigue for each item on a five-point Likert-type scale. Scale completion requires three to four minutes, and ratings range from 14 (no fatigue symptoms) to 70 (high fatigue). Instrument content was based on a conceptual definition of fatigue that was developed from a qualitative focus group study of adolescents with cancer. Items such as, "I don't feel like being with others," and "My mind has felt worn out," address the mental and emotional aspects of fatigue. Instrument reliability and construct validity, as well as the ability to measure change over time, were tested in 64 adolescents, with estimates for internal consistency of the FS-A ranging from 0.67–0.95 (Hinds, Hockenberry, Tong, et al., 2007). In this study, the range was 0.81–0.87 (Cronbach alpha).

The **Timed Up and Down Stairs (TUDS)** test is a physical performance measure of functional mobility that requires strength and endurance (Zaino, Marchese, & Westcott, 2004). The test involves the participants ascending one flight of 13 to 14 steps, turning around, and descending to the starting point. The tester instructs the participant to "Quickly, but safely, go up the stairs, turn around on the landing and come all the way down until both feet are on the landing." The score is measured in seconds from the "go" cue until the second foot returns to the bottom landing. The handrail can be used and shoes are worn. Intrarater, inter-rater, and test-retest reliability of TUDS was established for children and demonstrated strong concurrent validity to three other tests of functional capacity (Zaino et al., 2004). TUDS has been successfully used in studies with pediatric patients with cancer (Marchese & Chiarello, 2004; Marchese, Chiarello, & Lange, 2004).

The **6-Minute Walk Test (6MWT)** is a measure of maximal functional capacity and endurance of the cardiorespiratory system (American College of Sports Medicine, 2006). The participant is directed to walk as far as possible on a flat surface for six minutes with the goal of covering as much distance as possible. A stopwatch is used to record the time, and a distance measurement wheel is used to calculate distance in feet, which is then converted to meters. A straight, flat, corridor with a length ranging from 50–160 feet should be used for the test; studies have found that straight courses within this range have no significant effect on the distance walked. The course should be marked with clear turnaround points and laps should be counted. Standard phrases of encouragement should be offered as well (American Thoracic Society, 2002).

The 6MWT has been used to assess performance in ill patients with cardiac or pulmonary disease and demonstrates good test-rest reliability (Gulmans, van Veldhoven, deMeer, & Helders, 1996) and concurrent validity with peak oxygen update and physical work capacity (Nixon, Joswiak, & Fricker, 1996). Good reliability and validity also were found in a sample of healthy children (Li et al., 2005).

Procedures

After obtaining parental consent and participant assent, study measurements were administered during the first and third cycles of chemotherapy, between days 15 and 29 of each cycle, during a routine clinic visit or hospitalization. In that time period, the participants' blood counts had reached their nadir and most had started to recover. The fatigue instrument asked the participant to think about how they felt the previous week. That allowed participants to report how they felt during a period of neutropenia, which children and adolescents have reported as contributing to fatigue (Hockenberry-Eaton & Hinds, 2000). The three-cycle time period also allowed for the measurement of participants over a short trajectory of treatment while restricting the introduction of additional variables that occur over longer time periods. The fatigue instrument was administered prior to the performance measures to ensure that fatigue reports were not related to fatigue from physical performance measurements. The 6MWT was administered indoors on a flat, long hallway with a walking loop identified by arrows on the floor. The hall length ranged from 90–110 feet, with the range of one lap equaling 180–220 feet. The TUDS was administered within each hospital on a staircase with 13 steps of standard height, a landing, and a handrail.

Data Analysis

SPSS®, version 14.0, was used for data analysis. The distribution curves of the variables revealed a nonnormal distribution and, therefore, nonparametric statistical tests were used. A Wilcoxon signed-rank test with a two-sided significance level was used to evaluate the change from cycle 1 to cycle 3 in each variable: child fatigue, adolescent fatigue, TUDS, and 6MWT. The Mann-Whitney U test was performed for each cohort to test for differences between males and females in the amount of change in physical performance and fatigue. The Kruskal-Wallis test was used to compare the difference in the change in physical performance and change in fatigue between the three diagnostic groups (ALL, lymphoma, and solid tumors) in each cohort.

Spearman's rank-order correlation was used to examine the strength of the relationship between the change in TUDS and change in participant fatigue score and between change in the 6MWT and change in participant fatigue score. Guidelines developed by Cohen (1988) were used to interpret the strength of the relationship, with 0.1–0.29 signifying "small," 0.3–0.49 representing "medium," and 0.5–1 indicating "large." For this exploratory study, $p < 0.1$ and < 0.05 are reported as slight differences and significant differences, respectively, and exact p values of significance are reported.

Results

Demographics

Sixteen children and 14 adolescents were enrolled in the study and completed the study measurements. The distribution of patients by age, gender, race, and diagnostic group for each cohort is presented in Table 1. Gender in the child cohort was almost evenly distributed, whereas the adolescent cohort was predominantly males. The majority of the participants were Caucasian, which is reflective of the pediatric cancer population in Minnesota. Numbers of participants in three diagnostic groups (ALL, lymphomas, and solid tumors) were similar in the child cohort; however, half of the adolescent cohort were patients with lymphoma. The mean number of days between the initial and final assessments was 56.77 days, with a range of 35–88 days.

Change in Physical Performance

In the child cohort, both measures of physical performance, the TUDS and 6MWT, appeared to improve from cycle 1 to cycle 3 of chemotherapy (see Table 2). A significant difference was not noted between males and females in the amount of improvement on the TUDS (p = 0.84) or the 6MWT (p = 0.76). However, among the three diagnostic groups (ALL, lymphoma, and solid tumors), a slight difference in improvement was noted in the 6MWT (p = 0.09). The child ALL group had greater improvement in their median distance (Md) on the 6MWT (Md = –171.75) than the lymphoma group (Md = –84.73) or the solid tumor group (Md = 26.82). However, no difference in improvement was noted on the TUDS across the three diagnostic groups in the child cohort (p = 0.26).

In the adolescent cohort, the performance on the TUDS and 6MWT from cycle 1 to cycle 3 of chemotherapy evidenced little change. No significant difference was found between males and females in the amount of improvement on the TUDS (p = 0.94). However, a slight difference in improvement was seen on the 6MWT, with females walking farther on the second measurement (Md = –41.76, n = 3) than males (Md = 6.4, n = 11) (p = 0.1). Among the three diagnostic groups (ALL, lymphoma, and solid tumors) in the adolescent cohort, no significant differences were found in relation to change on the TUDS (p = 0.59) or 6MWT (p = 0.69).

Change in Fatigue

In the child cohort, the total score for the CFS significantly decreased during the first three cycles of chemotherapy (see Table 3). Males and females did not differ in the fatigue score change (p = 0.68). A statistically significant difference was noted in the change in total fatigue scores across the three diagnostic groups (p = 0.01). The child ALL group had greater median score change (decrease in fatigue) (Md = 17.5) than the lymphoma group (Md = 3) or the solid tumor group (Md = –3).

The score for adolescents on the FS-A did not significantly decrease from cycle 1 to cycle 3 of chemotherapy. Males and females did not differ in their change in fatigue (p = 0.64). The change in fatigue was not significantly different across the three diagnostic groups.

Relationship Between the Changes in Physical Performance and Fatigue

In examining the relationship between the change in physical performance and the change in fatigue in the child cohort, from cycle 1 to cycle 3 of chemotherapy, a large negative relationship was noted between the change in 6MWT and change in CFS total score, with an increase in the distance walked associated with a decrease in fatigue (p = 0.01) (see Table 4). The strength relationship between the change in the TUDS score and the change in CFS total score was medium to large, with a decrease in time on the TUDS being associated with a decrease in fatigue that approached significance (p = 0.11). In the adolescent cohort, associations between a change in physical performance and a change in fatigue were weaker and not statistically significant. A medium-sized relationship formed between an increase in the distance walked on the 6MWT and a decrease in fatigue (p = 0.27). A small-to-medium strength relationship was found between a decrease in time on the TUDS and a decrease in fatigue (p = 0.36).

Table 1. Patient Demographic Characteristics

Characteristic	Children (N = 16) n	Adolescents (N = 14) n
Gender		
Male	9	11
Female	7	3
Age at diagnosis		
6–8	8	–
9–12	8	–
13–14	–	9
15–17	–	5
Race or origin		
Caucasian	14	12
African American	1	1
Native American	–	1
Hispanic	1	–
Diagnostic group		
Acute lymphocytic leukemia	6	3
Acute myelogenous leukemia	–	1
Lymphoma	5	7
Solid tumor	5	3

Table 2. Change in Median Values of Physical Performance Variables

	TUDS (Seconds)			6MWT (Meters)		
Cohort	Cycle 1	Cycle 3	p	Cycle 1	Cycle 3	p
Child	15.88	14.04	0.09	359.05	406.4	0.09
Adolescent	10.88	8.3	0.22	460.55	461.62	0.36

6MWT—6-Minute Walk Test; TUDS—Timed Up and Down Stairs

Discussion

The outcomes of this exploratory study provide new insight into the symptom of fatigue in children and adolescents during the first three cycles of chemotherapy. Previous research in children and adolescents has focused on measuring fatigue at one time point during treatment (Collins et al., 2000, 2002; Hockenberry et al., 2003) or during two time points in one treatment cycle of days to weeks (Gedaly-Duff et al., 2006; Hinds, Hockenberry, Gattuso, et al., 2007; Hinds, Hockenberry, Rai, et al., 2007; Hinds, Hockenberry, Tong, et al., 2007; Hockenberry et al., 2003, 2010). When measured within a treatment cycle, fatigue has increased over time.

In this study, fatigue was measured over a natural treatment course of three chemotherapy cycles. Although the size of the child cohort was small, a significant decrease was found in the total fatigue score ($p = 0.05$) with a medium effect size ($r = 0.35$)—an unexpected and important finding. In the adolescent cohort, a tendency existed toward a decrease in fatigue ($p = 0.15$) with a small to medium effect size ($r = 0.27$). However, the direction of change was consistent with the child cohort. The decrease in fatigue that occurred without a specific fatigue intervention must be considered in future study designs. A fatigue intervention study would need to include a control group to allow for the comparison to the natural trajectory of this symptom during treatment. A potential reason for the decrease in fatigue could be that, at the first measurement point (cycle 1 of chemotherapy), patients experienced fatigue as a side effect of chemotherapy as well as an initial disease symptom that alerted youth or their family members to the fact that they were ill. At the second measurement point, all participants were in remission. A potential source of fatigue—the cancer itself—had been eliminated.

Nonparametric tests found no significant difference between males and females in the amount of change in fatigue in either cohort. A difference was noted in the change in fatigue between the three diagnostic groups (ALL, lymphoma, and solid tumors) in the child cohort but not in the adolescent cohort. The children with ALL had a significant improvement in their fatigue that may have influenced the significant decrease in fatigue found in the entire child cohort. The first measurement point for children with ALL was during induction therapy. The induction phase of treatment included high doses of corticosteroids. Side effects of corticosteroids can include muscle atrophy and fatigue. Chemotherapy at cycle 3 did not include corticosteroids, so this acute side effect would be expected to diminish. That finding is consistent with previous research that found an association between corticosteroids and fatigue (Hinds, Hockenberry, Gattuso, et al., 2007). In designing future studies, it will be important to recognize the potential influence that diagnosis and treatment have on the experience of fatigue.

In the adolescent group, the small cohort size combined with the uneven distribution of gender and diagnosis within the cohort limited the nonparametric tests of differences between independent groups. However, an interesting finding was that, even with a small number of adolescents with ALL, fatigue did not decrease in this subgroup after corticosteroids were no longer administered in the third chemotherapy cycle. Perhaps the side effects of corticosteroids are experienced differently in children and adolescents.

The child cohort in this study demonstrated an improvement in both measures of physical performance (TUDS and 6MWT), whereas the adolescent cohort showed little change. A tendency existed for children with ALL to have greater improvement in the 6MWT than children with lymphoma or solid tumors. That finding was consistent with the difference in fatigue found among the child diagnostic groups that might be caused by the influence of corticosteroids during cycle 1 and absence of corticosteroids on cycle 3 of chemotherapy. In the adolescent cohort, the uneven distribution of participants in both gender and diagnostic groups limited the analysis of differences among the groups.

Individual changes in performance were examined in relation to changes in fatigue. In the child cohort, a strong correlation was found between an increase in distance on the 6MWT and a decrease in the total fatigue score ($r_s = –0.6$). A medium-strength correlation existed between a decrease in the seconds measured on the TUDS and a decrease in total fatigue ($r_s = 0.41$). In the adolescent group, a medium-sized correlation was found between an increase in meters walked on the 6MWT and a decrease in fatigue scores ($r_s = –0.32$) and

Table 3. Change in Median Values of Fatigue Variables

Cohort	Cycle 1	Cycle 3	p
Child (CFS total)	18	10.5	0.05
Adolescent (FS-A)	23.5	20.5	0.15

CFS—Childhood Fatigue Scale; FS-A—Fatigue Scale for Adolescents

Table 4. Spearman Correlations Between Change in Fatigue and Change in Physical Performance

Cohort	TUDS		6MWT	
	r_s	p	r_s	p
Child	0.41	0.11	–0.6	0.01
Adolescent	0.28	0.36	–0.32	0.27

6MWT—6-Minute Walk Test; TUDS—Timed Up and Down Stairs

a weaker correlation (small to medium) between an improved time on the TUDS and a decrease in fatigue (r_s = 0.28). These study findings are consistent with the conceptual definition of fatigue in children with cancer developed by Hinds and Hockenberry-Eaton and others in their program of research (Hinds et al., 1999). Using a qualitative approach, they found that fatigue was described as a distressing, pervasive symptom with physical, mental, and emotional components characterized by a lack of energy. The subjective experience of fatigue differed by developmental level as the school-age group emphasized the physical sensation of fatigue, whereas the adolescent group emphasized mental tiredness that alternated and at times merged with the physical sensation of fatigue. The fatigue instruments for both cohorts included statements about physical, mental, and emotional components of fatigue. Strong relationships between measures of change in physical performance and fatigue were found in the child cohort, whereas the relationships in the adolescent cohort were less evident. Children with cancer experience fatigue primarily as a physical sensation; therefore, its correlation with physical performance is logical. Nurse scientists recognize that symptom experiences are different across developmental levels (Docherty, 2003; Linder, 2008). The complexity of the fatigue experience increases as development advances, so the adolescent's fatigue might have a weaker relationship with the physical domain as the mental and emotional components of fatigue evolve. The results provide new insight into how these variables relate to each other and may be influenced by the developmental level of the patient.

Limitations

The small sample size of each cohort limited the exploration of moderators such as age, gender, diagnosis, or hemoglobin. Many other variables were not measured, and they could influence fatigue and physical performance and their relationship. Those variables may include, but are not limited to, the individual's behaviors (i.e., exercise behaviors) and characteristics (i.e., self-efficacy) before the cancer diagnosis, coping and resilience, physiologic characteristics (i.e., height, weight, and metabolism), symptoms of the individual's cancer, and types of chemotherapy. Symptoms are temporal in nature; the experience of fatigue is subjective and a wide variation may be noted within a day, week, or month. Physical performance is dependent on muscle physiology and is less likely to have rapid shifts in a short time period. However, physical performance is influenced by motivation and a disinterested participant may have performed less well on the study measurements. The study also was limited by having two measurement points. With only two points, the trajectory of change is assumed to be linear. When three or more points are present, non-linear change can be detected that provides further insight into the trajectory of the cancer experience.

Conclusion

Children and adolescents diagnosed with cancer experience fatigue as a symptom of disease and also as a side effect of treatment. Although it appears to lessen as disease burden decreases, fatigue continues to be reported. Fatigue appears to be a multidimensional experience with the psychological distress of fatigue merging with the physical sensation. These study findings reveal the relationship between physical performance and fatigue and provide a foundation for future studies that evaluate exercise interventions for fatigue.

Implications for Nursing Practice

Insights into how fatigue relates to physical performance in children and adolescents receiving chemotherapy for cancer can assist the nurse in educating patients and families about management of this distressing symptom. The results of this exploratory study provide a foundation for future intervention studies that have the potential to guide practice in the management of fatigue in children and adolescents with cancer. Decreasing the burden of this symptom is important for improving quality of life during treatment and for providing energy for engaging in positive life experiences that advance children along the developmental continuum to a long and healthy future.

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Digital Object Identifier: 10.1188/11.ONF.649-657

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