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Nutritional Status Assessment in Children with Cancer: Preliminary Results of a Prospective Cohort Study

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Abstract

Background: Undernutrition and body composition changes are common in children with cancer and may negatively affect treatment tolerance and outcomes. However, data on early nutritional changes in children during chemotherapy and on the agreement between body mass index (BMI) and mid-upper arm circumference (MUAC) in this population are limited. Methods: In this single-center prospective cohort study, the nutritional status of children newly diagnosed with cancer was assessed at diagnosis and 6–9 weeks after chemotherapy initiation. Nutritional status was evaluated using BMI and MUAC, while body composition was assessed using bioelectrical impedance analysis (BIA). The agreement between methods used to assess patients' nutritional status was also evaluated. Results: Of 43 children enrolled, 22 completed follow-up. At diagnosis, undernutrition was identified in 7.0% by BMI, 14.0% by MUAC, and 18.6% by either criterion. BMI and MUAC z-scores were strongly correlated ($r = 0.76$) but showed slight categorical agreement ($\kappa = 0.14$) and wide limits of agreement. After 6–9 weeks, BMI z-score and BIA-derived fat-free mass and body water decreased slightly; no change was significant after correction for multiple testing. Conclusions: BMI and MUAC are not interchangeable for identifying undernutrition, and using both identifies more children meeting at least one criterion. Early BIA-derived changes were small and, given hydration effects and attrition, preliminary.

Keywords: nutritional assessment; arm circumference; body mass index; body composition

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1. Introduction

The nutritional status (NS) of children with cancer is influenced by disease-related, treatment-related, and individual factors. Growing evidence suggests that it influences treatment effectiveness, tolerance, chemotherapy metabolism, and quality of life [1–7]. Evidence also suggests that adverse alterations in body composition may increase the risk of treatment-related toxicities and impact treatment outcomes [7–9].

Accurate identification of malnourished patients depends on the assessment methods used. In routine practice, NS is most often evaluated anthropometrically, with body mass

index (BMI) being the most widely applied measure, because it is simple, inexpensive, and readily converted to age- and sex-specific z-scores. However, BMI reflects overall weight-for-height and cannot distinguish between fat and lean compartments. It may therefore remain within the normal range despite substantial depletion of lean tissue, and it is further confounded in oncology by tumor mass and edema [8,10]. Consequently, BMI alone may underestimate undernutrition in children with cancer [10,11]. Arm anthropometry offers a complementary, bedside approach: mid-upper arm circumference (MUAC) and triceps skinfold (TSF) provide regional estimates of peripheral muscle and subcutaneous fat stores, are less influenced by central fluid accumulation, and can be performed rapidly with minimal equipment [10,12,13]. Several studies have reported that arm anthropometry classifies more children as undernourished than BMI [10,13], supporting the view that no single anthropometric index captures the full spectrum of nutritional risk and that combined screening may identify more children at nutritional risk; MUAC also performs well against BMI and BIA for identifying excess adiposity [14,15].

Anthropometry, however, does not directly quantify body composition, which is increasingly recognized as clinically relevant in this population. Fat-free mass (FFM) and, in particular, skeletal muscle mass (SMM) determine physical function, influence the distribution and metabolism of cytotoxic drugs, and may be depleted or lost selectively even when weight and fat mass (FM) are preserved or increased [8,11,16]. Lower skeletal muscle density at diagnosis has been associated with greater hematological toxicity [7], and skeletal muscle quantity declines early in treatment while fat mass increases [9]; a relative excess of FM may mask this loss when only weight-based indices are used. Body composition can be assessed by reference methods such as air-displacement plethysmography [17], or by bioelectrical impedance analysis (BIA), a non-invasive and portable method that allows rapid estimation of FM and FFM [18]. These considerations support combining anthropometry with body composition analysis to better characterize NS in children with cancer.

Although the limitations of BMI and the complementary value of MUAC in children with cancer have been reported [10,12,13], previous studies have largely assessed correlation or categorical classification, and few have formally examined whether BMI and MUAC can be used interchangeably in individual patients. Data on early nutritional and body composition changes during the first weeks of chemotherapy, and on whether these changes differ between tumor types, are also limited.

We conducted a prospective cohort study to determine the prevalence of undernutrition at diagnosis of cancer in childhood, evaluate the agreement between BMI and MUAC for identifying undernutrition in this population, and describe early nutritional changes during the first weeks of chemotherapy. We hypothesized that BMI and MUAC would show strong correlation but poor categorical agreement, nutritional parameters would decline during early chemotherapy, and body composition changes would be detectable even when anthropometric changes were modest.

2. Materials and Methods

2.1. Study Design and Objectives

This single-center prospective cohort study enrolled children aged 5–18 years newly diagnosed with cancer and scheduled for systemic chemotherapy at the Department of Pediatrics, Hematology and Oncology in Gdansk, Poland, between September 2018 and September 2020. The study was approved by the Ethics Committee of the Medical University of Gdansk (NKBBN/441/2018). Written informed consent was obtained from parents/guardians and assent from patients aged 16 years or older.

Primary objectives were to determine the prevalence of undernutrition at cancer diagnosis using three definitions: BMI alone, MUAC alone, and combined BMI/MUAC criteria, and to assess categorical and continuous agreement between BMI and MUAC for identifying undernutrition. Secondary objectives were to describe changes in anthropometric measures from baseline to 6–9 weeks after chemotherapy initiation, to assess changes in body composition parameters during early treatment, and to determine undernutrition prevalence at the 6–9 week follow-up. Exploratory objectives were to compare nutritional changes between solid tumor (ST) and hematologic malignancy (HM) patients, to examine correlations among anthropometric measures and body composition parameters, and to retrospectively assess how often the criteria for starting nutritional treatment were met at baseline and to describe the structure of the indications for nutritional intervention.

The study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines, and the corresponding checklist was completed and included.

2.2. Study Population

Inclusion criteria: children aged 5–18 years, newly diagnosed with malignancy, scheduled to receive systemic chemotherapy, and able to undergo anthropometric assessments. Exclusion criteria included severe general condition at diagnosis (intensive care admission, inability to stand), prolonged surgical hospitalization before chemotherapy, ongoing urgent intensive fluid therapy, coexisting diseases affecting NS, implanted devices, and previous cancer diagnosis.

2.3. Treatment

Because the cohort was clinically heterogeneous, patients were grouped into two broad categories—HM and ST—reflecting the different treatment approaches applied to each, which in turn may differentially affect NS and body composition. The description below summarizes general treatment principles rather than specific protocols, as multiple risk-adapted regimens were applied. Patients with HM were treated with intensive, multiagent systemic chemotherapy administered in sequential phases. These regimens typically include repeated cycles of corticosteroids combined with multiple cytotoxic agents, and in some cases are supplemented with central nervous system-directed therapy, cranial radiotherapy, or hematopoietic stem cell transplantation. Patients with ST generally received multimodal therapy, in which cytotoxic chemotherapy is combined with surgical resection and/or radiotherapy. Corticosteroid exposure in this group is typically limited or short. ST treatment is more frequently associated with anorexia and tumor site-related effects on intake and digestion, which may predispose to a decline in NS. These contrasting treatment exposures provide the rationale for analyzing ST and HM separately and for anticipating divergent body composition responses between the two groups.

2.4. Nutritional Assessment

Anthropometric assessments were performed at baseline and at the 6–9 week follow-up by the same trained clinician. The baseline assessment was performed before or on the first day of chemotherapy in 24 patients (55.8%) and within 14 days of its start in the remaining 19 (days 1–7 in 10 and days 8–14 in 9).

Measurements included body weight, height, BMI, MUAC, TSF, and thigh circumference (TC). MUAC was measured on the non-dominant relaxed arm at the midpoint of the upper arm using a non-elastic tape, with readings to the nearest millimeter. TSF was assessed at the same site using a calibrated Holtain skinfold caliper (Holtain Ltd., Crymych, United Kingdom), to the nearest 0.1 mm. TC was measured at the standardized mid-thigh

point with a non-elastic tape while the participant stood with weight evenly distributed, to the nearest millimeter. All anthropometric measurements were performed in triplicate, and the mean value was used for analysis.

Results were converted to z-scores using Polish growth references for weight, height, and BMI [19], and US reference values for TSF [20] and MUAC [21], because Polish references allowing z-score calculation were not available for these two measures. Undernutrition was defined as BMI and/or MUAC z-score less than −2 standard deviations (SD). Deterioration in NS was defined as a decrease in BMI z-score of at least 1 SD, relative to the pre-diagnosis value at baseline and relative to the baseline assessment at follow-up; children meeting only this criterion were not classified as undernourished. For children with weight loss before diagnosis, pre-diagnosis body weight was defined as the highest body weight during the 2 months preceding diagnosis, as reported by caregivers (an approximate, recall-based value), and the corresponding BMI z-score was calculated using height measured at baseline.

Body composition was assessed using BIA (Tanita MC-780MA, TANITA Corporation, Tokyo, Japan). The measurements were performed according to the manufacturer's instructions and BIA preparation guidelines [22,23]. Assessments were conducted after bladder voiding, in a fasting state (approximately 4 h), and after avoiding vigorous physical activity for 24 h. Measurements were performed in clinically euvolemic patients, i.e., without clinical signs of edema or dehydration, and not during intensive intravenous hydration or high-volume chemotherapy infusions; hydration status was assessed clinically and was not quantified by an independent method. Participants were measured barefoot, wearing light underwear, with all metal accessories removed. Prior to each measurement, directly measured height, age, and sex were entered into the device. BIA-derived parameters (FM, FFM, and SMM) were obtained directly from the Tanita MC-780MA using the manufacturer's proprietary prediction equations based on segmental impedance analysis. No externally derived equations, manual recalculations, or additional correction factors were applied. Total body water (TBW) estimated by the device was also recorded; extracellular and intracellular water and phase angle were not available for all patients and were not analyzed.

Criteria for nutritional intervention included: undernutrition at diagnosis (BMI/MUAC < -2 SD), tumor location affecting nutrition, high-risk, advanced-stage, metastatic, or progressive disease, gastrointestinal symptoms or swallowing difficulties, gastrointestinal obstruction, planned hematopoietic stem cell transplantation, planned chronic steroid therapy, planned radiotherapy to critical regions, concomitant diseases affecting nutritional status, and low socioeconomic status or a non-compliant caregiver [24]. These criteria were applied retrospectively to baseline data. Nutritional support initiated during the study (oral nutritional supplements (ONS), enteral nutrition (EN), or parenteral nutrition (PN) was recorded. No dietitian-led counseling was part of routine care at the time of the study; all families received information on ONS from the investigator at enrollment.

2.5. Statistical Analysis

Continuous variables are summarized as mean and standard deviation or median (interquartile range), depending on distribution. Categorical variables are reported as counts and percentages, with 95% confidence intervals (CIs) calculated using the Wilson score method. Normality was assessed by inspection of histograms and Q-Q plots and by the Shapiro–Wilk test. Prevalence estimates were calculated using BMI-based, MUAC-based, and combined classification criteria. Agreement between BMI and MUAC was evaluated using Pearson correlation for continuous measures (95% CIs based on Fisher's z-transformation); Cohen's kappa for categorical agreement (interpreted as <0.20 slight, 0.21–0.40 fair, 0.41–0.60 moderate, 0.61–0.80 substantial, and >0.80 almost perfect; 95%

CIs based on the asymptotic non-null standard error), supplemented by observed, positive and negative agreement and the prevalence- and bias-adjusted kappa (PABAK); and Bland–Altman analysis, with approximate 95% CIs for the limits of agreement, to assess interchangeability.

Changes between baseline and follow-up were analyzed using paired t-tests; Wilcoxon signed-rank tests were used as a sensitivity analysis when paired differences deviated from normality. To account for multiple testing across the 13 anthropometric and BIA-derived body composition parameters, a Bonferroni-adjusted significance threshold was applied ($\alpha = 0.05/13 = 0.0038$); *p*-values below 0.05 that did not reach this threshold are reported as nominal and were not considered statistically significant. Baseline characteristics of completers and non-completers were compared using standardized mean differences (SMD), and the association of baseline nutritional status with completion of follow-up was examined using logistic regression adjusted for age. Exploratory analyses included comparisons between tumor types and correlation analyses among nutritional parameters; these analyses were hypothesis-generating and are reported using unadjusted *p*-values. All analyses were performed using Stata version 19.5 (StataCorp LLC, College Station, TX, USA).

2.6. Sample Size and Statistical Power

This preliminary study enrolled consecutive eligible patients during the study period; the sample size was determined by feasibility, and no a priori sample size calculation was performed for the agreement analyses. The initial planning considered the power to detect a correlation between BMI and MUAC z-scores (assuming r = 0.40–0.70, within the range of published pediatric BMI–MUAC correlations of 0.40–0.88 [25,26], 14 to 47 participants were required for 80% power at $\alpha = 0.05$); however, a strong correlation does not imply agreement. We therefore report the precision achieved for the agreement estimates: with 43 participants, the 95% CI of each Bland–Altman limit of agreement had a half-width of approximately 0.40 SD, and approximately 100 participants would be needed to narrow it to ± 0.25 SD. Because undernutrition was infrequent, the kappa estimates are imprecise, and the agreement analyses should be regarded as preliminary.

3. Results

3.1. Participant Flow and Baseline Characteristics

Of 122 newly diagnosed patients requiring systemic treatment during the study period, 43 met inclusion criteria and were enrolled at baseline. Figure 1 presents the study eligibility flowchart. Follow-up assessment was completed by 22 patients (51.2%); 21 patients (48.8%) did not complete follow-up. Reasons for missing follow-up were clinical deterioration precluding assessment, including caregiver refusal because of the child's poor condition and the need for intensive intravenous hydration (n = 13), family withdrawal (n = 1), and logistical barriers to reassessment (n = 7). Completers were older than non-completers (mean age at diagnosis 159.8 vs. 118.3 months; SMD = 0.90) and consequently had higher body weight and height, whereas BMI and MUAC z-scores, body composition percentages, the proportion of undernourished children and the distribution of HM and ST were similar (all $|\text{SMD}| \leq 0.25$; Table 1). In logistic regression adjusted for age, neither baseline BMI z-score nor MUAC z-score was associated with completion of follow-up. Leukemia was more frequent among non-completers: seven of 11 children with leukemia did not complete follow-up, compared with six of 16 children with lymphoma.

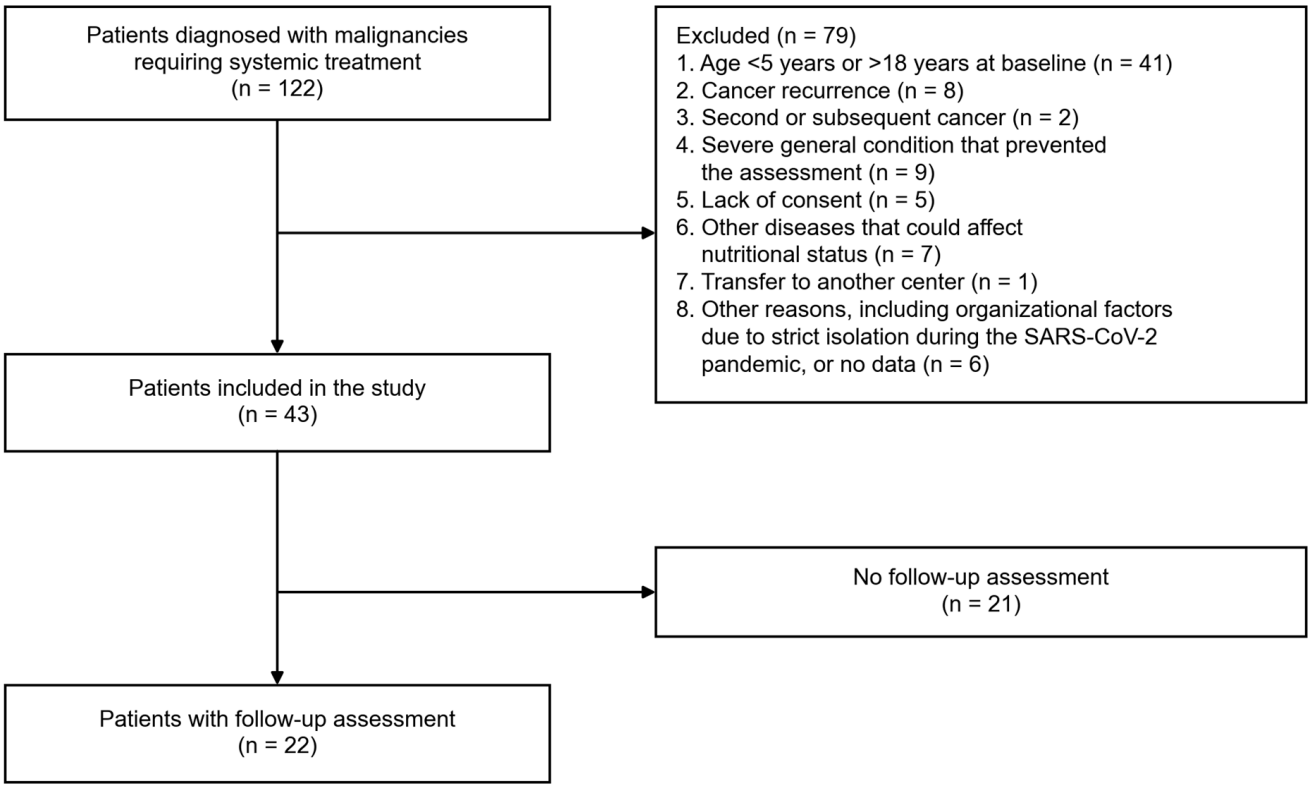


Figure 1. Study flowchart: Of 122 newly diagnosed patients, 43 were enrolled and 22 (51.2%) completed the follow-up assessment.

Table 1. Baseline characteristics of the study cohort, overall and by completion of follow-up: completers were older and larger, whereas nutritional and body composition parameters were similar.

Characteristic	Overall (n = 43)	Completers (n = 22)	Non-Completers (n = 21)	SMD
Age at diagnosis (months), mean (SD)	139.5 (50.1)	159.8 (47.7)	118.3 (44.2)	0.90
Male sex, n (%)	26 (60.5%)	12 (54.5%)	14 (66.7%)	−0.25
Hematologic malignancies, n (%)	27 (62.8%)	14 (63.6%)	13 (61.9%)	0.04
Solid tumors, n (%)	16 (37.2%)	8 (36.4%)	8 (38.1%)	−0.04
High-risk disease, n (%)	18 (41.9%)	9 (40.9%)	9 (42.9%)	−0.04
Weight loss reported before diagnosis, n (%)	7 (16.3%)	3 (13.6%)	4 (19.0%)	−0.15
Body weight (kg), mean (SD)	41.9 (17.0)	48.6 (16.6)	34.8 (14.6)	0.89
Height (cm), mean (SD)	150.8 (23.6)	159.7 (23.2)	141.5 (20.7)	0.83
BMI z-score, mean (SD)	−0.5 (1.1)	−0.4 (1.3)	−0.5 (0.9)	0.03
MUAC z-score, mean (SD)	−1.1 (1.0)	−1.0 (1.1)	−1.1 (1.0)	0.05
Undernutrition (BMI and/or MUAC z-score < −2 SD), n (%)	8 (18.6%)	4 (18.2%)	4 (19.0%)	−0.02

Table 1. *Cont.*

Characteristic	Overall (n = 43)	Completers (n = 22)	Non-Completers (n = 21)	SMD
Fat mass percentage, mean (SD)	20.8 (6.6)	21.2 (7.4)	20.3 (5.7)	0.13
Fat-free mass percentage, mean (SD)	79.2 (6.6)	78.7 (7.4)	79.6 (5.7)	−0.14
Skeletal muscle mass percentage, mean (SD)	44.4 (3.7)	44.2 (4.3)	44.6 (3.0)	−0.09

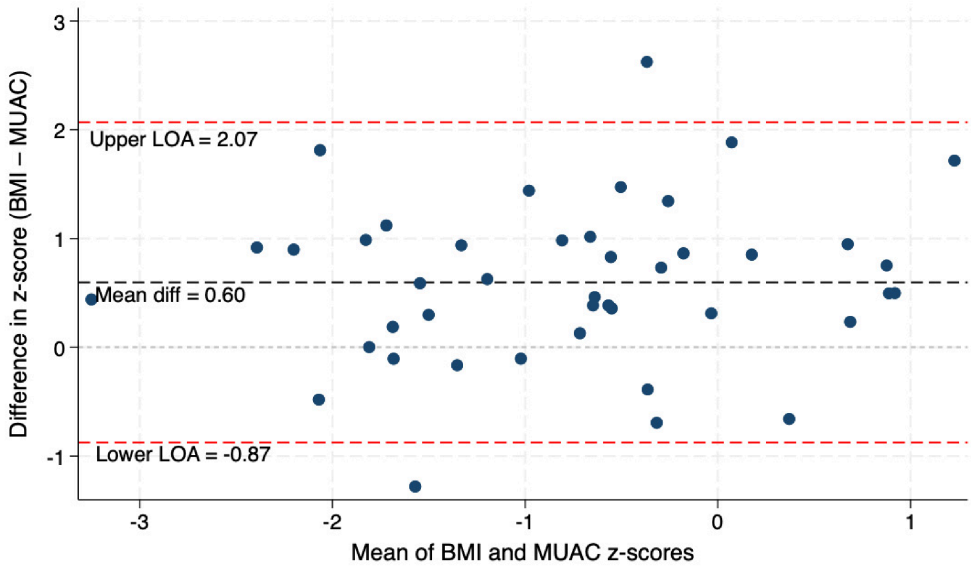
Hematologic malignancies included leukemia and lymphoma. Leukemia was present in 11 patients overall (25.6%), including four completers (18.2%). Lymphoma occurred in 16 patients overall (37.2%), including 10 completers (45.5%). Solid tumors included sarcomas [five patients overall (11.6%), with two completers (9.1%)], germ cell tumors [four patients overall (9.3%), including three completers (13.6%)], CNS tumors [two patients overall (4.7%), with two completers (9.1%)], and other tumors [five patients overall (11.6%), including one completer (4.5%)]. High-risk disease was defined by high-risk stratification according to disease-specific protocols. Continuous variables are presented as mean (SD). BMI was calculated as weight (kg)/height (m)^2; weight, height, and BMI z-scores were calculated using Polish growth references [19], and MUAC z-scores using US reference values [21]. Fat mass, fat-free mass, and skeletal muscle mass were estimated by BIA (manufacturer's equations) and are expressed as a percentage of body weight. SMD—standardized mean difference (completers vs. non-completers); absolute values of 0.2, 0.5, and 0.8 indicate small, moderate, and large differences. BMI—body mass index, MUAC—mid-upper arm circumference, SD—standard deviation.

3.2. Prevalence of Undernutrition and Agreement Between BMI and MUAC

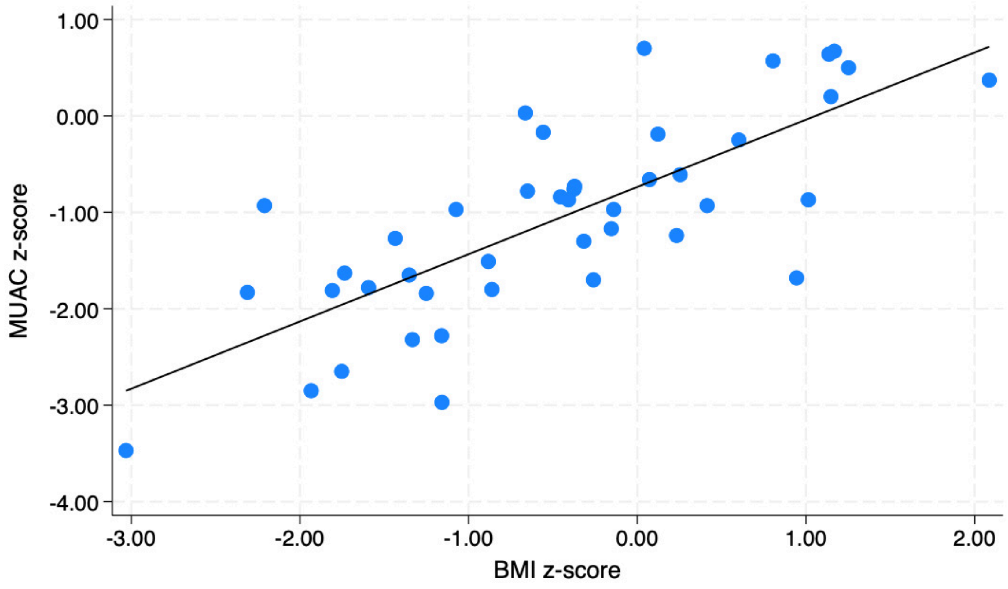
At baseline, undernutrition prevalence was 7.0% (3/43; 95% CI: 2.4–18.6%) by BMI, 14.0% (6/43; 95% CI: 6.6–27.3%) by MUAC, and 18.6% (8/43; 95% CI: 9.7–32.6%) by combined criteria. Only one of eight undernourished patients was identified by both measures; five patients had undernutrition by MUAC alone, and two by BMI alone. Using either criterion thus identified 2.7 times as many children as BMI alone.

Cohen's kappa for undernutrition classification was 0.14 (95% CI: −0.23 to 0.52), indicating slight agreement. Observed agreement was 83.7% (positive agreement 22.2%, negative agreement 90.9%) and the prevalence- and bias-adjusted kappa was 0.67, indicating that the low kappa largely reflects the low prevalence of undernutrition. Discordant classifications did not differ significantly in direction (five by MUAC only vs. two by BMI only; exact McNemar $p = 0.45$). Despite poor categorical agreement, BMI and MUAC z-scores were strongly correlated (r = 0.76, 95% CI: 0.60–0.86, $p < 0.0001$). Bland–Altman analysis revealed a mean difference of +0.60 SD (95% CI: 0.37 to 0.83; BMI z-scores systematically higher than MUAC z-scores) with 95% limits of agreement from −0.87 (95% CI: −1.27 to −0.47) to +2.07 SD (95% CI: 1.67 to 2.47) and no proportional bias ($p = 0.38$), indicating that the measures are not interchangeable for individual patient classification (Figure 2).

At follow-up (n = 22), undernutrition was identified in four children (18.2%) by BMI, five (22.7%) by MUAC and six (27.3%) by either criterion; among the same 22 children, the corresponding numbers at baseline were two, three and four (exact McNemar $p = 0.63$ for either criterion). Categorical agreement was moderate ($\kappa = 0.58$, 95% CI: 0.16–1.00), and the correlation was stronger (r = 0.92, 95% CI: 0.81–0.97). The Bland–Altman mean difference was +0.26 SD, with limits of agreement from −0.89 to +1.41 SD and evidence of proportional bias ($p = 0.004$). Table 2 summarizes prevalence and agreement findings.



(**A**)



(**B**)

Figure 2. BMI and MUAC z-scores at diagnosis are strongly correlated but not interchangeable (n = 43). (**A**) Bland–Altman plot: mean difference +0.60 SD, 95% limits of agreement −0.87 to +2.07 SD. (**B**) Correlation between BMI and MUAC z-scores (r = 0.76).

Table 2. Undernutrition prevalence by BMI, MUAC and combined criteria, and agreement between BMI and MUAC: strong correlation but low categorical agreement and wide limits of agreement.

Parameter	Baseline (n = 43)	Follow-Up (n = 22)
Prevalence of Undernutrition		
BMI z-score < −2 SD	3 (7.0%) [2.4–18.6]	4 (18.2%) [7.3–38.5]
MUAC z-score < −2 SD	6 (14.0%) [6.6–27.3]	5 (22.7%) [10.1–43.4]
Combined (BMI or MUAC < −2 SD)	8 (18.6%) [9.7–32.6]	6 (27.3%) [13.2–48.2]

Table 2. *Cont.*

Parameter	Baseline (n = 43)	Follow-Up (n = 22)
Agreement Measures		
Cohen's kappa (95% CI)	0.14 (−0.23 to 0.52)	0.58 (0.16 to 1.00)
Pearson correlation r (95% CI)	0.76 (0.60–0.86)	0.92 (0.81–0.97)
Bland–Altman mean difference (95% CI)	+0.60 SD (0.37 to 0.83)	+0.26 SD (0.00 to 0.52)
95% Limits of agreement	−0.87 to +2.07 SD	−0.89 to +1.41 SD
Observed agreement, %	83.7	86.4
Prevalence- and bias-adjusted kappa (PABAK)	0.67	0.73

Values presented as n (%) [95% CI] for prevalence. Undernutrition was defined as z-score < −2 SD; children meeting only the deterioration criterion (BMI z-score decrease ≥1 SD) are reported in Section 3.4. The 95% CIs for kappa are based on the asymptotic non-null standard error. BMI—body mass index, MUAC—mid-upper arm circumference, SD—standard deviation.

3.3. Changes in Anthropometric and Body Composition Parameters from Baseline to Follow-Up

For 22 patients with paired assessments (median follow-up interval: 55.5 days, IQR 46–61), the anthropometric and body composition changes are presented in Table 3. No change reached the Bonferroni-adjusted significance threshold ($\alpha = 0.0038$). Height increased slightly (mean +0.42 cm, 95% CI: 0.00 to 0.84; nominal $p = 0.048$), consistent with expected linear growth. BMI z-score decreased by 0.39 SD (95% CI: −0.77 to −0.02; nominal $p = 0.042$), corresponding approximately to a shift from the 33rd to the 20th percentile. MUAC z-score did not change ($p = 0.638$), although the study was underpowered to detect small changes.

Table 3. Changes in anthropometric and BIA-derived body composition parameters after 6–9 weeks of chemotherapy (n = 22): small decreases in BMI z-score, fat-free mass and body water, none significant after correction for multiple testing.

Parameter	Baseline Overall (n = 43) Mean (SD)	Baseline with Follow-Up (n = 22) Mean (SD)	Follow-Up (n = 22) Mean (SD)	Mean Change (Follow-Up − Baseline) (95% CI)	*p*-Value
Weight (kg)	41.87 (16.99)	48.64 (16.59)	47.03 (16.77)	−1.60 (−3.32 to 0.11)	0.066
Height (cm)	150.81 (23.61)	159.71 (23.18)	160.13 (22.94)	0.42 (0.00 to 0.84)	0.048
BMI z-score	−0.46 (1.13)	−0.44 (1.32)	−0.84 (1.37)	−0.39 (−0.77 to −0.02)	0.042
MUAC z-score	−1.06 (1.03)	−1.04 (1.08)	−1.10 (1.03)	−0.06 (−0.34 to 0.21)	0.638
TSF z-score	−0.15 (0.99)	−0.24 (1.00)	−0.13 (0.92)	0.11 (−0.18 to 0.41)	0.439
Thigh circumference (cm)	40.02 (8.30)	42.97 (8.40)	41.95 (8.08)	−1.03 (−2.06 to 0.01)	0.052
Fat mass (kg)	8.80 (5.34)	10.59 (6.18)	10.66 (6.13)	0.07 (−0.75 to 0.89)	0.855
Fat mass (%)	20.79 (6.56)	21.22 (7.44)	22.14 (7.80)	0.92 (−0.22 to 2.06)	0.107
Fat-free mass (kg)	33.07 (13.62)	38.05 (13.01)	36.37 (13.15)	−1.68 (−2.90 to −0.45)	0.010
Fat-free mass (%)	79.18 (6.57)	78.74 (7.45)	77.85 (7.79)	−0.89 (−2.04 to 0.26)	0.121
Skeletal muscle mass (kg)	18.53 (7.61)	21.34 (7.27)	20.62 (7.64)	−0.72 (−1.55 to 0.11)	0.084
Skeletal muscle mass (%)	44.39 (3.70)	44.23 (4.29)	44.12 (5.36)	−0.12 (−1.32 to 1.09)	0.844
Total body water (kg)	24.23 (10.01)	27.90 (9.58)	26.74 (9.74)	−1.16 (−2.14 to −0.18)	0.022

Values presented as mean (SD). *p*-values from paired t-tests; Wilcoxon signed-rank tests, used as a sensitivity analysis for variables with non-normally distributed differences (height and skeletal muscle mass %), gave consistent results ($p = 0.040$ and $p = 0.355$, respectively). No comparison reached the Bonferroni-adjusted threshold for 13 tests ($\alpha = 0.0038$). Fat mass, fat-free mass, skeletal muscle mass and total body water were estimated by BIA. BMI z-scores were calculated using Polish growth references [19], and TSF and MUAC z-scores using US reference values [20,21]. BMI—body mass index, MUAC—mid-upper arm circumference, SD—standard deviation, TSF—triceps skinfold.

BIA-derived FFM decreased by 1.68 kg (95% CI: −2.90 to −0.45; nominal $p = 0.010$) and TBW by 1.16 kg (95% CI: −2.14 to −0.18; nominal $p = 0.022$), whereas FFM percentage (−0.89%, $p = 0.121$), absolute and relative SMM (−0.72 kg, $p = 0.084$; −0.12%, $p = 0.844$) and FM (+0.07 kg, $p = 0.855$; +0.92%, $p = 0.107$) did not change significantly. Among these 22 patients, the ratio of TBW to FFM provided by the device was 73.3 ± 0.3% at baseline and 73.4 ± 1.0% at follow-up ($p = 0.50$), and individual changes in FFM and TBW were almost perfectly correlated (r = 0.97); thus, the decrease in BIA-derived FFM paralleled the decrease in estimated body water. Excluding the two patients who started enteral nutrition during follow-up did not materially change these estimates (mean FFM change −1.86 kg; BMI z-score change −0.38 SD). Changes in BMI and MUAC z-scores and in body composition are presented in Figure 3. These observations are preliminary and require confirmation in larger studies using methods less dependent on hydration.

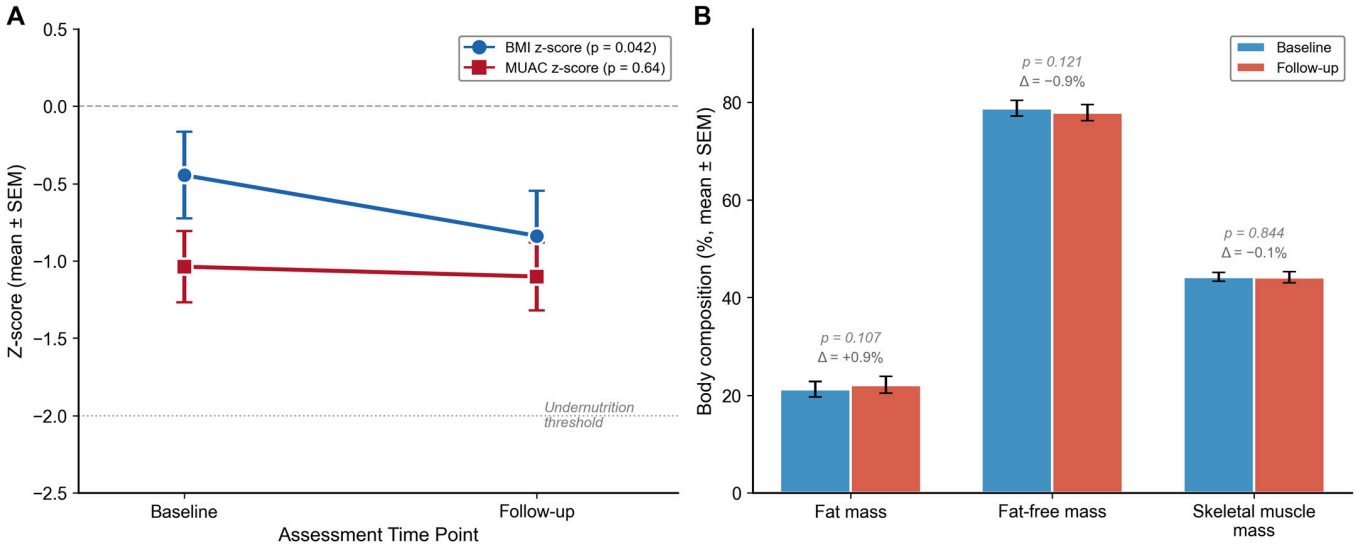


Figure 3. Between diagnosis and 6–9 weeks of chemotherapy (n = 22), BMI z-score decreased slightly while MUAC z-score and body composition percentages remained largely stable; no change was significant after correction for multiple testing. (**A**) BMI and MUAC z-scores (mean ± SEM). (**B**) BIA-derived fat mass, fat-free mass, and skeletal muscle mass (% of body weight, mean ± SEM). BMI—body mass index, MUAC—mid-upper arm circumference.

3.4. Deterioration in Nutritional Status

At the time of cancer diagnosis, weight loss before diagnosis was reported for seven patients (16.3%). Two of them (4.7% of the cohort) had a decrease in BMI z-score of ≥1 SD relative to the pre-diagnosis value. Among the 22 patients with complete baseline and follow-up assessments, four (18.2%) met the criterion of deterioration in NS during follow-up; in two of them, the BMI z-score remained above −2 SD, so they would not have been identified by the undernutrition criterion alone.

3.5. Exploratory Findings

3.5.1. Cancer Type Comparison

Exploratory comparison between ST and HM suggested different nutritional trajectories. At baseline, groups had similar NS with no significant differences in BMI z-score (−0.79 vs. −0.25, $p = 0.36$) or MUAC z-score (−1.39 vs. −0.84, $p = 0.26$). However, the longitudinal changes appeared to differ. ST patients showed greater BMI z-score decline (−0.95 vs. −0.07, difference −0.88, 95% CI: −1.57 to −0.18, unadjusted $p = 0.016$) and FM loss (−1.55 vs. +1.00 kg, difference −2.55 kg, 95% CI: −3.83 to −1.27, unadjusted $p < 0.001$),

while patients with HM showed FM gain. FFM percentage increased by 1.65 percentage points in ST and decreased by 2.35 percentage points in HM (difference 3.99 percentage points, 95% CI: 2.39 to 5.60, unadjusted $p < 0.001$); because absolute FFM changes were similar in both groups (−1.71 vs. −1.66 kg, unadjusted $p = 0.965$), these opposite shifts mirror the changes in FM rather than differences in lean tissue. SMM percentage also changed in opposite directions (ST +1.90% vs. HM −1.26%, unadjusted $p = 0.005$), although absolute SMM changes did not differ significantly. Detailed results are available in Supplementary Table S1.

Planned chronic corticosteroid therapy was part of the treatment plan in all patients with HM and in none with ST; therefore, the effect of corticosteroids cannot be separated from other differences between the groups. Within the HM group, the four children with leukemia had a larger mean decrease in FFM than the 10 with lymphoma (−5.0 vs. −0.3 kg), whereas the increase in FM was observed mainly in lymphoma; these subgroups were too small for formal comparison. These analyses are severely limited by small sample sizes and uncontrolled confounding (age, treatment protocols, steroid exposure) and should be considered strictly hypothesis-generating.

3.5.2. Correlations Among Anthropometric and Body Composition Measures

Strong correlations were observed between BMI and MUAC z-scores at baseline ($r = 0.76$, $p < 0.001$) and a moderate correlation between their changes ($r = 0.45$, $p = 0.034$). Both measures showed strong positive correlations with FM percentage (BMI: $r = 0.63$, MUAC: $r = 0.61$, both $p < 0.001$) and strong negative correlations with FFM percentage (BMI: $r = -0.63$, MUAC: $r = -0.61$) and SMM percentage (BMI: $r = -0.56$, MUAC: $r = -0.56$). Notably, BMI and MUAC z-scores were not correlated with absolute FFM and SMM in kg (r between −0.01 and 0.10) and were moderately correlated with absolute FM ($r = 0.58$ and $r = 0.46$, respectively), while TC showed strong positive correlations with absolute tissue masses (FM kg: $r = 0.83$, FFM kg: $r = 0.79$, SMM kg: $r = 0.80$, all $p < 0.001$). This pattern suggests that BMI and MUAC z-scores primarily reflect relative body composition (percentages), while TC better reflects absolute tissue masses. For changes from baseline to follow-up, negative correlations were observed between anthropometric z-score changes and SMM percentage changes (BMI vs. SMM%: $\rho = -0.57$, $p = 0.006$; MUAC vs. SMM%: $\rho = -0.51$, $p = 0.015$). This may reflect the compositional nature of percentage measures (SMM% can rise when FM decreases even if absolute SMM remains stable), measurement variability related to hydration and BIA-derived estimates, or small-sample effects. Positive correlations between anthropometric changes and FM percentage changes (BMI: $r = +0.43$, $p = 0.044$; MUAC: $r = +0.41$, $p = 0.059$) suggest that increases in BMI/MUAC are partly driven by fat accumulation. Complete correlation matrices are presented in Supplementary Tables S2 and S3.

3.5.3. Nutritional Intervention Indications

At baseline, 39 of 43 patients met at least one criterion for nutritional intervention. The mean number of indications per patient was 2.1 ± 1.3 (median 2, IQR 1–3, range 0–5). Only 9.3% of patients had no indications, while 23.3% had one, 30.2% had two, 23.3% had three, and 14.0% had four or more indications.

The most common indications were planned chronic steroid therapy (62.8%), high-risk disease (41.9%), and tumor location affecting nutrition (25.6%). Detailed data are presented in Supplementary Table S4. During the follow-up window, nutritional support was initiated in two patients (4.7%; both EN, both with ST); none of the eight children undernourished at baseline started nutritional support before the follow-up assessment. After the follow-up

assessment, nutritional support was started in a further four patients (ONS in one, EN in one, and PN in two).

4. Discussion

This study examined agreement between BMI and MUAC in identifying undernutrition and early nutritional changes during chemotherapy. BMI and MUAC were strongly correlated at the population level but showed poor categorical agreement in identifying undernourished individuals; in the 22 children reassessed, both correlation and categorical agreement were numerically higher at follow-up, although the confidence intervals were wide.

At baseline, using both measures identified 2.7 times as many children meeting at least one anthropometric criterion for undernutrition as BMI alone. Because no independent reference standard was available, and because an "either/or" definition necessarily identifies at least as many children as either measure alone, this reflects broader case-finding rather than demonstrated diagnostic accuracy.

The discordance between correlation and agreement has important clinical implications. Strong correlation indicates that BMI and MUAC vary together across populations, but the wide limits of agreement demonstrate that the measures cannot be used interchangeably for individual patient classification.

This pattern likely reflects, at least in part, different physiological domains. BMI assesses overall weight-for-height status, whereas MUAC reflects regional muscle and fat stores and is less influenced by central fluid accumulation. In our study, undernutrition at cancer diagnosis was identified in 7% of patients using BMI, and in twice as many using MUAC; however, the direction of discordant classifications did not differ significantly, and without a reference standard, the relative sensitivity of the two measures cannot be established. Part of the discordance, including the systematic mean difference of +0.60 SD, may also be methodological, because BMI z-scores were derived from Polish references and MUAC z-scores from US references [19,21].

Our findings align with previous studies showing poor categorical agreement between BMI and MUAC, a higher number of children identified when both measures are combined, and a tendency for MUAC to classify more children as undernourished; these studies differ substantially in design, setting, and timing, which warrants a cautious reading. The systematic review by Iniesta et al. reported higher undernutrition rates by arm anthropometry than by BMI at diagnosis and during treatment, with convergence only at therapy completion [10]. That review synthesized 46 heterogeneous primary studies and highlighted substantial variability in definitions and measurement techniques for malnutrition, as well as important methodological limitations across included studies, which limits the comparability and generalizability of the findings. Its conclusions therefore describe a broad direction of effect rather than a precise, transferable estimate. A comparable pattern was reported by Viani et al. [27], although in that cohort BMI identified more undernutrition than MUAC among children with central nervous system tumors. That study was a retrospective, single-center analysis of children referred to a dedicated nutrition service; referral-based sampling may over-represent children with established nutritional concerns and limits generalizability to a cohort such as ours. BMI and MUAC are moderately to strongly correlated in non-oncological pediatric populations ($r \approx 0.40$–0.88) [25,26]; in children with cancer, Barr et al. validated arm anthropometry against DXA-derived lean mass rather than testing BMI–MUAC interchangeability directly [12], and Yaprak et al. found malnutrition concentrated in younger children and in abdominal or advanced-stage tumors [13]. None of these studies formally evaluated continuous agreement between BMI and MUAC; most assessed correlation or categorical classification, which can coexist

with poor individual-level interchangeability—precisely the dissociation our Bland–Altman analysis demonstrates. Our findings therefore extend, rather than simply replicate, this literature. To our knowledge, this is one of the first prospective studies in pediatric oncology to assess individual-level agreement between BMI and MUAC z-scores at diagnosis using Bland–Altman analysis, alongside BIA-derived body composition and a reassessment during the first weeks of chemotherapy. Although related, BMI and MUAC are not interchangeable at the individual level, supporting the inclusion of MUAC alongside BMI as a complementary screening measure; whether combined assessment improves diagnostic accuracy requires validation against a reference standard of body composition.

In our study, undernutrition prevalence at baseline ranged from 7.0% to 18.6% depending on the criterion applied. These findings appear to be consistent with other studies conducted in populations from high-income countries [2], where prevalence is generally lower (up to 30%) compared to substantially higher rates observed in low- and middle-income countries (up to 90%) [2,28].

Among the 22 children reassessed, the number meeting the undernutrition criteria increased numerically (BMI from 2 to 4, MUAC from 3 to 5, either criterion from 4 to 6), and the mean BMI z-score decreased by 0.39 SD (nominal $p = 0.042$), corresponding approximately to a shift from the 33rd to the 20th percentile. Neither change was statistically significant after correction, and both should be interpreted with caution.

The reported prevalence of undernutrition in pediatric oncology varies widely depending on the population, criteria, timing of assessment, and methods used, which limits direct comparisons across studies.

Sasse et al. reported undernutrition in 29.3% at diagnosis; after 3 months of treatment within a structured institutional nutritional care program, nearly half of the initially malnourished children (12 of 26) remained malnourished, and 17.8% of those initially well-nourished became malnourished, although overall nutritional status improved [29]. This prospective, single-institution study was, however, restricted to ST in a developing-country setting, so its substantially higher baseline prevalence is not directly comparable with our cohort. Brinksma et al., in their prospective cohort of children with mixed diagnoses in a high-income setting, found that BMI and FM increased within the first three months of treatment, whereas FFM (BIA), already low at diagnosis, remained low [11]. This dissociation—improving weight-based indices masking sustained lean-tissue depletion—is directionally consistent with our observations, although in our cohort the lean-tissue signal derives from BIA and cannot be separated from changes in hydration.

To identify patients whose BMI and MUAC remained within normal ranges despite substantial weight loss before diagnosis or during treatment, we introduced the term deterioration in NS, defined as a decrease in BMI z-score of ≥1 SD. This approach highlights patients at risk of further nutritional decline despite apparently normal anthropometric values and includes those who deteriorated further during treatment. Pre-diagnosis weight was available only for the seven children (16.3%) whose caregivers reported weight loss, two of whom met the deterioration criterion; because this estimate relies on caregiver-reported pre-diagnosis weight, it should be interpreted with caution. During follow-up, 4 of 22 children (18.2%) had a BMI z-score decline of ≥1 SD, and in two of them the BMI z-score remained above −2 SD, so they would not have been identified by the undernutrition criterion alone.

Most studies concerning NS in children with cancer are based on BMI. The recent systematic review by the SIOP Nutrition Network is illustrative: in the 18 pharmacokinetic studies it appraised, BMI-based definitions predominated, none used MUAC, and only three (17%) used dual-energy X-ray absorptiometry (DXA) [8]. Anthropometric measures do not assess body composition, potentially underdiagnosing clinically relevant

tissue loss. Accordingly, one objective of our study was to track body composition during early treatment.

None of the longitudinal changes in body composition remained significant after correction for multiple testing. BIA-derived FFM and TBW decreased in parallel (−1.68 kg and −1.16 kg; nominal $p = 0.010$ and 0.022), whereas absolute and relative SMM and FM did not change significantly. Importantly, the device derives FFM from impedance-based estimates of TBW under an assumption of constant hydration of fat-free mass: in our data, TBW accounted for 72.9–74.0% of FFM in every child at baseline. This ratio did not change during follow-up, and changes in FFM and TBW were almost perfectly correlated (r = 0.97); SMM is in turn estimated from FFM. The observed decrease in FFM therefore cannot be distinguished from a reduction in body water, and it should be regarded as a preliminary BIA-derived signal rather than as demonstrated loss of lean tissue. Treatment-related changes in fluid balance—intravenous hyperhydration accompanying chemotherapy, vomiting, diarrhea, or reduced fluid intake—could produce a similar pattern. Confirmation with methods less dependent on hydration, such as DXA, is needed; multifrequency BIA with extracellular and intracellular water estimates and phase angle may add information, although their validity in altered hydration states remains to be established [22,23].

Similar early body composition changes have been reported in pediatric cancer patients shortly after therapy onset using various methods. Brinksma et al. observed persistently low FFM despite increases in BMI and FM during the first three months of treatment (BIA) [11].

Using DXA rather than BIA, Yang and Choi documented an early decrease in FFM during the first month, recovering by 12 months, with a concurrent increase in FM in a small prospective cohort (n = 30) [16].

The meta-analysis by Markarian et al. found a decline in skeletal muscle quantity during the early treatment phase; importantly, the pooled estimates varied with the body composition method used, underscoring that measurement technique is a major source of between-study heterogeneity [9]. Collectively, this literature indicates that the early phase of anticancer therapy may drive loss of lean tissue while fat stores remain stable or increase—a pattern poorly captured by conventional anthropometry [7,9]; moreover, low skeletal muscle density at diagnosis has been associated with higher hematological toxicity [7]. Our BIA-based observations are compatible with, but do not by themselves demonstrate, this pattern.

In this study, BMI and MUAC were strongly positively correlated with FM percentage and strongly negatively correlated with FFM and SMM percentages. These findings indicate that higher BMI and MUAC are associated with a higher relative proportion of body fat and a lower relative proportion of lean tissue and SMM, rather than reflecting a reduction in absolute tissue masses. This is consistent with the absence of correlation between BMI and MUAC z-scores and absolute FFM and SMM. As exploratory findings, these results should be interpreted with caution and considered as a direction for future research rather than as definitive conclusions. Overall, our results underscore the value of BIA in complementing BMI and MUAC for comprehensive body composition assessment. Our findings are consistent with a study in healthy adolescents showing a moderate positive correlation between BMI z-score and BIA-derived body fat percentage (r = 0.63) [30].

Both BMI and MUAC seem to reflect aspects of fat and lean tissue distribution in children. A systematic review by Sisay et al. identified MUAC as an accurate screening tool for overweight and obesity (pooled AUC 0.92–0.93), although almost exclusively against BMI-defined categories; evidence against direct measures of adiposity such as BIA was insufficient, and all studies were in non-oncological populations [14]. Similarly, Oriaifo et al. reported positive correlations between MUAC and BIA-derived body composition pa-

rameters, including body fat percentage, FM, and FFM index, indicating that higher MUAC reflects both higher relative fat content and lean mass [15]. This study was conducted in a general pediatric population in Nigeria and focused largely on overnutrition. These differences in population and reference method plausibly explain why not all aspects correspond with our findings, particularly the inverse relationship we observed between anthropometric z-scores and relative lean tissue and SMM. In children undergoing chemotherapy, percentage-based composition measures are interdependent (relative SMM can rise simply because fat is lost), and disease- and treatment-related fluid shifts further distinguish our cohort from healthy children screened for adiposity.

The exploratory objectives also included the comparison of nutritional changes between patients with ST and with HM. This analysis suggests that these groups may follow distinct nutritional trajectories. Despite similar baseline NS, the longitudinal changes differed: ST patients showed larger declines in BMI z-score and FM loss, whereas HM patients showed FM gain. Divergent patterns were observed for SMM percentage.

Two prospective studies report directionally comparable, diagnosis-dependent patterns, though both differ from ours in important respects. Yang and Choi, using DXA in a Korean cohort followed over the first year, observed an early increase in FM and decrease in FFM in the whole cohort, with a continued rise in body fat percentage in HM but not in ST [16]—concordant with the fat gain we saw in our HM subgroup, although over a longer follow-up and with a different measurement modality.

Kellerman et al., in a single-center South African cohort of newly diagnosed children assessed monthly by BIA during the first six months, similarly found an acute loss of SMM in both groups together with rapid early increases in weight, BMI, and FM specifically in those with HM [31]; notably, their cohort was considerably younger than ours (median age 4 years), but the acute changes they observed occurred within the first two months of chemotherapy, consistent with the timing of our 6–9-week reassessment.

The convergence of these findings across BIA- and DXA-based studies in different settings strengthens the hypothesis of diagnosis-specific trajectories, even though each individual study—ours included—is limited by small, heterogeneously treated samples.

A major driver of these divergent trajectories is likely the differing role of corticosteroids across treatment protocols. Regimens for HM incorporate prolonged, high-dose glucocorticoid therapy, and in our cohort, planned chronic steroid therapy was the most frequent indication for nutritional intervention (62.8%). This indication applied to all patients with HM and to none with ST; cumulative doses and the timing of steroid exposure relative to the assessments were not recorded. Glucocorticoids may stimulate appetite and energy intake and favor the accumulation and central redistribution of adipose tissue, which can lead to weight gain and a rise in BMI. Consistent with this, glucocorticoid administration has been associated with an increase in BMI z-score during the early phase of childhood leukemia treatment, confined to periods of active steroid exposure [32]; obesity, in turn, has been associated with greater treatment-related toxicity in ALL [3]. At the same time, glucocorticoids exert a catabolic action on skeletal muscle—so-called steroid myopathy [33]. This combination of fat accumulation with concurrent muscle catabolism offers a plausible, although unproven, explanation for the pattern observed in our HM group, in which BIA-derived FM increased while the relative proportion of SMM declined.

In contrast, ST patients are managed with cytotoxic chemotherapy, often combined with surgery and/or radiotherapy and without sustained high-dose steroids, and are more exposed to a catabolic state with loss of both fat and lean tissue, in keeping with the BMI z-score decline and FM loss we observed in this group. Because steroid exposure coincided completely with the HM group and was not quantified, its effect cannot be separated from that of disease type, and these mechanistic links remain hypotheses; the comparison is

exploratory and confounded by age, disease type, and uncontrolled treatment-related factors, and therefore requires confirmation in larger controlled studies.

Early changes in body composition during chemotherapy are likely multifactorial. Reduced energy and protein intake due to nausea, vomiting, and loss of appetite, reduced physical activity, and tumor-related metabolic alterations may all favor loss of lean tissue [4,5,11], and glucocorticoids exert a direct catabolic effect on skeletal muscle [33]; glucocorticoid exposure has also been associated with rapid gains in BMI [32], although in a Dutch cohort neither energy intake nor corticosteroid use explained the increase in fat mass [11]. Such changes may influence treatment tolerance and clinical outcomes [7–9]. At the same time, intravenous hyperhydration and gastrointestinal fluid losses can change body water independently of tissue mass, which is particularly relevant for BIA-derived estimates. These preliminary findings suggest diagnosis-specific nutritional risks and highlight the need for larger controlled studies to confirm these observations.

The frequency of meeting criteria for nutritional treatment at baseline was assessed. In this study, the criteria of the Polish national consensus were applied [24]. Overall, 90.7% of patients met at least one intervention criterion, reflecting a proactive approach aimed at prevention as well as treatment of undernutrition. However, nutritional support was initiated during the follow-up window in only two patients. The national consensus was published after recruitment was completed, and its criteria were applied retrospectively; many of them, such as planned corticosteroid therapy, reflect anticipated rather than current nutritional risk. Nevertheless, this gap illustrates that indication-based approaches need to be translated into structured monitoring and intervention pathways, and it underscores the need for studies evaluating intervention effectiveness. It also means that the trajectories observed in our cohort largely reflect the early course of treatment without nutritional support beyond the information on ONS provided at enrollment.

From a clinical perspective, our findings have several implications. First, because BMI and MUAC classify different children, adding MUAC—a quick, inexpensive bedside measure—to routine BMI assessment at diagnosis may help identify children who would otherwise be missed, particularly when tumor mass or edema may mask tissue loss in weight-based indices [8,10]. Second, monitoring should not rely solely on cross-sectional cut-offs, because children whose BMI z-score falls by ≥1 SD may remain above conventional thresholds for undernutrition. Third, BIA can add information on body composition, but during early chemotherapy, its results should be interpreted together with a clinical assessment of hydration. Future studies should use a reference method for body composition, include additional bioimpedance parameters, record cumulative corticosteroid exposure and nutritional support, apply harmonized reference populations for BMI and MUAC, and evaluate whether early, targeted nutritional support modifies these trajectories.

This study has several limitations. The sample was small and only 22 of 43 children (51.2%) completed the follow-up assessment, which limited statistical power and resulted in wide confidence intervals. The high attrition rate reflects the clinical reality of pediatric oncology care, where patients' conditions often preclude standardized assessments.

Completers and non-completers had similar baseline nutritional and body composition parameters, but completers were older; missing follow-up was most often due to clinical deterioration (13 of 21 children), and children with leukemia were over-represented among non-completers. Attrition may therefore be related to subsequent nutritional change, and the longitudinal estimates may be biased, possibly toward underestimating nutritional decline. In addition, nutritional support during follow-up was rare, corticosteroid exposure was not quantified, and pre-diagnosis weight was available only for children with reported weight loss. Disease heterogeneity precluded analysis by specific cancer types; therefore, patients were grouped as ST or HM based on distinct biology and treatment methods used in both

subgroups. A further limitation of the study was the necessity to exclude patients younger than five years due to BIA software (GMON (Professinal Edition); TANITA Corporation, Japan). requirements. There was also the need to exclude patients in a severe general condition that precluded complete nutritional evaluation. Both excluded groups may be at risk of undernutrition. Because BMI and MUAC z-scores were derived from different reference populations, part of their disagreement may be methodological; likewise, TSF z-scores were based on US reference data [20], which may not fully apply to Polish children. Body composition was estimated by BIA without an independent assessment of hydration.

As undernutrition was infrequent, kappa was strongly influenced by prevalence [34,35]; the prevalence- and bias-adjusted kappa was 0.67 at baseline, and the kappa estimates should be interpreted together with the observed and specific agreement and with the Bland–Altman limits of agreement, whose confidence intervals were wide [36]. Finally, both BMI and MUAC have methodological limitations in pediatric oncology, as they may be affected by fluid status, tumor mass, edema, and measurement variability.

A key strength of this study is the comprehensive, multi-dimensional assessment of NS, combining BMI, MUAC, and body composition analysis. The evaluation of agreement between BMI and MUAC at the individual patient level addresses an important gap in the existing literature, which has largely focused on correlations or categorical classifications. The prospective design, with baseline assessment close to the start of chemotherapy and standardized measurements by a single trained clinician, is a further strength. Although the longitudinal analysis was limited by a small sample size, it provided preliminary signals of early changes in NS and body composition during the initial phase of therapy.

If confirmed in larger studies, the observation of body composition changes at such an early stage of treatment is clinically important, as they may worsen over prolonged anticancer therapy and negatively affect treatment tolerance and outcomes.

5. Conclusions

In this preliminary study, BMI and MUAC z-scores were strongly correlated but showed poor categorical agreement and wide limits of agreement, indicating that the two measures are not interchangeable for identifying undernutrition in individual children with cancer. Using both measures identified more children meeting at least one anthropometric criterion than BMI alone; whether this improves diagnostic accuracy requires validation against a reference standard. During the first 6–9 weeks of chemotherapy, BMI z-score and BIA-derived FFM and total body water decreased slightly, but none of these changes remained significant after correction for multiple testing, and the BIA findings cannot be separated from changes in hydration. Given the small sample and the substantial loss to follow-up, these longitudinal observations should be regarded as preliminary. Larger studies using reference methods for body composition and recording corticosteroid exposure and nutritional support are needed to define disease-specific nutritional trajectories and to evaluate whether early, targeted nutritional support improves outcomes.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/nu18223796/s1. Table S1: Nutritional changes by tumor type (exploratory analysis), Table S2: Correlations among anthropometric and body composition measures at baseline, Table S3: Correlations between changes in anthropometric and body composition measures, Table S4: Frequency of nutritional intervention indications at baseline.

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Abbreviations

The following abbreviations are used in this manuscript:

BIA	Bioelectrical Impedance Analysis
BMI	Body Mass Index
DXA	Dual-Energy X-ray Absorptiometry
EN	Enteral Nutrition
FFM	Fat-Free Mass
FM	Fat Mass
HM	Hematologic Malignancies
MUAC	Mid-upper arm circumference
NS	Nutritional Status
ONS	Oral Nutritional Supplements
PN	Parenteral Nutrition
SD	Standard Deviation
ST	Solid Tumors
SMM	Skeletal Muscle Mass
TC	Thigh Circumference
TSF	Triceps Skinfold

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