Fat Free Body Weight of Swedish Air Force Pilots

WILHELM VON DÖBELN, M.D.

IN THE PHYSICAL characterization of an individual, a measure of body size is of fundamental importance. The measure usually used is body weight, stature or both. Since the first report by Behnke[1] in 1942, it has generally been accepted that "lean body weight" (LBW) or "fat free body weight" (FFW) is a much better expression of body size for many purposes than total body weight. However the use of this measure of body size has hitherto been limited to a few laboratories. The reason for this is that the determination of FFW requires relatively elaborate and time-consuming procedures. The need for a simple method for determination of FFW therefore seemed obvious.

METHOD

The best method for determination of LBM or FFW available at present is density determination combined with determination of total body water. Behnke and Siri[2] attempted to correlate LBW determined in this way with certain anthropologic measurements. They showed that LBW could be ascertained from anthropometric measurements with a standard error of about 6 per cent. This result induced us to again attempt to correlate anthropologic measures with FFW using both males and females as test subjects.[3]

As a result of this study it was found that height, femoral condylar breadth and bistyloid radioulnar breadth could be used in young healthy subjects for estimation of FFW.

The best regression equation in our material is

$$FFW = 15.1\ (L^2 \times R \times F \times 100)^{0.712}$$ where

L = height
R = sum of right and left bistyloid radioulnar breadth
F = sum of right and left femoral condylar breadth

Unit for FFW is kilogram and for L, R and F is meter.

The measurements are easy to obtain with a high degree of accuracy with the exception of F. In older subjects the soft tissues around the knee are sometimes hypertrophic which makes it difficult to obtain an accurate measure. Therefore we have also calculated an equation for estimation of FFW from L and R only, which is

$$FFW = 1.2 + 162 \times L^2 \times R$$

What can be achieved by introducing this method for estimation of FFW? FFW in young healthy subjects can be determed from body density with an error of < 2 per cent.[4] If predicted from height the error in our data is practically 9 per cent. If predicted from L and R the error is 4.5 per cent and if predicted from L, R and F the error amounts to 4 per cent.

From the Department of Physiology, Kungliga Gymnastiska Centralinstitutet, Stockholm Ö, Sweden.

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RESULTS

It can be seen that the anthropometric method is not as accurate as density determination for the estimation of FFW and consequently of fat content of the body. The accuracy is much higher however than values obtained from height calculations alone. The relationship between FFW determined from density and predicted from L, F and R is shown in Figure 1. In order to facilitate the calculation of FFW, Table I is referred to.

TABLE I. FAT FREE BODY WEIGHT (KG) DETERMINED FROM ANTHROPOMETRIC MEASUREMENTS (CM).

Height cm.	(Right+Left Femoral Condylar Breadth)×(Right+Left Bistyloid Radioulnar Breadth)										
	170	180	190	200	210	220	230	240	250	260	270
160	43.0	44.8	46.6	48.3	50.0	51.7	53.4	55.0	56.6	58.2	59.8
1	43.4	45.2	47.0	48.7	50.5	52.2	53.8	55.5	57.1	58.7	60.3
2	43.8	45.6	47.4	49.2	50.9	52.6	54.3	56.0	57.6	59.3	60.9
3	44.2	46.0	47.8	49.6	51.4	53.1	54.8	56.5	58.1	59.8	61.4
4	44.6	46.4	48.2	50.0	51.8	53.5	55.3	57.0	58.7	60.3	62.0
5	45.0	46.8	48.7	50.5	52.2	54.0	55.8	57.5	59.2	60.8	62.5
6	45.3	47.2	49.1	50.9	52.7	54.5	56.2	58.0	59.7	61.4	63.0
7	45.7	47.6	49.5	51.3	53.2	54.9	56.7	58.5	60.2	61.9	63.6
8	46.1	48.0	49.9	51.8	53.6	55.4	57.2	59.0	60.7	62.4	64.1
9	46.5	48.4	50.3	52.2	54.1	55.9	57.7	59.5	61.2	62.9	64.7
170	46.9	48.9	50.8	52.7	54.5	56.4	58.2	60.0	61.7	63.5	65.2
1	47.3	49.3	51.2	53.1	55.0	56.8	58.7	60.5	62.2	64.0	65.8
2	47.7	49.7	51.6	53.5	55.4	57.3	59.1	61.0	62.8	64.5	66.3
3	48.1	50.1	52.1	54.0	55.9	57.8	59.6	61.5	63.3	65.1	66.9
4	48.5	50.5	52.5	54.4	56.4	58.3	60.1	62.0	63.8	65.6	67.4
5	48.9	50.9	52.9	54.9	56.8	58.7	60.6	62.5	64.3	66.2	68.0
6	49.3	51.3	53.3	55.3	57.3	59.2	61.1	63.0	64.9	66.7	68.5
7	49.7	51.7	53.8	55.8	57.7	59.7	61.6	63.5	65.4	67.2	69.1
8	50.1	52.2	54.2	56.2	58.2	60.2	62.1	64.0	65.9	67.8	69.6
9	50.5	52.6	54.6	56.7	58.7	60.7	62.6	64.5	66.4	68.3	70.2
180	50.9	53.0	55.1	57.1	59.1	61.1	63.1	65.0	67.0	68.9	70.7
1	51.3	53.4	55.5	57.6	59.6	61.6	63.6	65.6	67.5	69.4	71.3
2	51.7	53.8	56.0	58.0	60.1	62.1	64.1	66.1	68.0	70.0	71.9
3	52.1	54.3	56.4	58.5	60.6	62.6	64.6	66.6	68.6	70.5	72.4
4	52.5	54.7	56.8	58.9	61.0	63.1	65.1	67.1	69.1	71.1	73.0
5	52.9	55.1	57.2	59.3	61.5	63.6	65.6	67.6	69.6	71.6	73.5
6	53.3	55.5	57.7	59.9	62.0	64.1	66.1	68.2	70.2	72.2	74.1
7	53.7	56.0	58.1	60.3	62.4	64.5	66.6	68.7	70.7	72.7	74.7
8	54.1	56.4	58.6	60.8	62.9	65.0	67.1	69.2	71.2	73.3	75.3
9	54.5	56.8	59.0	61.2	63.4	65.5	67.6	69.7	71.8	73.8	75.8
190	55.0	57.2	59.5	61.7	63.9	66.0	68.2	70.3	72.3	74.4	76.4
1	55.4	57.7	59.9	62.2	64.4	66.5	68.7	70.8	72.9	74.9	77.0
2	55.8	58.1	60.3	62.6	64.8	67.0	69.2	71.3	73.4	75.5	77.5
3	56.2	58.5	60.8	63.1	65.3	67.5	69.7	71.8	74.0	76.0	78.1
4	56.6	59.0	61.2	63.6	65.8	68.0	70.2	72.4	74.5	76.6	78.7
5	57.0	59.4	61.7	64.0	66.3	68.5	70.7	72.9	75.0	77.2	79.3

The physical fitness of air force pilots is carefully controlled. However, a disease which seems to be of increasing importance in civilized countries including pilots is obesity. To date lower grades of obesity have been difficult to recognize. A slightly overweight subject estimated from the usual relationship of height and weight is said to possess a sturdy body build. The determination of FFW from anthropometric measurements including skeletal diameters makes this concept invalid.

The anthropometric method was used in a random sample of 109 Swedish air force pilots. The result of the measurements is shown in Table II. The mean value for fat weight of 8.9 kg represents 13 per cent of body weight, which is just slightly greater than the mean value of 10 per cent found in a survey of students of physical education.[4] Consequently obesity does not seem to represent a major problem in the Swedish Air Force.

A comparative study was made using available data for United States pilots obtained from results reported by

Hertzberg et al.[5] This comparison is shown in Table II. The age distribution among the two groups were similar in that 98 per cent of the United States Air Force pilots and 88 per cent of the Swedish pilots were less than thirty-six years old.

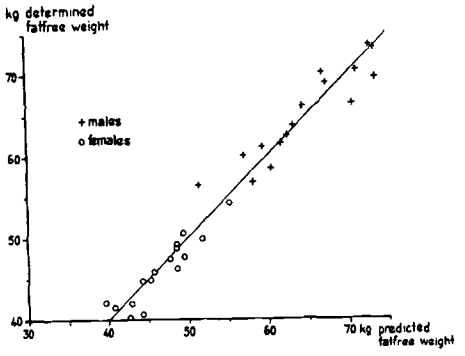

Fig. 1. Fat free weight determined from body density in relation to fat free weight predicted from anthropologic measurements.

The assumption was made that the composition and build of the fat free body of Swedish and United States Air Forces pilots is the same and that the difference is only in height. If this assumption is accepted, the FFW of the USAF pilots can be obtained from FFW data for Swedish pilots multiplied by the height scale raised to the third power. The figures for FFW and fat weight estimated in this way are shown. One can conclude that a definite difference in nutritional standards probably exists between pilots in the Swedish and United States Air Forces.

TABLE II.
MEAN PHYSICAL CHARACTERISTICS OF SWEDISH AND U. S. AIR FORCE PILOTS

	Mean		Difference Between Means
	Swedish	USAF	
Weight, kg.	70.64 ± 0.71	74.23 ± 0.15	−3.59
Height, cm.	178.2 ± 0.62	175.5 ± 0.09	+2.7
FFW, kg.	61.65 ± 0.57	58.9*	+2.75
Fat, kg.	8.91 ± 0.47	15.3*	−6.4

*Estimated values.

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Air and Space

United States and Soviet delegates to the International Aeronautical Federation meeting in Barcelona last month reached agreement on standards for judging world space-flight records and thus took an important step toward solution of the air-space controversy. Under the agreement, flights would have to reach an altitude of 62 miles to qualify as space flights, with records to be recognized for manned rocket vehicles only. Records would include duration, altitude, and weight. This was the first instance in which U. S. and Soviet representatives reached an accord with regard to the definition of "air" and "space," and may herald the beginning of international agreements on such definitions for legal purposes.—*Astronautics*, November, 1960.