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Assessment of the energy expenditure of Belgian nursing home residents using indirect calorimetry

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ABSTRACT

Objectives: The aim of this study was to assess the energy expenditure of Belgian nursing home residents using indirect calorimetry and compare the energy expenditure with energy intake.
Methods: Indirect calorimetry was performed in nursing home residents to estimate their basal metabolism. The basal metabolism was multiplied by a physical activity level coefficient and energy expenditure that was related to thermogenesis (i.e., 10% of the total amount of energy ingested over 24 h) was added. In this way, we obtained the total energy expenditure of each nursing home resident. The nutritional intake of each resident was calculated using the precise food-weighing method over a 3-d period. The difference between energy expenditure and consumption was calculated for each patient and the mean of the difference in the population was calculated. These quantitative variables were compared by means of analysis of variance.
Results: A total of 25 subjects were included in this study (88.1 ± 5.8 y; 84% women). The estimated mean basal metabolism was 1087.2 ± 163.2 kcal. The physical activity level was 1.29 ± 0.1 on average and the energy expenditure due to thermogenesis was 163.1 ± 28.9 kcal. Thus, the mean daily energy expenditure was 1575.2 ± 210.6 kcal, which was within the range of the actual calculated energy intake of the residents (1631.5 ± 289.3 kcal; $P = 0.33$).
Conclusions: The estimated energy intake of Belgian nursing home residents seems appropriate for their energy expenditure.

Introduction

Nutrition is an important element of health in the older population and affects the ageing process [1,2]. Over the past decade, the importance of nutritional status has been increasingly recognized in a variety of morbid conditions including impaired muscle function, cancer, heart disease, and dementia in persons over the age of 65 y [3,4]. However, according to data pooled from 24 data sets, the prevalence of malnutrition is high and affects 22.8% of older adults. This is increased in nursing home settings [5,6]. Therefore, food consumption studies in elderly people have become increasingly popular and special attention is given to this population of nursing home residents who are at risk of malnutrition.

Interestingly, some studies have shown that residents do not eat all meals that are served at their institution [7–10]. For example, we recently reported that residents eat 87% of the energy provided [8]. In addition, some studies reported that the amount of energy served in nursing homes is below the classic but challenged recommendations of 19.4 kcal/kg body weight per day in healthy elderly people [11]. The reduced food intake that was observed among nursing home residents could be explained, at least partially, by the fact that older people often have a reduced appetite and energy expenditure [1]. As a result of age-related changes in body composition (i.e., slight decline in lean body mass), the basal metabolism of the elderly diminishes over time [4], but this decrease has not yet been clearly established.

The measurement of energy expenditure is the most accurate method to assess energy needs. Indirect calorimetry remains a

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gold standard to measure energy expenditure in clinical settings [12]. Indirect calorimetry offers a scientifically based approach to customize patient energy needs and nutrient delivery to maximize the benefits of nutrition therapy [13]. Few studies have reported data related to the rest energy expenditure of nursing home residents and those that have concern Swedish [14,15] or US residents [16]. Nevertheless, to our knowledge, no studies have precisely measured the basal metabolism of Belgian nursing home residents.

The characteristics of residents differ from country to country; therefore, the aim of this study was to assess the energy expenditure of nursing home residents using indirect calorimetry and compare the energy expenditure with the actual energy intake of the residents. From a public health point, ensuring that energy expenditure is adequately compensated by energy intake to prevent complications related to malnutrition is important.

Materials and Methods

Population

The study population was composed of residents from one nursing home in Liège, Belgium. The selection criteria of the population included the following: 1) no disorientation in order to be able to provide informed consent and understand the questionnaires; 2) no acute infection as determined by a medical doctor; and 3) ability to walk and stand, possibly with technical assistance. Residents with methicillin-resistant staphylococcus aureus were excluded from the study to avoid contaminating other subjects.

All participants signed an informed consent form and the study was conducted between December 2015 and January 2016. The protocol was approved by the ethics committee of the University Teaching Hospital of Liège (number 2013/178). To ensure a sufficient statistical power, a calculation was made based on the study by Lammes and Akner [17] according to which the rest energy expenditure of Swedish nursing home residents is 1174 ± 29.3 kcal/d.

$$n = \frac{\left[QG\left(1-\frac{a}{2}\right)\right]^2 \sigma^2 N}{(N-1)\Delta^2 + \left[Qg\left(1-\frac{a}{2}\right)\right]^2 \sigma^2}$$

With σ^2 = (29.3 kcal/d)^2 and $\Delta = 0.10$ (to be sure that the observed value of energy expended is no more than 10% of the real value in the population). The result of this calculation gives n = 22, which means that a minimum of 22 subjects are needed to perform this study.

Data collected

Sociodemographic data

The following sociodemographic data were collected: age, sex, and anthropometric measurements. Weight was measured with a balance chair to the nearest 0.1 kg, after an overnight fast, and with minimal clothing. Height was measured with a measuring rod that was fixed onto the wall to the nearest 0.1 cm. Body mass index (BMI) was calculated from the measured height and weight. To monitor the most recent changes in weight, subjects were also weighed using the same device 1 mo before the beginning of the study.

Energy expenditure

Basal metabolism. To calculate the basal metabolism of the subjects, indirect calorimetry (ventilated hood system) was performed using a Deltatrac II (Datex-Ohmeda, Helsinki, Finland) device. After performing the daily calibration of the device using a mixture of oxygen and carbon dioxide, each patient was evaluated with the use of canopy and a flow rate of 40 l/min. Patients were evaluated in the morning with an empty bladder and stomach (i.e., fasted for at least 7 h) and they were at rest for 30 min in a thermoneutral, quiet, and dimly lit room in the supine position, without doing any activities including fidgeting, reading, or listening to music [18].

As recommended by Fullmer et al. [18], to minimize artifact (i.e., nonmetabolic variation in gas exchange) in the measurements, we discarded the first 7 min. Thereafter, we collected six times the data at 5-min intervals, which were averaged to obtain the basal energy expenditure. The machine consists of a flow meter, a paramagnetic oxygen sensor, and an infrared sensor to measure carbon dioxide. To verify the validity of the device before and after the study period, 5 mL of 96% ethanol (v/v) was burned, from which oxygen consumption and carbon dioxide production were measured.

Physical activity level coefficient. Physiotherapists assessed the physical activity patterns of subjects for placement into one of four physical activity level (PAL) categories: Sedentary, low active, active, or very active [19]. The PAL categories are closely linked to energy that is expended during physical activity in terms of metabolic equivalents. A metabolic equivalent is a numerical value that represents a multitude of the basal metabolic rates for a particular activity. This value applies to the level of energy expenditure that was achieved during the performance of a specific activity at a designated intensity and provides a way of expressing the total caloric cost of the activity [20]. The categorization of each individual in one of the four categories was made on the basis of the level of physical activity that was reported by residents using the Minnesota questionnaire [21]. The data that were self-reported by the residents with regard to their physical activity level were supplemented by the subjective appreciation of physiotherapists.

Thermogenesis. Diet-induced thermogenesis can be defined as an increase in energy expenditure above the basal fasting level divided by the energy content of the food ingested and is commonly expressed as a percentage [22]. Diet-induced thermogenesis, along with basal metabolic rate and activity-induced thermogenesis, is one of three components of daily energy expenditure. Theoretically, based on the amount of adenosine triphosphate that is required for the initial steps of metabolism and storage, diet-induced thermogenesis is different for each nutrient.

The reported diet-induced thermogenesis values for separate nutrients are 0% to 3% for fat, 5% to 10% for carbohydrates, 20% to 30% for protein [23], and 10% to 30% for alcohol [24]. In healthy subjects with a mixed diet, thermogenesis represents approximately 10% of the total amount of energy ingested over 24 h. When a subject is in energy balance (i.e., intake equals expenditure), diet-induced thermogenesis is 10% of the daily energy expenditure [22]. In this study, 10% of the energy that was consumed was used to determine the total energy expenditure.

Food intake

Food that is served to and consumed by nursing home residents was evaluated using the precise food-weighing method over a 3-d period. All foods were weighed before being served and at the end of the meal when all leftover foods on the plate were weighed. When foods were mixed together, we weighed the totality of the plate (served and uneaten) and referred to the recipe to estimate the quantity of each component that was consumed, specifying that the portion size was adapted to better meet a resident's need. Weighing was performed using a scale (DOMO, DO9105 W) with accuracy to 1 g. Subsequently, the energy nutrient content of food that was eaten was calculated by a dietitian using a food composition table [25] and food labels.

Nutritional status

Nutritional status was assessed using the Mini Nutritional Assessment (MNA). This test is comprised of two parts: a screening part followed by an assessment part. If the score obtained for the screening section is ≥12 points of 14 total possible points, the subject is classified as well-nourished and does not need to complete the assessment part. If the subject presents a screening score of ≤11 points, the assessment part has to be completed. The full evaluation is scored out of 30 points. A score of ≥24 points indicates that the subject is well nourished, a score between 17 and 23.5 points indicates a risk of malnutrition, and a score <17 points indicates malnutrition [26].

Statistical analysis

Quantitative variables that were normally distributed were expressed as the mean ± standard deviation after checking that these variables were normally distributed. A Shapiro-Wilk's test verified the normal distribution of all parameters. Qualitative variables were reported as absolute and relative frequencies (%).On the basis of basal metabolism, PAL coefficient, and thermogenesis, the total energy expenditure was calculated for each subject. Means ± standard deviation were calculated for all variables. The difference between energy expenditure and consumption was calculated for each patient and the mean of the difference in the population was calculated. These quantitative variables were compared by means of analysis of variance. The data analyses were performed using Statistica 12 software and the results were considered statistically significant when two-tailed P-values < 0.05.

Results

Study population

A total of 25 white subjects were included in this study. Twenty-one participants (84%) were women. The mean age of the population was 88.1 ± 5.79 y (range: 67–97 y), and the mean BMI score was 25.6 ± 6.36 kg/m^2 (range: 15.3–38 kg/m^2). According to the World Health Organization classification, 7 subjects were obese (BMI > 30 kg/m^2) and 1 subject was underweight (BMI < 18.5 kg/m^2) [27]. Among these 25 subjects, 5 subjects (20%) were

Table 1
Comparison between energy and macronutrients served to and consumed by residents, stratified by sex

	Food served	Food consumed	*P*-value
Total population (n = 25)			
Energy (kcal)	1843.1 ± 273.6	1631.5 ± 289.3	0.01
Protein (g)	64.6 ± 10.7	54.0 ± 11.9	0.02
Lipid (g)	83.9 ± 14.7	73.4 ± 17.1	0.02
Carbohydrates (g)	205.8 ± 40.2	185.8 ± 34.4	0.06
Women (n = 21)			
Energy (kcal)	1829.1 ± 284.2	1611.3 ± 295.4	0.02
Protein (g)	63.0 ± 9.98	55.1 ± 11.2	0.02
Lipid (g)	84.0 ± 15.6	73.2 ± 18.2	0.04
Carbohydrates (g)	203.5 ± 42.3	183.1 ± 34.3	0.09
Men (n = 4)			
Energy (kcal)	1933.9 ± 275.9	1737.5 ± 264.3	0.35
Protein (g)	73.0 ± 12.1	67.1 ± 12.3	0.51
Lipid (g)	83.7 ± 9.74	74.4 ± 10.8	0.25
Carbohydrates (g)	217.7 ± 27.6	199.9 ± 35.3	0.46

malnourished, 15 subjects (60%) were at risk for malnutrition, and 5 subjects (20%) had a normal nutritional status according to the MNA. The mean MNA was 20.4 ± 3.92 (range: 11.5–26.5). The calf circumference was 31.4 ± 4.07 cm, and 11 subjects (44%) had a calf circumference <31 cm.

Energy expenditure

The mean basal metabolism as estimated with indirect calorimetry in our study was 1087.2 ± 163.2 kcal. The mean PAL coefficient was 1.29 ± 0.03 and the mean energy expenditure due to thermogenesis was 163.1 ± 28.9 kcal. For each subject, we multiplied their own basal metabolism by the PAL coefficient and added the thermic effect of food to obtain the daily energy expenditure. In our population, the mean daily energy expenditure was 1575.2 ± 210.6 kcal.

When these data are stratified by sex, basal metabolism was 1082.3 ± 165.5 kcal for women and 1112.1 ± 171.7 kcal for men. The PAL coefficient was 1.29 ± 0.03 for women and 1.28 ± 0.05 for men Thermogenesis was 163.1 ± 28.9 kcal for women and 173.7 ± 26.4 kcal for men. On the basis of these data, the daily energy expenditure was equal to 1557.9 ± 216.1 kcal and 1681.9 ± 259.9 kcal for women and men, respectively.

Food intake

Energetic nutrients that were served to and consumed by the residents and measured over a 3-d period are shown in Table 1 for the total population as well as for men and women separately. The data show that the residents do not eat all of the meal that is served. When stratified by sex, women consumed 1611.3 ± 295.4 kcal per day and received 1829.1 ± 284.2 kcal, whereas men consumed 1737.6 ± 264.3 kcal per day and received 1933.9 ± 275.9 kcal.

Comparison between energy consumption and expenditure

As shown in Tables 2 and 3, there was no difference between energy consumed and expended (in kcal: $P = 0.33$; in kcal/kg: $P = 0.36$), and this was true for both men and women.

Thirteen of 25 subjects in this study (52%) had a negative energy balance. As shown in Table 4, the clinical characteristics were not significantly different between subjects with positive and negative energy balances, except for energy expenditure and consumption. Energy expenditure was higher in the first than in the second group ($P = 0.03$), whereas energy consumption was, as expected, lower in the first group compared with the second group ($P < 0.001$).

Table 2
Energy consumed and expended by the residents (kcal)

	Energy consumption	Energy expenditure	Mean difference between energy consumption and expenditure	*P*-value
Total population	1631.5 ± 289.3	1575.2 ± 210.6	331 ± 275.4	0.33
Women	1631.5 ± 295.4	1557.9 ± 216.1	367.9 ± 276.1	0.49
Men	1737.6 ± 264.3	1681.9 ± 259.9	80.5 ± 47.6	0.33

When comparing energy consumption and basal metabolism according to the MNA among malnourished, at risk of malnutrition, and well-nourished subjects, there was no significant difference ($P = 0.19$ and $P = 0.84$, respectively).

Discussion

Our study highlighted that the energy consumption of Belgian nursing home residents, as assessed with the precise food-weighing method, seems appropriate for their energy expenditure, as assessed using indirect calorimetry.

According to our results, the energy expenditure of nursing home residents is 1575.2 ± 210.6 kcal. To the best of our knowledge, no other study has used indirect calorimetry to evaluate the energy expenditure of nursing home residents. Lammes and Akner estimated the rest energy expenditure of Swedish nursing home residents and showed that the average value was 1174 ± 29.3 kcal/d [16,17]. In our study, the results are somewhat lower; however, a comparison is difficult because of the sociodemographic differences between Swedish and Belgian nursing home residents.

The daily food intake in our population, as assessed with a precise food-weighing method, was 1631.5 ± 289.3 kcal, which is broadly similar to the results that were obtained in one of our previous studies that included similar patients and used the same method [8]. According to this research, nursing home residents

Table 3
Energy consumed and expended by the residents (kcal/kg)

	Energy consumption	Energy expenditure	Mean difference between energy consumption and expenditure	*P*-value
Total population	25.7 ± 8.48	23.9 ± 4.84	1.79 ± 1.76	0.36
Women	26.2 ± 9.08	24.9 ± 4.78	1.76 ± 1.67	0.44
Men	23.2 ± 4.03	21.3 ± 4.98	1.95 ± 1.84	0.57

Table 4
Comparison of clinical characteristics between subjects with positive and negative energy balances

Characteristics	Subjects with negative energy balance (n = 13)	Subjects with positive energy balance (n = 12)	*P*-value
Age (y)	87.2 ± 7.46	89.0 ± 3.25	0.45
Sex (No. women)	11 (52.3 %)	10 (47.6 %)	0.98
BMI (kg/m^2)	27.1 ± 6.50	24.2 ± 6.08	0.25
Energy expenditure (kcal)	1659.8 ± 153.8	1483.5 ± 230.8	0.03
Energy consumption (kcal)	1314.9 ± 404.7	1836.4 ± 242.0	<0.001
MNA (No. patients)			
• Malnourished	2 (40%)	3 (60%)	0.70
• At risk of malnutrition	7 (46.7%)	8 (53.3%)	0.11
• Normal nutritional status	4 (80%)	1 (20%)	0.24

BMI, body mass index; MNA, Mini Nutritional Assessment.

consumed 1552.4 ± 342.1 kcal per day. In addition, we previously highlighted that nursing home residents do not eat the entire meal that is served (1783.3 ± 125.7 kcal), and this is confirmed in the present study where residents received 1843.1 ± 273.6 kcal per day but ate only 1631.5 ± 289.3 kcal. Other studies that were performed in different countries have reported findings that are consistent with our results [9,17].

In the critically ill population, in which patients are exposed to medical and surgical interventions, indirect calorimetry has greatly changed the practice of caloric administration and significantly reduced the total daily amount consumed [28]. The energy requirements are different in the different levels of functionality of the elderly (i.e., sarcopenic, frail, or robust subjects). Indeed, maintaining adequate physical activity is likely to ameliorate the age-related decrease in resting metabolic rate because physical activity aids in the preservation of lean mass among highly active older adults [29]. Despite the difference in body mass between a 75-y old and a 7- to 11-y old person, their total energy expenditure (EE) levels are estimated to be similar. This represents a decrease of approximately 500 kcal/d in total EE and thus, a decrease in the energy requirements [29,30]. According to Gaillard, total EE is lower in sick elderly people because their physical activity level is reduced during the illness [11]. The nutritional status of the elderly also influences their energy requirements because weight-adjusted rest-energy expenditure increases in line with a decrease in BMI [11]. In the same way, indirect calorimetry could also be used to clarify and adapt the energy needs for specific elderly populations.

Several studies reported that nursing home residents do not eat their entire meal but most residents are not malnourished [14]. These seniors do not report weight loss that is associated with a negative energy balance, which indicates nutritional challenges [31]. In addition, the energy intake of most residents is below the recommendations [31]. However, the current nutritional recommendations address healthy adult populations, and there are no consensual specific guidelines for the elderly including nursing home residents. With regard to our results, there is no difference between the energy consumption and expenditure of the residents. Therefore, their food intake seems to be adequate for their physical activity level, whereas their energy intake is below the nutritional recommendations. This finding strengthens the necessity to define nutritional recommendations that are adapted to the elderly and to specific populations of nursing home residents to fill this gap in the literature.

With regard to weight variations after 1 mo (i.e., at the time of inclusion compared with 1 mo before the beginning of the study), no significant difference was observed ($P = 0.51$). This corroborates the fact that residents seem to eat enough to meet their energy expenditure. However, some residents had a negative energy balance. These subjects were likely in the process of losing weight at the time of the study, but that this variation was too small to be noticed. A period of 1 mo is probably too short to observe a significant change. Therefore, monitoring patients prospectively over a longer period of time is important.

Another hypothesis is that the evaluation of energy expenditure was not accurate enough because the level of physical activity was estimated by physiotherapists and measured inaccurately. In the same way, whereas 60% of subjects are at risk of malnutrition and 20% are malnourished, weight was stable. Because MNA is a self-reported questionnaire, the estimated prevalence of malnutrition could be altered. Therefore, a confirmation or disconfirmation of the malnutrition state among the 60% of subjects at risk would be of interest.

The strength of this study is the originality of the data collected and the rigorous methodology used. Indeed, the most precise methods to assess energy expenditure (i.e., indirect calorimetry) and energy intake (i.e., food-weighing method) have been used. However, these methods are not without limitations. In theory, there are numerous technical aspects of measuring indirect calorimetry that we did not consider enough, which could influence the accuracy of the measurements (e.g., stress factors, medical conditions, or medication). However, to limit this potential bias, we included only patients in stable condition.

Another potential limitation of this study is the representativeness of the population due to the selection criteria of the population. Indeed, the frailest subjects were excluded from the analysis and frailty status admittedly influences energy requirements. Nevertheless, the proportion of malnourished subjects in our study (20%) is in line with the review by Agarwal et al. [32]. The measurements were performed in a single nursing home and among subjects who met the defined selection criteria.

The last limitation is related to the collection of food intakes; collection was carried out over a 3-d period, which is a short period of time to reflect the mean of food intakes. Nevertheless, the energetic nutrients of meals that were served each day in nursing homes are quite similar every day. Consequently, further investigations are needed to confirm these data to clarify the nutritional recommendations for elderly people.

Conclusions

The Belgian nursing home residents who were included in this study do not eat their entire meal as served. Nevertheless, their estimated energy intake seems appropriate for their energy expenditure. These results underline the importance of developing specific nutritional recommendations for elderly people.

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