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Leukemia and Lymphoma Cancer Survivors**

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Original Article

Health-Related Quality of Life and Sleep Quality in Childhood Leukemia and Lymphoma Cancer Survivors

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Abstract

Objective: To investigate health-related quality of life (HRQOL) and its determinant factors among childhood hematologic cancer survivors with a specific focus on the influence of growth status and sleep quality.

Materials and Methods: This cross-sectional study was conducted among 132 survivors of childhood hematologic malignancies who completed chemotherapy. HRQOL and sleep quality were assessed using the Thai version of the Pediatric Quality of Life Inventory (PedsQL™) 4.0 Generic Core Scales and the Children's Sleep Habits Questionnaire, respectively. Data were analyzed using univariable and multivariable linear regression analysis.

Results: The participants had a mean age of 13.44 ± 3.61 years. Sleep disturbances were highly prevalent (65.91%). The patients were observed to be overweight or obese and stunted (32.58% and 6.06% of patients, respectively). Overall HRQOL scores were within the normal range, with social functioning scoring highest and school functioning lowest. Patients who completed treatment for ≥ 2 years reported significantly higher HRQOL scores than those off treatment for < 2 years (p -value=0.02). However, this difference diminished at the 5-year post-treatment threshold (p -value=0.06). Multivariable linear regression analysis revealed that sleep quality was the sole independent factor predicting significantly lower total HRQOL ($B = -1.16$, p -value < 0.001).

Conclusion: Sleep quality independently predicts HRQOL among childhood cancer survivors. Proactive sleep disturbance screening and symptom management, particularly during the first two years post-treatment, are essential to improve the long-term quality of life in this population.

Keywords: childhood cancer survivors, quality of life, sleep quality

Introduction

Acute leukemia is the most common childhood malignancy, accounting for up to 28% of all pediatric cancers. Currently, treatment for acute leukemia mainly involves multi-agent chemotherapy, which has remarkably increased the 5-year relative survival rate of children with lymphoid leukemia to 90%¹. In the Thai context, recent evidence indicates that vulnerable groups, such as pediatric leukemia patients under 2 years of age, continue to experience poor survival outcomes and high relapse rates compared to developed nations². Nevertheless, childhood cancer

survivors face continuous long-term late effects from chemotherapy with substantial impact on lifestyle and overall health after treatment^{1,3}.

Growth abnormalities, such as overweight or stunting, are prevalent issues following treatment completion^{4,5}. Previous studies have reported the prevalence of overweight children with acute lymphoblastic leukemia (ALL) increasing from 7.2% at diagnosis to 20.8% post-treatment⁶, and obesity rates may escalate up to 40% in survivors at 10 years after therapy⁷. Furthermore, sleep quality remains a frequently overlooked factor. A recent study conducted by the Childhood Cancer Survivor Study (CCSS) in 2024 revealed that over 45.1% of childhood cancer survivors continue to exhibit suboptimal sleep quality^{8,9}.

Growth abnormalities and sleep disturbances negatively affect HRQOL among leukemia survivors. Although overall HRQOL generally improves after treatment completion, specific HRQOL domains, such as physical and social functioning, peer relationships, and school activities in particular, remain significantly poorer than in the healthy population¹⁰. Previous research in Thailand has established causal models demonstrating that functional status and psychological factors, particularly trait anxiety, significantly predict HRQOL in pediatric cancer patients¹¹. Although numerous studies have focused on HRQOL among cancer survivors, sleep quality and nutritional status are frequently examined separately. A lack of systematic understanding connecting sleep quality, growth status, and HRQOL remains, especially within a Thai context, which presents distinct genetic backgrounds, parenting cultures, and healthcare systems compared to Western nations. Therefore, this study explored sleep quality, growth status, HRQOL, and their determinants among childhood hematologic cancer survivors in Thailand.

Materials and Methods

Participants

This cross-sectional study was conducted at the pediatric hematology/oncology outpatient clinic, Songklanagarind Hospital, Songkhla, Thailand, from March 2025 to August 2026. The eligible population included 132 childhood hematologic cancer survivors (ALL, AML, and T-cell Lymphoma) aged 2 to 18 years who had completed chemotherapy according to the Thai Pediatric Oncology Group (ThaiPOG) guidelines for at least 2 months. Patients and primary caregivers (for children aged 2–7 years) were required to be able to communicate fluently in Thai. Patients with

cognitive or intellectual impairments (e.g., Down syndrome, cerebral palsy) and those with physical conditions precluding accurate height and weight measurement were excluded from the study.

Instruments

Data were collected using three main instruments: a Demographic Data Questionnaire, the Thai version of the Pediatric Quality of Life Inventory (PedsQL™) 4.0 Generic Core Scales, and the Thai version of the Children's Sleep Habits Questionnaire (CSHQ).

Demographic Data Questionnaire: Demographic and clinical characteristics of the patients, including gender, age, weight, height, type of cancer, and time off treatment, were collected using the demographic data questionnaire. Caregiver profiles encompassed patient relationship, education level, and household income.

The Thai version of the Pediatric Quality of Life Inventory (PedsQL™) 4.0 Generic Core Scales: Health-related quality of life (HRQOL) was assessed using the Thai version of PedsQL™ 4.0 Generic Core Scales originally developed by Varni et al.¹² Official permission to use the Thai version for this study was granted by the Mapi Research Trust (User License Agreement No. 92782). The questionnaire includes a proxy-report for parents of children aged 2–4 and 5–7 years, and a self-report for children and adolescents aged 8–12 and 13–18 years. PedsQL™ contains 23 items in four domains: physical functioning (8 items), emotional functioning (5 items), social functioning (5 items), and school functioning (5 items). Responses are rated on a 5-point Likert scale (0 = Never a Problem; 1 = Almost Never; 2 = Sometimes; 3 = Often; 4 = Almost Always). The items were reverse-scored and linearly transformed on a 0–100 scale (0 = 100, 1 = 75, 2 = 50, 3 = 25, 4 = 0). Higher mean scores represent better HRQOL. The instrument was pilot-tested with 20 participants prior to data collection, yielding a Cronbach's alpha coefficient of 0.84 for internal consistency.

The Thai version of the Children's Sleep Habits Questionnaire (CSHQ): Sleep quality was assessed using the Thai version of the Children's Sleep Habits Questionnaire (CSHQ), originally developed by Owens et al.¹³ and translated into Thai by Wanich et al.¹⁴. This parent-proxy questionnaire assesses the child's sleep behavior retrospectively over the past week using 33 items divided into eight domains: bedtime resistance (6 items), sleep onset delay (1 item), sleep duration (3 items), sleep anxiety (2 items), night wakings (3 items), parasomnias (7 items), sleep-disordered

breathing (3 items), and daytime sleepiness (8 items). Responses are scored on a 3-point scale based on occurrence frequency: 3 points = "Usually" (5–7 days/week), 2 points = "Sometimes" (2–4 days/week), and 1 point = "Rarely/Never" (0–1 day/week). CSHQ has a score range of 33–99 points, with higher scores indicating greater sleep problems. A total score above 41 was used as the clinical cut-off for significant sleep disturbance identification. A pilot test for test-retest reliability with a 1-week interval in 20 participants demonstrated an excellent Pearson's correlation coefficient of 0.99.

Data Collection

After the written informed consent and assent forms were obtained, data collection was conducted at the pediatric oncology outpatient clinic. Data on demographic characteristics, clinical characteristics, and anthropometric measurements (weight and height) were collected. In the sleep quality assessment, primary caregivers were asked to complete the Thai version of the CSHQ to retrospectively evaluate their child's sleep behavior over the past week. In the HRQOL assessment, parents completed the proxy-report for the Thai version of PedsQL 4.0 Generic Core Scales for children aged 2 to 7 years. Children and adolescents aged 8 to 18 years completed the self-report for the PedsQL 4.0 questionnaires independently. BMI was calculated as weight (kg) divided by height squared (m^2) and categorized based on the World Health Organization (WHO) criteria as severe thinness (z-score: < -3), thinness (z-score: -3 to -2), normal weight (z-score: > -2 to 1), overweight (z-score: > 1 to 2), and obesity (z-score: > 2 to 3). Furthermore, stunted growth was defined as a height-for-age Z-score of less than -2 according to the WHO child growth standards.

Statistical Analysis

Statistical analysis was performed using computer software (R version 4.2.2). Demographic data are presented as frequencies and percentages, or means and standard deviations (SD), as appropriate. Sleep quality, growth, and quality of life were compared between patient groups using the Wilcoxon rank-sum test or Kruskal-Wallis rank-sum test, as appropriate. Correlations between sleep quality, growth, and quality of life were calculated using Pearson's correlation coefficient. Univariable linear regression was used to evaluate the effect of each factor on quality of life. Multivariable linear regression analysis was used to evaluate the adjusted effects of these covariates on patient quality of life. Factors affecting patient quality of life are presented

as beta coefficients with 95% confidence intervals (CIs). A p-value of less than 0.05 was used to determine statistical significance.

Ethical Considerations

The study was conducted in accordance with human research ethical principles and approved by the Human Research Ethics Committee of [Blind]. Written informed consent was obtained from all legal guardians, and assent was obtained from children aged 7 years and older before data collection.

Results

Patient Characteristics

A total of 132 eligible children with cancer and their primary caregivers participated in the study. Patient demographic data, clinical characteristics, growth status, and caregiver profiles are described as follows: The male-to-female ratio was 56.06% to 43.94%. Patients had a mean age of 13.44 ± 3.61 years. The most common cancer types were acute lymphoblastic leukemia (ALL) ($n = 94$, 71.21%), T-cell lymphoma ($n = 28$, 21.21%), and acute myeloid leukemia (AML) ($n = 10$, 7.58%). The mean duration of complete treatment was 5.16 ± 3.66 years, with 49.24% of the patients having completed treatment for more than five years. Regarding nutritional status based on BMI, a majority of the participants (58.33%) had normal weight, followed by overweight (21.97%), obesity (10.61%), thinness (6.06%), and severe thinness (3.03%). Additionally, regarding linear growth, 6.06% of the participants were classified as stunted. Most of the primary caregivers were mothers (83.33%), and 25.76% of the families reported having an insufficient household income.

Sleep Quality and HRQOL

The mean total sleep score was 44.71 ± 5.77 . Notably, a high prevalence of sleep disturbances was observed, with the participants (65.91%; $n=87$) scoring above the clinical cut-off (> 41). Daytime sleepiness demonstrated the highest mean score (12.17 ± 2.87), followed by bedtime resistance (9.09 ± 2.22).

The mean total HRQOL score was 74.81 ± 15.28 . The psychosocial health summary score (73.21 ± 15.22) was lower than the physical health summary score (77.82 ± 19.77). Out of four domains, social functioning yielded the highest score (78.83 ± 18.01), followed by physical

functioning (77.82 ± 19.77) and emotional functioning (71.48 ± 19.13), while school functioning received the lowest score (69.32 ± 17.56).

Comparisons and Correlations of Sleep Quality, Growth, and HRQOL

Time off treatment was a significant factor associated with HRQOL. Patients who completed treatment for ≥ 2 years had significantly higher total HRQOL scores compared to those off treatment for < 2 years (76.73 ± 14.60 vs. 69.04 ± 16.05 , $p = 0.02$). However, this significant difference diminished when patients off treatment for ≥ 5 years were compared to those off treatment for < 5 years ($p = 0.06$). Time off treatment was not significantly correlated with sleep quality or growth status ($p > 0.05$). Furthermore, age, gender, and cancer type showed no statistically significant differences regarding sleep quality, growth, or HRQOL (Table 1).

Correlations between Sleep, BMI, and HRQOL Domains

The Pearson correlation matrix revealed several statistically noteworthy associations among the study variables. As illustrated in the heatmap, cells shaded in cyan/blue represent positive correlations, while cells shaded in salmon/red indicate negative correlations, with color intensity reflecting the magnitude of association.

Total sleep score demonstrated moderate negative correlations with all the HRQOL subscales, as evidenced by the salmon-shaded cells across its row, including physical functioning ($r = -0.29$), emotional functioning ($r = -0.43$), social functioning ($r = -0.42$), and school functioning ($r = -0.42$), as well as with the total HRQOL score ($r = -0.46$), suggesting that higher sleep disturbance is associated with poorer health-related quality of life across multiple domains. BMI z-scores, however, exhibited negligible correlations with all variables (r ranging from -0.06 to 0.07), appearing as near-white or faintly colored cells, indicating no meaningful linear relationship between BMI and either the sleep or HRQOL outcomes.

Moderate to strong positive intercorrelations were observed among the HRQOL subscales, reflected by the prominently cyan-shaded cells in the lower-right quadrant of the matrix. Physical functioning showed the strongest association with total HRQOL score ($r = 0.87$), represented by the deepest cyan shading in the matrix, followed by school functioning ($r = 0.82$), social functioning ($r = 0.77$), and emotional functioning ($r = 0.77$). Intercorrelations among HRQOL subscales ranged from $r = 0.50$ (emotional and social functioning) to $r = 0.61$ (social and school functioning), reflecting substantial construct coherence within the HRQOL instrument.

Notably, total sleep score exhibited the strongest negative association with total HRQOL score ($r = -0.46$), displayed as the most deeply salmon-shaded cell in its row, compared to any individual subscale, underscoring the cumulative impact of sleep disturbance on overall pediatric quality of life (Figure 1).

Determinant factors of HRQOL

Univariable linear regression revealed that sex, age, duration of complete treatment, completion of treatment over 5 years, obesity, insufficient household income, and sleep quality (including its subdomains) were associated with total HRQOL (Table 2). However, in the multivariable linear regression analysis, sleep quality was the only independent factor with a significant negative influence on the total HRQOL score ($B = -1.16$, $p < 0.001$). Other clinical and demographic factors, including gender, age, cancer type, time off treatment, PICU admission, nutritional status, and household income, were not associated with HRQOL (Table 3).

Discussion

This study had a primary objective to investigate sleep quality, growth status, health-related quality of life (HRQOL), and determinants influencing HRQOL among pediatric hematologic cancer survivors who have completed chemotherapy. The findings highlight multi-dimensional long-term health consequences and HRQOL predictors as discussed below.

The findings demonstrate that a high prevalence of sleep disturbances was observed despite chemotherapy completion (65.91%). The above prevalence surpassed the general population average of 13–50%. This finding aligns with a recent study by Chopra et al.⁹ indicating that sleep disorders remain highly prevalent and constitute a major health issue even after treatment cessation. The most frequently encountered problems were daytime sleepiness and bedtime resistance. These issues extend beyond behavioral factors and can be explained by biological mechanisms. Daniel et al.⁸ reported that cancer therapies impose long-term disruption to the nervous system and the sleep-wake rhythm through cytokine and endocrine dysfunctions, leading to cancer-related fatigue. Consequently, this fatigue continuously undermines patients' energy, concentration, and learning capabilities, which strongly correlates with how the school functioning domain received the lowest HRQOL score in our findings.

Regarding growth status, a double burden of malnutrition was observed, with 32.58% of the survivors being overweight or obese, and 6.06% being stunted. This abnormality is closely linked to sleep quality. Serpas et al.⁵ found poor sleep quality to have promoted inappropriate dietary habits and physical inactivity, thereby exacerbating the risk of being overweight and obese. Simultaneously, stunting reflects long-term late effects following cancer treatment that disrupt metabolism and growth hormone deficiency⁴, preventing the body from fully absorbing nutrients or reaching optimal growth potential. This highlights how malnutrition remains a chronic late effect necessitating continuous long-term monitoring even after treatment.

Overall, HRQOL among the survivors was favorable. Notably, the physical health summary score was distinctly higher than the psychosocial health summary score. Based on Varni et al.,¹⁵ four domains, including physical and emotional recovery, were well achieved, reflecting clinical treatment success and psychological healing. This is consistent with Schwartz et al.¹⁶, who found that physical recovery outpaces psychosocial adjustment, which requires a more complex healing process. Across specific domains, social functioning achieved the highest score, whereas school functioning was prominently diminished. This corroborated the findings of Rothmund et al.¹⁷ The high social functioning score illustrates strong social support mechanisms encompassing peer acceptance and the societal understanding crucial for bolstering the patients' psychological resilience.¹⁶ Conversely, the significantly low school functioning score can be further explained by cancer-related cognitive impairment (CRCI) resulting from neurotoxic chemotherapy.^{18,19} When underlying cognitive vulnerability is compounded by sleep disturbances²⁰, children's capacity for self-regulated learning declines, culminating in the lowest school functioning HRQOL.

In evaluating the clinical factors, time since treatment completion emerged as a significant factor in HRQOL recovery, albeit with a non-linear trajectory. Our findings indicate that survivors in the late recovery phase (≥ 2 years) reported significantly higher HRQOL scores compared to those in the early phase (< 2 years) ($p = 0.02$). However, this statistical significance diminished when the threshold was extended to the 5-year mark ($p = 0.06$), suggesting a 'recovery plateau' in psychosocial restoration. This implies that despite rapid adjustments within the first two years post-chemotherapy, time alone becomes an insufficient catalyst for sustained HRQOL improvement thereafter. This aligns with the perspective of Schwartz et al.¹⁶, who noted that while physical recovery often stabilizes quickly, more complex psychosocial healing processes require active and continuous support. From a nursing perspective, this plateau underscores how survivors

who have achieved 5-year remission are not necessarily free from HRQOL deficits. Therefore, nursing surveillance must shift from a 'wait-and-see' approach to proactive symptom management. To break through the identified recovery plateau, Advanced Practice Nurses (APNs) should prioritize interventions targeting modifiable factors, most notably sleep hygiene, to ensure that survivors' long-term quality of life continues to evolve rather than stagnate.^{20,21}

This finding also aligns with a recent study by Sudnawa et al.²¹ in Thai pediatric oncology patients, which demonstrated that completing treatment is positively correlated with total HRQOL scores and primarily attributed to the absence of frequent hospitalizations and treatment-related anxiety. No significant differences in HRQOL were observed regarding cancer types and gender. This may be due to the pathophysiology of treatment, as all three hematologic malignancies utilize intravenous chemotherapy that induces similar levels of neurotoxicity, resulting in a shared experience of illness and psychological trauma regardless of gender or specific diagnosis²². Furthermore, the consistency in HRQOL scores between proxy-reports for younger children and self-reports for older adolescents indicates that the severity of the disease and treatment impacts is distinctly perceived by both patients and caregivers, reaffirming the reliability of the PedsQL instrument.¹⁵ Regarding sleep quality and growth status, no significant differences were found across age groups, gender, cancer types, or time off treatment. This suggests that the toxic effects of chemotherapy on sleep-wake cycles and endocrine systems are inevitable and chronic late effects experienced equally by all survivors.^{4,8} Therefore, these issues necessitate continuous clinical vigilance for all patients.^{7,9}

The most crucial finding of this study is that sleep quality independently and powerfully predicted total HRQOL ($B = -1.16$, $p < 0.001$), surpassing all other clinical and physiological factors. The diminished school functioning score is attributable to the neurobiological mechanisms of sleep, which play a vital role in restoring the prefrontal cortex—the region governing executive functions such as working memory, attention, and emotional regulation.¹⁹ Chronic sleepiness impairs these neurobehavioral capacities, leading to learning difficulties, cognitive fatigue, and diminished academic achievement, which ultimately diminishes the school HRQOL score.²³ This corresponds with our finding that the daytime sleepiness domain received the highest mean score among the sleep disturbance subscales.

Conversely, growth status (BMI z-score) did not significantly influence HRQOL. This phenomenon can be explained clinically and perceptually. Clinically, BMI may not accurately

capture true body composition, as chemotherapy often induces 'sarcopenic obesity' (muscle loss replaced by fat accumulation), which is found in up to 65.8% of childhood cancer survivors²⁴. Perceptually, weight changes occur gradually without provoking acute physical pain, allowing patients to adapt and maintain their daily activities without immediately perceiving a reduction in their QOL.²⁵ In stark contrast, sleep disturbances acutely and continuously undermine daily functioning. When poor sleep quality is combined with underlying CRCI, which affects 40–60% of leukemia and lymphoma survivors due to cumulative neurotoxicity,^{18,26} these factors act synergistically as a symptom cluster that immediately and drastically impairs daily learning and overall well-being.

Conclusion

Sleep quality is the sole determinant with significant ability to predict HRQOL among childhood hematologic cancer survivors who have completed treatment. Although the overall HRQOL was desirable, survivors remain confronted with hidden long-term health consequences. These include a remarkably high prevalence of sleep disturbances (65.91%) and nutritional abnormalities, particularly overweight and obesity (32.58%).

This study emphasizes that long-term survivor care must transcend cancer relapse surveillance. Medical institutions and multidisciplinary teams should proactively integrate sleep screening and metabolic management into standard clinical practice, along with systematic symptom monitoring. Such proactive interventions will ultimately enhance school performance and sustainably improve overall HRQOL among childhood cancer survivors.

Limitations

The cross-sectional nature of this study limited the ability to establish definitive causal relationships. Therefore, future longitudinal studies are recommended to thoroughly explain the trajectories of sleep quality and HRQOL over time. Furthermore, two methodological constraints regarding the assessment tools must be acknowledged. First, the parent-reported CSHQ is typically utilized for children aged 4 to 10 years; applying it across our broader age range (2–18 years) may limit the precision of sleep evaluation in toddlers and older adolescents. Second, regarding the HRQOL assessments, although combining proxy-reported PedsQL assessments for younger

children with self-reported assessments for older patients introduces potential methodological heterogeneity, age variables were systematically controlled during statistical modeling to minimize potential bias. Lastly, sleep quality and growth status were evaluated using subjective caregiver-reported questionnaires and BMI Z-scores, respectively. The BMI Z-score may not comprehensively reflect true body composition, particularly regarding chemotherapy-induced sarcopenic obesity. Future investigations should incorporate objective measurements such as actigraphy, polysomnography, and comprehensive body composition analysis (e.g., bone and muscle densitometry) to provide a more thorough biological perspective.

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Conflict of Interest

The authors declare that they have no competing interests.

References

1. Siegel RL, Kratzer TB, Wagle NS, Sung H, Jemal A. Cancer statistics, 2026. *CA Cancer J Clin.* 2026. doi: 10.3322/caac.70043.

2. Yam-ubon U, Songthawee N, Chavananon S, Sripornsawan P, Kittivisuit S, McNeil EB, et al. Clinical outcomes of acute leukemia in children less than 2 years: experience from a tertiary center in Thailand. *J Health Sci Med Res.* 2025;43(5):e20251163. doi: 10.31584/jhsmr.20251163.
3. Ehrhardt MJ, Krull KR, Bhakta N, Liu Q, Yasui Y, Robison LL, et al. Improving quality and quantity of life for childhood cancer survivors globally in the twenty-first century. *Nat Rev Clin Oncol.* 2023;20(10):678-96. doi: 10.1038/s41571-023-00802-w.
4. Diakatou V, Vassilakou T. Nutritional status of pediatric cancer patients at diagnosis and correlations with treatment, clinical outcome and the long-term growth and health of survivors. *Children (Basel).* 2020;7(11):218. doi: 10.3390/children7110218.
5. Serpas DG, Sauls R, Gray HL, Stern M. Sleep quality, nutritional habits, and physical activity in pediatric cancer survivors: a dyadic analysis approach. *Nutrients.* 2025;17(2):250. doi: 10.3390/nu17020250.
6. Galati PC, Rocha PR, Gruezo ND, Amato AA. Body mass trajectory from diagnosis to the end of treatment in a pediatric acute lymphoblastic leukemia cohort. *Sci Rep.* 2023;13:13590. doi: 10.1038/s41598-023-39287-z.
7. Al-Mahayri ZN, AlAhmad MM, Ali BR. Long-term effects of pediatric acute lymphoblastic leukemia chemotherapy: can recent findings inform old strategies? *Front Oncol.* 2021;11:710163. doi: 10.3389/fonc.2021.710163.
8. Daniel LC, Wang H, Brinkman TM, Ruble K, Zhou ES, Palesh O, et al. Mechanisms of sleep disturbances in long-term cancer survivors: a childhood cancer survivor study report. *JNCI Cancer Spectr.* 2024;8(2):pkae010. doi: 10.1093/jncics/pkae010.
9. Chopra KK, Gupta AK, Meena JP, Chakrabarty B, Sagar R, Pandey RM, et al. Sleep disturbances in survivors of childhood acute lymphoblastic leukemia: a cross-sectional study. *Indian Pediatr.* 2025;62:828-31. doi: 10.1007/s13312-025-00122-5.
10. Winzig J, Inhestern L, Paul V, Nasse ML, Krauth KA, Kandels D, et al. Parent-reported health-related quality of life in pediatric childhood cancer survivors and factors associated with poor health-related quality of life in aftercare. *Qual Life Res.* 2023;32:2965-74. doi: 10.1007/s11136-023-03436-8.

11. Khamchan P, Punthmatharith B, Petpichetchian W, Chotsampancharoen T. A causal model of health-related quality of life in Thai children with cancer. *Suranaree J Sci Technol.* 2020;27(1):070002(1-13).
12. Varni JW, Seid M, Kurtin PS. PedsQL 4.0: reliability and validity of the Pediatric Quality of Life Inventory version 4.0 generic core scales in healthy and patient populations. *Med Care.* 2001;39(8):800-12. doi: 10.1097/00005650-200108000-00006.
13. Owens JA, Spirito A, McGuinn M. The Children's Sleep Habits Questionnaire (CSHQ): psychometric properties of a survey instrument for school-aged children. *Sleep.* 2000;23(8):1043-51. doi: 10.1093/sleep/23.8.1d.
14. Wanich P, Virunphanich W, Wattanasit P. Influences of stress, pain, and nursing activities on sleep quality among pediatric cancer patients receiving chemotherapy. *Songklanagarind J Nurs.* 2019;39(1):28-40. (in Thai)
15. Varni JW, Seid M, Rode CA. The PedsQL: measurement model for the pediatric quality of life inventory. *Med Care.* 1999;37(2):126-39. doi: 10.1097/00005650-199902000-00003.
16. Schwartz ER, Rensen N, Steur LMH, Gemke R, van Eijkelenburg NKA, van der Sluis IM, et al. Health-related quality of life and its determinants during and after treatment for paediatric acute lymphoblastic leukaemia: a national, prospective, longitudinal study in the Netherlands. *BMJ Open.* 2023;13(10):e070804. doi: 10.1136/bmjopen-2022-070804.
17. Rothmund M, Sodergren S, Rohde G, de Rojas T, Paratico G, Albini G, et al. Updating our understanding of health-related quality of life issues in children with cancer: a systematic review of patient-reported outcome measures and qualitative studies. *Qual Life Res.* 2023;32:965-76. doi: 10.1007/s11136-022-03223-3.
18. Semendric I, Barker TH, Haller OJ, Pollock D, Collins-Praino LE, Whittaker AL. Prevalence of cancer-related cognitive impairment in pediatric patients and survivors of non-CNS cancers: a systematic review and meta-analysis. *Neurosci Biobehav Rev.* 2025;176:106283. doi: 10.1016/j.neubiorev.2025.106283.
19. Tønning Olsson I, Lubas MM, Li C, Mandrell BN, Ehrhardt MJ, Krull KR, et al. Insomnia and neurocognitive functioning in adult survivors of childhood cancer. *JNCI Cancer Spectr.* 2020;4(3):pkaa008. doi: 10.1093/jncics/pkaa008.

20. Walsh S, Mulraney M, McCarthy MC, De Luca CR. Fatigue in children who have recently completed treatment for acute lymphoblastic leukemia: a longitudinal study. *Health Qual Life Outcomes*. 2024;22:27. doi: 10.1186/s12955-024-02241-2.
21. Sudnawa KK, Yeepae J, Photia A, et al. Health-related quality of life and its determinant factors in Thai children with cancer: parents vs. children perspectives. *BMC Pediatr*. 2024;24(1):531. doi: 10.1186/s12887-024-04987-w.
22. Brinkman TM, Recklitis CJ, Michel G, Grootenhuys MA, Klosky JL. Psychological outcomes in adolescent and young adult cancer survivors. *J Clin Oncol*. 2023;41(33):5133-43. doi: 10.1200/JCO.23.01465.
23. Oswald KA, Richard A, Hodges E, Heinrich KP. Sleep and neurobehavioral functioning in survivors of pediatric cancer. *Sleep Med*. 2021;78:153-9. doi: 10.1016/j.sleep.2020.12.026.
24. Nimmankiatkul L, Kritsaneepaiboon S, Ina N, Chotsampancharoen T, Chavananon S. Sarcopenia and sarcopenic obesity after chemotherapy in childhood lymphoma. *Ann Hematol*. 2026;105:188. doi: 10.1007/s00277-026-06946-w.
25. Brennan EM. The characterization of sleep quality in pediatric cancer survivors with overweight/obesity [dissertation]. Tampa (FL): University of South Florida; 2025.
26. Országhová Z, Mego M, Chovanec M. Long-term cognitive dysfunction in cancer survivors. *Front Mol Biosci*. 2021;8:770413. doi: 10.3389/fmolb.2021.770413.

Table 1. Comparison of sleep quality, growth status, and quality of life (N = 132)

Characteristics	Sleep Quality Mean (SD)	p-value	Growth (BMI Z-score) Mean (SD)	p-value	Quality of Life Mean (SD)	p-value
Sex		.70		.20		.07
	44.67					
Male	(5.91)		0.03 (1.73)		77.52 (13.43)	
	44.63					
Female	(5.22)		0.47 (1.35)		72.57 (16.41)	
Age Group		.30		.30		.09
	46.21					
2-7 years	(6.22)		-0.05 (1.19)		68.99 (17.32)	
	44.43					
8-18 years	(5.49)		0.27 (1.63)		76.24 (14.45)	
Diagnosis		.40		.90		.50
	44.69					
ALL	(5.59)		0.23 (1.53)		75.36 (14.65)	
	42.40					
AML	(3.06)		0.32 (1.84)		79.78 (15.27)	
	45.17					
T-cell Lymphoma	(6.12)		0.19 (1.71)		74.03 (16.00)	
Time off Treatment						
(1)		.12		.07		.02*
	46.24					
< 2 years	(6.65)		-0.30 (1.75)		69.04 (16.05)	
	44.20					
≥ 2 years	(5.39)		0.37 (1.47)		76.73 (14.60)	
Time off Treatment						
(2)		.90		.40		.06

Characteristics	Sleep Quality Mean (SD)	p-value	Growth (BMI Z-score) Mean (SD)	p-value	Quality of Life Mean (SD)	p-value
< 5 years	44.82 (6.27)		0.06 (1.64)		72.40 (15.45)	
≥ 5 years	44.61 (5.27)		0.34 (1.48)		77.22 (14.84)	

SD = Standard deviation; * $p < .05$.

Table 2. Univariable linear regression analysis predicting total quality of life (N = 132)

Predictive variables	B	95% CI for B		p-value
		Lower	Upper	
Sex (Ref: Female)				
Male	5.31	0.07	10.55	0.05
Age	1.00	0.29	1.71	0.01
Age Group (Ref: 2–7 years)				
8-18 years	6.8	-0.64	14.23	0.07
Diagnosis (Ref: ALL)				
AML	5.16	-4.92	15.25	0.31
T-cell Lymphoma	-0.94	-7.47	5.59	0.78
Time off Treatment (Ref: < 2 years)				
2-5 years	6.44	-0.81	13.7	0.08
>5 years	8.35	2.01	14.7	0.01
Height Z-score	0.47	-2.22	3.15	0.73
Height Z-score Group (Ref: Normal)				
Stunting	-3.7	-14.75	7.35	0.51
BMI Z-score	-0.27	-1.96	1.43	0.75
BMI Z-score Group (Ref: Normal)				
Obesity	-9.39	-18.1	-0.67	0.04

Predictive variables	B	95% CI for B		p-value
		Lower	Upper	
Overweight	-0.31	-6.84	6.23	0.93
Severe Thinness	-7.72	-23.1	7.67	0.32
Thinness	-5.95	-17.1	5.19	0.29
Household Income (Ref: Sufficient)				
Insufficient	-6.61	-12.11	-0.22	0.04
PICU (Ref: No)				
Yes	-4.53	-10.02	0.95	0.10
Sleep Quality (Total sleep score)	-1.21	-1.62	-0.8	<0.001
Sleep Disturbance (Ref: No)				
Yes	-10.51	-15.78	-5.25	<0.001
Bedtime Resistance	-2.2	-3.33	-1.06	<0.001
Sleep Onset Delay	-1.78	-5.21	1.65	0.31
Sleep Duration	-2.11	-4.05	-0.16	0.03
Sleep Anxiety	-3.09	-5.93	-0.25	0.03
Night Wakings	-2.84	-5.48	-0.2	0.04
Parasomnias	-4.19	-6.31	-2.06	<0.001
Sleep-disordered Breathing	-1.41	-5.54	2.71	0.50
Daytime Sleepiness	-1.56	-2.44	-0.68	<0.001

B=unstandardized coefficient, CI=confidence interval

Table 3. Multivariable linear regression analysis predicting total quality of life (N = 132)

Predictive variables	B	95% CI for B		p-value
		Lower	Upper	
Constant	122.67	100.82	144.52	< .001
Sleep Quality (Total sleep score)	-1.16	-1.60	-0.72	< .001
Sex (Ref: Female)				

Predictive variables	B	95% CI for B		p-value
		Lower	Upper	
Male	4.08	-0.88	9.04	0.11
Age Group (Ref: 2–7 years)				
8 – 18 years	1.57	-6.25	9.38	0.69
Household Income (Ref: Sufficient)				
Insufficient	-1.60	-7.32	4.11	0.58
Diagnosis (Ref: ALL)				
AML	2.64	-6.37	11.66	0.56
T-cell Lymphoma	-1.16	-7.10	4.79	0.70
Time off Treatment (Ref: < 2 years)				
2 – 5 years	2.42	-4.94	9.79	0.52
> 5 years	4.03	-3.27	11.33	0.28
PICU (Ref: No)				
Yes	-4.39	-9.69	0.91	0.10
Growth Status				
Height Z-score	1.16	-1.53	3.85	0.40
BMI Z-score	-0.37	-2.08	1.33	0.70

$R^2 = 0.28$, Adjusted $R^2 = 0.22$, F-statistic= 4.40, ***p-value <0.001, B=unstandardized coefficient, CI=confidence interval



Figure. 1 Pearson correlation matrix of sleep quality, growth status, and quality of life (N = 132).