

The Non-adipose Body Mass of Obese Women: Evidence of Increased Muscularity

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BODY mass less the mass of its adipose tissue (non-adipose body mass or NAB) is an approximate indicator of total muscle mass and body protein content.^{1,2} The indirect measurement of NAB in obese man is of interest because of its relation to muscle mass, and therefore to physical fitness, in this all too common nutritional disorder. Furthermore, NAB might reflect reduced body protein content in instances of suspected "metabolic obesity", an entity recently proposed by Gordon *et al.*³ and thought to be the result of a metabolic derangement similar to that of hereditarily obese hyperglycemic mice. (These animals have a greatly reduced total body protein.⁴) The recognition of "metabolic obesity"—perhaps by a reduced NAB—could have therapeutic relevance, since it has been suggested that this disorder accounts for many instances of refractoriness to moderate caloric restriction.³

Adipose tissue mass, the value subtracted from body weight to obtain NAB, is a function of body fat‡ mass and the latter can be estimated in living subjects following concurrent determinations of total body water (by an indicator dilution method) and body density (by underwater weighing).⁵ Many patients are unable or unwilling to be immersed for weighing, but more approximate values for body fat mass may be derived for normally hydrated individuals from total body water (TBW) and body weight only.‡

The calculation of adipose tissue mass from body fat mass requires knowledge of the weight of the non-lipid components of adipose tissue. The authors have made direct measurements of the per cent non-lipid components in the adipose tissue of obese and non-obese patients undergoing surgery.⁵ For both groups the mean water content was $15 \pm 5\%$, fat-free solids accounting for a negligible fraction. These data have made possible the approximate derivation of adipose tissue mass using indirect methods.

The present communication reports indirect estimations of NAB for obese and non-obese women. Somewhat similar studies on men have been reported elsewhere.⁵

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‡For present purposes fat is defined to be the lipid components of the body. For normally nourished and obese subjects only a very small fraction of body fat is not in adipose tissue.

ABSTRACT

Non-adipose body mass (NAB) is an approximate indicator of total muscle mass and body protein content. The indirect measurement of NAB in obese man is of interest because of its relationship to muscle mass and, therefore, to physical fitness. Furthermore, NAB might reflect reduced body protein in instances of suspected "metabolic obesity".

Adipose tissue mass and NAB were derived from measurements of body weight and total body water in 48 obese and 19 normally nourished women with the aid of previously determined constants for the water fractions of adipose tissue and NAB.

The mean NAB was increased in 23 moderately obese patients (42.1 kg. vs. 35.2 kg. for the controls). A higher mean NAB (51.3 kg.) was found in eight grossly obese women.

It was concluded that obese women have a larger than normal mean muscle mass.

A height-weight table gave a grossly misleading estimate of the degree of obesity in two unusually muscular siblings.

SUBJECTS AND METHODS

Total body water (TBW) was determined on 48 women attending the Victoria General Hospital (Halifax) Obesity Clinic; all were over 130% of the mean "ideal" weight for their height (medium frame) according to Metropolitan Life Insurance Company tables.⁶ Eight women were over 200% of mean "ideal" weight. TBW was also determined on 19 normally nourished women (90 to 110% of mean "ideal" weight). The mean heights of the groups were within 0.5 inch of each other. The mean age of the obese group was 39 years and that of the control group 37 years. Subjects with manifest edema, metabolic or serious systemic disease were excluded from the study.

All TBW determinations were carried out in the fasting state using the deuterium oxide* dilution method of Schloerb *et al.*^{7,8} The precision of the method in this laboratory has been reported elsewhere.⁵

*Deuterium oxide was obtained from Atomic Energy of Canada Ltd. and, through the kindness of Dr. E. Lozinski, was prepared for injection by Charles E. Frosst & Co., Montreal.

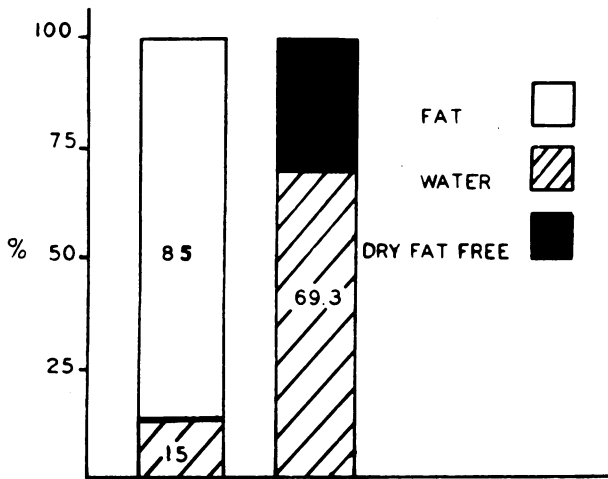


Fig. 1.—Mean human adipose tissue (left) and non-adipose body (right) water percentages. The values were not altered by the presence or absence of moderate obesity. Adipose tissue contained < 1% dry fat-free solids.

Calculations.—An equation for deriving adipose tissue mass from TBW and body weight, using the water fractions shown in Fig. 1 as constants, follows: $AT^* = 1.28 M^* - 1.85 TBW^*$

The mean NAB water fraction shown in Fig. 1 was derived from data on obese and non-obese men subjected to concurrent measurements of body density and TBW.⁵

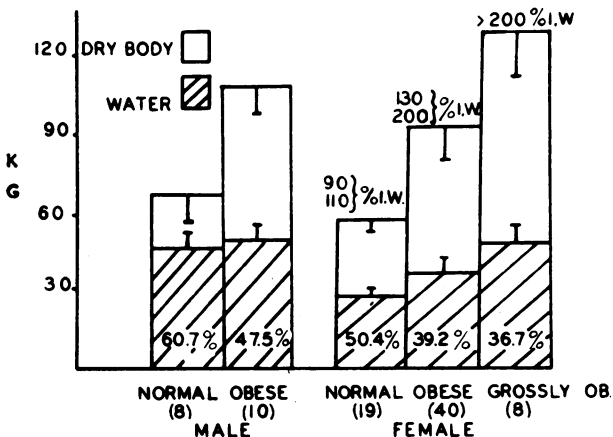


Fig. 2.—Mean body mass and TBW mass of obese and non-obese male and female subjects. The women were grouped by their % "ideal" weight (IW). The standard deviations are indicated by the perpendicular lines above and below the means. Per cent TBW is also indicated.

RESULTS

Mean TBW values for 19 normally nourished, 40 obese and eight grossly obese (> 200% of ideal weight) women are presented in Fig. 2. Data from 18 men have been included to show the sex difference in % TBW, this making it necessary to deal with results from the sexes separately. In both men and women the TBW mass increased with obesity, but the % TBW decreased, because of the greater increase in dry weight (fat and possibly fat-free solids).

The mean NAB's of the normal, obese and grossly obese groups of women are shown in Fig. 3. Mean NAB was increased in the obese and grossly obese groups ($p < 0.05$).

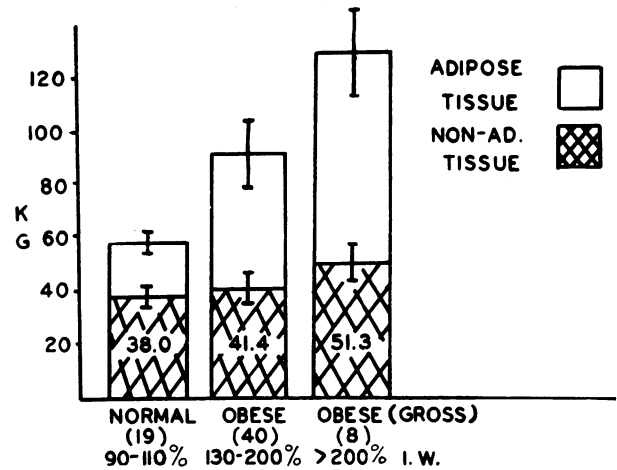


Fig. 3.—Mean body mass and NAB mass of obese and non-obese women grouped by % "ideal" weight. The three groups had similar mean heights.

However, the water fraction constants shown in Fig. 1 were calculated from observations on normally nourished individuals and those suffering from obesity of more moderate degree (122 to 176% of "ideal" weight). These constants might, therefore, not be valid for the large number of very obese cases used in the present study. This consideration led to a comparison of mean NAB values between the 20 least overweight of the 48 obese women and the 19 controls. The former group showed a slightly higher NAB but the difference was not significant ($p > 0.05$).

A reclassification of all normal and obese subjects on the basis of per cent body fat (i.e. 85% of adipose tissue mass) was, therefore, carried out. This procedure resulted in minor changes in the composition of the groups, those reclassified as normal being characterized by having approximately 23 to 35% fat and the 23 least obese of the overweight group 39 to 47% fat. As shown in Fig. 4, the latter (i.e. the "moderately" obese)

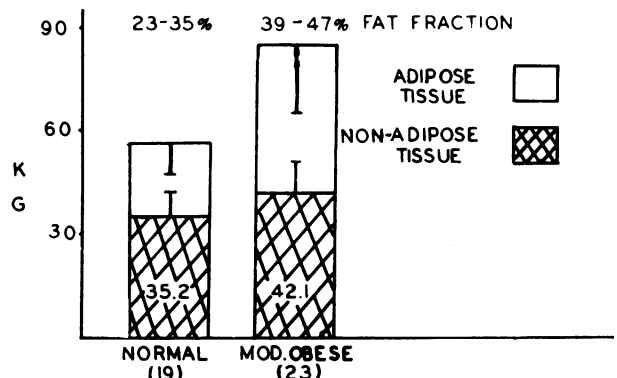


Fig. 4.—Mean body mass and NAB mass of moderately obese and non-obese women grouped by % body fat. The two groups had similar mean heights.

*AT = adipose tissue mass, M = body mass, and TBW = body water mass.

now demonstrated a highly significant increase in mean NAB (42.1 kg. vs. 35.2 kg. for the control group, $p < 0.01$).

DISCUSSION

The value of single studies of body fat mass, adipose tissue mass or NAB is limited by the large individual variation in the hydration of adipose tissue and to a lesser extent that of NAB. The method is more reliable, however, when comparing normally hydrated groups of normally nourished and/or moderately obese subjects.

Other investigators have reported an increased body protoplasmic mass (a function of total exchangeable potassium, intracellular water and fat-free solids) in obesity.⁹ However, lack of quantitative information regarding the protoplasmic fraction of adipose tissue has delayed the decision whether this change in protoplasmic mass with obesity resulted from increased adipose tissue mass only (as was proposed by von Döbeln¹⁰) or from a combination of this increase plus an augmented NAB cell mass. Recent studies from our laboratory have indicated that the protoplasmic fraction of adipose tissue is very small (mean value 3 to 4%),⁵ leading one to favour the alternative that NAB cell mass is increased in obesity. The present study provides strong support for this conclusion when applied to women, since it has been shown that NAB is increased in obese females. No augmentation of NAB was found by the present authors in a small group of obese men, however.⁵ The reason for this discrepancy is not known.

Since muscle makes up about 50% of NAB,^{1,2} it seems likely that obese women are more muscular than non-obese controls. Possibly the increased muscle mass is due to a training effect of carrying a large adipose tissue burden.

The grossly obese women had the greatest apparent increase in NAB. This may indicate that the "metabolic obesity" of Gordon *et al.*³ (see introduction) is not a common phenomenon among extremely obese patients.

There was considerable variation in the percentage of adipose tissue and NAB among individuals of similar height and weight. The error inherent in height-weight tables for the quantitative evaluation of obesity was especially noteworthy in two instances. A woman, 184% of "ideal" weight, had a normal fat fraction of 32% because of her remarkably large NAB (70 kg.). Her brother was 182% of "ideal" weight and had the largest NAB (81 kg.) of any male studied to date. One would have expected from his fat fraction of 34% that he would have been closer to 140% of "ideal" weight. Both siblings were muscular in appearance but the impression of obesity was predominant.

SUMMARY

Adipose tissue mass and non-adipose body mass (NAB) were derived from measurements of body weight and total body water in 48 obese and 19 normally nourished women with the aid of previously determined constants for the water fractions of adipose tissue and NAB.

The mean NAB was increased in the obese group, probably because of a larger than normal mean muscle mass.

A height-weight table gave a grossly misleading estimate of the degree of obesity in two unusually muscular siblings.

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PAGES OUT OF THE PAST: FROM THE JOURNAL OF FIFTY YEARS AGO

A REALLY UNITED BODY

When the Canadian Medical Association was re-organized seven years ago with the object of making the profession in Canada a really united body, the means proposed to accomplish this object were mainly two—the establishment of an official journal and the affiliation of the various provincial and local societies with the national association. The JOURNAL is, and will continue to be, the main link binding the individual physician to the Association. Since its establishment in 1911, there has been a gratifying increase in membership and in the attendance at the annual meetings. In the matter of affiliation progress has been

made. All the provinces except Quebec, where the diversity of language has unfortunately prevented it, have their own medical associations. These are all now officially affiliated with the national body. The by-laws of the latter provide that each affiliated society may elect to the Executive Council, the governing body of the Canadian Association, a number of delegates proportionate to its own membership. Hitherto the Council has consisted only of the fifteen members elected at the annual meeting, but it is expected that in the future all the provincial associations will appoint their delegates.—Editorial, *Canad. Med. Ass. J.*, 4: 312, 1914.