Assessment of Body Composition through Sports

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Abstract: The objective of this subject was to compare several methods of assessing body composition: dual energy X-Ray absorptiometry (DEXA), air-displacement plethysmography (ADP), skinfold measurements, and bioelectrical impedance analysis (BIA). It was hypothesized that the parameters of body composition determined by the four methods would be similar. This hypothesis will be tested by comparing results obtained from DEXA, ADP, skinfold measurements, and BIA.

Methods

The body composition of NUTR 301 students was assessed using various methods. This subject will focus on a 19 year old female subject, and the results of the subject will be compared to the class average.

Prior to the DEXA scan, all female subjects provided urine samples to test for pregnancy, as DEXA uses very low dose x-rays that may potentially harm a fetus. To prepare for the test, subjects removed metals and clothing, and then changed into a paper gown. A technician conducted the DEXA scan, which was approximately five minutes in duration. Body composition was also tested using ADP. Students were instructed to avoid food, drink, and exercise for two hours before the test. Directly before, they also voided their bladder and changed into a bathing suit and swim cap. Subjects then sat quietly for five minutes inside a chamber, which measures body composition through small pressure change .

In the NUTR 301 lab, students conducted skinfold measurement on each other. Subjects were instructed to be relaxed, and a caliper was applied to the following areas: triceps, subscapularis, biceps, iliaccrest, and front thigh. All skinfolds were completed in triplicate, with the mean used for evaluation. Body composition was then calculated from the skinfold measurements using the following predictive equations: Sloan, Durnin and Womersley (DW), and Jackson and Pollock(JP).

The value obtained from each equation was then identified in Tables 1 and 3 to determine the percentage body fat of the subject.

Sloan:

Body density = 1.0764 - 0.00081 (3.33) - 0.00088 (2) = 1.0755

Percent Body fat = ((4.95/1.0755) - 4.5) x 100 = 10.3%

Durnin and Womersley:

triceps + biceps + subscapular + iliac crest

2 + 3 + 4 + 3.33 = 12.33mm

This value was not on Table 1. The smallest value of 15mm was used to find % body fat. 10.5%

Jackson and Pollock:

iliac crest + triceps + front thigh

3.33 + 2 + 1 = 6.33mm

This value was not on Table 3. The smallest value of 23mm was used to find % body fat. 9.7%

Students also measured body composition using BIA. Prior to the test, subjects were instructed to avoid alcohol for 48 hours, refrain from eating, drinking and exercise for four hours, and empty the bladder immediately before. Subjects then removed metals and stepped onto the BIA unit with bare feet to obtain optimal results.

Results

Table 1. Subject and Class Average Body Fat using Various Methods.

	Method	Subject (%)	Class (%)
	DEXA	20	29
	ADP	22	27
Skinfolds	Sloan	10	22
Skinfolds	Durnin and Womersley	11	27
Skinfolds	Jackson and Pollock	10	23
	BIA	15	26

DEXA: Dual X-Ray Asorptiometry. ADP: Air-Displacement Plethysmography..BIA: Bioelectrical Impedance Analysis. Sloan, Durnin and Womersley, and Jackson and Pollock are equations used to calculate body fat based on skinfold measurements. Subjects are NUTR 301 students (n = 33 females, age = 23 ± 4 y), subject is a 19 year old female from this class.

Table 2. Body Fat Assessment of Subject using Reference Percentiles.

Method	Measurement	Percentile
Triceps Skinfold	2 mm	5th
Subscapular Skinfold	4 mm	5th
BIA	15% body fat	5th
DEXA	20% body fat	10th

BIA: Bioelectrical Impedance Analysis. DEXA: Dual X-Ray Absorptiometry. Percentiles were determined from reference tables in the Laboratory Manual. Subject is a 19 year old female from the NUTR 301 class.

Body composition assessment of the subject varied greatly between the four methods. ADP reported the highest value of 22% body fat, while skinfolds reported the lowest value, only 10% (Table 1). For the class, skinfolds also reported the lowest body fat (24%), while DEXA was the highest at 29% (Table 1). Body composition assessment for the class did not vary as drastically between the methods than it did for the subject. Interestingly, the class average showed that even within the skinfold method, there was some variance between the three body fat equations. DW was at 27%, while Sloan and JP were 22% and 23%, respectively (Table 1). In addition, BIA was 7% lower than ADP in the subject, whereas the class average reported that BIA was only 1% lower than ADP (Table 1).

Using reference tables in the Laboratory Manual, it was determined that the triceps skinfold, subscapular skinfold, and BIA results of the subject all fell into the 5th percentile from fat mass.

Discussion

In the subject, DEXA and ADP were quite similar, but BIA and skinfolds were much lower. The greatest difference in the methods was 12% body fat (DEXA 22%, skinfolds 10% - see Table 1), which is quite a large variance considering these tests were all done within the same week, and this does not give the subject enough time to change body fat mass so substantially. The class results varied by at most 7% body fat.

A possible reason for why skinfolds in the subject was much lower than the rest of the methods is that the subject and lab partners were inexperienced at taking skinfold measurements. They reported having trouble with distinguishing between muscle and fat tissue. Even with a trained technician, there is usually 3-4% error. In addition, the subject was ticklish and may have tensed up during the application of pressure, which can skew the results. However, the skinfolds of the subject were measured so incorrectly that the measurements obtained were not even on Tables 1 and 3. As such, the smallest values on these two tables were taken as it is very unlikely that the subject had a lower

body fat than 10%, which is already far lower than results from DEXA, considered the gold standard of body composition assessment.

In the subject, ADP reported the highest amount of body fat: 2% higher than DEXA. It is possible that the subject was not wearing a completely skin tight bathing suit, or had some hair poking out from underneath the swim cap, changing body volume and air displacement. The subject also reported rushing to fetch a bathing suit right before the test, and therefore was not relaxed, and small movements may affect the accuracy of ADP.

For both the subject and the class, skinfolds reported the lowest body fat. Other than inexperience, a factor that may have played a role was simple courtesy. As high body fat seems to be undesirable in modern society, it is possible that lab partners underreported measurements so as not to be rude to their classmates. With regards to skinfolds, both the subject and the class reported that DW gave a higher body fat than did Sloan and JP (Table 1). This may be due to the way the equations were structured, because DW used four measurements as opposed to three in JP. In addition, a given sum of skinfolds in DW corresponds to a higher percentage body fat than that same sum in JP. For example, a skinfold sum of 25 mm in DW corresponds to 16.8% body fat in females aged 16-29, whereas a skinfold sum of 25 mm in JP corresponds to 9.9% in females aged 23-27. Finally, the JP equation uses front thigh skinfolds. Lab partners of the subject reported that this measurement was very difficult to take and may have struggled to apply the caliper correctly, underreporting the true sum of skinfolds for JP.

BIA was lower than DEXA and ADP in the subject, likely because the subject did not follow protocols and ate two hours instead of four hours before the test. The BIA value of subject is likely to be inaccurate, because it can have an error of 3 – 5% even when all pretest protocols are strictly adhered to. Although the skinfolds and BIA measurements suggest that the subject is in the 5th percentile, if the DEXA value was used in Table 4, the subject would be in the 10th percentile. This means that 90% of healthy white adults aged 15-24 have a higher percentage fat mass than the subject.

Overall, every method has advantages and disadvantages. DEXA is the most precise and has no pre-test protocols, but it is also the most expensive to purchase (> $150 000), and it cannot be used by pregnant women. ADP is quite accurate with an error of 1-2% body fat, but is expensive to buy and maintain, and has some protocols to follow. BIA is less expensive ($200) and easy to run, but it has a higher error of 3-5%, and many pre-test protocols to follow. Skinfolds have 3-4% error and requires a trained technician for best results. It also involves being touched by another person which may not be very appealing to many people. However, skinfolds do have an advantage over all the above methods – it can be used by pregnant women or people with pacemakers, and is inexpensive and portable.

Conclusion

Contrary to the hypothesis, the percentage of body fat determined by each of the four methods turned out to be quite different. If an accurate body fat value is desired, then DEXA or ADP may be a good choice. If those units are not available, or only an approximate estimation of body fat is needed, then BIA and skinfolds would be appropriate. However, it is imperative that a trained technician is taking the skinfold measurements because as seen in the subject, inexperience can cause drastically inaccurate results. Each technique has its own benefits and drawbacks, so it is best to consider one's own circumstances when selecting a method of assessing body composition.

References

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Appendix 1

Body Composition Results of the Class

			Skinfolds		
DEXA (corrected)	BODPOD	BIA	Sloan	Durnin & Womerley	Jackson & Pollack
35.0		26.7	29.1	29.7	29.3
35.8		33.7	31.0	37.8	36.3
32.9	28.4	27.6	19.0	26.5	18.6
22.6		22.2	19.1	23.4	17.2
17.1	16.6	18.5	17.0	24.5	19.3
33.0		30.1	11.7	10.5	9.7
39.4	34.8	34.0	24.6	33.7	31.7
29.9		18.6	17.0	21.5	18.6
34.1	33.3	29.5	21.3	27.8	22.7
27.5		24.3	19.3	26.5	20.6
23.6	26.5	17.3	21.4	25.0	19.5
25.5		25.8	24.4	29.1	27.5
35.1		21.0	22.8	31.2	22.7
20.2	21.2	21.8	17.3	19.5	16.0
20.6	18.2	21.2	18.4	19.5	18.3
27.9		19.3	12.6	29.1	20.6
31.3		26.6	30.6	35.6	32.5
33.4	29.3	34.0	22.8	27.8	27.8
21.6	24.1	20.9	24.5	30.2	23.7
37.6	27.8	29.6	30.6	26.9	32.5
21.5		12.5	22.0	25.8	21.9
24.3	19.8	23.9	13.5	14.1	9.9
32.3		28.5	23.1	28.7	27.5
25.3		22.3	15.4	19.5	17.2
33.5	30.3	31.5	27.6	34.0	25.9
36.6		36.6	28.0	33.1	28.4
35.3	28.9	30.9	21.4	31.2	23.7
25.4		20.7	19.4	25.0	20.8
32.0	29.2	24.5	20.4	26.5	20.6
26.4	25.4	27.2	32.2	35.6	34.8
Averages					
29	27	22	27	23	

Data is % total body fat. All subjects are NUTR 301 students (females, *n*= 33, age = 23 ± 4 y).