ORIGINAL RESEARCH

Motor Proficiency and Occupational Performance in Children With Leukemia Across Age Groups: A Cross-Sectional Study

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Background: Motor disability represents a major challenge in children with leukemia, profoundly affecting their ability to perform activities of daily living. The aim of this study is to examine the relationship between motor proficiency and the ability to perform daily tasks in children with leukemia who are not attending school during treatment. **Methods:** This cross-sectional study was conducted in a Pediatric Oncology Department and included 102 children with leukemia aged 6 to 17 years. Occupational performance was assessed using the Canadian Occupational Performance Measure (COPM), and motor skills were evaluated with the Bruininks-Oseretsky Test of Motor Proficiency–Short Form (BOTMP-SF). **Results:** Approximately half of the participants were high school students, with 54.9% being male. COPM and BOTMP-SF differed significantly between age groups ($P < .05$). BOTMP-SF fine and gross motor proficiency found significant differences between primary, secondary, and high school age groups for gross motor proficiency ($P < .05$). **Conclusion:** The relationship between motor proficiency and participation in activities of daily living in children with leukemia has a crucial impact on occupational performance. In this context, it is important to implement specific interventions that take into account the age-specific needs of children with cancer. **(Rehab Oncol 2025;000:1–8)** *Key words: children, leukemia, motor proficiency, occupational performance, participation*

INTRODUCTION

Leukemia is the most prevalent cancer in children and adolescents, accounting for nearly one-third of all pediatric cancer cases.[1,2] Most childhood leukemias are acute lymphoblastic leukemia (ALL), while acute myeloid leukemia (AML) accounts for the majority of the remaining cases. Chronic leukemias are rare in children.[3] Despite advancements in medical treatment leading to improved survival rates, cancer and its therapies continue to significantly impact quality of life.[4] Moreover, a cancer diagnosis often alters social and family expectations, as well as children's own expectations regarding medical treatment, psychosocial support, and participation in daily activities.[5]

Occupational performance, a crucial component of quality of life, embodies a dynamic process characterized by an individual's capacity to select, organize, and engage in fulfilling and meaningful activities pertinent to their age, development, culture, and environment.[6] The Canadian Occupational Performance Measure (COPM) assesses 3 key areas of occupational performance: *self-care, productivity*, and *leisure*, each of which is typically performed in different contexts.[7] According to the 4th edition of Occupational Therapy Practice Framework, occupations are divided into areas as activities of daily living, instrumental activities of daily living, health management, rest and sleep, education, work,

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play, leisure, and social participation.[8] Children undergoing cancer treatment often show reduced performance and satisfaction across activity domains, particularly in self-care, due to their health condition.[9] Declines in occupational performance may affect motor proficiency, thereby limiting daily functioning. Prolonged treatment can further reduce motor proficiency, encompassing both fine and gross motor skills, which significantly influence cognitive, academic, and social development.[10] Motor proficiency refers to competence in both fine and gross motor skills, reflecting multiple aspects of motor development.[11] Fine and gross motor skills play a critical role in children's cognitive, academic, and social development.[12] Understanding the extent of motor proficiency challenges is pivotal for devising rehabilitation strategies aimed at enhancing quality of life.[13]

Ongoing treatment and prolonged hospitalization negatively affect children's participation in daily activities, which are vital for health and well-being regardless of age, health status, or skill level.[14] It is well documented that many childhood individuals surviving cancer endure late effects such as pain, fatigue, cognitive impairments, and psychosocial difficulties, which further impede participation in daily life and diminish motor skill proficiency.[15,16] Reduced participation negatively affects leisure and social activities, leading to greater challenges in daily life and increased motor limitations. This highlights that quality of life is shaped by the interdependence of physical and psychological factors, which interact to significantly influence overall well-being.[15] Existing literature suggests that children with leukemia may experience impairments in motor performance, persisting throughout acute treatment and into the post-treatment phase.[17,18] Formal education, particularly within the school setting, plays a pivotal role in fostering gross and fine motor proficiency alongside other essential skill domains.[19] The term "educational stages" refers to the levels of formal learning, typically divided into primary, secondary, and higher education. In our country, the compulsory education period lasts for 12 years and is structured into 3 stages: primary, secondary, and high school. This structure is commonly referred to as the "4 + 4 + 4" system.[20] Prolonged interruptions in schooling precipitate decreased academic attainment, heightened dropout risks, behavioral challenges in adulthood, and increased unemployment rates.[21]

The relationship between motor proficiency and occupational performance in children who cannot attend school because of leukemia has not been well studied. Understanding this relationship is important to better understand the impact of motor difficulties during the disease process on occupational performance in daily activities and education.[22] This study seeks to bridge this gap by investigating the relationship between motor proficiency levels and occupational performance across age groups among children diagnosed with leukemia.

METHODS

Study Design and Participants

This cross-sectional study was conducted at 2 centers within the Department of Pediatric Oncology at a university hospital. Ethical approval was obtained from the University Non-Interventional Research Ethics Committee (Approval No.: 2021/378), and written informed consent was provided by each child and/or their parent. The inclusion criteria were as follows: (1) age between 6 and 17 years, (2) *undergoing hospital-based cancer treatment*, (3) absence of surgical intervention, and (4) minimum treatment duration of 3 months. Exclusion criteria were as follows: (1) disease relapse or palliative care, (2) intellectual or developmental disabilities, (3) lack of fluency in the national language among the child or parent, and (4) more than 15 months of treatments.[22] A total of 120 inpatients were screened. Eighteen children were excluded for the following reasons: developmental disorders (n = 6), insufficient fluency in Turkish (n = 5), treatment duration longer than 15 months (n = 4), and disease relapse or surgical intervention (n = 3). Ultimately, 102 children met the inclusion criteria. During data collection, it was observed that none of the school-aged participants were attending school, as their treatment schedules and health conditions prevented school attendance. This was not an inclusion criterion but rather a consequence of their medical circumstances.

Data were collected between January 2022 and March 2024. Assessments were conducted by a team of 2 physiotherapists and 3 occupational therapists, each with at least 4 years of professional experience and training in the administration of the Bruininks-Oseretsky Test of Motor Proficiency–Short Form (BOTMP-SF). The COPM was administered by 3 occupational therapists with expertise and prior training in its use. Each child underwent individual assessment, which required approximately 45 to 60 minutes per participant.

Measurements

Demographic information form

Demographic characteristics such as age and sex, along with clinical information including diagnosis, time to diagnosis, and received treatments, were collected using a demographic information form. In accordance with our country's compulsory education system, children aged 6 to 9 years were classified as primary school age, those aged 10 to 13 years as middle school age, and those aged 14 to 17 years as high school age.

Canadian Occupational Performance Measurement (COPM)

Occupational performance and participation were assessed utilizing the COPM. Through a semi-structured interview, children's occupational performance and participation problems were identified in 3 different activity areas: self-care, productivity, and leisure.[23,24] Each of the activities was given an *importance* score between 1 (not *importance*) and 10 (extremely *importance*) by the child. Subsequently, the most

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importance activities are listed, and the top 5 activities were rated for satisfaction (1: not satisfied, 10: extremely satisfied) and performance (1: unable to do, 10: able to do extremely well). The mean performance score (COPM-P) and the mean satisfaction score (COPM-S) were computed by summing the ratings and dividing by the number of problems. A lower score average is indicative of substandard performance and diminished satisfaction. COPM has been established as a reliable and valid assessment tool through previous validation studies.[24] It has demonstrated strong psychometric properties, including high test-retest reliability (Cronbach alpha = .89) and intraclass correlation coefficient (ICC) values of .99 for performance and .98 for satisfaction.[25]

Bruininks-Oseretsky Test of Motor Proficiency-Short Form (BOTMP-SF)

Motor competence was measured using the BOTMP-SF in children with leukemia. Designed for children, adolescents, and young adults aged 4 to 21 years, this assessment consists of 8 subtests evaluating gross and fine motor proficiency. It has demonstrated effectiveness in diagnosing and describing motor issues in this age group.[26] BOTMP-SF encompasses 3 basic components: gross motor functions, fine motor functions, and combined motor functions (together gross and fine). In the present study, standard scores were utilized due to the fact that they facilitate the interpretation of the BOTMP-SF values based on normative data.[27] Each subtest yields raw scores (eg, completion time or number of successful trials), which are converted into point scores. These are then compiled to form composite scores, which can be expressed in standard scores, percentile ranks, or age-equivalents according to the test manual. Higher scores indicate better motor competence. The internal consistency alpha coefficient (.87) and test-retest reliability coefficient (.89) for the BOTMP-SF total score were found to be high. Additionally, it was reported that the internal consistency and alpha coefficient for subtests ranged between .50 and .71.[28]

Data Analysis

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 23. The Kolmogorov-Smirnov test was used to determine the normality of the distribution. The level of significance was set at .05 for all statistical analyses, and the results are expressed as percentage (%) or mean ± standard deviation (age, age at diagnosis, COPM-P, COPM-S, and BOTMP-SF). The chi-square test was used to compare percentages between 2 groups, and the *t*-test was used to compare means. The Pearson correlation coefficient test was used to assess associations between the outcome measures. The data conforming to the normal distribution were analyzed using 1-way ANOVA, followed by the Scheffe *post hoc* test to determine between-group differences. One-way ANOVA was used to test whether there was a difference between different age groups of primary, secondary, and high school in terms of COPM performance and satisfaction, BOTMP-SF gross, fine, and combined proficiency.

RESULTS

The study comprised 102 children (mean age = 11.95 ± 2.41 years), including 46 females and 56 males, all of whom were undergoing treatment for leukemia. Among them, 28 children were categorized as primary school age, 31 as secondary school age, and 43 as high school age. Of the total sample, 52 children were diagnosed with ALL and 50 with AML, all receiving hospital-based treatment. Fifty-five children (54%) were undergoing chemotherapy alone, while 47 (46%) were receiving combined chemotherapy and radiotherapy. Additional demographic and clinical characteristics are detailed in Table 1.

Analysis of COPM activities across occupational performance areas revealed that primary school–aged children experienced the greatest difficulty in leisure activities (68.3%), whereas secondary school–aged (44.5%) and high school–aged (54.6%) children had the most challenges in productivity and self-care (Fig. 1).

For the total sample, the COPM total scores were 9.45 (SD = 2.30) for primary school children, 8.78 (SD = 2.10) for secondary school children, and 9.28 (SD = 2.20) for high school children. COPM performance and satisfaction scores showed significant differences between age groups ($P = .011$ and $P = .01$). According to the BOTMP-SF results, there was a significant increase in both gross and fine motor proficiency with increasing age ($P < .05$). *Post hoc* analyses showed significant differences in gross and fine motor proficiency between all age groups, with the differences being most pronounced between primary and high school students ($P < .01$). However, no significant differences were found between age groups for combined gross and fine motor proficiency ($P = 0.38$; Table 2).

Correlation analyses indicated that BOTMP-SF gross motor proficiency was not significantly associated with COPM satisfaction ($r = .315$, $P = .0758$). In contrast, a significant correlation was found between COPM satisfaction and BOTMP-SF fine motor proficiency and combined gross and fine motor proficiency ($P < .05$). Similarly, a very strong correlation was observed between BOTMP-SF fine motor proficiency and COPM performance ($r = .928$, $P = .001$). All scores were given in Table 3.

DISCUSSION

The study found that high school–aged children demonstrated higher occupational performance and greater gross and fine motor proficiency than younger peers, consistent with developmental progression, whereas satisfaction was highest in the primary school–aged group. However, when gross and fine motor functions were combined into a single composite score, no significant age-related differences were

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TABLE 1
Demographic characteristics of children with leukemia

Characteristics	N (%)	M ± SD	Range
Age (years)	102 (100%)	11.9 (2.41)	6-17
Age at diagnosis (months)	102 (100%)	8.6 (1.82)	6-12
School age groups	102 (100%)		6-17
Primary school	28 (27.5%)		6-9
Secondary school	31 (30.4%)		10-13
High school	43 (42.2%)		14-17
Gender	102 (100%)		
Female	46 (45.1%)		
Male	56 (54.9%)		
Diagnosis	102 (100%)		
Acute lymphoblastic leukemia	52 (50.9%)		
Acute myeloid leukemia	50 (49.1%)		

observed, suggesting that the composite measure may be less sensitive, whereas separate analyses provide a clearer picture of developmental differences. Overall, these findings underscore the importance of considering age-related differences in both performance and motor skills.[29]

In the present study, the leukemia groups comprised children diagnosed with ALL and AML. This categorization is consistent with previous studies that similarly distinguished between these diagnostic groups.[30] In order to prevent cancer-related disabilities in children, there is a necessity for the establishment of appropriate rehabilitation guidelines and detailed assessment studies.[31] Children with cancer frequently experience fine and gross motor difficulties caused by treatment-related neuromuscular effects and physical limitations, which negatively affect daily activities, self-care, play, and academic performance.[22,32]

Significant differences in BOTMP-SF scores, particularly in gross and fine motor scores, were observed between different school-age groups, which is consistent with the existing literature on the influence of chronic illness on motor development.[33] These findings further support the clinical utility of the BOTMP-SF as a widely used measure of motor proficiency in pediatric populations.[34] Notably, the age-related differences in fine and total motor skill levels

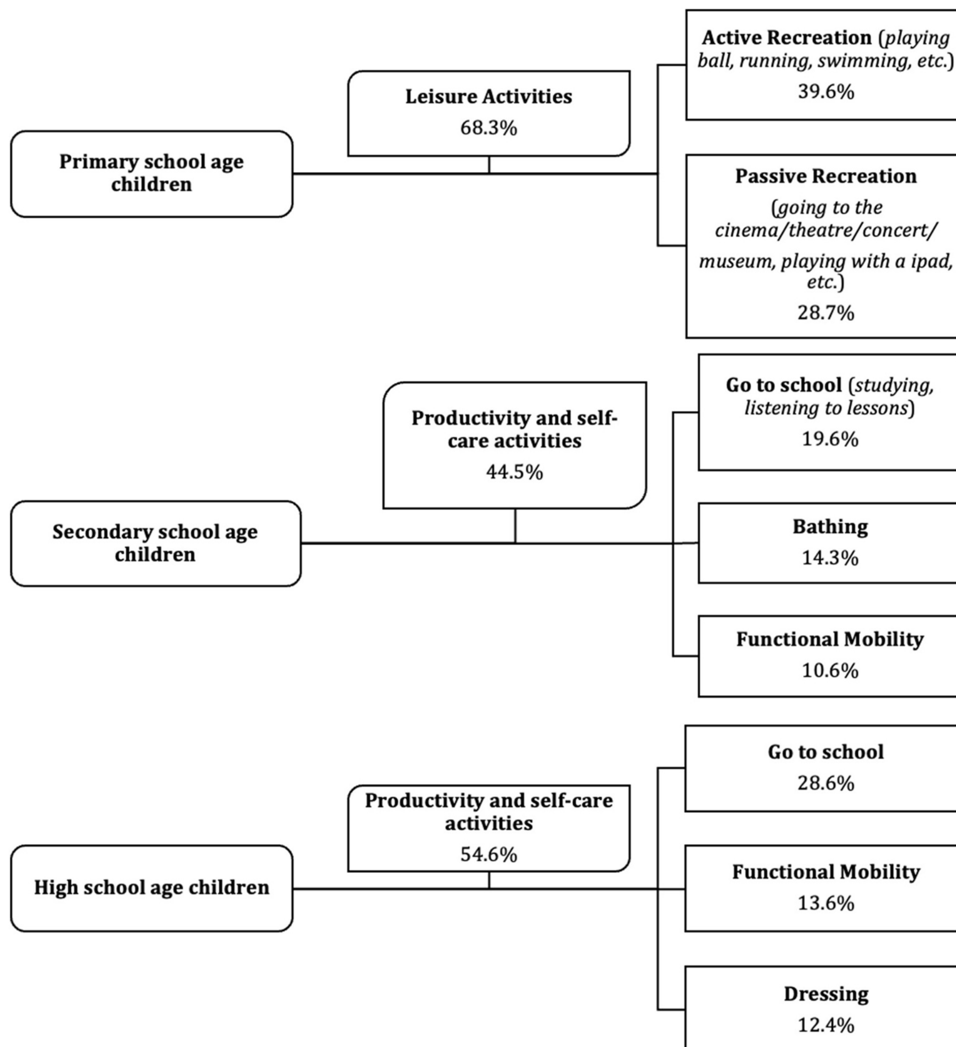

Fig. 1. Occupational performance areas that children diagnosed with leukemia want to do but have difficulty with compared to their school-age groups.

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TABLE 2

One-Way ANOVA Results

N = 102	Age Groups	M ± SD	*P*	*F*	Range	*P′*
COPM performance	(1) Primary school age	4.31 (2.63)	.011	2.478	1-2	.056
	(2) Secondary school age	4.69 (2.54)			1-3	.02
	(3) High school age	5 (2.37)			2-3	.04
COPM satisfaction	(1) Primary school age	6.14 (2.59)	.01	2.500	1-2	.036
	(2) Secondary school age	4.09 (2.75)			1-3	.028
	(3) High school age	4.28 (2.74)			2-3	.06
BOTMP-SF gross motor proficiency	(1) Primary school age	29.4 (6.63)	.020	3.115	1-2	.018
	(2) Secondary school age	32.36 (4.49)			1-3	.005
	(3) High school age	35.9 (3.46)			2-3	.016
BOTMP-SF fine motor proficiency	(1) Primary school age	54.57 (2.63)	.024	2.527	1-2	.034
	(2) Secondary school age	56.92 (4.77)			1-3	.013
	(3) High school age	59.89 (4.3)			2-3	.035
Combined gross and fine motor proficiency	(1) Primary school age	3.93 (0.46)	.38	3.000		
	(2) Secondary school age	4.12 (0.17)				
	(3) High school age	4.39 (0.13)				

Abbreviations: BOTMP-SF, Bruininks-Oseretsky Test of Motor; COPM, Canadian Occupational Performance Measurement.
Proficiency Short Form: *P*, 1 way ANOVA test; *P′*, Scheffe test.

emphasize the importance of considering developmental stages in assessing motor proficiency.[35] Factors such as fatigue, obesity, reduced cardiopulmonary capacity, and impaired musculoskeletal and motor performance have been identified as limiting physical activity during and after cancer treatment.[18]

Hamari et al reported that in children with cancer, motor performance, particularly balance, was more impaired in those with ALL compared to other diagnostic groups.[36] In our study, half of the participants were children diagnosed with ALL. As noted in previous literature, motor impairments may be more prevalent in children with ALL because the disease affects the entire body rather than a localized area.[37] This may also be attributed to prolonged absence from school and physical activities due to hospitalizations and treatment-related isolation, which likely limited children's exposure to typical age-related motor learning experiences.[36] In addition, cancer-related fatigue, a well-known negative side effect, may play a role in participation in motor activities during and after treatments.[38] Interestingly, no significant differences were found between school-age groups in the combined gross and fine motor proficiency test, which includes upper extremity coordination tasks. Upper extremity coordination is a process that involves complex motor skills and requires organizing both gross and fine motor skills.[39] Our findings align with earlier research indicating significant motor competence impairments in children with cancer, including those with leukemia. Notably, the lack of statistically significant differences in combined motor scores across age groups may point to disruptions in the expected developmental trajectory, potentially caused by the treatment process. This finding suggests an interruption in the typically expected motor development patterns, which may be attributable to the treatment process.

TABLE 3

Relationship Between COPM and BOTMP-SF

	COPM-Performance		COPM-Satisfaction	
	r	*P*	*r*	*P*
BOTMP-SF gross motor proficiency	.736	.012	.315	.0758
BOTMP-SF fine motor proficiency	.928	.001	.586	.03
Combined gross and fine motor proficiency	.696	.036	.794	.021

Abbreviations: BOTMP-SF; Bruininks-Oseretsky Test of Motor Proficiency–Short Form; COPM, Canadian Occupational Performance Measurement.
r: Pearson correlation coefficient test.

Individuals with newly diagnosed or recently relapsed AML often view participation in meaningful activities as a way to regain purpose, enhance their sense of health and independence, and foster hope for recovery.[40] In this study, leisure, productivity, and self-care activities of children with leukemia were all identified as affected domains, highlighting the pervasive impact of leukemia on daily life. These findings are consistent with previous research that highlights the complex and multifaceted challenges faced by pediatric cancer patients.[41] Heightened protective behaviors from families after a child's cancer diagnosis may restrict the child's participation in daily activities and diminish their perceived independence, ultimately affecting their health, well-being, and occupational performance.[42]

This study identified age-specific occupational challenges: primary school–aged children primarily experienced difficulties in leisure activities, whereas those in secondary and high school faced greater challenges in productivity and self-care domains. Young children focus on fun-oriented activities such as play and recreation, while older children focus on reintegration to school and development of independent self-care skills such as going to school and bathing. This finding is consistent with previous research indicating

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that the impact of chronic illnesses on daily activities differs across developmental stages.[9] Children with cancer experience difficulties in occupational performance areas such as self-care, productivity, and leisure, with studies indicating that a COPM score of 6 or below reflects low levels of performance and satisfaction.[6,9] These findings highlight the importance of developing tailored interventions that address the distinct needs of children at different developmental stages.

Given the significant age-group differences observed in COPM-P, COPM-S, and BOTMP-SF gross and fine motor scores—and the absence of such differences only in the combined score—these challenges should be interpreted as age-sensitive rather than uniformly applicable across all children.[43] Furthermore, the study revealed a significant positive correlation between various BOTMP-SF scores and both occupational performance and satisfaction, underscoring the importance of addressing motor proficiency deficits in rehabilitation strategies during treatment. To our knowledge, this is the first study to explore the occupational performance and expectations of children with leukemia. This situation demonstrates the critical role that the development of motor skills plays in not only establishing basic abilities but also in facilitating daily living activities and promoting general well-being in individuals. In this context, the "bottom-up" approach refers to designing treatment plans based on an individual's specific motor deficits and their feedback regarding participation and performance in daily life. In contrast, the "top-down" approach involves applying expert-defined treatment strategies, which are then guided and refined by the individual's overall functional goals.[44] A bottom-up approach may be particularly effective in addressing foundational motor skill deficits. However, a top-down approach remains essential for integrating these motor skills into daily life tasks and improving functional independence. It is also recommended that rehabilitation approaches for the pediatric cancer population be planned with consideration of personal, treatment-related, and organizational factors in order to enhance the adaptation process.[45] Ultimately, the development of basic motor skills—and their translation into daily living competencies—plays a vital role in enhancing occupational performance and quality of life in children with cancer.

The study demonstrates a significant positive relationship between various BOTMP-SF scores and occupational performance and satisfaction in children with leukemia. This corroborates existing literature emphasizing the connection between motor proficiency and overall functional abilities in pediatric populations.[46] The identified motor proficiency, such as fine motor accuracy, integration, manual dexterity, coordination, balance, speed, agility, upper limb coordination, and endurance, is consistent with components highlighted in previous research on motor proficiency in children.[47] These skills are necessary for children to perform adequately in daily living activities, play, recreation, and leisure activities.

Limitations

Despite its contributions, this study has limitations, including its cross-sectional design and its focus on a specific population. A limitation of this study is the lack of pre-leukemia data on motor proficiency, which makes it difficult to determine whether the observed differences are due to the developmental process or the effects of the disease itself. This study has its cross-sectional design, which does not allow developmental changes to be followed over time. Future longitudinal studies examining pre- and post-diagnosis trajectories would provide a more comprehensive understanding of the impact of leukemia on motor proficiency and occupational performance. In addition, future research could use longitudinal designs and include children affected by different types of cancer, as well as those with other chronic pediatric conditions, to broaden the understanding of motor and occupational performance outcomes. Moreover, the absence of a healthy control group limits direct comparisons, and future studies should include healthy peers to strengthen the findings. Qualitative research could also provide deeper insights into the experiences of children and their families facing these challenges.

CONCLUSION

Overall, this study significantly enhances our understanding of the complex interplay between age, motor proficiency, and occupational performance in children with leukemia. It highlights the importance of tailored interventions and provides avenues for future research to further enrich our comprehension of the challenges faced by this vulnerable population. Tailored interventions have been shown to facilitate the development of therapeutic strategies that target motor deficits and functional impairments, as well as emotional and social difficulties.[48] These strategies are designed to take into account each patient's unique needs, medical history, disease stage, and personal abilities. These findings suggest that rehabilitation planning for children with leukemia should account for age-related differences in performance and motor skills. Clinically, this underscores the need for comprehensive rehabilitation guidelines tailored to the specific developmental needs of this population.

STUDY DETAILS

Author Contributions

Role	Author
Conceptualization	K.Y.
Data curation	F.B.Ç.
Formal analysis	M.T. and G.G.Y.
Investigation	K.Y., M.T., G.G.Y., C.D., and S.Ş.
Methodology	K.Y., M.T., G.G.Y., and S.Ş.
Writing—original draft	K.Y., M.T., and C.D.
Writing—review & editing	G.G.Y. and S.Ş.

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Ethics Approval

The study was approved by the local institutional ethical board (Bezmailem Vakif University Non-Interventional Clinical Research Ethics Committee) with registration number (Approval No.: 2021/378).

Data Sharing Statement

The data are not available for publication because the participants of this study did not give written consent for their data to be shared outside the study team.

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