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Marked Differences in Measurement between Two Interpretations of the Suprailiac Skinfold Site

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ABSTRACT

This study examined potential error associated with the measurement of the suprailiac skinfold site at two commonly interpreted locations within ACSM guidelines. Forty-six, young, apparently healthy (20.9±1.2 y; 24.3±4.7 kg/m^2) college-aged students were recruited. Three skinfold measures were taken at each of three distinct anatomical sites using standard collection methods by a criterion anthropometrist. One trial (SUPRA1) of three measures was taken at a site inferior to the anterior axillary line observed from the sagittal plane. A second trial (SUPRA2) was taken at a site visually identified as the anterior axillary line from the frontal plane. A reference trial (SUPRA3) was taken at a site marked by hanging a plumb bob at the anterior axillary line. A repeated-measures analysis of variance test was conducted to compare differences in measured skinfold thickness between sites, using a Bonferroni adjustment. An a-priori α-significance level was set at 0.05. A greater average distance was measured between SUPRA1 and SUPRA3 compared to SUPRA2 and SUPRA3 (6.7±1.5 v. 1.3±0.9cm, respectively). Significant differences in measured skinfold thickness were recorded between SUPRA1 and SUPRA3 (-11.8mm; $p<0.05$), and SUPRA 2 and SUPRA3 (3.1mm; $p<0.05$). Future studies should assess the impact of impact of these differences on total body fat estimation. Site identification may have a marked effect on the measurement of the suprailiac skinfold site.

Keywords: kinanthropometry; body composition

INTRODUCTION

Skinfold measurement is a valid, economical test, which allows the assessment of body composition and estimation of body fat percentage. Both the American College of Sports Medicine (ACSM) and the National Strength and Conditioning Association (NSCA) recommend the seven-site Jackson-Pollock method for a comprehensive measurement of skinfold thickness and the estimation of body density and assessment of body composition (Pescatello 2014, American College of Sports Medicine 2014, Swain 2014, Miller 2012). Briefly, this method involves the measurement of skinfold thickness at seven anatomical sites which are then entered into specific equations for body density with regard to sex, ethnicity, age, and athleticism (Swain 2014, International Society for the Advancement of Kinanthropometry 2001, Lohman, Roche & Martorell 1988).

Skinfold testing is not considered to be a gold standard of body composition assessment, as assumptions are made in translating a sum of the subcutaneous tissue thickness (i.e. skinfolds) to a body density estimation, and then in translating this body density estimation into a percentage of body fat. Therefore, while the exact body fat measure is subject to a moderate degree of variation (±3.5%), a reliable skinfold tester can provide a client with an accurate representation of a change in body fat percentage from baseline to post testing. This is dependent, however, on the reliability (i.e. consistency) of testing procedures. In this light, it has been established that precision in site location has a tremendous impact on measurement accuracy (Lohman, Roche & Martorell 1988, Hume, Marfell-Jones 2008). The use of unambiguous (primarily skeletal) landmarks is the hallmark of accurate skinfold site location and measurement (Lohman, Roche & Martorell 1988). As such, clear and precise guidelines and instructions for the location and use of these unambiguous landmarks are unequivocally important in regards to the proper training in implementation of this test.

Variation in measuring the suprailiac skinfold site is consistently larger across populations when compared to the measurement of other skinfold sites (International Society for the Advancement of Kinanthropometry 2001, Haas, Flegal 1981, Johnston, Hamill & Lemeshow 1974), highlighting the need for standardization of suprailiac site identification. ACSM literature (Pescatello 2014, p64) states that the location of the suprailiac site is *'in line with the natural angle of the iliac crest taken in the anterior axillary line immediately superior to the iliac crest'*. However, this guideline is not necessarily *precise* or *clear* regarding the anatomical view by which the tester should interact with the subject. For example, if the tester views the subject from the frontal view (which may be implied with the inclusion of the term *anterior* in the site definition) the anterior axillary line would intersect with the iliospinale (Figure 1) landmark (International Society for the Advancement of Kinanthropometry 2001). In contrast, if the measurement is taken with the tester viewing the subject from a sagittal view, the anterior axillary line would intersect with the iliocristale (Figure 2) landmark (International Society for the Advancement of Kinanthropometry 2001) The current photographic reference provided in several ACSM texts (Pescatello 2014, Swain 2014, International Society for the Advancement of Kinanthropometry 2001, Lohman, Roche & Martorell 1988) may cause further confusion because the subject is turned at a 45-degree angle.

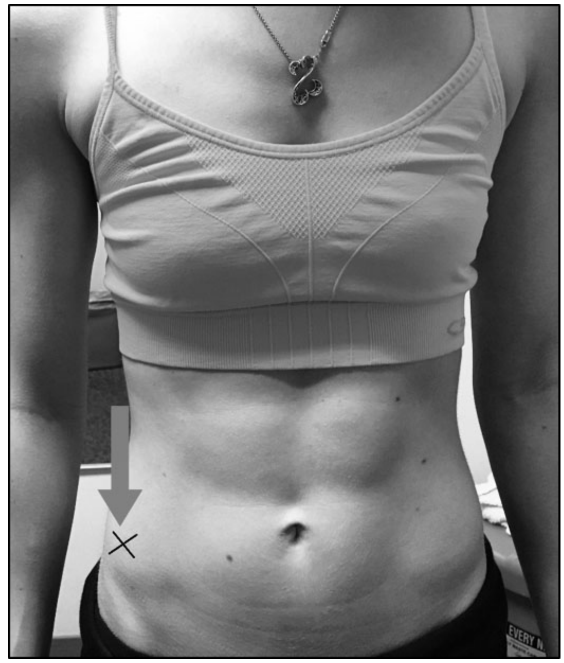

Figure 1. Identified site for SUPRA 1. Frontal view with an *iliospinale* reference point as bony landmark.

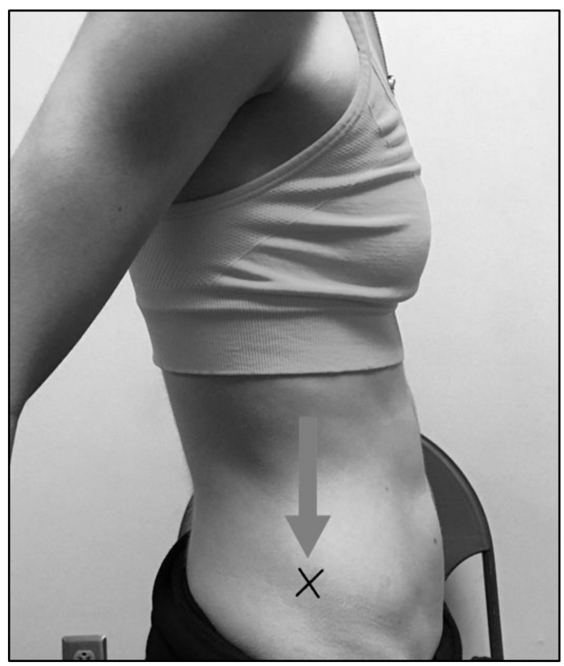

Figure 2. Identified site for SUPRA 2. Sagittal view with an *iliocristale* reference point as bony landmark.

Guidelines regarding the use of the Jackson-Pollock method lack precision and clarity in the identification of the suprailiac skinfold site (Jackson & Pollock 1978, Jackson, Pollock, & Ward 1980, Pollock 1975, Pollock 1976), and may contradict previously established standards. In fact, manuscripts relating the development of the original Jackson-Pollock method (Jackson & Pollock 1978, Jackson, Pollock, & Ward 1980, Pollock 1975, Pollock 1976) do not provide clear locations for the measurement of the seven skinfold sites used in the equation, rather, they cite the consensus methods of the Committee on Nutritional Anthropometry of the Food and Nutrition Board of the National Research Council (Keys 1956). The Keys paper, in contrast, only includes clear site locations for the triceps and 'scapular' skinfold sites (Keys 1956). Further investigation into the source material for the Jackson-Pollack manuscripts reveals consistent reference to two additional investigations (Durnin 1967, Katch 1968) who both list the site location of the 'iliac' skinfold site in the midaxillary line.

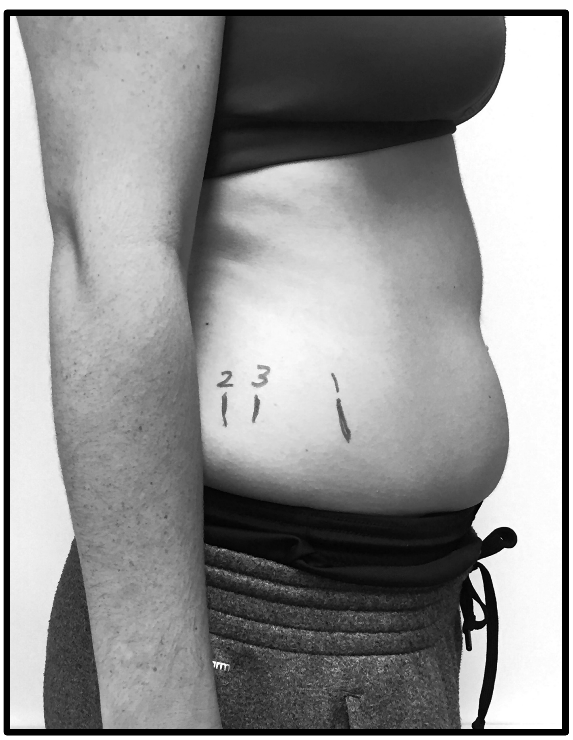

Figure 3. Identified sites for SUPRA 1, 2, 3. Sagittal view with identified *iliospinale*, *iliocristale*, and *plumb bob* locations.

While evidence has been presented to demonstrate that variations in suprailiac skinfold location (e.g. midaxillary v. anterior axillary line) are highly correlated and do not offer unique quantification (Sinning, Wilson 1984), experience in both our laboratory and classroom settings contradicted these findings. Interestingly, like the methods of Durnin and Katch, the suprailiac site was standardized during the Airlie Consensus Conference as *'on the midaxillary line immediately superior to the iliac crest'* (Lohman, Roche & Martorell 1988; p63) and *'immediately superior to the iliocristale site'* (International Society for the Advancement of Kinanthropometry 2001; p35). This selection of the midaxillary line as a reference point for the location of the suprailiac site was originally due to the ease of anatomical location and clarity (Lohman, Roche & Martorell 1988). There are several important implications of variance in the measurement site of the suprailiac site due to unclear guidelines. These include, but may not be limited to, inaccurate measurement and classification of clinical and research subjects, and a lack of precision in the instruction of students. At the very least, reliability in the measurement of body composition through skinfold testing may be compromised if conflicting suprailiac site locations are used.

Therefore, the intent of the present study was to examine the error in estimation of percent body fat associated with measurement of the suprailiac site (using two distinct sites which could be logically assumed within the language of the current written guidelines and visual references). It was hypothesized that there would be a significant difference, both statistically and clinically, in suprailiac skinfold site measures between those taken in the frontal and sagittal plane views.

METHODS

Participants

Forty-six, young, apparently healthy individuals (20.9±1.2 y; 24.3±4.7 kg/m^2; 28 female, 18 male) were recruited to participate in the data collection. Before data collection, approval for the study was secured from the Institutional Review Board and each participant was required to provide written informed consent.

Procedures

A consistent investigator used a surgical pen to mark the anatomical location of the 'iliospinale' skinfold site (SUPRA 1; undermost point, front of hip bone; anterior axillary line viewed from frontal plane) and 'iliocristale' skinfold site based on ISAK guidelines (SUPRA 2; point of most lateral aspect on top of hip bone; anterior axillary line viewed from sagittal plane) (International Society for the Advancement of Kinanthropometry 2001). Also, this investigator hung a plumb bob from the anterior axillary fold and marked this as a reference site (SUPRA 3). Distances were measured between both experimental sites (SUPRA 1 and SUPRA 2) and the reference site (SUPRA 3). Following these markings and measurements, a criterion anthropometrist measured the skinfold thickness at SUPRA1, SUPRA 2, and SUPRA 3 in duplicate using a consistent set of Lange skinfold calipers. In line with skinfold measurement guidelines, a third measurement of each site was taken if there was not a reliable measure (within 2mm) found within two trials.

Data Analysis

A within-subjects, repeated measures analysis of variance with a Bonferroni correction was used to compare the average skinfold thickness values between the measured sites. An a priori α-significance level of 0.05 was established to indicate a statistical difference.

RESULTS

Forty-six subjects completed all of the requirements of this study. Participant demographics revealed a wide range of BMI values in both sexes (♀- 17.5-40 kg/m^2; ♂- 22.5-44 kg/m2), with the average female participant within the normal range and the average male at the low end of the overweight range (Table 1).

Table 1: Participant Demographics.

	Age (y)	**Height (cm)**	**Weight (kg)**	**BMI (kg/m^2)**
Female (n=28)	20.8 ±1.2	167.5 ±8.4	65.7 ±15.2	23.3 ±4.5
Male (n=18)	21.0 ±1.2	180.5 ±5.5	84.1 ±16.9	25.8 ±4.7
Total (n=46)	20.9 ±1.2	172.69.7	72.9 ±18.2	24.3 ±4.7

On average, there was a greater distance (6.7±1.5cm) between the SUPRA 1 site and SUPRA 3 site (reference standard), than between the SUPRA 2 and the SUPRA 3 site (1.3±0.9; Table 2). There were statistically significant differences between the skinfold thickness measurement at both the SUPRA 1 and SUPRA 2 sites, SUPRA 1 and SUPRA 3 sites, and SUPRA 2 and SUPRA 3 sites (Table 3; P=0.0001). A medium effect size, bordering on large (partial η^2= 0.786) was noted in relation to these differences. On average, values for SUPRA 1 (anterior view) were low compared to SUPRA 3 (reference; ♀ -13.3mm; ♂ -9.7mm). In contrast, values for SUPRA 2 (sagittal view) were greater than those measured for SUPRA 1 (♀ +16.6mm; ♂ +12.4mm) and SUPRA 3 (♀ +3.3mm; ♂ +2.7mm).

DISCUSSION

The present study identified the site location of, and measured skinfold thickness at, two logical interpretations of the suprailiac skinfold site definition addressed from different anatomical planes, and contrasted their location and measurement with that of a reference site. The location of the visually identified suprailiac sites in the frontal plane was nearly 5mm further away from the reference site when compared to the previously validated sagittal view (SUPRA 2; iliocristale landmark).

Table 2: Average Distance from Reference Standard (SUPRA 3).

	SUPRA 1	SUPRA 2
Distance from SUPRA 3 (cm)	6.7±1.5	1.3±0.9

SUPRA 1- visually determined from frontal view, SUPRA 2- visually determined from sagittal view, SUPRA 3- measured with plumb bob, reference standard

While both visually identified (experimental) skinfold thickness measures were significantly different from the reference standard, the magnitude of their difference and potential clinical significance were quite large (Table 3).

Table 3: Differences in Skinfold Thickness at Various Sites.

	SUPRA 1	SUPRA 2	SUPRA 3
Female (mm; n=28)	17.2±10.4[a,b]	33.8±11.3[a]	30.5±11.8
Male (mm; n=18)	18.1±14.5[a,b]	30.5±16.2[a]	27.8±15.3
Total (mm; n=46)	17.6±12.0[a,b]	32.5±13.4[a]	29.4±13.2

SUPRA 1- visually determined from frontal view, SUPRA 2- visually determined from sagittal view, SUPRA 3- measured with plumb bob, reference standard; [a]significantly different from SUPRA 3, [b]significantly different from SUPRA 2

When the average differences in the suprailiac skinfold measurements in this study are entered into the seven-site Jackson Pollack formula for body density estimation, large discrepancies become apparent. For example, when the average differences are substituted into the equation of a sample 20-year old female track athlete (SUPRA 3; sum of skinfolds: 69mm; body density: 1.0647; Siri body fat percentage estimate: 14.92%), a change to the measured SUPRA 1 value (average difference: -13.3mm) would change the sum of skinfolds by ~24% (55.7mm). Body density would change to 1.07, and the Siri body fat percentage estimate would change to 12.61% (~18% decrease). Use of the visually determined suprailiac skinfold site from the sagittal view (SUPRA 2; average difference: +3.3mm) would result in a more modest change in the sum of skinfolds (~5%; 72.3mm), body density (1.0634), and Siri body fat percentage estimate (~4% increase; 15.49%).

Early experts in the study and implementation of anthropometric measurements determined that the midaxillary line (or the iliocristale skeletal landmark) was optimal for identification of the suprailiac skinfold site due to consistency and clarity (International Society for the Advancement of Kinanthropometry 2001, Lohman, Roche & Martorell 1988, Durnin 1967, Katch 1968). Further, the findings of this study indicate that prior assertion that no differences exist between various sites of suprailiac measurement may have been misguided (Sinning, Wilson 1984).

As a systematic review (Fogelholm, van Marken Lichtenbelt 1997), and several subsequent studies have demonstrated, skinfold assessment underestimates percent body fat compared to air-displacement plethysmography and bioelectrical impedance analysis (Vicente-Rodriguez et al. 2012), dual x-ray absorptiometry (Ravaglia et al. 1999), and deuterium oxide dilution (Bhat et al. 2005). The extent to which the location of site measurement, and particularly that of the suprailiac site, affects these relationships is unknown. Ultimately, consistency in the location of skinfold sites is critical to the best practices use of the technique. In a situation where an Exercise Physiologist is using the skinfold method to measure pre- and post- training measurements on a client, it is far more important, in our opinion, to be consistent with suprailiac site location (for example, consistently measuring at the *anterior axillary line viewed from the sagittal plane*) than to ultimately choose one site as preferred. In terms of the validity of the method, of course, clarification in the site location used to develop the equations would be ideal.

Future studies are needed to determine if potential differences in suprailiac site identification may affect the validity of body composition assessment in young, apparently healthy individuals or other population groups including athletes. Further, as skinfold assessment is often used as a matter of convenience or economy, it is critical that error in this method be reduced to the smallest possible increment.

LITERATURE CITED

American College of Sports Medicine (2014). *ACSM's health-related physical fitness assessment manual.* 4th edn. Philadelphia: Wolters Kluwer Health/Lippincott Williams & Wilkins.

Bhat, D.S., Yajnik, C.S., Sayyad, M.G., Raut, K.N., Lubree, H.G., Rege, S.S., Chougule, S.D., Shetty, P.S., Yudkin, J.S. & Kurpad, A.V. (2005). Body fat measurement in Indian men: comparison of three methods based on a two-compartment model. *International journal of obesity, 29*(7), 842-848.

Durnin, J.V.G.A., Rahaman, M.M. (1967). The assessment of the amount of fat in the human body from measurements of skinfold thickness. *British journal of nutrition. 21*, 681-689.

Fogelholm, M. & van Marken Lichtenbelt, W. (1997). Comparison of body composition methods: a literature analysis. *European journal of clinical nutrition, 51*(8), 495-503.

Haas, J.D. & Flegal, K.M. (1981). Anthropometric Measurements. In *Progress in Cancer Research: Vol. 17. Nutrition and Cancer: Etiology and Treatment.* (edited by G.R. Newell and N.M. Ellison), pp. 123-140. Raven Press.

Hume, P. & Marfell-Jones, M. (2008). The importance of accurate site location for skinfold measurement. *Journal of sports sciences, 26*(12), 1333-1340.

International Society for the Advancement of Kinanthropometry (2001). *International Standards for Anthropometric Assessment.* Australia.

Jackson, A.S. & Pollock, M.L. (1978) Gerneralized equations for predicting body density of men. *British journal of nutrition, 40*, 497-504.

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*(3), 175-182.

Johnston, F.E., Hamill, P.V. & Lemeshow, S. (1974). Skinfold thickness of youths 12-17 years, United States. *Vital and health statistics. Series 11, Data from the national health survey, 132*, 1-75.

Katch, F.J., Michael, E.D. (1968). Prediction of body density from skinfold and girth measurements of college females. *Journal of applied physiology, 25*, 92-94.

Keys, A. (1956). Recommendations concerning body measurements for the characterization of nutritional status. *Human biology, 28*, 111-123.

Lohman, T.G., Roche, A.F. & Martorell, R. (1988). *Anthropometric standardization reference manual.* Champaign, IL: Human Kinetics Books.

National Strength & Conditioning Association (U.S.) & Miller, T. (2012). *NSCA's guide to tests and assessments.* Champaign, IL: Human Kinetics.

Pescatello, L.S., American College of Sports Medicine (2014). *American college of sports medicine guidelines for exercise testing and prescription*. 9th edn. Baltimore, MD: Lippincott, Williams and Wilkins.

Pollock, M.L., Lauthridge, E.E., Coleman, B., Linnerud, A.C., Jackson, A. (1975). Prediction of body density in young and middle-aged women. *Journal of applied physiology, 38*(4), 745-749.

Pollock, M.L., Hickman, T., Kendrick, Z., Jackson, A., Linnerud, A.C., Dawson, G. (1976). Prediction of body density in young and middle-aged men. *Journal of applied physiology*, *40*(3), 300-304.

Ravaglia, G., Forti, P., Maioli, F., Boschi, F., Cicognani, A. & Gasbarrini, G. (1999). Measurement of body fat in healthy elderly men: a comparison of methods. *The journals of gerontology. Series A, Biological sciences and medical sciences, 54*(2), M70-6.

Sinning, W.E. & Wilson, J.R. (1984). Validity of 'generalized' equations for body composition analysis in women athletes. *Research quarterly for exercise and sport, 55*, 153-160.

Swain, D.P., American College of Sports Medicine (2014). *ACSM's resource manual for guidelines for exercise testing and prescription.* 7th edn. Philadelphia: Wolters Kluwer Health/Lippincott Williams & Wilkins.

Vicente-Rodriguez, G., Rey-Lopez, J.P., Mesana, M.I., Poortvliet, E., Ortega, F.B., Polito, A., Nagy, E., Widhalm, K., Sjostrom, M., Moreno, L.A. & HELENA Study Group (2012). Reliability and intermethod agreement for body fat assessment among two field and two laboratory methods in adolescents. *Obesity (Silver Spring, Md.), 20*(1), 221-228.