

Correlation between body mass index, body fat percentage and fat mass index

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Abstract

Objectives: Methods of assessment of body composition in a clinical setting are compared. Body composition classification systems are also compared.

Methods: Ninety-three males and sixty-nine female subjects' body composition was determined using 3-, 4-, or 9-point skinfold measurements, bioelectrical impedance and dual energy x-ray absorptiometry (DEXA). Results using these methods were compared. Body composition category was also compared using body mass index (BMI), fat mass index (FMI) and percent body fat (%BF).

Results: The 9-point skinfold measurement for females was comparable to DEXA. Neither the skinfold method or bioelectrical impedance in males was comparable to DEXA. Body composition classification systems give significantly different outcomes: BMI misclassifies 'low-weight' and 'obese' individuals when compared to either FMI or %BF.

Conclusions: DEXA is the preferred method to measure body composition with 9-point skinfold being comparable in women. BMI is not the best system to use to classify individuals body composition.

Key Words: *Obesity, Body Mass Index, Fat Mass Index, Percent Body Fat, Body Composition*

Introduction

In recent decades, there has been a noticeable increase in both the number of individuals that are overweight or obese as well as the scale that people are over their target weights¹. There are various methods that are commonly used to analyze a patient's body composition including body mass index (BMI), bio-electrical impedance, skin fold measurements, dual energy x-ray absorptiometry (DEXA)², and fat mass index (FMI).

The current standard of body analysis is the use of BMI. This measurement has been studied extensively and has been found to have an inability to distinguish between lean and fat mass³. BMI was devised between 1830 and 1850 by the Belgian polymath Adolphe Quetelet¹⁴. BMI is described as the individual's body mass divided by the square of their height. BMI was first used in 1972 by Ancel Keys, who found that it was the best resource for body fat percentage at the time^{14, 15}. Related to BMI is the more developed use of fat mass index (FMI)¹⁰. FMI has been used heavily in the research setting⁹. FMI is calculated by taking the fat mass components of BIA and dividing them by height squared.

Another method is the measurement of skin-fold thickness, a method that assesses body fatness through the use of calipers at particular body sites. This assessment has shown a strong correlation with body adiposity measured by reference methods. By using generalized equations for men and women, skin-fold measures can predict estimates of body fat from body density⁵. Limitations of this method include reproducibility, inter- and intra-individual variation, and the difficulty in obtaining accurate measures in very obese subjects¹¹.

A more sophisticated approach to analyzing the fat deposits of individuals is bioelectrical impedance analysis (BIA). BIA is widely accepted and used in clinical and research settings⁶. BIA has been researched and compared to DEXA⁶ for its accuracy. It has been shown to be a valid form of assessment to examine individuals on their level of fat mass¹². Though BIA has been validated, the limitations exist that require equations that are specifically developed for different populations, ethnicities, age groups, and sex⁷. Another limitation of BIA is diet related. To gain proper readings, there is a list of dietary restriction that if not strictly adhered to will produce imprecise results¹².

The gold standard for the evaluation of body fat mass is DEXA⁸. This method uses dual energy x-ray beams to analyze the different densities of the human body. The analysis used in DEXA helps make this one of the best methods for analyzing individuals¹³. With this advantage come disadvantages. DEXA machines both require a large amount of monetary resources as well as a designated clinical space with the proper protection to operate the machine. Because this method uses x-ray, there are also limitations with pregnant females as well as individuals with metal in the body. It is because of these restrictions, that there is a limit with the use of DEXA in the clinical setting.

Using DEXA as a baseline and as a standard to better determine the accuracy of various methods of body fat analysis, the research conducted will use BIA, 9 point skin folds, 4 point skin folds and 3 point skin folds to find a more clinically accessible method of determining the fat composition of individuals. While using these various methods, the study strives to maximize the clinical relevancy of each method of

evaluation. The researchers hypothesize that the 9 point skin fold measurements will be the most comparable technique to DEXA in the accuracy of determining body fat composition that is clinically accessible.

BMI, FMI and Body Fat Percentage have been used to categorize individuals as underweight, normal weight, overweight and obese. Using a statically relevant number of patients, this study will evaluate the variance in the aforementioned methods utilized as well as aid in the determination of clinical relevance. While considering the research that is available, the study will show the most clinically appropriate tool of body composition analysis is hypothesized to be FMI.

Methods

Participants

One hundred sixty-two individuals (93 males and 69 females) participated in this study. The subjects were doctor of chiropractic students and college faculty members. The ages of the males were between 21 and 65 years old with an average of 28.0 years old. The ages of the females were between 20 and 60 years old with an average of 25.2 years old. Of the 169 subjects that participated in the study, only 158 subjects were used in this study. Three subjects' measurements were dropped from the study because their skin-fold measurements were taken by a different individual. Leaving their results in the study would have corrupted the integrity of the study. One individual withdrew from the study after beginning for reasons unknown to the researchers. The participants' descriptions are listed in Table 1.

Table 1

	Minimum	Maximum	Mean	Std. Deviation
Age				
Males	21	65	28.0	7.41
Females	20	60	25.2	5.74
Height (inches)				
Males	63.5	79	70.3	2.68
Females	53.5	72.5	65.1	2.56
Weight (pounds)				
Males	143	319	193.0	35.05
Females	96	208	143.0	19.61

Procedures

Preparation. The subjects each signed up for a 20 minute time slot on a scheduled day to show up and participate in the study. As the subjects showed up for their scheduled time, they were required to sign an informed consent form (see Appendix A) that disclosed all potential benefits and risks of participating in the study. They were also given a study form (see Appendix B) and asked to fill out Side 1 of the form, and that Side 2 would be filled out by the researchers. Upon completion of Side 1 of the study form, the subject returned the form to the researcher which then assigned the subject a participant number. The researcher explained to the subjects that they would need to change into shorts and a gown, and to remove all metal prior to beginning the study. The subjects were shown to a designated changing area where they had privacy to change.

Height and weight. Once subjects were changed, a researcher weighed and measured height of the subjects using a professional upright Doctor's scale that was balanced and calibrated. The subjects' weight was rounded to the nearest pound and their

height was rounded to the nearest half inch. The researcher recorded these as the subject's official height weight for the experiment on Side 2 of the study form.

DEXA scan. Subjects were asked to lie down on a GE Lunar Prodigy Primo™ scanner and positioned by a researcher. Velcro straps were placed around the subject's legs to minimize movement during the scan. Following the positioning of the subject, the researcher entered the necessary information into the DEXA's computer software program for a full body measurement including the height and weight that was measured. Prior to beginning the scan, the researcher informed the subject not to move or talk during the scan. Once the subject was ready the scan was initiated by the researcher. All subjects fell in either a large body type or medium body type. The large body type subjects required an 11 minute 30 second scan. The medium body type subjects required a 6 minute 20 second scan. The subjects' body type was determined by the DEXA software program. Upon completion of the DEXA scan, the BMI and total body fat percentage was calculated by the software program. The researcher recorded the BMI and body fat percentage on Side 2 of the study form along with the category listing provided by the World Health Organization as either underfat (low), normal, overweight or obese. An individual report of the DEXA scan results was printed for the subjects to keep. The researchers explained all the findings from the DEXA scan report to the patient which included BMI, body fat percentage and bone density.

Bioelectrical impedance Analysis. The subjects' age, sex and height were in put into a Tanita BF-522W Body Fat Analyzer. When the set-up was completed, the subjects were asked to step up on the BIA unit with bare feet and to make sure their feet had good contact with the metal leads. The BIA calculated the subjects' body fat percentage. The

category of the subjects' body fat percentage was assigned as per the body fat chart published by the World Health Organization.

Skin-fold. The subjects were directed by the researcher in positioning so a Parrillo Method (nine point) skin-fold could be completed. The nine points consisted of the chest, abdomen, thigh, bicep, tricep, subscapular, suprailiac, low back, and calf. Each point was measured on the right side of the body and was measured three separate times. The average measurement for each of the points was recorded on Side 2 of the study form. The researcher used a pair of Beta Technology Lange Skinfold calipers. All the skin fold measurements were taken by the same researcher to help preserve the integrity of the study. The researcher chosen to take the skin-fold measurements was qualified and had adequate experience to take the measurements.

The body fat percentage was calculated for the Parrillo Method using the following formula:

$$\text{Body fat}\% = \frac{(\sum \text{chest, abdominal, thigh, bicep, tricep, subscapular, suprailiac})27}{\text{weight}}$$

The category of the subjects' body fat percentage was assigned as per the body fat chart published by the World Health Organization. The categories are low, normal, high and very high. However, this study substituted high with overweight and very high with obese.

The corresponding measurements were filled in on Side 2 of the study form to complete a Jackson/Pollock four point and Jackson/Pollock three point measurement calculation as well. The points for the Jackson/Pollock four point are the abdomen, tricep, thigh and suprailiac. The points for the Jackson/Pollock three point consists of the chest, abdomen and thigh for males, and the tricep, suprailiac and thigh for females. The

body fat percentage for the Jackson/Pollock four point calculation was found using the following formulas:

Male

$$\begin{aligned} \text{Body fat\%} = & \left(0.29288 \times \sum \text{abdominal, tricep, thigh, suprailiac} \right) \\ & - [0.0005 \left(\sum \text{abdominal, tricep, thigh, suprailiac} \right)^2] + (0.15845 \times \text{age}) \\ & - 5.76377 \end{aligned}$$

Female

$$\begin{aligned} \text{Body fat\%} = & \left(0.29669 \times \sum \text{abdominal, tricep, thigh, suprailiac} \right) \\ & - [0.00043 \left(\sum \text{abdominal, tricep, thigh, suprailiac} \right)^2] + (0.02963 \times \text{age}) \\ & + 1.4072 \end{aligned}$$

The body fat percentage for the Jackson/Pollock three point calculation was found using the following formulas:

Male

$$\begin{aligned} \text{Body fat\%} = & 1.10938 - \left(0.0008267 \times \sum \text{chest, abdominal, thigh} \right) \\ & + [0.0000016 \left(\sum \text{chest, abdominal, thigh} \right)^2] - (0.15845 \times \text{age}) \end{aligned}$$

Female

$$\begin{aligned} \text{Body fat\%} = & 1.0994021 - \left(0.0009929 \times \sum \text{tricep, thigh, suprailiac} \right) \\ & + [0.0000023 \left(\sum \text{tricep, thigh, suprailiac} \right)^2] - (0.0001392 \times \text{age}) \end{aligned}$$

The body fat percentages for the Jackson/Pollock four point and three point calculations was recorded on side 2 of the study form. The category of the subjects' body fat percentage was assigned as per the body fat chart published by the World Health Organization.

Fat Mass Index. The fat mass index was calculated using the height, weight and body fat percentage recorded from the DEXA scan. The Fat Mass Index was calculated using the following formula:

$$FMI = \frac{\left[\text{weight} \left(\frac{bf\%}{100} \right) \right] 0.453}{(\text{height} \times 0.0254)^2}$$

After the Fat Mass Index was calculated, the categories were also recorded. The categories for Fat Mass Index has had limited research published, therefore, the researchers extrapolated using recommendations from Peltz, et. al. (2010) and Shutz, Kyle, Pichard (2002). The Fat Mass Index categories can be seen in Table 2.

Table 2

FMI Categories				
	Low	Normal	Overweight	Obese
Males	≤1.8	1.8-5.1	5.2-6.5	≥6.6
Females	≤3.8	3.9-8.2	8.3-9.4	≥9.5

Results

Table 3 reveals that men were taller and weighed more than women. On average, women had a lower BMI than men. Women had greater average body fat percentage (31.5% versus 22.3%) than men, according to DEXA. BIA measurements revealed that women had a higher average body fat percentage (28.9% versus 16.1%) than men. The nine point skin fold analysis showed that woman had higher average percent body fat (31.4% versus 19.1%) than men. The four point skin fold analysis showed that women had higher average percent body fat (27.8% versus 19.2%) than men. The three point

skin fold analysis revealed that women had higher average percent body fat (28.1% versus 15.2%).

Body Mass Index. The BMI of the 66 female participants is as follows: 48 normal, 17 overweight, and 1 obese. The BMI of the 92 male participants is as follows: 27 normal, 47 overweight, and 18 obese. Women's minimum BMI reading was 18.7 while the maximum was 32.1. The mean BMI for females was $23.80 \text{ kg/m}^2 \pm 3.05$. Men's minimum BMI reading was 20.2 while the maximum was 39.9. The mean BMI for males was $27.35 \text{ kg/m}^2 \pm 4.24$.

DEXA. Categorization through DEXA body fat percent readings for the 66 female participants is as follows: 4 low, 34 normal, 16 overweight, 12 obese. Categorization through DEXA body fat percent readings for the 92 male participants is as follows: 3 low, 41 normal, 16 overweight, and 32 obese. Women's minimum percent body fat reading according to DEXA was 13.0% while the maximum was 48.3%. The mean DEXA for females was 31.50% body fat ± 7.67 . Men's minimum percent body fat according to DEXA was 5.7% while the maximum was 44.8%. The mean DEXA for males was 22.30% body fat ± 8.91 .

Bioelectrical Impedance Analysis. Categorization through BIA body fat percent readings for the 66 female participants is as follows: 6 low, 42 normal, 13 overweight, 5 obese. Categorization through BIA body fat percent readings for the 92 male participants is as follows: 5 low, 69 normal, 8 overweight, and 10 obese. Women's minimum percent body fat reading according to BIA was 15.4% while the maximum was 45.3%. The mean BIA for females was 28.9% body fat ± 6.25 . Men's minimum percent body fat reading

according to BIA was 4.0% while the maximum was 38.7%. The mean BIA for males was $16.10\% \pm 6.70$.

9 point skin fold. Categorization through 9 point skin fold measurements for the 66 female participants is as follows: 2 low, 32 normal, 27 overweight, and 5 obese. Categorization through 9 point skin fold measurements for the 92 male participants is as follows: 53 normal, 28 overweight, and 11 obese. Women's minimum percent body fat measurement via 9 point skin fold technique was 17.9% while the maximum was 45.1%. The mean 9 point skin fold measurement for females was $31.40\% \pm 5.76$. Men's minimum percent body fat measurement via 9 point skin fold technique was 8.9% while the maximum was 31.6%. The mean 9 point skin fold measurement for males was $19.10\% \pm 4.86$.

4 Point Skin Fold. Categorization through 4 point skin fold measurements for the 66 female participants is as follows: 7 low, 49 normal, 6 overweight, 4 obese. Categorization through 4 point skin fold measurements for the 92 male participants is as follows: 4 low, 50 normal, 21 overweight, and 17 obese. Women's minimum percent body fat measurement via 4 point skin fold technique was 18.9% while the maximum was 40.9%. The mean 4 point skin fold measurement for females was $27.80\% \pm 5.50$. Men's minimum percent body fat measurement via 4 point skin fold technique was 5.3% while the maximum was 33.8%. The mean 4 point skin fold measurement for males was $19.20\% \pm 6.69$.

3 Point Skin Fold. Categorization through 3 point skin fold measurements for the 66 female participants is as follows: 5 low, 47 normal, 12 overweight, 2 obese. Categorization through 3 point skin fold measurements for the 92 male participants is as

follows: 9 low, 62 normal, 12 overweight, and 9 obese. Women's minimum percent body fat measurement via 3 point skin fold technique was 18.3% while the maximum was 40.8%. The mean 3 point skin fold measurement for females was $28.10\% \pm 5.15$. Men's minimum percent body fat measurement via 3 point skin fold technique was 3.8% while the maximum was 31.2%. The mean 3 point skin fold measurement for males was $15.20\% \pm 6.30$.

DEXA versus BIA. The ANOVA comparison for females revealed that DEXA versus BIA had a mean difference of 2.67% body fat, which is significantly different ($p < 0.01$). The ANOVA comparison for males revealed that DEXA versus BIA had a mean difference of 6.26% body fat, which is significantly different ($p < 0.01$).

DEXA versus 9 Point Skin Fold. The ANOVA comparison for females revealed that DEXA versus 9 point skin fold measurement had a mean difference of 0.12% body fat, which is not significantly different ($p > 0.05$). The ANOVA comparison for males revealed that DEXA versus 9 point skin fold measurement had a mean difference of 3.27% body fat, which is significantly different ($p < 0.01$).

DEXA versus 4 Point Skin Fold. The ANOVA comparison for females revealed that DEXA versus 4 point skin fold measurement had a mean difference of 3.73% body fat, which is significantly different ($p < 0.01$). The ANOVA comparison for males revealed that DEXA versus 4 point skin fold measurement had a mean difference of 3.17% body fat, which is significantly different ($p < 0.01$).

DEXA versus 3 Point Skin Fold. The ANOVA comparison for females revealed that DEXA versus 3 point skin fold measurement had a mean difference of 3.41% body fat, which is significantly different ($p < 0.01$). The ANOVA comparison for males

revealed that DEXA versus 3 point skin fold measurement had a mean difference of 7.14% body fat, which is significantly different ($p < 0.01$).

Chi-squared Test for Independence. For males the Chi-square value was 32.248 with six degrees of freedom. For females the Chi-square value was 19.924 with six degrees of freedom. The null hypothesis is that the probabilities for each outcome (classification as low, normal, overweight, obese) are independent of the treatment (method of determining BMI, FMI and %BF classification system).

Table 4 shows the Chi-square P-value is < 0.0001 for males. Table 5 shows the Chi-square P-value is 0.0029 for females. The Chi-square P-values for males and females reveal that the null hypothesis is invalid. Therefore, the classification outcomes are significantly affected by which treatment (or classification system) is utilized. Each classification system may give significantly different outcomes.

Linear Pearson Correlation.

Males: The coefficient of determination between BMI and %BF expressed as a Pearson r value (r^2) was 0.6272, which is extremely significant ($p < 0.0001$). The coefficient of determination between FMI and BMI expressed as a Pearson r value (r^2) was 0.8154, which is extremely significant ($p < 0.0001$). The coefficient of determination between %BF and FMI expressed as a Pearson r value (r^2) was 0.9317, which is extremely significant ($p < 0.0001$).

Females: The coefficient of determination between BMI and %BF expressed as a Pearson r value (r^2) was 0.4873, which is extremely significant ($p < 0.0001$). The coefficient of determination between FMI and BMI expressed as a Pearson r value (r^2) was 0.6931, which is extremely significant ($p < 0.0001$). The coefficient of

determination between %BF and FMI expressed as a Pearson r value (r^2) was 0.9055, which is extremely significant ($p < 0.0001$).

Table 3

Comparison of males and females for anthropometric measures

	Males (n=92)	Females (n=66)
Average Height (inches)	70.3	64.9
Average Weight (pounds)	193	143.3
Average BMI (kg/m ²)	27.35	23.8
• Low	0	0
• Normal	27	48
• Overweight	47	17
• Obese	18	1
Average BF% DEXA	22.3	31.5
• Low	3	4
• Normal	41	34
• Overweight	16	16
• Obese	32	12
Average BF% BIA	16.1	28.9
• Low	5	6
• Normal	69	42
• Overweight	8	13
• Obese	10	5
Average BF% 9 Point	19.1	31.4
• Low	0	2
• Normal	53	32
• Overweight	28	27
• Obese	11	5
Average BF% 4 Point	19.2	27.8
• Low	4	7
• Normal	50	49
• Overweight	21	6
• Obese	17	4
Average BF% 3 Point	15.2	28.1
• Low	9	5
• Normal	62	47
• Overweight	12	12
• Obese	9	2

Table 4

Chi-squared Test for Independence (Males)

Row	Total	Percent
BMI	92	33.33%
FMI	92	33.33%
%BF	92	33.33%
Total	276	100.00%

Column	Total	Percent
Low	6	2.17%
Normal	102	36.96%
Overweight	83	30.07%
Obese	85	30.80%
Total	276	100.00%

Table 5

Chi-squared Test for Independence (Females)

Row	Total	Percent
BMI	66	33.33%
FMI	66	33.33%
%BF	66	33.33%
Total	198	100.00%

Column	Total	Percent
Low	5	2.53%
Normal	122	61.62%
Overweight	44	22.22%
Obese	27	13.64%
Total	198	100.00%

Table 6

Linear Pearson Correlation			
Variable	Correlation Coefficient (r)	P-value	R ²
Males			
BMI vs. %BF	0.7919	< 0.0001	0.6272
BMI vs. FMI	0.9030	< 0.0001	0.8154
%BF vs. FMI	0.9652	< 0.0001	0.9317
Females			
BMI vs. %BF	0.9680	< 0.0001	0.4873
BMI vs. FMI	0.8325	< 0.0001	0.6931
%BF vs. FMI	0.9516	< 0.0001	0.9055

Table 7

Comparison of DEXA Other Anthropometric Measures

Variable	Males	p Value Males	Females	p Value Females
DEXA v. BIA	6.26%	< 0.01	2.67%	< 0.01
DEXA v. 9 point	3.27%	< 0.01	0.12%	> 0.05
DEXA v. 4 point	3.17%	< 0.01	3.73%	< 0.01
DEXA v. 3 point	7.14%	< 0.01	3.41%	< 0.01
<i>* Variables reported as percent body fat (PBF)</i>				

Discussion

The results showed that when comparing body fat percentage measurements between DEXA and the other anthropometrics in males, the accuracy of the BIA, and the skin fold measurements were not accurate enough to meet the standard of DEXA. However, in females, the 9 point skin fold method revealed enough statistical precision to be used in place of DEXA in a clinical setting. "...Site-specific selection for skin fold thickness measurements based on sex has been recommended¹⁰." Furthermore, this supports the hypothesis that 9 point skin fold was the most comparable to DEXA in women, but not in men.

The 9 point skin fold method is a useful tool for standard assessment of human body fat percentage. The method is safe and noninvasive; it requires special skills on the part of the operator but not the subject. Subject cooperation is moderate in that exposure to the nine anatomical sites must be accessed in order to take measurements. Skin fold measurements utilizing the 9 point method are consistent and fast; and the instrument is moderately priced and portable. "While accuracy and precision of skin fold measurements largely relates to the expertise of the anthropometrist, it is cheap, non-invasive, portable and a convenient method and readily available in many countries⁵."

The limitation to any skin fold measurement utilizing calipers is that "...body density is not linearly related to subcutaneous fat mass²." In contrast, other studies reveal that when using skin fold measurements to assess body fat through the use of calipers, at specific anatomical sites, show a strong connection with body fat when calculated by reference techniques¹⁰. Studies also show that the probability of an error will increase if skin fold thickness is very large or very small².

According to Peltz et al., BIA has been validated as a measure of body fat when compared to DEXA, although the results of this particular study do not support this claim¹⁰. Another study revealed that BIA has a strong relationship with fat-free mass, total body water, and total body potassium suggesting this approach may be very useful as a tool for routine assessment of human body composition⁸.

“Body mass index (BMI) is commonly used to determine overweight and obesity in clinical and field research settings. However, BMI does not distinguish between lean and fat body mass¹⁰.” “BMI has been utilized as an expression to report the link of excess relative weight to morbidity and mortality...the generalizability and applicability of the BMI and its cut-off points to other populations has been questioned and its sensitivity as a measure of excess fat queried¹⁴.” Other studies convey that ideal body weight is routinely used as a “basis of reference, the relative body weight then being expressed as percentages of values in the tables published by Metropolitan Life Insurance Company. Those tables take no account of age; in effect they simply list the average weights of insurance applicants of given sex and height at age about 25¹⁵.” According to Peltz et al. BMI is routinely and very conveniently used, requiring only height and weight to calculate, but the categorization of obesity is broad and imprecise¹⁰.

“A potential indicator of body adiposity that may prove to be highly useful in field research is the fat mass index (FMI)....Although it can be argued that FMI, BMI, and PBF are composed of the same variables and are one and the same, they each categorize overweight and obesity differently. BMI takes into account body weight and body height while FMI requires information on body weight, body height, and fat mass content. Height is positively correlated with weight, although for calculation of BMI and FMI, this confounding variable is removed. Therefore, the comparison between BMI and FMI

is directly influenced by fat mass content, which is the desired variable to be measured in obesity studies. On the other hand, in studies on body composition, FMI has shown superiority over PBF since PBF is not corrected by height. Because FMI takes height into account, it reduces the bias associated with PBF¹⁰.”

There is general standard is that BMI is the easiest, most widespread and expedient method of determining body fat. According to Peltz et al., since BMI is mathematically equal to the sum of FMI and FFMI the use of FMI as a measure of adiposity is more appropriate and relates to the adiposity content of BMI¹⁰. In a recent study it was determined that BMI had miss-classified an average of 36% overweight individuals compared to FMI categorization of individuals¹⁶. “BMI fails to assess the accumulation of abdominal fat, which mainly increases the risk of diabetes, hypertension, and cardiovascular disease risks; and BMI is relatively insensible to body composition changes¹⁶.”

This study is not without limitations. Any estimate of body composition is limited by errors in the experimental method and in the hypothetical assumptions. Limitations to skin fold thickness measurements include reproducibility, inter- and intra-individual variation and the difficulty in obtaining accurate measures in very obese subjects¹⁰. All in vivo results of human body composition are indirect and consequently the accuracy of the results is questionable.

Conclusion

DEXA was utilized as the “standard” to analyze body composition and record measurements as percent body fat, bone density, and fat free mass. Other anthropometric measures were compared to DEXA to identify possible correlations via body composition measurements; more specifically percent body fat values. The study identified a significant correlation between 9 point skin fold and DEXA measurements (Table 7). The 9 point skin fold

method has benefit in the healthcare field for providers that treat females. The data suggest that classification outcomes are significantly affected by which treatment is utilized (Table 4 & 5). Each classification system may have significantly different outcomes which refutes the null hypothesis. The hypothesis that FMI is the more effective tool in analyzing body composition in a clinical setting is supported through Pearson r data (Table 6). The utilization of FMI in the healthcare field will allow providers to more accurately determine body composition.

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