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# Analysis of the relationship between body mass index and relative fat content

Analiza zależności między wskaźnikiem BMI a prawidłową masą ciała

### INTRODUCTION

Establishing normal values for body mass is of great importance not only for individuals, but for medical, nutrition and health insurance professionals as well. The results of epidemiological studies indicate that an elevated mortality due to cardio-circulatory disorders, diabetes, and gall bladder diseases, is associated with excessive body mass. On the other hand, increased mortality due to respiratory and digestive tract diseases, is associated with an excessively reduced body mass [4]. Various measures have been employed to establish an appropriate body mass, e.g. Broca-Brunsch's formula, or the most widely used Body Mass Index (BMI) [6]. Usually, BMI is considered a substitute for the relative fat content (FAT%) and individual recommendations – medical and dietary – are based on BMI [2].

It was reported earlier [5] that in women aged 20 or 30 years, their relative body fat content was significantly elevated with respect to normal values, despite a normal mean BMI value. An assessment of nutritional status, derived from BMI only, might thus result in erroneous recommendations in individual cases, and this prompted us to study the BMI-FAT% relationship in more detail.

#### **SUBJECTS**

The study was conducted in 2002 in Warsaw, in course of a promotion of dietary food supplements manufactured by Vitalas Co., organised by Cefarm (Poland). A group of 138 women, aged 20 - 39 years, not engaged in physical activities, volunteered to participate in the study. Two age groups were formed (20 - 29 and 30 - 39 years), since the official normal values of relative fat content differ for those age classes.

# **METHODS**

Relative body fat content (FAT%) was determined by infrared photometry with the use of FUTREX–6100/XL device (Futrex, USA) [3]. Body height was measured with an accuracy of 1 mm, body mass with an accuracy of 0.1 kg.

### **RESULTS AND DISCUSSION**

Data characterising the women studied are presented in Table 1.

Table 1. Basic characteristics of women studied (means  $\pm$  SD)

	Group 1 (n = 87)	Group 2 ( $n = 51$ )
Age (years)	$24.0\pm2.91$	$34.3\pm2.58$
Body height (cm)	$165.7\pm5.58$	$164.3\pm5.71$
Body mass (kg)	$59.5 \pm 10.17$	$63.7 \pm 11.21$
BMI (kg/m <sup>2</sup> )	$21.6 \pm 3.19$	$23.6\pm3.98$
Fat content (%)	$25.1 \pm 4.90$	$29.0\pm5.85$

According to recommendations of the Food and Nutrition Institute, BMI values in the range from 18.5 to 24.9 kg/m<sup>2</sup> correspond to normal body mass, from 25.0 to 29.9 kg/m<sup>2</sup> – to overweight, above 30.0 – to obesity, and below 18.5 – to underweight. The distribution of percentages of women from both groups according to that classification is presented in Fig. 1.



Fig. 1. Frequencies of women classified by BMI-values as underweight, normal, overweight or obese (n = 136)

According to the American College of Sports Medicine, relative fat contents equal to 16 - 24% or 17 - 25% are considered normal for women aged 20 - 29 or 30 - 39 years, respectively [1]. An increase by 20% with respect to those ranges is regarded as overweight, and

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by 50% - as obesity. According to these criteria, 54 and 74% of women from Group 1 and 2, respectively, had excessive fat content.





Fig. 2. Relative body fat content in women in relation to recommended values

Fig. 3. Relationship between Body Mass Index (BMI) and relative fat content (FAT%) in women aged 20 - 29 (Group 1; n = 87) or 30 - 39 years (Group 2; n = 51)

Legend for categories according to BMI and FAT%: A - Underweight/normal; B - Underweight/ underweight; C - Normal/normal; D - Normal/overweight+obesity; E - Overweight/obesity; F - Obesity/obesity.

When classifying women according to normal ranges of BMI and FAT% taken together, only 29% of them (Category C) could be regarded as normal with respect to those ranges taken separately, and nearly all other women had more fat than expected from BMI (cf. Fig.3). One-third of women had normal body mass according to BMI criterion, but were overweight or obese with respect to FAT% (Category D). Nearly all women whose BMI exceeded 25 (overweight) had FAT% values indicating obesity (Category E). About 5% of women rated as underweight by BMI criterion had normal fat content (Category A). Only 3

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subjects (2%) were underweight (Category B) and 6% were obese (Category F) by both criteria. On the whole, only 41% of women were classified by both criteria concordantly, the other ones were mostly underestimated by the BMI criterion.

The presented results indicate that BMI alone is not a reliable indicator of fat content. Therefore, when preparing dietary and/or medical recommendations, especially regarding weight reduction, body fat content should be determined and used in conjunction with BMI.

#### CONCLUSIONS

- 1. Body Mass Index may not be a reliable criterion in individual assessment of underweight, overweight, or normal body mass;
- 2. Body Mass Index and relative fat content values are concordant only in obese women;
- 3. In order to establish a normal body mass, both BMI and relative fat content should be determined.

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#### STRESZCZENIE

Celem pracy była ocena zależności między wskaźnikiem BMI a procentową zawartością tkanki tłuszczowej (FAT %). Przebadano 138 kobiet nieaktywnych fizycznie w wieku od 20 do 39 lat. Względną zawartość tłuszczu (FAT%) oznaczono metodą fotometrii w podczerwieni (FUTREX). Jednoczesna analiza BMI i FAT% wskazuje, że jedynie u 41% badanych wynik wskaźnika wagowo-wzrostowego pokrywa się z oceną procentowej zawartości tkanki tłuszczowej. U pozostałych kobiet FAT% jest większa niż wskazuje na to BMI. Prawie wszystkie kobiety, których BMI przekracza wynik 25 kg/m<sup>2</sup> (nadwaga) mają zawartość tłuszczu jak osoby otyłe. Dziewięć badanych kobiet (5%), które zakwalifikowano wg BMI do niedowagi miała prawidłową zawartością tkanki tłuszczowej. Analiza uzyskanych wyni-ków pozwoliła wysunąć następujące wnioski: Wskaźnik BMI nie ocenia rzetelnie niedowagi, nadwagi i prawidłowej masy ciała. Wartości BMI i FAT% są jednoznaczne tylko w kategorii kobiet otyłych. W celu ustalenia prawidłowej masy ciała należy równocześnie analizować BMI i procentową zawartość tkanki tłuszczowej.

## SUMMARY

The aim of the study was to analyse the relationship between the Body Mass Index (BMI) and relative fat content (FAT%). In 138 women, aged 20 - 39 years, not engaged in physical activities, FAT% was determined by infrared photometry, using Futrex-device. Upon applying normal intervals for BMI and FAT% simultaneously, only 41% of women were classified by both criteria concordantly, in the other ones their relative fat content was higher than expected from BMI. Nearly all women, whose BMI exceeded 25 kg/m<sup>2</sup> and were classified as overweight, had fat content indicating obesity, while 9 women (5%) classified by BMI as underweight, had normal fat content. It was concluded that: 1) Body Mass Index might not be a reliable criterion in individual assessment of underweight, overweight, or normal body mass; 2) Body Mass Index and relative fat content values are concordant only in obese women; 3) In order to establish a normal body mass, both BMI and relative fat content should be determined.

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