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ASSESSMENT OF BODY COMPOSITION OF PHYSICALLY ACTIVE MALE YOUTH

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Abstract: *Body composition assessment by skinfolds (SKF) and body mass index (BMI) was conducted on physically active males applying for admission to the Hungarian University of Physical Education to determine if BMI is a good indicator of percent body fat. The sample (N=203) was divided into four groups as follows: GR1 (N=46), those with BMI under 20.0; GR2 (N=43), with both height and weight ranges of 176.4-177.4 cm and 68.3-69.7 kg, respectively; GR3 (N=52), with BMI over 24.0; and GR4 (N=62), with BMI between 21.9 and 22.3. Although GR3 exhibited "undesirable obesity" according to BMI (mean=25.62) and was significantly different from the other groups (p<.05), percent fat predicted from SKF for GR3 and GR4 were statistically similar (p>.05). At the same time, GR2 and GR4 had similar BMIs but statistically different percent fat levels (p<.15). GR1, with the lowest BMIs, still showed significantly higher percent fat than GR2. Therefore, BMI in itself, is not necessarily a good predictor of percent body fat with college-age, physically active males.*
Key words: *Body composition; Physical activities.*

Introduction

The estimation of percent body fat for identification of obesity has been manifested by an assortment of techniques varying in cost, equipment, ease of use, and accuracy. While some methods are cost prohibitive to users, skinfold measurements and underwater weighing remain the most widely used assessment standards. From a strictly practical standpoint, anthropometric measurements using a reasonably accurate body mass index (BMI) is the most cost-effective approach.

A number of different BMI prediction indices have been cited in the literature (Lohman, 1992; Womersley & Dumin, 1977), including ratios of weight (W) to height (H), W to H^2, W to H^3, H to $W^{.33}$, and waist to hip circumference (WHR). The Quetelet index (W to H^2) is the most recognized body mass index (Nieman, 1995). This index represents body mass relative to linear growth; the higher the BMI score, the greater the inclination toward obesity. The Surgeon General's Report (U.S. Department of Health and Human Services, 1988) defines the "moderately obese" and "severely obese" risk categories for women as 27-32 and >32, respectively. For men, the corresponding values are 28-31 and >31. Other studies (Jequier, 1987; Lukaski, 1987) cite increased health risks associated with BMIs beginning in the range of 25-30.

Caution is in order when using body mass index as an indicator of obesity because it may not be appropriate with certain groups. The American College of Sports Medicine (1995) notes that "BMI is a relatively good indicator of total body composition in population-based studies." Investigations by Smalley et al. (1990) and Garn, Leonard, and Hawthorne (1986) reported correlations of 0.82 (women) and 0.70 (men) for BMI and densitometry and 0.65 for BMI and percent lean body mass, respectively. However, Lohman (1992) notes that BMI can be misleading, especially in populations experiencing rapid muscle and bone mass changes, i.e., in children and the elderly. This study looks at the relationship between BMI and percent fat and the predictive ability of BMI with respect to percent fat of physically active college age males.

Methods

Subjects

Data from a sample of 203 physically active males were drawn from individuals applying for admission to the Hungarian University of Physical Education from 1991 to 1995. The subjects were divided into four groups based on body mass index and according to height and weight. The four groups were as follows: Group 1 (N=46), lean subjects with BMIs under 20.0; Group 2 (N=43), medium height and weight subjects falling within the height range of 176.4-177.4 cm and weight range of 68.3-69.7 kg; Group 3 (N=52), "fat" subjects with BMIs over 24.0; and Group 4 (N=62), subjects with medium BMIs between 21.9 and 22.3.

The upper and lower limits for BMI for Group 4 (MED BMI) were established as (1.0 confidence interval at 95% from the normative data of Eiben et al. (1992) on 862 Hungarian male youths. Likewise, both height (176.4 cm to 177.4 cm) and weight (68.3 kg to 69.7 kg) criteria for Group 2 (MED HW) were established in similar fashion, that is, within ± 1.0 confidence interval. Subjects for Groups 1 and 3 (LEAN and FAT) were selected on the basis of two recognized BMI categories, that is, they tended to fall within the "lean, underweight" or "Grade 1 obesity" categories (Jequier, 1987).

Measurements

Measurement data are presented in Table 1. Anthropometric data (height, weight, chest depth, breadth and girth, shoulder width, arm and forearm girth, hand girth, thigh girth, and calf girth) and skinfold measurements were collected for each subject. Calculation of body density was based on measurements from the skinfold sites of biceps, triceps, subscapular, suprailiac, and calf, using Szmodis et al. (1976) modification of the equation of Parizkova (1961). The measurements were made by Lange calipers. Percent fat was derived from body density according to Brozek et al. (1963). Muscle mass, as a percentage of total mass, was calculated using the Drinkwater technique (Drinkwater & Ross, 1980) whereby the body is partitioned into four components of mass, i.e., skin and adipose tissue, muscle, bone, and residual. Equation 1 gives the muscle mass:

$$\text{Muscle mass (\%)} = r^2 \times \text{Stature} \times 6.41 \quad \text{(Eq. 1)}$$

r = [arm girth/3.14 - triceps SKF/10 + thigh girth/3.14 - thigh SKF/10
calf girth/3.14 - calf SKF/10 + chest girth/3.14 - subscapular SKF/10] / 8

In addition, two indices of physique - one to estimate degree of rotundness or mass per linear growth, and the other to estimate degree of muscle and bone development - were calculated according to Conrad (1963). These indices, identified as the Metric Index (MIX) and Plastic Index (PLX), respectively, are depicted in scatter plot form (Figure 1).

Table 1: Anthropometric and Body Composition Data*

	Group 1	Group 2	Group 3	Group 4
No. Subjects	46	43	52	62
Weight (kg)	63.76 (4.85)	69.13 (0.50)	82.02 (7.88)	70.88 (5.09)
Height (cm)	181.91 (4.71)	177.01 (0.28)	178.54 (6.78)	178.71 (6.16)
BMI (kg m-2)	19.24 (0.73)	22.06 (0.17)	25.62 (1.27)	22.10 (0.14)
Percent Fat (%)	11.92 (3.29)	10.91 (2.56)	13.42 (3.44)	13.03 (2.59)
Muscle Mass (%)	46.46 (1.48)	47.33 (1.59)	47.37 (1.73)	47.05 (1.57)
Metric Index	1.75 (0.31)	1.15 (0.35)	1.04 (0.40)	1.42 (0.31)
Plastic Index	86.25 (2.49)	87.37 (1.93)	91.10 (3.82)	87.72 (2.71)

*Mean and standard deviation (in parentheses)

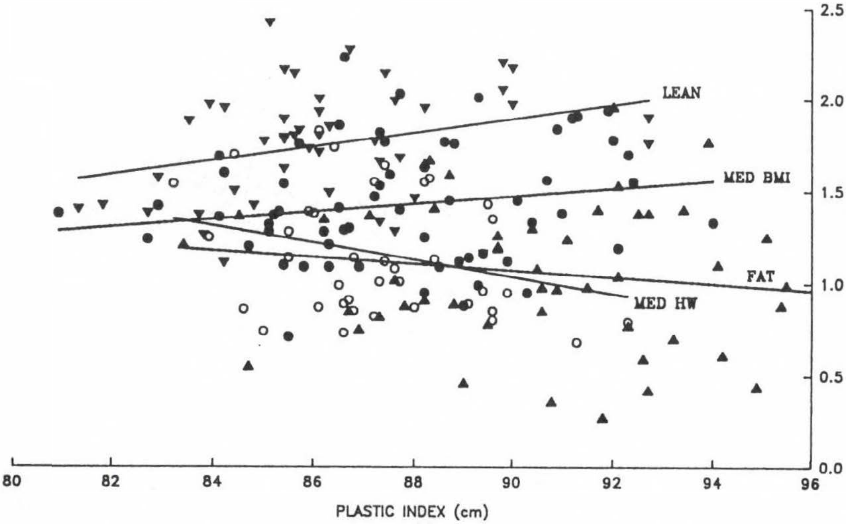

Fig. 1: Data points for metric index and plastic index for LEAN, MED HW, MED BMI, FAT.

Results

The relationship between body mass index and percent body fat for the our subject groups combined (N=203) was tested with the Pearson correlation coefficient. A significant correlation coefficient (r=.251, t=3.68, p>.01) was found to exist between BMI and percent fat. Viewed separately, the relationship between BMI and percent fat for each of the four groups was positive. Figure 2 shows the plotted points for the four groups. Groups 2 and 4 (MED HW and MED BMI, respectively) naturally demonstrate steeper slopes than the LEAN and FAT groups but upon closer inspection, their own slopes are similar (Figure 3).

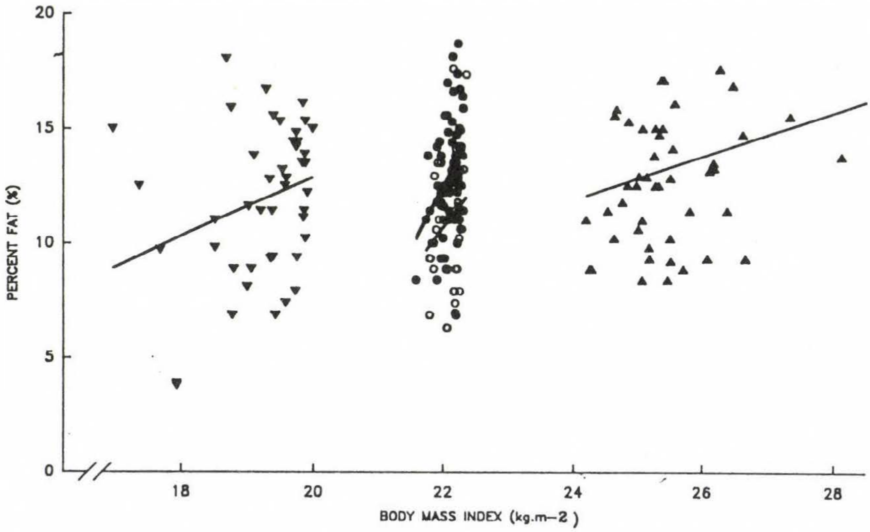

Fig. 2: Data points for body mass index and percent fat for LEAN, MED HW, MED BMI, FAT.

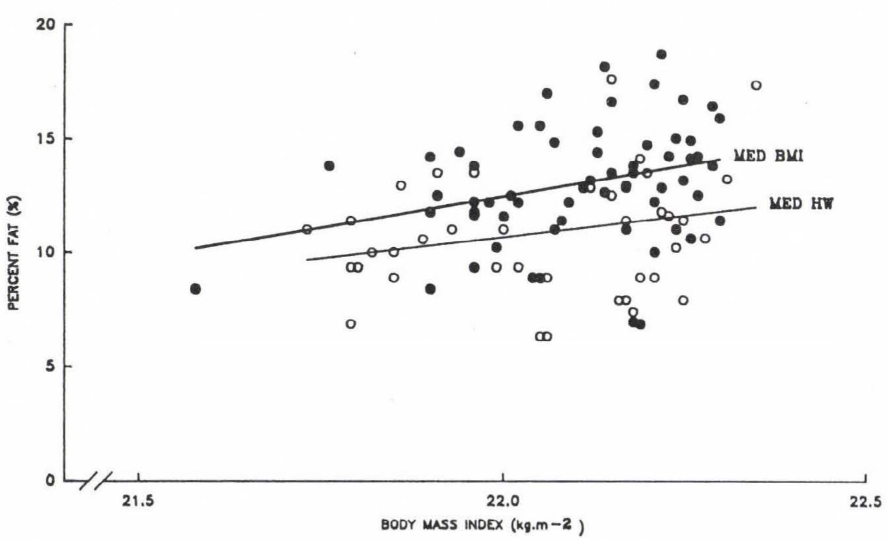

Fig. 3: Data points for body mass index and percent fat for MED HW and MED BMI.

Additional analyses demonstrate that other factors need to be taken into consideration with regard to the accuracy of body mass index. First, Group 3 (FAT), the group exhibiting the greatest tendency toward obesity (BMI mean = 25.62), was compared to the other groups. ANOVA revealed it to be significantly different (F=610.94, df=3, 199, p<.05) from each of the other groups, i.e., Group 1 (LEAN, BMI mean=19.24), Group 2 (MED HW, BMI mean=22.06), and Group 4 (MED BMI, BMI mean=22.08) (see Table 2). Yet, at the same time, percent fat for Group 3 (FAT) and Group 4 (MED BMI), 13.42% and 13.03%, respectively, were statistically similar (p>.05).

Secondly, while a non-significant difference (p>.05) was found between BMIs of Group 2 (MED HW, mean=22.06) and Group 4 (MED BMI, mean=22.08), analysis by ANOVA (F=6.91, df=3, 199, p<.05) and Scheffe (F=3.83, df=3, 199, p<.01) revealed a significant difference between the two groups for the variable of percent body fat (see Table 3).

Finally, Group 1 (LEAN), the group with the lowest mean BMI (19.24) and statistically different from Group 2 (MED HW, mean=22.06), nevertheless demonstrated a higher percent body fat (mean=11.91%) compared to the latter group (mean=10.91%).

Discussion

This investigation sought to examine the relationship between percent body fat, as calculated from skinfold measures, and a specific body mass index, the Quetelet Index. Because body mass indices, including the one used here, depend on weight and height, the use of BMI to estimate percent body fat is often subject to error. A major drawback in using weight (in a BMI equation) to represent body mass is that it inadequately discriminates the varying proportions of fat, muscle, and skeletal mass in many subjects.

In this investigation of athletes and physically active males, a low but significant correlation (r=.15, t=2.15, p<.05) was found between BMI and percent muscle mass. The determination of muscle mass using girth and skinfold measurements (Drinkwater & Ross, 1980) resulted in percent muscle masses of 46.46%, 47.33%, 47.37%, and 47.05%, respectively, for the four subject groups. The values of the latter three groups were statistically similar (p<.05). That, in spite of the finding that Groups 2, 3, and 4 are statistically different (p<.05) with regard to percent fat. Naturally, muscle mass and percent fat are negatively related (Figure 4). In this study, a much stronger relationship (r=-.519, t=-8.60, p<.001) existed between muscle mass and percent fat that between BMI and percent fat (r=.250) (Figure 5).

It is also apparent that BMI is more strongly related to each of the anthropometric indices, MIX-Metric Index and PLX-Plastic Index, than to percent fat. A significant relationship (r=-.570, t=-.9.84, p<.001) was found for BMI and MIX. For BMI and PLX, the correlation coefficient was r=.583 (t(10.18, p<.001). Graphically, the relationship between BMI and MIX is presented in Figures 6 and 7.

The use of height and weight and other anthropometric measurements has its place for yielding descriptive data on body build and composition. Body mass index, as shown here, demonstrated high correlations with both MIX and PLX, anthropometric indices for body rotundness and bone/muscle development, respectively. To a much lesser extent, BMI was shown to correlate with percent fat. In addition, separate ANOVA analysis of BMI and percent fat revealed that BMI alone, is not necessarily a good predictor of percent body fat with college-age, physically active males.

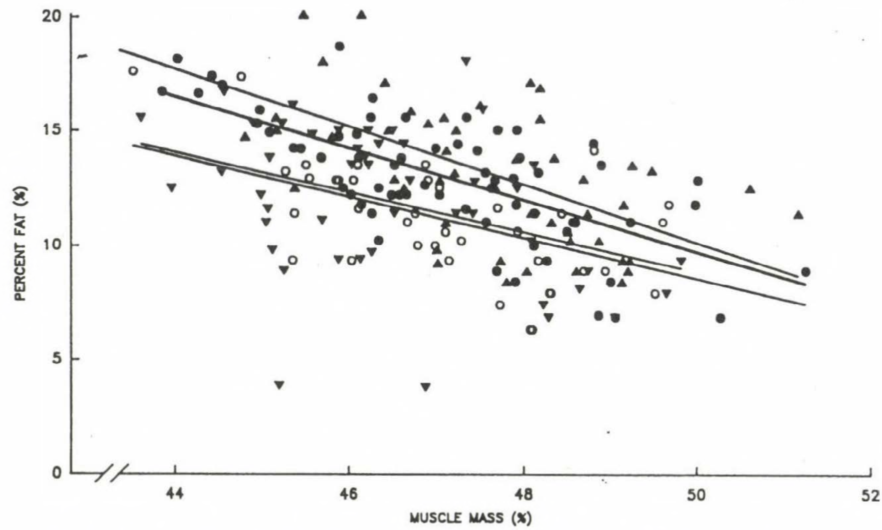

Fig. 4: Data points for muscle mass and percent fat for LEAN, MED HW, MED BMI, FAT.

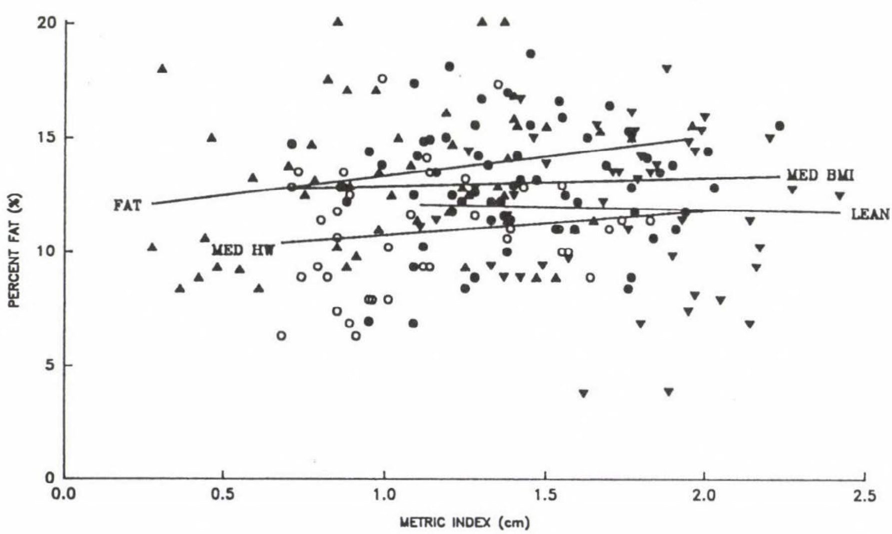

Fig. 5: Data points for metric index and percent fat for LEAN, MED HW, MED BMI, FAT.

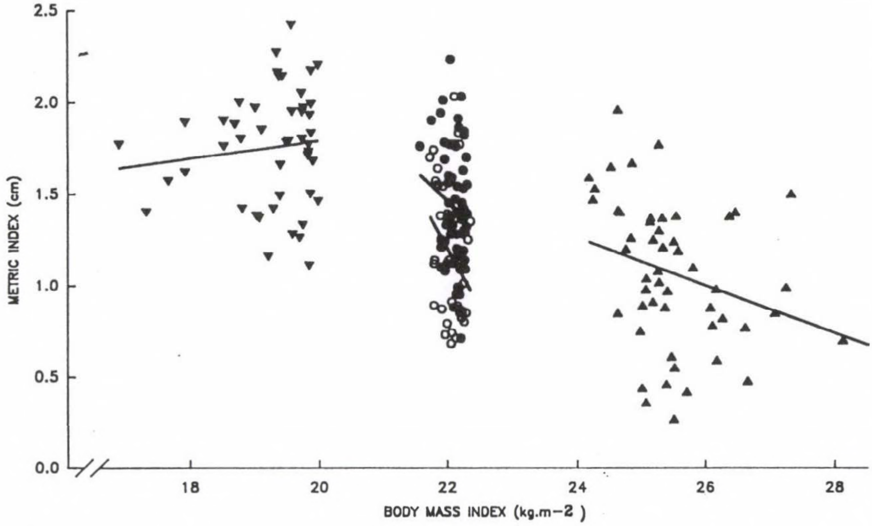

Fig. 6: Data points for body mass index and metric index for LEAN, MED HW, MED BMI, FAT.

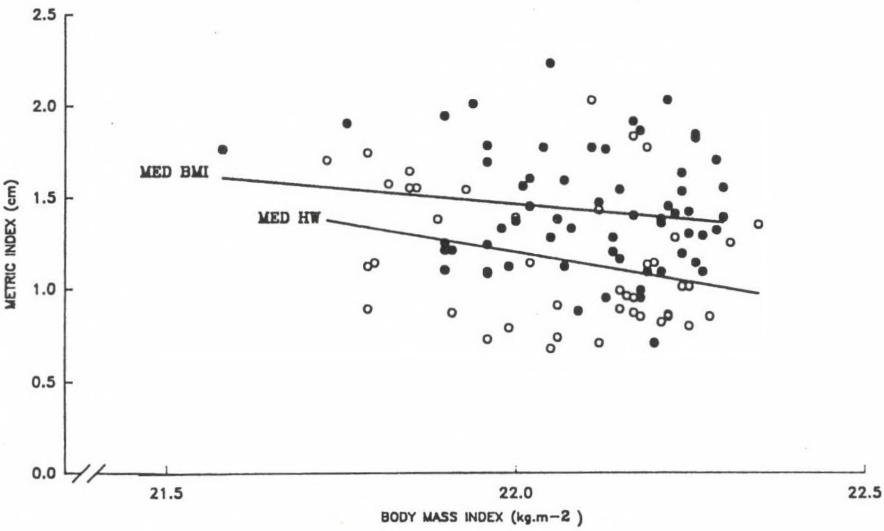

Fig. 7: Data points for body mass index and metric index for MED HW and MED BMI.

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