Assessment of the basal metabolic rate (BMR) with dual energy x-ray absorptiometry (DXA) in the management of the obese patient

Poster No.: P-0067
Congress: ESSR 2012
Type: Scientific Exhibit
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Keywords: Eating disorders, Metabolic disorders, Experimental investigations, Treatment effects, Absorptiometry / Bone densitometry, Abdomen, Musculoskeletal soft tissue, Management
DOI: 10.1594/essr2012/P-0067

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Purpose

The epidemic of obesity has been documented in several regions worldwide, with the prevalence of obesity rising in most countries. The estimated total numbers of overweight and obese adults in 2005 were 937 million and 396 million, respectively. By 2030, the respective number of overweight and obese adults was projected to be 1.35 billion and 573 million individuals. If recent secular trends continue unabated, the absolute numbers were projected to total 2.16 billion overweight and 1.12 billion obese individuals [1].

Obesity constitutes a heavy economic burden, which includes treatment costs, the management of its complications (diabetes, heart diseases, stroke, arthritis and some cancers), and loss of work productivity. In 1998 in the US, the total cost of overweight and obesity amounted to 51 billion dollars. In 2007 the cost of the weight reduction in 72000 obese patients who underwent dietary therapy, was estimated to be $ 55 billion. These costs have been largely wasted because only a small percentage of individuals in dietary therapy has been successful in losing more than 5% of their initial weight and maintain weight loss for at least 5 years [2,3].

From the physiopathological view-point the obesity occurs when the calories introduced exceed than the body consumed. The balance between calories-in and calories-out differs for each person (Fig. 1 on page 4) and depend from a lot of factors (genes, environment, exercise, culture, food intake). The Total Energy Expenditure (TEE) of a man or woman over a whole day is often divided into three different components:

1. **Resting Energy Expenditure (REE)** corresponding at almost the 70% of TEE, represents the minimum amount of energy that a body requires when lying in physiological and mental rest.
2. **Activity Energy Expenditure (AEE)** includes the additional energy expenditure due to muscular activity and comprises minor physical movement (such as shivering and fidgeting) as well as purposeful gross muscular work or physical exercise, on average it accounts for 15 to 30% of total daily TEE but can vary more in very active persons.
3. **Diet-Induced Thermogenesis (DIT)** accounts for about 10% of total energy intake for a mixed western diet, this is the amount of energy utilised in the digestion, absorption and transportation of nutrients [3,4].

The largest component of daily TEE, especially in sedentary people, is REE. To determine reliable and objective REE measurements in obese individuals is important in order to establish reachable goals for dietary intervention and weight loss [5]. Dual energy X-ray absorptiometry (DXA) has an important research and future clinical role in the management of obesity and in particular in the field of REE assessment [6,7].
The aim of our study was to assess the relationship between REE estimated by densitometry and the variations of body composition (BC) in a group of obese patients after medical treatment.
Fig. 1

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Methods and Materials

Population and BC analysis

We prospectively enrolled 96 obese patients (27M-69F, BMI=37.9±9.1 kg/m²) that performed a whole-body scan using a new generation fan-beam densitometer (Lunar iDXA, Madison, WI, USA) before and after 3 months of medical treatment, for the total and regional assessment of fat mass (FM), non-bone lean mass (LM) and bone mineral content (BMC). Region of interests (ROIs) included five different corporeal districts (legs, arms, trunk, gynoid and android regions); moreover with the new iDXA software (enCORE™ 2011 software 13.6) we obtain the visceral volume mass and the visceral fat mass in the android region.

The treatment consists in a cognitive-behaviour therapy designed to provide patients with a set of principles and techniques to modify their eating and activity habits. The intervention was integrated with specific recommendations on diet and exercise [8].

REE estimation and statistical analysis

We evaluate by DXA the predict REE using the tissue-organ level model developed by Hayes et al. [7], which consists in the summed heat productions from the weights of the brain, skeletal muscle mass (SM), adipose tissue (AT), bone and tissue organs (Tab.1).

<table>
<thead>
<tr>
<th>Compartment</th>
<th>Mass model (kg)</th>
<th>Energy model (kcal/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain</td>
<td>0.005 x skull area + 0.2 x sex* + 0.24</td>
<td>EE_B = 240 x Brain</td>
</tr>
<tr>
<td>SM</td>
<td>LST x 1.13 - 0.02 x age + 0.61 x sex* + 0.97</td>
<td>EE_SM = 13 x SM</td>
</tr>
<tr>
<td>Bone</td>
<td>1.85 x Mo</td>
<td>EE_Bone = 2.3 x Bone</td>
</tr>
<tr>
<td>AT</td>
<td>1.18 x fat mass</td>
<td>EE_AT = 4.5 x AT</td>
</tr>
<tr>
<td>Residual</td>
<td>BW - (Brain + SM + AT + Bone)</td>
<td>EE_RM = 43 x Residual</td>
</tr>
<tr>
<td>Total</td>
<td>BW = Brain + SM + AT + Bone + Residual</td>
<td>REE_p = EE_B + EE_SM + EE_Bone + EE_AT + EE_RM</td>
</tr>
</tbody>
</table>

Area is DXA skull area (in cm²).

*Sex = 0 for female, 1 for male.
AT, adipose tissue; BW, body weight in kilograms; EE, component resting energy expenditure; LST, DXA appendicular lean soft tissue in kilograms; Mo, DXA bone mineral in kg;

REEp, predict resting energy expenditure; SM, skeletal muscle.

Table 1. Calculation of tissue organ mass and estimation of REE

Arbitrarily, the patients were classified into two groups according to their predict REE:

- **Group-1 (≤1400 cal)**: 53 patients (1M-52F, BMI=35.1±7.8 Kg/m², age=65.8±6.3) (Fig. 2 on page 7)
- **Group-2 (>1400 cal)**: 43 patients (26M-17F, BMI=40.1±7.1 Kg/m², age=60.4±1.2) (Fig. 3 on page 7)

Data were analyzed by Student's t-tests (p were considered significant for values less than 0.05).
Fig. 2

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Fig. 3

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Results

**Total weight** was reduced by 4.4±4.4 kg in Group-2 and 3.3±2.8 kg in Group-1 (p<0.001), with major decrease of **total fat mass** in Group-2 (7.5% vs. 6.7%; p<0.001). **Total non-bone lean mass** decrease more in Group-1 (1.1%; p=0.0053), than in Group-2 (0.6%; p=0.17).

**Android fat mass** decreased more in Group-2 (9.4% vs. 8.0%; p<0.001), mainly with a reduction of the **subcutaneous adipose tissue** (7% vs. 5.9%; p<0.001) compared to the **visceral** one (11.3 vs. 11.0%; p<0.001) (Fig. 4 on page 10 and Fig. 5 on page 10).
**Fig. 4:** Total weight (TW), total fat mass (TFM), total lean mass (TLM), Android fat mass (AFM), Subcutaneous adipose tissue (SAT) and visceral adipose tissue (VAT) in Group-1.

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**Fig. 5:** Total weight (TW), total fat mass (TFM), total lean mass (TLM), Android fat mass (AFM), Subcutaneous adipose tissue (SAT) and visceral adipose tissue (VAT) in Group-2.

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Conclusion

REE is central to the study of energy physiology and nutritional requirements in humans.

The REE estimated by DXA is an innovative tool that may influence the therapeutic approach and provide prognostic information, expanding the use of DXA in the management of the obese patient.

As the matter of fact DXA is an easy to use, quick, not expensive and non invasive (very low dose to the patient) technique that could be considered as a first choice approach in the clinical practice to study the obese patient demonstrating an highly correlation with the indirect calorimetry [7].

This innovative method of REE analyses could be integrated with other clinical values, to increase the between-individual differences.
References


