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The anthropometric estimation of body density and lean body weight of male athletes

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ABSTRACT. The purpose of this investigation was to evaluate the validity of using selected equations which had been derived from anthropometric measures of general populations for estimating the body density (D_B) and lean body weight (LBW) of college athletes. New regression equations were also derived on the basis of measurements taken on the sample of athletes studied. True D_B (underwater weighing), true percent fat, skinfolds (SF), and skeletal diameters were measured in 50 male, spring sports participants (17 baseball, 15 track and field 11 spring football and 7 tennis). The correlation for true D_B and estimates from the equation of Pascale, et al. were significant (.76) as was that for Sloan's equation (.74). Correlations between Behnke's technique using skeletal diameters and different k values were significant (all .85). Multiple correlations between true D_B and D_B estimated from newly derived equations ranged from .43 for equations using only skeletal diameters to .90 for equations using SF's and diameters. The highest multiple correlation (.90) was obtained from the equation $D_B = 1.02967 - .00131$ subscapular SF $+ .00196$ bitrochanteric diameter $- .00126$ abdominal SF $- .00096$ triceps SF $+ .00260$ sum of knee diameters $- .00114$ biiliac diameter. When the established and newly derived equations were used to estimate D_B values of sub-groups formed according to the sports represented, it was found that groups at the high or low extremes of body density were not as accurately evaluated as those groups nearer the total sample mean.

Anthropometric measures such as skinfolds, skeletal diameters or body circumferences are frequently used to predict (i.e., estimate) body fat and lean body weight (LBW) via regression equations. Such procedures have fair accuracy as long as the sample to which an equation is applied is comparable to one from which it was derived. Unfortunately, such equations have not been developed from samples of athletes even though studies have suggested that they may comprise a distinct physical group (2,9,10).

The purpose of the present investigation was to study the use of skinfolds and skeletal measures for the estimation of fat and LBW in athletes. Two questions relative to the problem were considered: (1) Could selected regression equations derived from nonathletic populations give a valid estimation of body composition in athletes? and (2) Could a suitable regression equation for making such estimates be derived from a sample of athletes?

METHODS

Subjects were 50 male athletes participating in varsity sports at Springfield College during the Spring of 1969. Except for one 29 year old subject, they ranged in age from 19 to 22 years. The sports represented were baseball (17 subjects), track and field (15 subjects), spring football (11 subjects), and tennis (7 subjects). Physical characteristics are summarized in Table 1.

The underwater weighing method was used to measure body density (D_B). In the procedure employed, the underwater weight and residual lung volume were measured simultaneously.

Subjects were weighed dry to an accuracy of ±½ oz. (14 gm.) by use of a platform balance. Underwater weight was measured with an autopsy scale (John Chatillon and Sons) sensitive to ±10 gm. The residual lung volume was measured by a modification of the closed-circuit, N_2 dilution technique described by Wilmore (11) at the same time as underwater weight. The N_2 concentration in the oxygen which was inhaled and exhaled by the subject was monitored by placing the sampling needle of the nitrogen analyzer (Model 305 AR Nitralyzer by Med-Science) at the connection between the spirometer and the rubber hose rather than in the mouthpiece. Preliminary testing revealed no significant difference between the results from the two methods.

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TABLE 1. Mean values for measurements taken on subjects.

Measurement	Mean	S.D.
Height (cm)	179.0	0.56
Weight (kg)	77.2	8.71
Body Density	1.072	0.0102
Percent Body Fat[a]	12.2	4.08
Lean Body Weight (kg)	67.7	7.40
Skeletal Diameters (cm)		
biacromial	40.9	1.84
bitrochanteric	32.8	1.44
wrists (right + left)	11.7	0.58
ankles (right + left)	14.4	0.69
chest	26.9	1.62
bi-iliac	28.2	1.45
elbows (right + left)	14.2	0.74
knees (right + left)	18.1	9.7
Skinfolds (millimeters)		
abdomen	10.0	3.34
chest (mid-axillary line)	8.0	3.49
chest (juxta-nipple)	7.0	2.40
back (subscapular)	11.0	2.75
thigh	13.0	3.65
upper arm (triceps)	11.0	3.14

[a] computed according to equation of Brozek et al. (3)

The equation of Goldman and Buskirk (4) was used to compute D_B from dry and underwater weights. Prior to collecting data, 24 replicate measures were taken on different subjects, the second measurements all falling within ±.002 gm/cc of the first.

Biacromial, chest, bi-iliac, bitrochanteric, knee, ankle, elbow and wrist diameters were measured according to procedures and standards of accuracy first used by Behnke (1), later by Behnke and Royce (2) and by Wilmore and Behnke (12). Gneupal anthropometers (Gilliland Instrument Company) were used to take the measurements.

Chest (juxta-nipple), chest (mid-axillary line), triceps, subscapular and thigh skinfolds were measured on the right side of the body by use of a Lange skinfold caliper (Cambridge Scientific Industries, Inc.). The two chest and triceps folds were measured as described by Pascale, et al. (6) while the sites for the subscapular and thigh folds were measured as described by Sloan (7). The competency of taking the skinfold measures was established prior to collecting data by taking 100 duplicate measurements of the different skinfolds. Test-retest correlation coefficients were then computed to establish reliability of the tester. All correlations were .85 or better.

Two regression equations were arbitrarily selected to estimate body density from the skinfold measures. These were the ones developed by Pascale, et al. (6) and by Sloan (7). The former equation is as follows (all skinfolds in cm): $D_B = 1.088468 - .007123$ mid-axillary $- .004834$ juxta-nipple $- .005513$ triceps. Sloan's equation is (all skinfolds in mm): $D_B = 1.1043 - 0.001327$ thigh $- 0.00131$ subscapular. These equations were selected because they were originally derived from college-age populations, were felt to be typical of skinfold equations, used different skinfold sites, and were practical for testing large groups if found to have high validity in the present study.

TABLE 2. Table of k values.

(cm) Diameter	k values[a] Present Study	Wilmore & Behnke (13)	Behnke (1)
Biacromial	21.4	21.3	21.6
Bitrochanteric	17.2	17.3	17.4
Wrist[b]	6.1	5.9	5.9
Ankles[b]	7.5	7.2	7.4
Chest	14.1	15.5	15.9
Bi-iliac	14.8	14.7	15.6
Elbows[b]	7.4	7.1	7.4
Knees[b]	9.5	9.7	9.8

[a] $k = c / \sqrt{LBW/h}$ and $LBW = 0.204 \times h^2$ (h in decimeters)
[b] sum of right and left sides.

The equation of Behnke (1) was used to estimate LBW from skeletal diameters. The equation used was: $LBW = D^2 \times h$, where h is height in decimeters and D is the average of d values obtained for any person, $d = c/k$, c is the measured value for a given diameter, and k is a conversion factor specific for it. Estimates of LBW were made using 3 sets of k values, those by Behnke derived from Naval personnel (1), those by Wilmore and Behnke derived from college males (13), and those derived from the present sample according to Behnke's instructions (see Table 2).

The percent body fat was computed from the D_B values, whether obtained via underwater weighing or skinfolds, according to the equations of Brozek, et al. (3) [$\% \text{ Fat} = (4.570/D_B - 4.142) \times 100$], and of Siri (8) [$\% \text{ Fat} = (4.950/D_B - 4.500) \times 100$]. The LBW was computed from total body weight (TBW) according to the formula: $LBW = TBW - (TBW \times \% \text{ Fat}/100)$.

True LBW's, as determined by underwater weighing, were correlated (product-moment method) with the LBW's obtained using Behnke's method. The D_B's obtained by underwater weighing were correlated with the D_B's obtained using the regression equations. Regression equations were also developed from the present data for the estimation of D_B by using the stepwise, multiple-regression procedure (IBM Model 360 Computer). The combinations of variables used for developing different equations are shown in Table 5. Separate equations were developed using (1) all of the measurements, (2) only the skinfolds, (3) skinfolds with height, weight, and Ponderal Index, (4) only diameters, and (5) diameters with height, weight and Ponderal Index. Such a procedure produced a variety of equations which could be evaluated relative to their accuracy in estimating body composition factors as well as their usefulness for testing large groups.

RESULTS

The mean values for the measures taken are shown in Table 1. The mean body density of the athletes (1.072 gm/cc ± 0.0102) was higher than values of 1.064 ± .010 gm/cc reported in 1968 by Wilmore and Behnke (13) on college men and 1.066 ± .013 gm/cc reported by the same authors on another sample of college men in 1969 (12). It was also higher than the value of 1.068 ± .012 gm/cc reported by Pascale, et al. (6) for military personnel. It was less, however, than the values of 1.074 ± .018 gm/cc reported by Michael and Katch (5) on high school boys and 1.075 ± .020 gm/cc by Sloan (7) on young men.

The mean body fat value of 12.2 percent of total body weight was lower than 15.36 percent and 14.69 percent reported by Wilmore and Behnke on college men (12, 13) when using the same equation (8) to estimate fat from D_B. In Sloan's study, (7), in which South African students were used as subjects, the average was lower being only 10.8 percent. By sport, the percentages were as follows: 15 track men, 9.4 percent with the middle-distance and long-distance runners averaging 8.0 percent; 17 baseball players, 12.1 percent; 6 tennis players, 14.6 percent and 11 spring football players, 14.5 percent. These compare favorably to percentages of 8.4 to 9.6 percent and 8.9 to 14.2 percent found by Behnke and Royce (2) on track men and basketball players respectively.

A summary of the intercorrelations obtained between true and estimated values of D_B and LBW is presented in Table 3. The means for the estimated body densities were very close to the true means, being within acceptable limits of error on replicate measures in a single experiment. However, the variance of the estimates were not similar, the standard deviations for the equations of Pascale and co-workers and of Sloan being considerably less than the true value of 0.0102. The attained correlations of .74 between Sloan's equation and true D_B was very close to the value of .731 found by Wilmore and Behnke (12) on college men. The correlation of .76 between the true D_B and the D_B estimated by the question of Pascale, et al. (6) was also significant.

The correlations between true LBW and estimates made by use of Behnke's technique were highly significant. There was a tendency to underestimate true LBW. There was very little difference between values obtained when k factors computed by Wilmore and Behnke (13) or k factors computed from the present data were used, the underestimate of LBW being 1.9 and 2.1 kg. respectively. When the k factors originally developed by Behnke from Naval personnel were used, (1) the average true LBW was underestimated by 3.8 kg.

The zero-order correlations among the variables are shown in Table 4. There was a high relationship among the skinfold measurements in that all correlations were significant beyond the .01 level of confidence. All of the correlations between the skinfold thicknesses and body density were negative and significant beyond the .01 level. The sum of the right and left knee diameters was the only skeletal measurement that showed significant relationships with the skinfold measures; all of the correlation coefficients were significant at or beyond the .01 level of confidence. The intercorrelations among the skeletal measurements were all significant at or beyond the .05 level, but none of them correlated significantly with body density.

TABLE 3. Body densities and lean body weights and coefficients of correlation using data from present study.

	Mean	Standard Deviation
Body Densities (gm/cc)		
(1) Present study	1.072	0.0102
(2) Pascale et al. equation	1.073	0.0048
(3) Sloan equation	1.073	0.0076
Lean Body Weights (kg)		
(4) Measured value	67.7	7.40
(5) Estimated by equation of Behnke from present study *k* factors	65.6	6.40
(6) Estimated by equation of Behnke using Wilmore and Behnke *k* factors	65.8	6.46
(7) Estimated by equation of Behnke using Reference Man *k* factors	62.9	6.16

Coefficients of Correlation*

	r		*r*
(1) with (2)	.76	(4) with (5)	.85
(1) with (3)	.74	(4) with (6)	.85
(2) with (3)	.87	(4) with (7)	.85

* .05 Level = .273 .01 Level = .354

The computed regression equations and coefficients of multiple correlation (R) are presented in Table 5. Of the six combinations of data used, equations 1a and 1b were developed twice; first when all of the variables measured were used and again when only the skinfolds and skeletal diameters were used.

As shown in Table 5, there was very little difference among the R values and standard errors of estimate from equations using all variables (1a and 1b), skinfolds and skeletal diameters (2a and 2b), and skinfolds, height, weight and ponderal index (3a and 3b). Equations where skinfolds were excluded from the matrix (4a and 4b, 5a and 5b), did not approach equations 1, 2 and 3 in size of R or standard error of estimate.

Examination of Table 5 also reveals that not all of the measures taken were entered into an equation through the stepwise multiple regression analysis. Of the skeletal measurements, the biacromial, ankle, and elbow diameters were not used. Of the skinfolds, the chest (juxta-nipple) and thigh measures were not entered into the derived equations.

The correlation coefficients between true and estimated values are presented in Table 6 according to sport. With the exception of those for the tennis

TABLE 4. Matrix of zero order correlation coefficients.

	Weight	Pond. Index	Biacrom.	Bitroch.	Wrists	Ankles	Chest	Bi-iliac	Elbows	Knees	Abdomen	Chest (MAL)	Chest (JN)	Back	Thigh	Upper Arm	Body Density
Height	.60	.32	.48	.61	.59	.49	.50	.44	.58	.46	.06	.09	.10	.06	—.10	—.01	.19
Weight		—.56	.48	.53	.61	.70	.49	.36	.60	.79	.49	.56	.55	.52	.23	.36	—.25
Ponderal Index			—.09	—.01	—.13	—.31	—.05	.01	—.10	—.47	—.49	—.53	—.53	—.53	—.38	—.43	—.49
SKELETAL DIAMETERS																	
Biacromial				.51	.59	.49	.55	.43	.44	.38	—.06	—.14	.04	.02	—.16	—.15	.19
Bitrochanteric					.54	.58	.35	.59	.69	.52	.06	.09	.19	.02	.06	.01	.25
Wrists						.71	.44	.33	.61	.62	.02	.05	.16	.06	.02	.03	.21
Ankles							.46	.34	.71	.73	.17	.22	.20	.17	.02	.15	.08
Chest								.41	.37	.31	.13	.09	.03	.17	—.17	—.08	—.01
Bi-iliac									.38	.32	—.12	—.13	—.14	—.08	—.22	—.11	.18
Elbows										.65	.14	.23	.18	.16	.11	.12	.13
Knees											.37	.49	.42	.43	.32	.42	—.12
SKINFOLDS																	
Abdomen												.84	.82	.83	.59	.68	—.79
Chest (MAL)													.77	.82	.59	.62	—.65
Chest (JN)														.77	.68	.69	—.68
Back															.63	.71	—.79
Thigh																.70	—.57
Upper Arm																	—.71
			SKELETAL DIAMETERS								SKINFOLDS						

To be significant at the .05 level of confidence with forty-eight degrees of freedom, r must reach a value of .273; at the .01 level, .354.

TABLE 5. Regression equations for estimation of body density.

Measurements[a] Included	Equation No.	Derived Equation[b]	R	S.E. est.	Level of Sig.
s, d, ht, wt, P.I.	1a	$Y = 1.03523 - .00156X_{15} + .00207X_5 - .00140X_{12}$	.87	.005	.05
	1b	$Y = 1.02967 - .00131X_{15} + .00196X_5 - .00126X_{12} - .00096X_{17} + .00260X_{11} - .00114X_9$	.90	.005	.01
s	2a	$Y = 1.10300 - .00168X_{15} - .00127X_{12}$	.82	.006	.05
	2b	$Y = 1.10647 - .00162X_{15} - .00144X_{12} - .00077X_{17} + .00071X_{13}$	.84	.006	.01
s, ht, wt, P.I.	3a	$Y = 1.02415 - .00169X_{15} + .00444X_1 - .00130X_{12}$	.86	.005	.05
	3b	$Y = 1.03316 - .00164X_{15} + .00410X_1 - .00144X_{12} - .00069X_{17} + .00062X_{13}$	.87	.005	.01
d, ht, wt, P.I.	4a	$Y = .84512 + .01335X_3 + .00488X_6$	.55	.009	.05
	4b	$Y = .88314 + .00651X_3 + .00666X_6 - .00060X_2 + .00255X_5$	.61	.008	.01
d	5a	$Y = 1.03900 + .00238X_5 - .00646X_{11} + .00616X_6$	.43	.010	.05
	5b	$Y = 1.04798 + .00255X_5 - .00645X_{11} + .00710X_6 - .00096X_8$	.44	.010	.01

[a] s all skinfolds, d all diameters, ht height, wt weight, P.I. Ponderal Index;

[b] variables are as follows: Y estimated body density, X_1 height (decimeters), X_2 weight (kilograms), X_3 Ponderal Index, X_4 biacromial diameter (cm), X_5 bitrochanteric diameter (cm), X_6 wrist diameters (right + left, cm), X_7 ankle diameters (right + left, cm), X_8 chest diameter (cm), X_9 bi-iliac diameters (cm), X_{10} elbow diameters (right + left, cm), X_{11} knee diameters (right + left, cm), X_{12} abdominal skinfold (mm), X_{13} chest skinfold (mid-ax. line, mm), X_{14} chest skinfold (juxta-nipple, mm) X_{15} back skinfold (subscapular, mm), X_{16} thigh skinfold (mm), X_{17} upper arm skinfold triceps, (mm).

TABLE 6. Zero order correlations between true and estimated body densities according to sport.

Method	Baseball (N = 17) M	r[a,b]	Football (N = 11) M	r	Track (N = 15) M	r	Tennis (N = 7) M	r
True D_B	1.072	—	1.067	—	1.079	—	1.064	—
Sloan	1.072	.60	1.071	.79	1.079	.74	1.068	.32
Pascale	1.072	.87	1.071	.68	1.077	.60	1.071	.41
1 a[c]	1.071	.89	1.069	.95	1.078	.81	1.067	.71
1 b	1.072	.92	1.068	.85	1.077	.81	1.067	.88
2 a	1.071	.89	1.069	.95	1.077	.71	1.067	.38
2 b	1.072	.88	1.068	.88	1.078	.75	1.066	.35
3 a	1.070	.90	1.069	.92	1.078	.79	1.067	.49
3 b	1.071	.90	1.068	.93	1.078	.81	1.066	.46
True LBW	68.1	—	70.8	—	66.1	—	65.5	—
Sample k's	63.7	.80	66.5	.93	66.6	.93	66.3	.73
Wilmore and Behnke's k's	63.9	.80	66.8	.93	66.8	.93	66.6	.73
Behnke's k's	61.1	.80	63.8	.93	63.8	.93	63.6	.73

[a] To be significant at the .05 level of confidence r must equal or exceed .48 with 15 df, .60 with 9 df, .51 with 13 df, and .75 with 5 df. ($df = N - 2$).
[b] All correlations are between the estimated and true values.
[c] 1a through 3b refer to regression equations derived in the present study; refer to Table 5.

group, all coefficients were significant. For that group, only the correlations between true D_B and D_B estimated with equations 1a and 1b were significant. A ranking of the correlations for each method reveals that with the exception of equation 1b, the tennis group always had the lowest correlation.

The low correlations obtained for the tennis group were apparently due to two factors: (1) the small sample size, and (2) the sub-sample as a group represented the low extreme in body density. The mean D_B for the tennis players was 1.064 while that for the total sample was 1.072. All of the equations overestimated the mean true D_B.

A similar but opposite effect was shown for the track group whose mean true D_B of 1.079 represented the high extreme for the sub-groups. With exception of Sloan's equation where the true D_B is accurately estimated and the attained correlation is second highest, and equation 1b where it was lowest, the ranking of its correlation for a given method was always next to lowest. The tendency was to slightly underestimate the true D_B by all but Sloan's equation.

A further analysis of the accuracy of estimation for sub-groups is shown in Figure 1 where Sloan's equation was used as an example. It is apparent that the regression line showing the relationship between true and estimated D_B values does not follow the line of identity. Because the line slope was less than 1.00, there was a tendency for higher values to fall below the line of identity and low values to fall above it. By comparing the obtained regression line to the line of

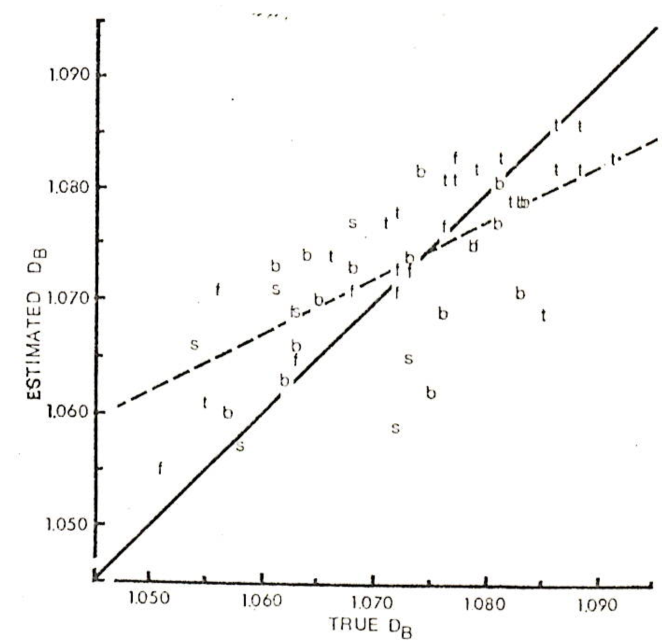

Figure 1—The relationship between true D_B and D_B estimated according to Sloan's equation is shown by the broken line. ($Y = .4801 + .5531X$; SE_{est} .0052) The line of identity is shown by the solid line. Values plotted above the line of identity are overestimates of true D_B, those below underestimates. Note that the plotted regression line and the line of identity cross at 1.075 on the Y axis. This was the true D_B for the sample from which Sloan's equation was derived. Plotted points are *b*, baseball; *f*, football; *s*, tennis; *t*, track.

identity, it would be expected that Sloan's equation would, on the average, underestimate true D_B by about .002 gm/cc when the true value was 1.079 (track) or overestimate it by about .004 gm/cc when the true D_B was 1.064. Although the estimated mean D_B for the track group was accurate, the error for the tennis group was what would be expected.

Figure 1 also illustrates the problem of using equations to estimate D_B values for individuals. Although the mean D_B estimated by Sloan's equation was only .001 gm/cc higher than the true mean (Table 3), there was considerable inaccuracy for individual cases.

DISCUSSION

Validity of using regression equations derived from non-athlete populations.

The equation of Pascale et al. (6) like that of Sloan (7) showed significant correlations with true values. The similarity between the correlation coefficients for the present sample and the one found by Wilmore and Behnke (13) with Sloan's estimate (.74 and .731 respectively) suggests that the equation is equally applicable to college-age athletes and college-age men in general. The multiple correlation coefficient found by Sloan between the estimated and true values for the population from which the coefficient was derived was .845 (7). The multiple correlation coefficient between estimated and true values found by Pascale et al. was .8495.

Behnke's equation produced correlation coefficients between true and estimated LBW (r in all cases 0.85) similar to those obtained in previous studies on non-athletic populations. In 1959 Behnke reported an r of 0.90 between the true and estimated LBW for the same combination of measures used here. Wilmore and Behnke (12,13) later found values of 0.799 and 0.893. Even though there was a tendency to underestimate LBW, the correlations between true and estimated LBW suggest this technique can estimate LBW in athletes as well as in non-athletes.

Development of a new regression equation.

Six equations which have value for estimating D_B of athletes were developed (Table 5, 1a through 3b). The multiple correlation coefficients obtained suggest that all of them would have more precision for estimating D_B than the equations of Sloan or Pascale et al. However, the multiple correlations were only equal to or slightly higher than the zero-order correlations obtained by use of Behnke's estimates of LBW.

When evaluated by the size of R and standard error of estimate, there is very little difference among the six equations. Equation 1b would be expected to give the greatest accuracy, but very little accuracy would be lost by using the more convenient measures of equations 1a or 3a when dealing with a large number of subjects.

Use of regression equations with select groups.

The analysis of results for each sport suggests that extreme caution must be used when estimating body composition in specialized groups by use of regression equations. Even sub-groups within a sample from which an equation is derived may be poorly estimated. Table 6 would be of some help in making a selection from the equations studied here.

Wilmore and Behnke (13) observed that predictive equations attain maximum accuracy only when they are applied to samples similar to those from which they were derived. The present results strongly support their observation and suggest that such equations have reasonable accuracy only over a very limited range. Perhaps it would be more appropriate to develop such equations according to sport rather than trying to develop them for athletes as a group.

Comment.

There was apparently no greater inaccuracy in using the previously established equations to estimate D_B or LBW in athletes than one would expect for college-aged males in general. The equations developed from the present sample did have higher correlation coefficients than the other equations between true and estimated D_B when applied to the sample as a whole. However, a high correlation between the estimated and true values is expected when a regression equation is applied to the sample from which it was derived. The failure of the established equations as well as the new equations, to produce consistent results with sub-groups composed of athletes divided according to the sport represented suggests these equations are highly specific relative to their application. It may be most appropriate to develop new equations according to sport rather than to athletes as a group.

REFERENCES

1. Behnke, A. R. Quantitative Assessment of Body Build. *J. Appl. Physiol.* 16:960-968, 1961.
2. Behnke, A. R., and J. Royce. Body Size, Shape and Composition of Several Types of Athletes. *J. Sports Med.* 6:75-88, 1966.
3. Brozek, J., et al. Densitometric Analysis of Body Composition: Revision of Some Quantitative Assumptions, *Ann. N.Y. Acad. Sci.* 110:113-140, 1963.
4. Goldman, R. F., and E. R. Buskirk. Body Volume Measurement by Underwater Weighing: Description of a Method. *Techniques for Measuring Body Composition* edited by Brozek and Henschel. National Academy of Sciences—National Research Council, Washington, D.C., 78-89, 1961.
5. Michael, E. D., Jr., and F. I. Katch. Prediction of Body Density from Skinfold and Girth Measurements of 17 year-old Boys. *J. Appl. Physiol.* 25:747-750, 1968.

6. PASCALE, L. R., et al. Correlations between Thickness of Skinfolds and Body Density in 88 Soldiers. *Human Biol.* 28:165-176, 1956.
7. SLOAN, A. W. Estimation of Body Fat in Young Men. *J. Appl. Physiol.* 23:311-315, 1967.
8. SIRI, W. E. *Body Composition from Fluid Spaces and Density.* Donner Lab. Med. Physics (Univ. Calif.) Rept. of 19 March, 1956.
9. TANNER, J. M. *The Physique of the Olympic Athlete.* London: George Allen and Unwin, Ltd., 1964.
10. THOMPSON, C. W., et al. Changes in Body Fat Estimated from Skinfold Measurements of College Basketball and Hockey Players during a Season. *Res. Quart.* 27:418-430, 1956.
11. WILMORE, J. H. A Simplified Method for Determination of Residual Lung Volumes. *J. Appl. Physiol.* 27:96-100, 1969.
12. WILMORE, J. H., AND A. R. BEHNKE. An Anthropometric Estimation of Body Density and Lean Body Weight in Young Men. *J. Appl. Physiol.* 27:25-31, 1969.
13. WILMORE, J. H., AND A. R. BEHNKE. Predictability of Lean Body Weight through Anthropometric Assessment in College Men. *J. Appl. Physiol.* 25:349-355, 1968.