Nutritional assessment and resting energy expenditure in maintenance haemodialysis patients with chronic kidney disease in children

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Summary

The objective of this study was to explore the associations between resting energy expenditure (*REE*) and nutritional indicators in paediatric chronic kidney disease (CKD) patients undergoing maintenance haemodialysis (MHD). Fifteen MHD children were stratified by body mass index (*BMI*) into malnutrition ($n = 7$) and normal nutrition ($n = 8$) groups. *REE* was measured via metabolic cart and compared with Harris-Benedict formula predictions. Anthropometric indices, including triceps skinfold (*TSF*), mid-arm circumference (*MAC*), mid-arm muscle circumference (*MAMC*), and bone-free arm muscle area (*AMA*), were assessed alongside biochemical indices: leptin, insulin-like growth factor-1 (*IGF*-1), albumin, prealbumin, cholesterol, transferrin). Anthropometric indices (*TSF, MAC, MAMC, AMA*) differed significantly between groups ($P < 0.05$), while leptin and *IGF*-1 showed intergroup differences ($P < 0.05$). Albumin, prealbumin, cholesterol, and transferrin did not differ significantly. Measured *REE* aligned with predicted values overall and within subgroups. No correlations emerged between *REE* and anthropometric/biochemical indices. *REE* did not differ between malnourished and normally nourished groups, suggesting it may not reliably reflect nutritional status in this population.

Keywords

children; chronic kidney disease; haemodialysis; resting energy expenditure; malnutrition

Malnutrition is a common complication of chronic kidney disease (CKD) in children and an important cause of poor prognosis. Energy imbalance and increased energy expenditure are one of the important causes of malnutrition in CKD patients. In this study, nutritional status of children with CKD stage 5 maintenance haemodialysis was assessed to study the relationship between resting energy expenditure (*REE*) and anthropometric and biochemical indices, and to explore the value and significance of *REE* measurement in nutritional assessment and monitoring of children with CKD maintenance haemodialysis (MHD).

The initial hypothesis that *REE* might reflect malnutrition was rooted in the fundamental understanding that *REE* is inherently linked to body composition, particularly lean body mass and adipose tissue. In healthy populations, malnutrition-induced loss of lean mass was postulated to reduce *REE*, while adequate nutrition was thought to maintain normal *REE* levels, forming a plausible mechanistic link between metabolic expenditure and nutritional status. This assumption was further supported by observations in non-CKD populations where *REE* correlated with markers of nutritional health, such as muscle mass and adiposity. However, the decision to test this hypothesis in paediatric CKD patients undergoing MHD arose from the recognition that CKD imposes unique metabolic perturbations. Uremic toxins, chronic inflammation, hormonal dysregulations and fluid-electrolyte imbalances in this population could independently alter *REE*, potentially dissociating it from nutritional status.

Existing literature has demonstrated context-dependent relationships between *REE* and malnutrition: in heart failure patients, *REE* inversely correlates with malnutrition but is confounded by

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inflammatory states [1]; in cancer cachexia, *REE* often elevates alongside lean mass loss, outperforming body mass index (*BMI*) as a marker of metabolic stress [2]; and in elderly populations, age-related *REE* decline is exacerbated by protein-energy malnutrition [3]. These divergent findings underscored the need to validate *REE*'s utility in CKD-specific contexts.

While *BMI* remains a cornerstone for nutritional screening due to its simplicity, it fails to capture critical nuances in CKD. *BMI* cannot distinguish between oedema-induced weight gain and true nutritional status, nor does it reflect muscle-fat composition or metabolic activity [4]. *REE* offers distinct advantages here: it directly quantifies basal metabolic demand, enabling personalized energy prescription for hospitalized patients, and reveals metabolic abnormalities that *BMI* overlooks. For instance, in MHD children, *REE* may unmask "metabolic paradoxes" where elevated energy expenditure coexists with insufficient nutrient intake, guiding targeted nutritional interventions beyond *BMI*-based assessments.

In the study, the 3rd percentile of *BMI* was used as the cut-off for malnutrition based on the 2009 Chinese national growth standards for children and adolescents [5, 6]. These standards specifically define *BMI* below the 3rd percentile for age and sex as indicative of malnutrition, differing from the WHO's 5th percentile cut-off for underweight. The Chinese guidelines were adopted to align with the population-specific growth references for Chinese children, ensuring culturally and epidemiologically appropriate nutritional assessment. This criterion is consistent with previous paediatric CKD studies in China that have utilized the same percentile thresholds for malnutrition stratification. The choice of cut-off is supported by national normative data to enhance the study's relevance to the target population.

MATERIALS AND METHODS

Research objects

A total of 15 children with stage 5 CKD undergoing MHD at Beijing Children's Blood Purification Centre (Beijing Children's Hospital, Capital Medical University, Beijing, China) were studied. At the first evaluation, all the 15 children received haemodialysis treatment for ≥ 3 months, 3 times a week for 3–4 h each time. The condition of the 15 children was stable during the study period. Other factors causing malnutrition, such as trauma, tumour, digestive tract disease, acute infection, hyperthyroidism, etc. were excluded during the study period. Active hepatitis, acute heart failure, severe water and sodium retention, and severe cardiovascular and cerebrovascular diseases were excluded.

Study methods

Body mass index evaluation group

The height and weight of 15 children with dry body mass were measured and *BMI* was calculated. According to the standardized growth curve of *BMI* of children and adolescents aged 0–18 years in China in 2009 [5, 6], the *BMI* of 15 children was evaluated. *BMI* in the 3rd to 97th percentile of children of the same age and sex was considered as the normal range, and *BMI* below the 3rd percentile of children of the same age and sex was considered as the malnourished group. A *BMI* higher than the 97th percentile of children of the same age and sex was considered as the over-nutrition group.

Anthropometric indicators

Triceps skinfold

The thickness of triceps skinfold (*TSF*) on the non-arteriovenous fistula side of the patient was measured by the sebum thickness measuring instrument developed by the General Administration of Sport of China (Beijing, China). The upper limb of the patient naturally drooped on the side of the body, 2 cm above the midpoint of the line between acromion and olecranon of the ulna. The examiner pinched the skin and subcutaneous tissue of the patient with the thumb and index finger to measure the thickness of the skinfold of the thumb. The thickness of the skinfold of the thumb was corrected by gravity before measurement, and the same part was measured for 3 consecutive times to obtain the average value.

Mid-arm circumference

The midpoint of the upper arm on the non-arteriovenous fistula side was taken, and the circumference was measured by a tape measure for 3 times to obtain the average value of mid-arm circumference (*MAC*) in centimetres.

Mid-arm muscle circumference

The mid-arm muscle circumference (*MAMC*) was calculated according to Eq. 1 and expressed in centimetres:

$$MAMC = MAC - 3.14 \times TSF \quad (1)$$

where *TSF* was measured in centimetres.

This formula standardizes *MAMC* calculation by adjusting the *MAC* for subcutaneous fat, providing an estimate of muscle mass. All measure-

ments were performed using standardized anthropometric techniques, with values recorded in centimetres to maintain unit consistency across variables.

Bone-free arm muscle area

The bone-free arm muscle area (*AMA*) was calculated using sex-specific formulas and expressed in square centimetres. For male participants (AMA_M), the formula is Eq. 2. For female participants (AMA_F), the formula is Eq. 3.

$$AMA_M = \left(\frac{MAMC}{3.14 \times 4}\right)^2 - 10 \quad (2)$$

$$AMA_F = \left(\frac{MAMC}{3.14 \times 4}\right)^2 - 6 \quad (3)$$

These formulas adjust the *MAMC* to estimate skeletal muscle area by accounting for sex-specific differences in body composition, with units standardized to square centimetres for consistency in anthropometric analyses.

Detection of biochemical indicators

Peripheral venous blood samples were collected from the children in the morning after an overnight fast, during the interval between dialysis sessions. The following biochemical indicators were determined:

- albumin (*ALB*) – measured using the bromomethyl phenol green method [7], the normal reference value is ≥ 35 mg·ml^{-1};
- prealbumin (*PA*) – quantified via immunotransmission turbidimetry [7], the normal reference value is ≥ 0.2 mg·ml^{-1};
- cholesterol (*CHOL*) – determined using the COD-CE-PAP enzyme method [7], the normal reference value is ≥ 2.59 mmol·l^{-1};
- transferrin (*TF*) – measured by enzyme-linked immunosorbent assay (ELISA) [8];
- leptin (*LEP*) – quantified using enzyme-linked immunosorbent assay (ELISA) [9];
- insulin-like growth factor-1 (*IGF*-1) – determined via enzyme-linked immunosorbent assay (ELISA) [10].

Measurement of resting energy expenditure

The medical graphics cart desktop analysis system CCM metabolic Vehicle (MedGraphics, St. Paul, Minnesota, USA) was used. It consists of a microcomputer, a pressure sensor, a zirconia oxygen analyser, and an infrared CO_2 analyser. Using each breath method to measure the ventilation, O_2 concentration and CO_2 concentration, according to the indirect calorimetric energy conservation and chemical reaction equal ratio law, through the computer aid, the body in a certain period of time oxygen consumption (V_{O2}) and carbon dioxide production (V_{CO2}).

On the non-dialysis day, 2 h after eating, the child enters a quiet environment, room temperature ± 20 °C. A room with temperature set to 20 °C, lying flat for 30 min, wearing a mask to measure for 20 min, the computer calculates the actual *REE* of the child by measuring the changes in O_2 and CO_2 before and after exhalation. At the same time, the computer calculated the predicted *REE* value according to the energy expenditure prediction formula (Harris-Benedict formula), and compared the actual measured *REE* value with the predicted *REE* value.

Statistical methods

The anthropometric indices, biochemical indices and *REE* values were compared and the correlation analysis was made. Analysis of variance was used to test the significance of pairwise comparison between multiple group means. For data with non-normal distribution, median and quartile spacing were used to represent their mean level and discrete trend, and rank sum test was used for hypothesis test. $P < 0.05$ was considered statistically significant.

RESULTS AND DISCUSSION

Anthropometric indicators

Among the 15 children, 10 were males (66.7 %) and 5 were females (33.3 %). The youngest age was 6 years 7 months, the oldest was 16 years 4 months, and the median age was 13 years. Among the 15 cases, the primary disease was glomerular disease in 2 cases, congenital kidney and urinary tract malformation in 10 cases, haemolytic uremic syndrome in 1 case, anti-neutrophil cytoplasmic antibody-associated vasculitis in 1 case, and hereditary nephropathy in 1 case.

The average *BMI* of 15 children was (15.95 ± 2.81) kg·m^{-2}. According to the standardized growth curve of *BMI* of children and adolescents aged 0–18 years in China in 2009, the 3rd to 97th percentile of *BMI* of children of the same age and sex were in the normal nutrition group, with a total of 8 cases, including 5 males and 3 females, with an average *BMI* of (17.69 ± 2.85) kg·m^{-2}. *BMI* below the 3rd percentile of children of the same age and sex was the malnourished group, with 7 cases, including 5 males and 2 females; The mean *BMI* was (13.97 ± 0.63) kg·m^{-2}. Children with *BMI* higher than the 97th percentile of the same age and sex were in the over-nutrition group,

Tab. 1. General information and body mass index of 15 pediatric patients with chronic kidney disease stage 5 on maintenance hemodialysis.

Patient No.	Age (years)	Gender	Primary disease	Height [m]	Weight [kg]	*BMI* [kg·m^{-2}]
1	13.9	Male	CAKUT	1.51	38.1	16.7
2	16.0	Male	CAKUT	1.54	41.7	17.6
3	8.0	Female	Haemolytic uremic syndrome	1.10	19.6	16.2
4	6.6	Female	CAKUT	1.09	17.1	14.4
5	10.0	Female	ANCA-associated vasculitis	1.27	27.7	17.2
6	13.0	Male	CAKUT	1.42	31.1	15.4
7	15.0	Male	CAKUT	1.54	52.4	22.1
8	15.8	Male	Nephrotic syndrome	1.44	45.4	21.9
9	15.2	Female	CAKUT	1.53	33.5	14.3
10	12.0	Male	CAKUT	1.27	22.7	14.1
11	14.3	Male	CAKUT	1.46	29.8	14.0
12	16.3	Female	CAKUT	1.56	36.3	14.9
13	12.0	Male	Hereditary nephropathy	1.50	32.0	14.2
14	9.0	Male	Nephrotic syndrome	1.30	22.1	13.1
15	9.7	Male	CAKUT	1.19	18.7	13.2

BMI – body mass index, CAKUT – congenital anomalies of the kidney and urinary tract, ANCA-associated vasculitis – anti-neutrophil cytoplasmic antibody associated vasculitis.

with 0 cases. General information and *BMI* of 15 paediatric patients with stage 5 CKD on MHD are described in Tab. 1.

The mean *TSF* of the 15 cases was (1.71 ± 0.58) cm. The mean *TSF* of malnutrition group was (1.37 ± 0.20) cm. The average *TSF* of the normal nutrition group was (2.01 ± 0.65) cm. The difference between the two groups was statistically significant, $P = 0.028$.

The mean *MAC* of 15 patients was (20.00 ± 3.21) cm. The mean *MAC* of the malnourished group was (17.79 ± 0.81) cm. The mean *MAC* of normal nutrition group was (21.94 ± 3.30) cm. The difference between the two groups was statistically significant, $P = 0.009$.

The mean *MAMC* of 15 cases was (14.62 ± 1.64) cm. The mean *MAMC* of the malnourished group was (13.48 ± 0.89) cm. The average *MAMC* of the normal nutrition group was (15.63 ± 1.51) cm. The difference between the two groups was statistically significant, $P = 0.006$.

The mean *AMA* of the 15 patients was (8.56 ± 4.52) cm^2. The mean *AMA* in the malnourished group was (5.66 ± 3.38) cm^2. The mean *AMA* of normal nutrition group was (11.10 ± 3.91) cm^2. The difference between the two groups was statistically significant, $P = 0.013$.

Anthropometric indicators in malnourished and normal nutrition groups are shown in Tab. 2.

Biochemical indices

The average *ALB* level was (45.89 ± 11.12) mg·ml^{-1} in 15 cases, and less than 35 mg·ml^{-1} in 3 cases. The average *ALB* level in the malnourished group was (44.78 ± 14.02) mg·ml^{-1}. The average *ALB* level in the normal nutrition

Tab. 2. Anthropometric indicators in malnourished and normal nutrition groups.

Anthropometric indicator	Total (n = 15)	Malnourished group (n = 7)	Normal nutrition group (n = 8)	*P* value
Triceps skinfold [cm]	1.71 ± 0.58	1.37 ± 0.20	2.01 ± 0.65	0.028
Mid-arm circumference [cm]	20.00 ± 3.21	17.79 ± 0.81	21.94 ± 3.30	0.009
Mid-arm muscle circumference [cm]	14.62 ± 1.64	13.48 ± 0.89	15.63 ± 1.51	0.006
Bone-free arm muscle area [cm^2]	8.56 ± 4.52	5.66 ± 3.38	11.10 ± 3.91	0.013

Values represent average ± standard deviation.

group was (46.84 ± 8.74) mg·ml^{-1}. There was no significant difference between them (P = 0.737).

The mean *PA* level of 15 children was (193.32 ± 64.80) mg·ml^{-1}, and that of 9 children was less than 200 mg·ml^{-1}. The average level of *PA* in the malnourished group was (174.99 ± 77.47) mg·ml^{-1}. The average level of *PA* in the normal nutrition group was (209.36 ± 51.22) mg·ml^{-1}. There was no significant difference between them (P = 0.323).

The average *CHOL* level of 15 cases was (5.62 ± 1.24) mmol·l^{-1}, and 0 cases were less than 2.59 mmol·l^{-1}. The average *CHOL* level in the malnourished group was (5.23 ± 1.01) mmol·l^{-1}. The average *CHOL* level in the normal nutrition group was (5.96 ± 1.38) mmol·l^{-1}. There was no significant difference between them (P = 0.271).

The median *TF* was 330.87 nmol·l^{-1}, and the interquartile distance was 368.07 nmol·l^{-1}. The median *TF* was 275.50 nmol·l^{-1} in the malnutrition group and 585.38 nmol·l^{-1} in the normal nutrition group, and there was no statistically significant difference between them (P = 0.487).

The average *LEP* level in the malnourished group was (60.56 ± 22.24) μg·l^{-1}. The average *LEP* level in the normal nutrition group was (17.59 ± 4.00) μg·l^{-1}. The difference between them was statistically significant (P < 0.001).

The mean *IGF*-1 level in the malnourished group was (7.85 ± 0.61) μg·l^{-1}. The average *IGF*-1 level in the normal nutrition group was (27.08 ± 8.72) μg·l^{-1}. The difference between them was statistically significant (P < 0.001).

Tab. 3. Resting energy expenditure measurements and comparisons.

Category	*REE* [kJ·d^{-1}]	*P* value
Measured value	5 437 ± 967	0.493
Predicted value	4 944 ± 894	–
Malnutrition (n = 7)	5 377 ± 1 033	0.696
Normal nutrition (n = 8)	5 473 ± 971	–

REE – resting energy expenditure (average ± standard deviations is given).

Resting energy expenditure

The average measured *REE* value of 15 children was (5 437 ± 967) kJ·d^{-1}. The predicted *REE* value was (4 944 ± 894) kJ·d^{-1}. There was no significant difference between them (P = 0.493). The average *REE* measured in the malnutrition group was (5 377 ± 1 033) kJ·d^{-1}. The average *REE* measured in the normal nutrition group was (5 473 ± 971) kJ·d^{-1}. There was no significant difference between them (P = 0.696). *REE* measurements and comparisons are shown in Tab. 3.

Correlation analysis

The correlation analysis results between anthropometric indicators (*BMI, TSF, MAC, MAMC, AMA*), biochemical indicators (*ALB, PA, CHOL, LEP, IGF*-1) and measured *REE* values of 15 cases in this study are shown in Tab. 4, and no correlation was found.

Tab. 4. Correlation analysis of resting energy expenditure with anthropometric and biochemical indicators in 15 cases.

Indicator	Designation	*REE*	
		r	*P* value
Anthropometric indicators			
Body mass index [kg·m^{-2}]	*BMI*	0.383	0.159
Triceps skinfold [cm]	*TSF*	0.130	0.645
Mid-arm circumference [cm]	*MAC*	–0.001	0.998
Mid-arm muscle circumference [cm]	*MAMC*	–0.145	0.607
Bone-free arm muscle area [cm]	*AMA*	0.206	0.462
Biochemical indicators			
Albumin [mg·ml^{-1}]	*ALB*	0.146	0.604
Prealbumin [mg·ml^{-1}]	*PA*	0.062	0.826
Cholesterol [mmol·l^{-1}]	*CHOL*	–0.137	0.627
Leptin [μg·l^{-1}]	*LEP*	–0.149	0.597
Insulin-like growth factor-1 [μg·l^{-1}]	*IGF*-1	0.270	0.330

REE – resting energy expenditure, *r* – Pearson correlation coefficient.

DISCUSSION

Malnutrition is a common complication of childhood CKD and a significant threat to long-term survival and quality of life in children with MHD. Malnutrition can cause growth retardation, intellectual retardation, and reduced immune function in children, which is an important reason for poor prognosis of children [11, 12]. Current studies have shown that the occurrence of malnutrition in CKD patients is related to the levels of relevant hormones, reduced nutrient intake, microinflammatory status in the body, residual kidney function and other factors, and the adequacy of dialysis in MHD patients also has an impact on the occurrence of malnutrition [13, 14]. In this study, children with CKD maintenance haemodialysis were selected as the research object, and anthropometric and biochemical indices were selected to evaluate the nutritional status of children. The influence of *REE* measurement on the nutritional status of children and the possibility of using it as an objective evaluation index were analysed and discussed. In the study of 15 children with CKD stage 5 MHD, the ratio of normal nutrition group to malnourished group was 1.14 : 1, and no children in the over-nutrition group were found.

TSF, MAC, MAMC and *AMA* are all commonly used anthropometric indices to judge the nutritional status of adults. *TSF* is an indicator of subcutaneous fat consumption, and is used to evaluate the degree of energy deficiency or obesity. Studies have found that the combination of *TSF* and *MAMC* can more accurately evaluate the nutritional status and prognosis of patients. In this study, it was found that there were significant differences in the above 4 anthropometric indicators between the normal nutrition group and the malnourished group, but it was also found that the interference factors such as oedema at the measurement site substantially affected the measurement results in children.

ALB and other biochemical parameters have long been considered as reliable indicators for monitoring nutritional status. In this study, it was found that there was no significant difference between *ALB, PA, CHOL* and *TF* in the normal nutrition group and the malnourished group, suggesting that *ALB, PA, CHOL* and *TF* should not be used as the evaluation indicators of nutritional status alone.

LEP is a protein hormone secreted by adipose cells, which can inhibit appetite, increase protein breakdown and inhibit fat synthesis. *LEP* is not only cleared by the kidney, but also has the expression of its receptors in the kidney tissue. Studies have shown that *LEP* is an important link between energy balance, nutritional status and immune function in CKD maintenance dialysis patients [15]. This study found that there was a significant difference in *LEP* level between children in the normal nutrition group and the malnourished group, and the *LEP* level of children in the malnourished group was significantly higher than that in the normal nutrition group.

The synthesis of *IGF*-1 is affected by a variety of hormones and nutritional factors. Studies have found that the effect of *IGF*-1 is the opposite of *LEP*, and *IGF*-1 can directly inhibit the secretion of *LEP* in adipose tissue, and *IGF*-1 has a short half-life, so it can be used as a good indicator to evaluate malnutrition [16]. This study found that there was also a significant difference in *IGF*-1 level between children in the normal nutrition group and the malnourished group. Contrary to the *LEP* level, the *IGF*-1 level of children in the malnourished group was significantly lower than that in the normal nutrition group.

Energy metabolism is mainly composed of basic energy consumption, active metabolism, special dynamic action of food, and growth and development consumption. Basal energy expenditure refers to the energy expenditure of the human body when it is awake and extremely quiet and is not affected by muscle activity, ambient temperature, food and mental stress. *REE* refers to the human body energy consumption measured by fasting for more than 2 h, lying flat or sitting quietly for more than 30 min at an appropriate temperature. Clinically, resting energy consumption is often measured to replace basic energy consumption. In the past, *REE* measurement results of CKD maintenance haemodialysis patients were different. Some studies found that *REE* in haemodialysis patients was higher than that in healthy people [17]. There are also studies that there is no difference in *REE* between haemodialysis patients and healthy people [18]. Normal kidney energy consumption accounts for 20 % of resting energy consumption, while kidney energy consumption in CKD patients is less than that in healthy people, so *REE* value is lower than that in healthy people. However, haemodialysis treatment, uremic toxin, acidosis, anaemia, microinflammation and other factors may increase the energy consumption of patients. This study found that there was no significant difference between the measured *REE* value and the predicted *REE* value calculated by the Harris-Benedict formula in 15 children with CKD, and there was no significant difference between the measured *REE* value and the predicted *REE*

value in the normal nutrition group and the malnourished group. At the same time, no correlation was found between anthropometric indices, biochemical indices and measured *REE* value, which may be related to the limited number of samples.

A study conducted by Ramos-Acevedo et al. [19] on 71 non-dialysis patients with CKD stages 3–5 employed indirect calorimetry to measure *REE*, bioelectrical impedance analysis to assess body composition, handgrip strength testing, and subjective global assessment (SGA) to evaluate nutritional status. The study identified fat-free mass, body weight, nutritional status (SGA score), hypertension, sex and age as significant predictors of *REE*. Malnutrition (SGA B/C) was significantly associated with lower *REE* [19]. This work provides a more comprehensive model for estimating *REE* in CKD patients and indicates that simple formulas may be inaccurate, particularly for patients with low energy expenditure. It recommends using specific formulas that incorporate body weight and nutritional status for more personalized assessment.

The current study had a relatively small sample size; future research will expand the sample size to reduce data bias and error. Furthermore, previous studies have shown that pubertal development significantly increases basal metabolic rate [20]. Therefore, with a sufficient sample size in the future, stratifying child subjects into pre-pubertal, pubertal, and post-pubertal stages may help clarify the relationship between *REE* and various measured indicators.

CONCLUSIONS

While this study with a limited sample size (n = 15) did not demonstrate the utility of *REE* as a marker for nutritional status in paediatric CKD patients on MHD, the findings highlight the need for further investigation. The lack of correlation between *REE* and nutritional indices may be attributed to the small cohort and inherent metabolic complexities in CKD. The presented limited sample set did not reveal usefulness of *REE* in evaluating nutritional status of the patients, but more data from bigger sample set would provide a clearer picture. Until such data are available, *REE* measurement alone cannot be recommended for routine nutritional assessment in paediatric CKD, though it may hold promise as part of comprehensive metabolic profiling with increased evidence.

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REFERENCES

1. Yasuhara, S. – Maekawa, M. – Bamba, S. – Kurihara, M. – Nakanishi, N. – Yamamoto, T. – Sakai, H. – Yagi, N. – Nakagawa, Y. – Sasaki, M.: Energy metabolism and nutritional status in hospitalized patients with chronic heart failure. Annals of Nutrition and Metabolism, *76*, 2020, pp. 129–139. DOI: 10.1159/000507355.
2. Wu, J. – Huang, C. – Xiao, H. – Tang, Q. – Cai, W.: Weight loss and resting energy expenditure in male patients with newly diagnosed esophageal cancer. Nutrition, *29*, 2013, pp. 1310–1314. DOI: 10.1016/j.nut.2013.04.010.
3. Ocagli, H. – Lanera, C. – Azzolina, D. – Piras, G. – Soltanmohammadi, R. – Gallipoli, S. – Gafare, C. E. – Cavion, M. – Roccon, D. – Vedovelli, L. – Lorenzoni, G. – Gregori, D.: Resting energy expenditure in the elderly: systematic review and comparison of equations in an experimental population. Nutrients, *13*, 2021, article 458. DOI: 10.3390/nu13020458.
4. Herrington, W. G. – Smith, M. – Bankhead, C. – Matsushita, K. – Stevens, S. – Holt, T. – Hobbs, F. D. – Coresh, J. – Woodward, M.: Body-mass index and risk of advanced chronic kidney disease: Prospective analyses from a primary care cohort of 1.4 million adults in England. PLoS One, *12*, 2017, article e0173515. DOI: 10.1371/journal.pone.0173515.
5. Li, H. – Ji, C. Y. – Zong, X. N. – Zhang, Y. Q.: Height and weight standardized growth charts for Chinese children and adolescents aged 0 to 18 years. Zhonghua Er Ke Za Zhi (Chinese Journal of Pediatrics), *47*, 2009, pp. 487–492. DOI: 10.3760/cma.j.issn.0578-1310.2009.07.003. In Chinese.
6. Li, H. – Ji, C. Y. – Zong, X. N. – Zhang, Y. Q.: Body mass index growth curves for Chinese children and adolescents aged 0 to 18 years. Zhonghua Er Ke Za Zhi (Chinese Journal of Pediatrics), *47*, 2009, pp. 493–498. DOI: 10.3760/cma.j.issn.0578-1310.2009.07.004. In Chinese.
7. Block, D. R. – Cotten, S. W. – Franke, D. – Mbughuni, M. M.: Comparison of five common analyzers in the measurement of chemistry analytes in an authentic cohort of body fluid specimens. American Journal of Clinical Pathology, *158*, 2022, pp. 47–61. DOI: 10.1093/ajcp/aqab218.
8. Wang, H. – Shang, H. – Wang, L.: Laboratory diagnostics. 2th ed. Beijing : People's Medical Publishing House, 2010. ISBN: 9787117130141. In Chinese.
9. Akib, R. D. – Aminuddin, A. – Hamid, F. – Prihantono, P. – Bahar, B. – Hadju, V.: Leptin levels in children with malnutrition. Gaceta Sanitaria, *35*, 2021, pp. S278–S280. DOI: 10.1016/j.gaceta.2021.10.033.
10. Wan, X. – Lu, X.: Diagnostics. 9th edition. Beijing :

People's Medical Publishing House, 2018. ISBN: 9787117263740. In Chinese.
11. Rees, L. – Mak, R. H.: Nutrition and growth in children with chronic kidney disease. Nature Reviews Nephrology, *7*, 2011, pp. 615–623. DOI: 10.1038/nrneph.2011.137.
12. Rees, L.: Protein energy wasting; what is it and what can we do to prevent it? Pediatric Nephrology, *36*, 2021, pp. 287–294. DOI: 10.1007/s00467-019-04424-2.
13. Shen, C. L. – Liebstein, D. – Fernandez, H.: Malnutrition and protein energy wasting are associated with severity and progression of pediatric chronic kidney disease. Pediatric Nephrology, *39*, 2024, pp. 243–250. DOI: 10.1007/s00467-023-06078-7.
14. Mastrangelo, A. – Paglialonga, F. – Edefonti, A.: Assessment of nutritional status in children with chronic kidney disease and on dialysis. Pediatric Nephrology, *29*, 2014, pp. 1349–1358. DOI: 10.1007/s00467-013-2612-7.
15. Coimbra, S. – Rocha, S. – Valente, M. J. – Catarino, C. – Bronze-da-Rocha, E. – Belo, L. – Santos-Silva, A.: New insights into adiponectin and leptin roles in chronic kidney disease. Biomedicines, *10*, 2022, article 2642. DOI: 10.3390/biomedicines10102642.
16. Brown, D. D. – Dauber, A.: Growth hormone and insulin-like growth factor dysregulation in pediatric chronic kidney disease. Hormone Research in Pediatrics, *94*, 2021, pp. 105–114. DOI: 10.1159/000516558.
17. Painter, P. – Krasnoff, J. – Mathias, R.: Exercise capacity and physical fitness in pediatric dialysis and kidney transplant patients. Pediatric Nephrology, *22*, 2007, pp. 1030–1039. DOI: 10.1007/s00467-007-0458-6.
18. Kamimura, M. A. – Draibe, S. A. – Avesani, C. M. – Canziani, M. E. – Colugnati, F. A. – Cuppari, L.: Resting energy expenditure and its determinants in hemodialysis patients. European Journal of Clinical Nutrition, *61*, 2007, pp. 362–367. DOI: 10.1038/sj.ejcn.1602516.
19. Ramos-Acevedo, S. – Rodríguez-Gómez, L. – López-Cisneros, S. – González-Ortiz, A. – Espinosa-Cuevas, Á.: Nutritional status and other clinical variables are associated to the resting energy expenditure in patients with chronic kidney disease: a validity study. Frontiers in Nutrition, *9*, 2022, article 881719. DOI: 10.3389/fnut.2022.881719.
20. Bitar, A. – Fellmann, N. – Vernet, J. – Coudert, J. – Vermorel, M.: Variations and determinants of energy expenditure as measured by whole-body indirect calorimetry during puberty and adolescence. The American Journal of Clinical Nutrition, *69*, 1999, pp. 1209–1216. DOI: 10.1093/ajcn/69.6.1209.

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