EQUATIONS FOR DETERMING BODY FAT CONTENT BY SKINFOLD METHOD

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The purpose of this study was to determine body fat content by skinfold (SKF) and hydrodensitometry methods. The subjects that were selected included 435 males and 410 females. Results showed that fat percentage (F%) calculated by SKF equations from other countries was significantly different from those measured by classical hydrostatic weighing techniques. This indicates that the SKF equations from other countries are not suitable for calculation of body fat content in the Chinese population. By establishing the body density (Db) of Hydrodensitometry as standard, the predicted regressive equations of body fat content in Chinese by skinfold method were developed.

KEY WORDS: body density, hydrostatic weighting, body composition, skinfold

INTRODUCTION: Body fat is one of the major health-related components of fitness. Excess body fat content is linked to the high rate of many kinds of illness, such as cardiovascular disease, diabetes, and cancers. For various types of athletes, dancers and other special professions, high body fat content can affect their fitness and performance. Therefore, a simple effective method for determining body fat content is always a concern for athletes and related professionals. Hydrodensitometry is one of the most basic ways in determining body fat content. It is presented as "gold standard" in many studies (Bonge & Donnelly, 1989; Dale & Vivian 1999). Consequently, any improvements or development in methods of determining body fat content are compared with the results acquired by hydrodensitometry. The skinfolds method is a popular method of estimating body density due to its relatively low cost and simple procedure. Brozek and Keys published the first valid SKF equations in 1951 (Brozek & Keys, 1951). From that time, more than 100 prediction equations using various combinations of anthropometric variables have been reported in the literature (Jackson, & Pollock, 1978; Lohman, 1981). However, because of ethnic variations in body composition, accumulation of subcutaneous fat has different characteristics. If a specific-population SKF equation is used to estimate body density of different ethnic groups, it is to be expected that discrepancies would be found (Vickery, Cureton, & Collins, 1988). The purpose of this study was to derive specific regressive equations for determining body fat content by skinfold method in the Chinese population.

METHODS: A total of 435 males and 410 females volunteered as subjects for this study. Their age ranged from between 18 and 50 years of age. The sample was representative of a wide range of Chinese people who varied considerably in body structure, body composition, and exercise habits. Skinfold thickness was measured at the triceps (P1), sub-scapular (P2), abdomen (P3), supra-iliac (P4), thigh (P5), and chest (P6) (only for men) with a Evyoken-Type caliper (Wagner, (1996; Oppliger, Harms, Herrmann, Streich, & Clark, 1995). The caliper had a constant pressure of 10g/mm and measures were taken on the right side by one technician. The measures of each site were made in triplicate, and the mean of the three values was calculated for subsequent analysis. Subsequently,according to the equations of Jackson-Pollock (1980) and Suzuki-Nagamine, body density was determined. Fat percentage was calculated from the formula of Siri (1956). The hydrostatic weighing measurements were taken in swimming pool with 25-27 °C of water temperature and 25-28 °C air temperature. All subjects wore appropriate swimwear. Body weight was measured prior to entering the pool. Each subject was tested for his or her vital capacity (VC) three times with pneumanometer. The highest value was taken into Wilmore equations (Wilmore, 1969) to determine residual volume (RV). When conducting underwater weighing, a chair was suspended from a tension detector and digital counter with sensitivity of 0.01kg. This hydrostatic weighing method was developed by McArdle (1981). For each subject, six to eight trials of under water weighing were conducted, until three similar readings were obtained. Fat percentage (%F) was calculated from the formula of Siri. The data were analyzed using American START statistical software. Values expressed as mean (SD). Fat percentage values were obtained by hydrodensitometry and SKF equations of Jackson and Suzuki were compared using significance test. Multiple regression analysis was used to derive the generalized equations. The dependent variable was hydrostatically determined body density and the independent variables were skinfolds and age.

RESULTS: Table 1 lists the body fat percentage values measured by hydrodensitometry and calculated by the SKF equations of Jackson and Suzuki. There were significant differences (P < 0.0001) between the measurements from different methods.

Table1 Body Fat Percentage Values measured by Hydrodensitometry and calculated by the Equations of Jackson-pollock and Suzuki-Nagamine

Sex	% F	% F skinfold method	
	Hydrodensitometry	Jackson-Pollock's formula	Suzuki's formula
Male	10.38 ± 4.71	13.64 ± 5.26*	8.99 ± 5.38*
Female	23.12 ± 3.97	28.82 ± 7.64*	27.59 ± 5.33*

*p<0.0001

Table 2 and Table 3 lists the results of multiple regression, Four variables, P2, P4, P5 and age were chosen for the generalized equation for males. For women, P1, P3, P5 and age were chosen. The regressive formulas developed by this study are as follows:

Db (male) = 1.0991 - 0.0004 × P4 (mm) - 0.0005 × P5 (mm) -0.0004 × P2 (mm) - 0.0003 × Age (year)

Db (female) = 1.0837 - 0.0004 × P1 (mm) - 0.0005 × P3 (mm) - 0.0004 × P5 (mm) - 0.0003 × Age (year)

Table2 Body Density Step-wise Regression Analysis for Men

Variable	Regression Co-efficient	Std. Error for Co-efficient.	Computed T-Value	Beta Co-efficient
P4	-0.0005	0.0001	-6.5741	-0.3786
P5	-0.0005	0.0001	-6.5057	-0.2612
P2	-0.0004	0.0001	-4.2290	-0.2179
Age	-0.0003	0.0001	-5.5763	-0.1590
Intercept: 1.0991				

Table3 Body Density Step-wise Regression Analysis for Women

Variable	Regression Co-efficient	Std. Error for Co-efficient.	Computed T-Value	Beta Co-efficient
P1	-0.0005	0.0001	-6.5741	-0.3786
P3	-0.0005	0.0001	-6.5057	-0.2612
P5	-0.0004	0.0001	-4.2290	-0.2179
Age	-0.0003	0.0001	-5.5763	-0.1590
Intercept: 1.0837				

DISCUSSION: Having an accurate, easy method to determine body fat content, building up a correct evaluation standard is a valuable tool for assessing body fitness. Hydrostatic weighing method is believed to have the highest degree of accuracy and is the most reliable method in determining body fat content. Data collected can be used as the standard to regulate other methods. However, it is a complex technique and difficult to be widely applied. The SKF method is a popular field method for estimating Db. It relies on several assumptions. One is that SKF is a good measure of subcutaneous fat (Hayes, Swood, Belyavin, Cohen, & Smith, 1988), another is that there is a good relationship between subcutaneous fat and total body fat (Behnke, 1969). At the present time, there are many kinds of prediction equations generally used, such as American Jackson-Pollock equations, Japanese Suzuli-Nagamine equations, and others. However, these equations may be not suitable for all kinds of people because of ethnic variations. The results of this study demonstrated that there were significant differences in the measured results of body fat content in the Chinese population comparing hydrodensitometry and SKF method of Susuki and Jackson equations. The findings have indicated that these equations are not suitable to apply directly to Chinese subjects. Therefore this study has used body density calculated from hydrostatic weighing method as dependent variable, by step-wise regression analysis, to select the variables to be included in regression equations. There are respectively four variables selected as prediction parameters of men and women. Compared with these three equations, the variables of Suzuki equations were skinfolds of triceps and scapular, without involving abdomen and lower limbs. Between Jackson equations and equations developed by this study, the sensitive sites of SKF were similar but showed a slight difference. The results calculated with Jackson, when compared with the study equation developed for the study showed that fat distributes in males mainly in the trunk. Conversely, for females, fat accumulates mainly in the limbs. Therefore, the regressive formulas that were calculated by this research are more suitable for determining Chinese body fat content.

CONCLUSION: 1) This study demonstrated that body fat content determined by skinfold equations from other countries is significantly different from that obtained by classical hydrostatic weighing method in the Chinese population. Therefore, skinfold equations from other countries are not appropriate for calculation of body fat content in Chinese people. (2) Having established the hydrostatic weighing method as standard, the regressive equations for calculating the body fat content in Chinese based on skinfold measurement were developed through this study.

REFERENCES:

Bonge, D., & Donnelly, J.E. (1989). Trials to criteria for hydrostatic weighing at residual volume. *Research Quarterly for Exercise and Sports*, **60**, 176-179.

Brozek, J., & Keys, A. (1951). The evaluation of leanness-fatness in man: Norms and intercorrelations. *British Journal of Nutrition*, **5**, 194 -205.

Behnke, A.R. (1969). New concepts in height-weight relationships. In N.L. Wilson (Ed.), *Obesity*. Philadelphia: F.A. Davis. pp. 25-53.

Dale R., & Vivian H. (1999). Techniques of body composition assessment: a review of laboratory and field methods. *Research Quarterly for Exercise and Sports,* **70**, 135-149.

Hayes, P.A., Swood, P.J., Belyavin, A., Cohen, J.B., & Smith, F.W. (1988). Subcutaneous fat thickness measured by magnetic resonance imaging, ultrasound, and calipers. *Medicine and Science in Sports and Exercise*, **20**, 303- 309.

Jackson, A.S., & Pollock, M.L. (1978). Generalized equations of pridicting body density of men. *British Journal of Nutrition*, **40**, 497-540.

Jackson, A.S., Pollock, M.L., & Ward, A. (1980). Generalized equations for predicting body density of women. *Medicine and Science in Sports and Exercise*, **12**, 175- 182.

Lohman, T.G. (1981). Skinfold and body density and their relationship to body fatness: A review. *Human Biology*, **53**, 181- 225.

McArdle W. D. (1981). Exercise physiology, Lea & febifer, Philadelphia.

Oppliger, R.A., Harms, R.D., Herrmann, D.E., Streich ,C.M., & Clark, R.R. (1995). The Wisconsin wrestling minimum weight projeck: a model for weight control among high school

wrestlers. *Medicine and Science in Sports and Exercise*, **27**, 1220- 1224.
Siri, W.I. (1956). *Body compostion from fluid spaces and density.* Donner Lab. Med. Physics (Univ. Claf.) Rept. Of 19, March.
Vickery, S.R., Cureton, K.J., & Collins, M.A. (1988). Prediction of body density from skinfolds in black and white young men. *Human Biology*, **60**, 135-149.
Wagner, D.R. (1996). Body composition assessment and minimal weight recommendayions for high school wrestlers . *Journal of Athletic Training*, 31, 262- 265.
Wilmore, J.H. (1969) A simplified method for determination of residual lung volumes. *Journal of Applied Physiology,* **27**, 96-100.