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RESEARCH

Review

Energy Balance in Patients with Pressure Ulcers: A Systematic Review and Meta-Analysis of Observational Studies

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ABSTRACT

Medical nutrition therapy is reported to contribute to wound healing. However, effective intervention requires an accurate estimation of individual energy needs, which, in turn, relies on accurate methods of assessment. The primary aims of this systematic review and meta-analysis were to evaluate the resting energy expenditure (REE) of patients with pressure ulcers (PUs) compared to matched control groups and the potential estimation bias of REE predictive equations. The recommended daily energy requirements of patients with PUs were also assessed, along with their energy balance (daily energy requirement vs intake). All language, original, full-text research articles published between January 1, 1950, and July 31, 2010, were searched through electronic databases. Relevant studies were also identified by reviewing citations. Observational (case-control and case-series) studies providing data on measured REE were initially included. Data extracted were measured REE, predicted REE, and daily energy intake. Five studies were included in the meta-analysis. Compared to controls (n=101), patients with PUs (n=92) presented higher measured REE (weighted mean 20.7±0.8 vs 23.7±2.2 kcal/kg/day; $P<0.0001$). In these patients, measured REE was also higher than predicted REE (calculated using the Harris-Benedict formula in all studies; 21.0±1.0 kcal/kg/day; $P<0.0001$), whereas energy intake (n=78; 21.7±3.1 kcal/kg/day) was significantly lower ($P<0.0001$) than total daily requirement, which was calculated as 29.4±2.7 kcal/kg/day. Patients with PUs are characterized by increased REE and reduced energy intake. In the estimation of REE using the Harris-Benedict formula, a correction factor (×1.1) should be considered to accurately assess energy needs. Moreover, an energy intake of 30 kcal/kg/day seems appropriate to cover the daily requirements of patients with PUs.

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Pressure ulcers (PUs) are a widespread problem affecting between 1% and 70% of patients, depending on the health care setting and patients' overall health (1). A PU is defined as "a localized injury to the skin and/or underlying tissue usually over a bony prominence, as a result of pressure or pressure in combination with shear" (2). Along with these factors, malnutrition has also been frequently associated with the occurrence of PUs (3-6). Accordingly, current international guidelines recommend nutrition screening and assessment to identify and treat any imbalance in energy intake vs expenditure (2). Conventional treatment of decubitus ulcers is based on pressure relief (through repositioning protocols and/or appropriate devices) and the use of adequate dressings and topical treatments (1,2). However, it has been demonstrated that medical nutrition therapy can also contribute to the healing process of PUs (2,7,8), and an energy intake of 30 to 35 kcal/kg/day has been recommended. It should be noted that this recommendation is the result of expert consensus (2), based on evidence collected in malnourished patients (9,10), rather than the result of a rigorous methodologic approach.

Planning of effective nutrition interventions requires an accurate estimation of individual energy needs, which, in turn, relies on accurate methods of assessment. Unfortunately, the gold standard method, indirect calorimetry (11), is often not feasible in most settings due to lack of access, technical difficulties, patients who are unable to participate, or the need to limit costs. Accordingly, predictive equations (eg, those by Harris and Benedict) to determine resting energy expenditure (REE) have been introduced in clinical practice (12,13). An accurate prediction of energy needs clearly depends on the accuracy of the predictive equations, and previous studies have reported an estimation bias related to underlying diseases and nutritional status, suggesting the need for the introduction of correction factors (13-17). Because no comprehensive evaluation of the energy needs and the use of predictive equations for REE in patients with PUs is available, the primary aims of this systematic literature review and meta-analysis were to summarize the evidence collected on the REE of PU patients compared to matched controls, evaluate the potential estimation bias deriving from the use of predictive equations for REE, and estimate the recommended total daily energy for this type of patient population. A secondary objective was to evaluate the energy balance of patients with PUs. Accordingly, available data on daily energy intake were compared to estimated total daily energy requirements (TDEE).

METHODS

Study Identification and Retrieval

Searches for all language, original, full-text research articles that were published between January 1, 1950, and July 31, 2010, were carried out within electronic databases (Medline [PubMed], Cochrane Library, Turning Research Into Practice, Clinical Evidence, Cumulative Index to Nursing and Allied Health Literature, and Commonwealth Agricultural Bureaux Abstracts), using combinations of the following keywords: "decubitus ulcer," "pressure sore," and "pressure ulcer" coupled with "resting metabolic rate," "resting energy expenditure," "basal metabolic rate," and "indirect calorimetry." Search terms were adapted to the requirements of each database and both free text and MESH terms were used where appropriate. Relevant studies, some of which were published before 1950, were also identified by reviewing citations from the retrieved articles.

Inclusion Criteria

Observational studies (case-control and case-series) providing data on REE measured by indirect calorimetry in patients with PUs were potentially all eligible for inclusion. Manuscripts were initially selected on the basis of the title and the abstract by two independent reviewers; if they were worthy of further review, sufficient data to normalize expenditures per kilogram of body weight were also required. For those articles published in a foreign language (other than English) and potentially suitable for inclusion, a translation was provided by a native speaker. In the evaluation of measured REE for patients with PUs, only those studies providing data on a control group (case-control) were included in the meta-analysis. However, with regard to the evaluation of estimation bias deriving from the use of REE predictive equations, studies were included regardless of the presence of a control group (case-control and case-series). Finally, in the evaluation of energy balance, inclusion in the study was considered only if assessment of energy intake was obtained by validated quantitative or semi-quantitative methods (18). No additional exclusion criteria were considered.

Data Extraction

Data were tabulated onto a spreadsheet using Microsoft Excel 2000 (2003, Microsoft Corp, Redmond, WA) by two independent reviewers. Information gathered included study design, setting, sample size (for patients with PUs and controls where available), sex and type of patients and controls (where available), ulcer stage, measured REE (in patients with PUs and controls where available), predicted REE (only for patients with PUs), and daily energy intake (only for patients with PUs). Authors of trials were also contacted for further information as necessary. According to the World Health Organization recommendations, and assuming that all the patients included were bedridden, TDEE were obtained by multiplying measured REE for a minimal physical activity level by a correction factor of 1.26 (19). All the data on energy expenditure and intake were expressed in and analyzed as kilocalories per kilogram per day. If necessary, conversion to kilocalories per day of data expressed in kilojoules was performed (1 kcal=4.184 kj). Any discrepancies in data extraction were resolved by discussion.

Assessment of Risk of Bias in Included Studies

Quality of methodology was also assessed and all differences were resolved by discussion. A sensitivity analysis was carried out based on the quality assessment. The following aspects of validity were taken into account: comparability between PU patients and controls, and presence of confounding factors possibly affecting the measurement of REE (underlying diseases such as diabetes, cancer, thyroid disease, and infections).

Statistical Analysis

The weighted (based on study sample sizes) means, standard deviations, medians, and interquartile ranges (25th to 75th percentile) of the groups and of the items (measured and predicted REE, TDEE, and total daily energy intake) considered were initially calculated. Meta-analyses were conducted and effect sizes calculated using both fixed and random-effect models, which combine estimates of effect size according to the absence or the existence of heterogeneity between study results, respectively. Heterogeneity of studies and consistency of results for each meta-analysis was assessed through the I^2 statistic. When the I^2 statistic was $>20\%$, we considered the random-effect to be preferable. The effect size for each issue considered (measured REE in PU patients vs controls; measured REE vs predicted REE in PU patients; TDEE vs energy intake in PU patients) was calculated as standardized mean difference (SMD) and 95% confidence intervals (95% confidence interval [CI]).

$$\text{SMD} = \frac{\text{Difference in Mean Outcome between Groups}}{\text{Standard Deviation of Outcome amont Participants}}$$

The SMD expresses the size of the intervention effect in each study relative to the variability observed in that study. Forest plots were used to present the effect size of each meta-analysis. The Funnel plot method was considered to assess the publication bias. However, such plots and associated statistics (Begg and Mazumdar's rank correlation and Egger's regression intercept method) were only used when $\geq$10 studies were included in the meta-analyses (20). Finally, sensitivity analyses were also considered on the basis of study quality assessment and related criteria. All the statistical analyses were performed with STATA (version 11, 2009, StataCorp, College Station, TX). Level of significance was established in a