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ORIGINAL RESEARCH / *ÖZGÜN ARAŞTIRMA*

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Comparison of Calculated and Measured Energy Expenditure Determination Methods

Hesaplanan ve Ölçülen Enerji Tüketimi Belirleme Yöntemlerinin Karşılaştırılması

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ABSTRACT *Objective:* Indirect calorimetry (IC) is considered the gold standard in the accurate determination of energy consumption in intensive care patients. This study compared measured energy expenditure (MEE) with estimated energy expenditure (EEE), calculated from predictive equations, in mechanically ventilated patients.
Materials and Methods: This study was conducted on 40 patients hospitalized in our medical/surgical intensive care unit. Twenty four-hour energy consumption measured by IC and energy consumption calculated by adding correction factors for actual and corrected weights using Harris-Benedict, Schofield, Ireton-Jones and Swinamer equations were compared.
Results: MEE was 2697.9±606.0 kcal/day. All of the EEE values, calculated using equations were moderately correlated with MEE and correlations were stronger with adjusted body weights, however, Bland-Altman statistics represent wide limits of agreement. From another perspective, EEE corresponding to between 80% and 110% of MEE was considered an adequate feeding range and provided the best levels of proficiency using adjusted body weight and Long factors; however, at least, 20% of patients remained at under-or overfeeding risk.
Conclusion: It was concluded that the estimation equations are unreliable in determining energy consumption in mechanically ventilated intensive care patients due to wide limits of agreement. Estimates falling in the range of 80-110% of MEE also indicate the possibility of malnutrition. Our study supports previous studies, which indicated that nutrition management requires an individual approach.
Keywords: Indirect calorimetry, estimating energy expenditure, mechanical ventilation, nutrition, intensive care unit

ÖZ *Amaç:* Yoğun bakım hastalarında enerji tüketiminin doğru belirlenmesinde indirekt kalorimetri (İK) altın standart olarak kabul edilir. Bu çalışmanın amacı mekanik ventilasyon uygulanan hastalarda ölçülen enerji tüketimini (ÖET), tahmin ettirici eşitliklerle hesaplanan enerji tüketimi (HET) ile karşılaştırmaktır.
Gereç ve Yöntem: Bu çalışma tıbbi/cerrahi yoğun bakım ünitemize yatırılan kırk hasta üzerinde yapıldı. İK ile ölçülen 24 saatlik enerji tüketimi ile Harris-Benedict, Schofield, Ireton-Jones ve Swinamer denklemleri kullanılarak aktüel ve düzeltilmiş kilolara göre, düzeltme faktörleri de eklenerek karşılaştırıldı.
Bulgular: ÖET'nin ortalaması 2697,9±606,0 kcal/gün olarak bulundu. Eşitlikler kullanılarak hesaplanan tüm HET değerleri ÖET ile koreleydi ve düzeltilmiş kilolar ile korelasyon güçlenmekteydi, bununla birlikte Bland-Altman analizi uyum limitlerinin geniş olduğunu gösterdi. HET'nin ÖET'nin %80 ve %110 arasına tekabül etmesi yeterli beslenme aralığı olarak kabul edildi ve düzeltilmiş vücut ağırlığı ve Long faktörlerinin kullanılması ile en iyi yeterlilik düzeylerini sağladı; ancak en iyi ihtimalde bile hastaların %20'sinin düşük veya yüksek beslenme riski altındaydı.
Sonuç: Geniş uyum limitleri nedeniyle mekanik ventilasyon uygulanan yoğun bakım hastalarında enerji tüketimini belirlemede tahmin denklemlerinin güvenilir olmadığı sonucuna varılmıştır. ÖET'nin %80-110'u aralığına giren tahminler de yetersiz beslenme ihtimalini işaret etmektedir. Çalışmamız, beslenme yönetiminin bireysel yaklaşım gerektirdiğini işaret eden çalışmaları desteklemektedir.
Anahtar Kelimeler: İndirekt kalorimetri, enerji tüketiminin tahmini, mekanik ventilasyon, beslenme, yoğun bakım ünitesi

Introduction

Nutrition is one of the most important parts of critical care. Underfeeding leads to increase infections, organ failure, risk of mortality and prolonged mechanical ventilation, and length of hospital stay. Hyperglycemia, hyperlipidemia, hepatic steatosis, azotemia, hypercapnia, and increased mortality are considered complications related with overfeeding. Therefore determining adequite energy needs prevent critically ill patients from the harmful effects of overfeeding and underfeeding (1,2).

Indirect calorimetry (IC) devices measure energy expenditure (MEE). The working principle of indirect calorimeter is described by Weir Equation obtained from the values of inspired oxygen (VO_2) and expired carbon dioxide (VCO_2) (3). IC is the gold standard for assessing EE and for managing nutrition in critically ill patients (1,4). European Society for Clinical Nutrition and Metabolism (ESPEN) and American Society for Parenteral and Enteral Nutrition guidelines recommended IC, in critical care settings (1,4-6). IC devices are expensive and measuremets are time-consuming and needs trained staff. Therefore, predictive equations have been more commonly used to predict EE in critically ill patients (2,4,5,7).

This study aims to compare widely used four predictive equations [Harris-Benedict (HB), Schofield (SCH), Ireton-Jones (IJ), and Swinamer (SW)] with IC measurements in mechanically ventilated patients within the first 48 hours of admission.

The association between MEE and Acute Physiology and Chronic Health Evaluation II (APACHE-II) and Simplified Acute Physiology score II (SAPS II) scores, was also investigated.

Materials and Methods

After Selçuk University Meram Faculty of Medicine Ethics Committee approval (decision no: 2007/167, date: 23.07.2007), written informed consent was obtained from the legal guardians of the patients. Mechanically ventilated patients, within the first 48 hours of admission were included in this study.

Patients younger than 18 years old, needed FiO_2 >0.6 or positive end-expiratory pressure >12 cm H_2O, had a chest tube leak, were ventilated via tracheostomy, underwent lobectomy or pneumonectomy operation, with an amputated limb, and required continuous renal replasman therapy were excluded.

Patients whose measurements were not completed due to extubation or exitus and whose respiratory quotient (RQ) values were measured outside of physiological values (<0.7 or >1.3) were not included in the study.

Patients' primary diagnosis, height, weight, age, and gender were recorded. Patients were grouped according to their body mass index (BMI): BMI <19 kg/m^2, BMI between 19-29.9 kg/m^2, and BMI ≥30 kg/m^2 in order to calculate adjusted body weights (ABW) for underweight and obese patients using predictive equations (8).

HB, SCH, IJ, and SW equations were used to calculate estimated energy expenditure (EEE). Previous studies have reported better results with a correction coefficient between 1.1 and 1.6 (8-10). Long factors are coefficient factors related to the patient's mobility and disease severity and are used as adjustment factors for calculating EEE with HB equation (11). For this reason, the results calculated by HB and SCH equations were multiplied by 1.3 and 1.6 and the results calculated by HB equation were also calculated by adding Long factors (Table 1).

Pressure or volume-targeted assist/- controlled ventilation modes were used in accordance with the cause of respiratory failure and patients' requirements. Patients were given sedatives and analgesics either to avoid ventilator asynchrony or to reduce pain and anxiety for achieving Ramsey sedation score 2-3 if needed. IC measurement was performed via the Datex-Ohmeda M-CAiOVX module (GE Healthcare/Datex-Ohmeda, Helsinki, Finland) for 24 hours, and mean MEE values were recorded for each patient.

Routine nursing care including suctioning, daily body care, and repositioning was performed in accordance with the general principles of intensive care.

All patients were receiving nutritional support based on ESPEN guidelines on clinical nutrition in the intensive care unit (5). Standard isocaloric enteral formulas were used for enteral nutrition. The parenteral route was used when enteral nutrition was insufficient or not possible.

APACHE-II and SAPS II were recorded within 24 hours of the study period.

Table 1. Long factors

Activity factor	Use	Injury factor	Use
Confined to bed	1.2	Minor operation	1.2
Out of bed	1.3	Skeletal trauma	1.35
		Sepsis	1.6
		Severe thermal burn	2.1

Agreement was defined as EEE within 80% and 110% of MEE, in accordance with the literature (12,13). The frequency of EEE, using study equations within 80-110%, below 80%, and above 110% was calculated.

Data are presented as mean ± standard deviation (SD). P values <0.05 were accepted statistically significant for the Pearson correlation test and p<0.0001 for Bland-Altman analysis with 95% confidence intervals.

Statistical Analysis

Statistical software program (SPSS 12.0 2003, SPSS Inc., Chicago, IL, USA) and MedCalc software (Mariakerke, Belgium) were used for statistical analysis. Descriptive statistical methods (mean, SD, frequency) were used for data analysis. Pearson correlation was used to determine the relationship between MEE, and EEE values of the equations, APACHE-II, and SAPS II scores. Bland-Altman limits of agreement analysis were undertaken to determine the extent of error with MEE and EEE.

Results

Fifty-seven patients were enrolled in the study. After excluding seven patients due to the RQ values outside of the physiological quotient, five patients due to extubation, three patients because of death, and 2 patients as their oxygen requirements rose above 0.6; the study was conducted with forty patients (Table 2).

Patients whose BMI were between 19.9-29.9 accounted for 72.5% (n=29). Three (7.5%) of the remaining were underweight, while eight (20%) of them were overweight/obese. Since the study was conducted in a mixed intensive care unit both medical and surgical patients have been included in the study. Sepsis (n=12, 30%), multiple trauma (n=8, 20%), intracranial hemorrhage (n=7, 17.5%), Guillain-Barré syndrome (n=5, 12.5%), HELLP syndrome (n=4, 10%) were predominant causes of admission, the rest of them were admitted for other medical conditions. Four of the sepsis patients (33.3%), two of the multi-trauma patients (20%) and two of the intracranial hemorrhage patients (28.6%), and all of the HELLP patients (n=4) were admitted after surgery.

All of the EEE, calculated by equations were moderately correlated with MEE and correlations were stronger with ABW: HB =0.62 and HBadj =0.87; SCH =0.55 and SCHadj =0.82; IJ =0.52 and IJadj =0.85; SW =0.57 (p<0.05).

Bland Altman's analysis showed wide limits of agreement for all equations and in all adjustment groups (Table 3) (Figure 1). Therefore, these wide limits of agreements emphasize the potential under-or overfeeding with a nutrition protocol based on predictive equations.

From the point of view of 80-110% of MEE, HB with ABW and Long factors represents the best fit with 80% adequacy. This context of definition showed the benefits of Long factors and ABW, in general (Table 4).

Mean ± SD in MEE was 2697,9±606.0 kcal/day. Mean ± SD values of APACHE-II and SAPS II were 20.6±8.8 and 47.9±19.9, respectively. There was no correlation between MEE and severity scores (p<0.05).

Table 2. Patient characteristics

Variables		Number of patients	Mean ± SD
Sex	F	16	
	M	24	
Age (years)		40	45.8±18.9
Height (cm)		40	166.5±10.2
Body weight (kg)		40	73.9±15.6
BMI (kg/m^2)		40	26.7±5.7
BSA (m^2)		40	1.8±0.2
APACHE-II		40	20.6±8.8
SAPS II		40	47.9±19.9
MEE (kcal/day)		40	2697,9±606.0

F: Female, M: male, SD: standard deviation, BMI: body mass index, BSA: body surface area, APACHE-II: Acute Physiology and Chronic Health Evaluation II, SAPS II: Simplified Acute Physiology score, MEE: measured energy expenditure

Table 3. Bland-Altman analysis: Differences between MEE and EEE calculated using different prediction equations, adjusted body weights, and correction factors		
Bland-Altman tests	**Bias**	**r (p)**
HB	-1145±77.7	0.80 (<0.0001)
HBx1.3	-678±75.5	0.71 (<0.0001)
HBx1.6	-272±78.3	0.10 (=0.0013)
HBxL	-91±62.5	-0.07 (>0.0001)
HBadj	-1071±88.3	0.58 (<0.0001)
HBadjx1.3	-768±80.1	0.54 (<0.0001)
HBadjx1.6	-319±76.8	0.22 (=0.0002)
HBadjxL	-141±59.9	0.08 (=0.0235)
SCH	-999±88.5	0.62 (<0.0001)
SCHx1.3	-670±85.7	0.53 (<0.0001)
SCHx1.6	-192±86.0	0.08 (=0.0310)
SCHadj	-1019±92.8	0.58 (<0.0001)
SCHadjx1.3	-705±85.1	0.52 (<0.0001)
SCHadjx1.6	-234±84.9	0.16 (=0.0080)
I-J	-590±83.8	0.60 (<0.0001)
I-Jadj	-657±82.4	0.64 (<0.0001)
SW	-1115±83.7	0.62 (<0.0001)

HB: Harris-Benedict, SCH: Schofield, I-J: Ireton-Jones, SW: Swinamer, MEE: measured energy expenditure, EEE: estimated energy expenditure

Discussion

The results of the study showed that none of the equations is sufficient to determine the actual caloric needs of the patients, and even when using estimated values corresponding to 80-110%, at least 20% of the patients are under- or overfed.

Optimal nutrition constitutes one of the important treatment components in reducing mortality and morbidity in intensive care patients. IC is accepted as the gold standard for determining resting EE (1,2). There are different types of IC devices in the market. In this study, M-CAiOVX modules, integrated into the hemodynamic monitors (GE Healthcare/ Datex-Ohmeda, Helsinki, Finland) were used. This module has the advantages of continuous gas sampling and measurement of EE and is user-friendly.

It is known intermittent measurements of REE have shown wide variations. Activities within routine nursing care have been shown associated with increased EE and the more clinically stable patients demonstrated less variability in measurements. Continuous measurement was preferred because; especially in the first few days of admission to the intensive care unit, only a few patients could reach to required stability for short-term or intermittent IC measurements (14).

Mean MEE was 2697,9±606 kcal/day and was higher than in previous studies (12-15). However, Reid (12) studied 27 patients for five days and use the mean value of the days. In our study, measurements were commenced within 48 hours of admission, and only for 24 hours, Sungurtekin et al. (15) conducted a study on 100 patients, according to a 30-minute duration protocol. Short-duration measurements, at a steady-state condition, may not reflect 24 hours. Because, energy costs associated with interventions during daily nursing care such as aspiration, repositioning, and pulmonary physiotherapy are not reflected in the measurements (7). In addition, the study population (mean age 45.8 years) was younger than previous studies that found lower MEE (12,15,16), but on the other hand, the mean MEE value of the study was similar to a study in which mean age of the patients were comparable (14). Furthermore, the high prevalence of surgery and trauma patients might have contributed to the high MEE values.

Predictive equations are found moderately correlated with IC and the correlation was even stronger when correction coefficients were added. These findings are consistent with the previous studies (7,8,12,15). However, Bland Altman's analysis showed that the agreement between MEE and the EEE values of the four equations was poor. This poor agreement did not change when different correction factors or Long coefficient factors and/or ABW of MEE were used. The lowest bias was found with SCH equation, added Long factor (0.1±65.8 kcal/day), but even here, the limits of agreements were wide (-815/816 kcal/day).

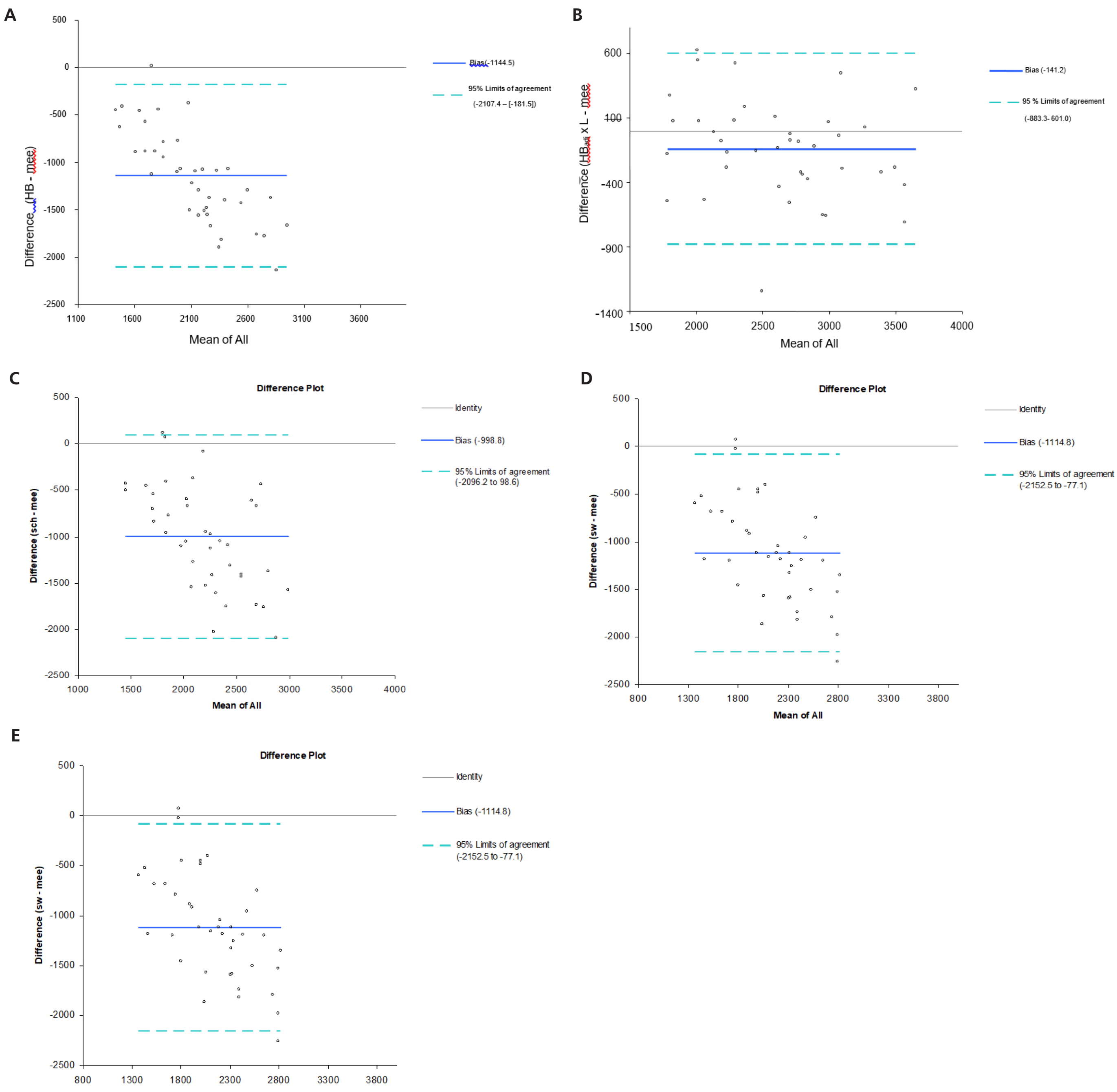

Figure 1. Bland-Altman plots. Differences between measured energy expenditure (MEE) and estimated energy expenditure calculated using different prediction equations: **(A)** MEE versus Harris-Benedict (HB) equation; **(B)** MEE versus HB equation with adjusted body weight, and Long factor; **(C)** MEE versus Schofield (SCH) equation **(D)** MEE versus Ireton-Jones (IJ) equation; **(E)** MEE versus Swinamer (SW) equation

Table 4. Number (%) of energy expenditure estimates (calculated using the different equations and adjustments) within 80% and 110% of MEE values and the number (%) of estimates that would result in under (<80% MEE) and overfeeding (>110% MEE)

Equation	Mean ± SD	Percentage of EEE <80% of MEE	Percentage of EEE within 80-110% of MEE	Percentage of EEE >110% of MEE
MEE	2698±606			
HB	1553±250	95.0	5.0	0.0
HBx1.3	2020±326	70.0	27.5	25.0
HBx1.6	2478±397	20.0	62.5	17.5
HBxL	2067±547	10.0	72.5	17.5
HBadj	1524±242	95.0	5.0	0.0
HBadjx1.3	1982±315	72.5	25.0	2.5
HBadjx1.6	2431±383	25.0	60.0	15.0
HBadjxL	2556±523	7.5	80	12.5
SCH	1599±244	92.5	7.5	0.0
SCHx1.3	2083±318	57.5	40.0	2.5
SCHx1.6	2559±391	20.0	55.0	25.0
SCHadj	1573±237	20.0	55.0	25.0
SCHadjx1.3	2049±309	60.0	37.5	2.5
SCHadjx1.6	2517±380	22.5	55.0	22.5
I-J	2055±306	65.0	27.5	7.5
I-Jadj	2041±311	65.0	27.5	7.5
SW	1515±316	95.0	5.0	0.0

HB: Harris-Benedict, SCH: Schofield, I-J: Ireton-Jones, SW: Swinamer, MEE: measured energy expenditure, SD: standard deviation

When the frequency of EEE values corresponding to <80% below, 80-110%, and 110% above the MEE were calculated, HB with ABW and Long factors addition found the most reliable equation. 80% of patients were found within the adequate range; 5% were in underfeeding, and 12.5% were in overfeeding categories. Although the use of ABW in the calculation of energy consumption is still controversial (17), in our study, using ABW for both HB and SCH equations provided lower overestimation and higher adequate estimations. However, these results may still be unreliable, at least 20% of patients likely to receive inaccurate feeding.

These findings were correlated with those published in the literature (12,13,15,18). Reid (12) compared IC with HB, SCH, and American College of Chest Physicians equation in 27 critically ill patients with 192 days of measurements, and found wide limits of agreement with Bland Altman analysis in their study.

According to the aforementioned percentage approach, the number of patients in the adequate feeding range was highest when the ABW and Long factors were used; however, it is important to realize that a high proportion of patients are at risk of under- or overfeeding.

Faisy et al. (18) compared HB equation with IC in their study, which was conducted on 70 mechanically ventilated patients. They found a mean bias of 73±502 kcal/day between MEE and calculated EE and the limits of agreements between the two methods were -932/-1078. In another study conducted with 100 mechanically ventilated patients, predictive values of HB, SCH, SW, IJ, and Penn State equations were investigated (15). High confidence intervals indicated the equations unreliability of the equations. De Waele et al. (16) found an unacceptable correlation between elderly and obese critically ill patients, in a study, they examined three hundred and twenty-five IC measurements of 161 patients' recordings to determine the agreement between eleven predictive equations and IC. Recently, Zusman et al. (13) concluded a retrospective validation study with different predictive equations and Long correction factor addition. They analyzed a total of 3573 REE measurements of 1440 patients and found that HB with a correction factor of 1.3 showed the highest correlation, while none of the equations provided acceptable percentages of adequate feeding (85-115%).

Although previous studies have been conducted on different patient groups and with different methods, all have pointed out that the predictive equations are unreliable in EEE (12,13,15,18). Studies suggested an individualized nutritional approach due to the individual and iatrogenic factors, which might cause highly variable EEs among patients (1,19). It is also reported that adding Long factors provided more accurate estimates for each patient than adding a standard coefficient factor for all. These findings supported the individual management of nutrition (11,15,18).

The correlation between illness severity scores and MEE is still debated. Swinamer et al. (7) reported a good correlation between APACHE-II scores and MEE, but on the other hand, Brandi et al. (20) and Sungurtekin et al. (15) documented that there was no correlation between disease severity and EE. Our results also indicated that there was no correlation between APACHE-II and SAPS II scores, and MEE.

The study has limitations. First of all, it is a single-center study and conducted on a heterogenic patient population. Therefore, although heterogeneous, its small sample size was not enough for detailed subgroup analysis. The second limitation is the evaluation of only four equations despite a huge amount of equations being defined in the literature.

Conclusion

This study confirms the variability of EE among critically ill patients and pointed out the importance of IC. Although its small sample size, this study, like many before it, showed that, the level of accuracy of predictive equations was insufficient in mechanically ventilated patients. Wide limits of agreement and high overestimation and underestimation ratios indicate that, with equation-based nutrition, critically ill patients are at notable risk of under-or overfeeding.

Ethics

Ethics Committee Approval: Ethics committee approval was obtained from the Selçuk University Meram Faculty of Medicine (decision no: 2007/167, date: 23.07.2007).

Informed Consent: Written informed consent was obtained from the legal guardians of the patients.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Concept: M.D., A.Y., Design: M.D., A.Y., Data Collection and Process: M.D., Analysis or Interpretation: M.D., A.Y., Literature Search: M.D., Writing: M.D.

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References

1. Delsoglio M, Achamrah N, Berger MM, Pichard C. Indirect Calorimetry in Clinical Practice. J Clin Med 2019;8:1387.
2. Ndahimana D, Kim EK. Energy Requirements in Critically Ill Patients. Clin Nutr Res 2018;7:81-90.
3. WEIR JB. New methods for calculating metabolic rate with special reference to protein metabolism. J Physiol 1949;109:1-9.
4. Oshima T, Berger MM, De Waele E, Guttormsen AB, Heidegger CP, Hiesmayr M, et al. Indirect calorimetry in nutritional therapy. A position paper by the ICALIC study group. Clin Nutr 2017;36:651-62.
5. Singer P, Blaser AR, Berger MM, Alhazzani W, Calder PC, Casaer MP, et al. ESPEN guideline on clinical nutrition in the intensive care unit. Clin Nutr 2019;38:48-79.
6. McClave SA, Taylor BE, Martindale RG, Warren MM, Johnson DR, Braunschweig C, et al. Guidelines for the Provision and Assessment of Nutrition Support Therapy in the Adult Critically Ill Patient: Society of Critical Care Medicine (SCCM) and American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.). JPEN J Parenter Enteral Nutr 2016;40:159-211.
7. Swinamer DL, Phang PT, Jones RL, Grace M, King EG. Twenty-four hour energy expenditure in critically ill patients. Crit Care Med 1987;15:637-43.
8. Barak N, Wall-Alonso E, Sitrin MD. Evaluation of stress factors and body weight adjustments currently used to estimate energy expenditure in hospitalized patients. JPEN J Parenter Enteral Nutr 2002;26:231-8.
9. Boullata J, Williams J, Cottrell F, Hudson L, Compher C. Accurate determination of energy needs in hospitalized patients. J Am Diet Assoc 2007;107:393-401.
10. MacDonald A, Hildebrandt L. Comparison of formulaic equations to determine energy expenditure in the critically ill patient. Nutrition 2003;19:233-9.
11. Long CL, Schaffel N, Geiger JW, Schiller WR, Blakemore WS. Metabolic response to injury and illness: estimation of energy and protein needs from indirect calorimetry and nitrogen balance. JPEN J Parenter Enteral Nutr 1979;3:452-6.
12. Reid CL. Poor agreement between continuous measurements of energy expenditure and routinely used prediction equations in intensive care unit patients. Clin Nutr 2007;26:649-57.
13. Zusman O, Kagan I, Bendavid I, Theilla M, Cohen J, Singer P. Predictive equations versus measured energy expenditure by indirect calorimetry: A retrospective validation. Clin Nutr 2019;38:1206-10.
14. Frankenfield DC, Coleman A, Alam S, Cooney RN. Analysis of estimation methods for resting metabolic rate in critically ill adults. JPEN J Parenter Enteral Nutr 2009;33:27-36.
15. Sungurtekin H, Karakuzu S, Serin S. Energy Expenditure in Mechanically Ventilated Patients: Indirect Calorimetry vs Predictive Equations.Turkish Journal of Medical & Surgical Intensive Care Medicine/ Dahili ve Cerrahi Bilimler Yoğun Bakım Dergisi 2019;10.
16. De Waele E, Opsomer T, Honoré PM, Diltoer M, Mattens S, Huyghens L, et al. Measured versus calculated resting energy expenditure in critically ill adult patients. Do mathematics match the gold standard? Minerva Anestesiol 2015;81:272-82.
17. Ireton-Jones C. Adjusted body weight, con: why adjust body weight in energy-expenditure calculations? Nutr Clin Pract 2005;20:474-9.
18. Faisy C, Guerot E, Diehl JL, Labrousse J, Fagon JY. Assessment of resting energy expenditure in mechanically ventilated patients. Am J Clin Nutr 2003;78:241-9.
19. Vasileiou G, Qian S, Iyengar R, Mulder MB, Gass LM, Parks J, et al. Use of Predictive Equations for Energy Prescription Results in Inaccurate Estimation in Trauma Patients. Nutr Clin Pract 2020;35:927-32.
20. Brandi LS, Santini L, Bertolini R, Malacarne P, Casagli S, Baraglia AM. Energy expenditure and severity of injury and illness indices in multiple trauma patients. Crit Care Med. 1999;27:2684-9.