ABSTRACT: Body fat percent measurement is an important indicator of health in the general public and important in athletes. The purpose of this study was to determine possible differences between a more expensive hand-foot (whole-body) bioelectrical impedance analysis (BIA) device (BodyStat1500) and an inexpensive foot-to-foot (lower-body) BIA device (Tanita Innerscan BC534). We hypothesized that there would be no difference in percent body fat or percent body water determination between the whole-body and lower-body method. Sixteen subjects of both genders volunteered to participate. Height and weight was taken on a physician's scale without shoes, then each subject had BIA performed on them with both devices. It was found that there were no statistically significant differences between percent body fat and percent body water between the two machines. There was also no difference between the physician's scale and the Tanita for weight. Differences in recommended daily caloric intake (DCI) were statistically significant between the BodyStat and the Tanita with the Tanita recommending greater caloric consumption. This experiment showed that there was no difference between whole-body and lower-body BIA assessment using these specific devices. The cheaper foot-to-foot scale provides accurate measurements and is more practical for most people and regular athletes to use.

INTRODUCTION & HYPOTHESIS: The prevalence of obese and overweight individuals has increased in both adults and youth in recent years (4). Obesity is a health concern because it can lead to many diseases, including type 2 diabetes, hypertension and kidney disease. Measuring body fat percentage serves as an indicator of an individual's risk for disease or can indicate their level of physical fitness.

While there are many techniques available to measure body composition, bioelectrical impedance analysis (BIA) is easy and non-invasive. In the hand-to-foot or whole-body method, electrodes are attached to the hand and foot and a painless electrical current is passed through the body while the person is relaxed in the supine position. Hand-to-foot BIA has been proven to provide an accurate measurement of body composition (1). Devices that conduct foot-to-foot BIA send an electrical current up one leg and down the other while the subject stands barefoot on metal plates. This method does not account for fat in the superior part of the body (including visceral adiposity), and comparisons between the two methods have found minor differences between them. One study found a strong correlation between the two methods, but no absolute fat percentage (2). Another study found minor differences between hand-to-foot and foot-to-foot BIA results (3).

The purpose of the present study was to determine if there were statistically significant differences in measurements between a hand-to-foot BIA machine (BodyStat1500) and a foot-to-foot BIA machine (Tanita Innerscan BC534) (4). The measurements of interest were body fat percentage, total body water percentage, and daily caloric intake (DCI). Also, another comparison between the Tanita and physician's scale was done to compare the accuracy of weight measurements. The hand-to-foot BIA machine is significantly more expensive than the foot-to-foot BIA machine, so we want to determine its accuracy. We hypothesized that there would be no statistically significant differences in the measurements between the hand-to-foot BIA machine and the foot-to-foot BIA machine.

MATERIALS & METHODS: Approval from the Institutional Review Board was obtained, and the identification number is IRB 2008-09010. Informed consent was obtained from all participants after the experimental procedures were explained. No exclusion criteria were used in this study. All participants were at least 10 years old. There were 16 subjects included in the study, 8 females and 8 males. The materials used included the BodyStat1500 (5) (BodyStat Inc., Douglas, Isle of Man, British Isles), and the Tanita Innerscan BC534 (6) (Tanita Corp., Arlington Heights, IL). A standard physician's scale (Healthometer Professional Physician Beam Scale 402L/BHW, Healthometer, Alsip, IL) and small measuring tape were also used to find required measurements.

In this experiment, bioelectrical impedance analysis (BIA) was used to determine the percent body fat and percent body water of the participants as well as to calculate the estimated daily caloric intake (DCI). The Tanita only sampled the lower half of the body. The BodyStat sampled the entire body. In order to have consistent results, each person was tested using both machines during the same lab period. Subjects' height and weight were measured on a physicians scale with their shoes off. Waist circumference and hip circumference were measured using a tape measure. Waist circumference measurements were taken at approximately the level of the iliac crest and the hip circumference was taken five inches below the waist measurement.

Tanita Innerscan BC534, Age, height, gender, and relative activity level were inputted into the device for each subject individually. Once finished, the subject removed their shoes and socks and stood on the scale for 3 seconds for an assessment.

BodyStat 1500. Alcohol pads were used to wipe skin sites for electrode attachment. Four electrodes (two on the right hand and two on the right foot) were placed, and each was attached to the device. Age, gender, height, weight, waist and hip circumferences, and relative activity level were inputted into the device for each subject individually. Subjects were instructed to relax motors in the supine position during the analysis, which lasted approximately 3 seconds.

The percent body fat, percent body water, and DCI from each device were put into an Excel spreadsheet and then paired t-tests were run to analyze the findings. Three separate sets of t-tests were run comparing measurements between the Tanita and BodyStat: Body fat percentages; total body water percentages; and DCI. A fourth t-test was used to compare the Tanita and physician's scales with different results.

RESULTS: Figure 1 shows the difference in percent body fat between the BodyStat and the Tanita. The average percent body fat for the BodyStat 1500 was 23.65% and the average percent body fat for the Tanita was 24.91% (p = 0.116). Figure 2 shows the differences in percent body water between the BodyStat and the Tanita. The average percent body water for the BodyStat 1500 was 54.31% and the average percent body water for the Tanita was 53.18% (p = 0.023). Figure 3 shows the difference in weight between the physician's scale and the Tanita. The average weight for the physicians scale was 178.08 pounds and the average for the Tanita was 178.94 pounds (p = 0.347). Figure 4 shows the difference in daily caloric intake (DCI) between the BodyStat and the Tanita. The average DCI for the BodyStat was 3177.06 calories per day and the average DCI for the Tanita was 3300.88 calories per day (p = 0.047).

DISCUSSION & CONCLUSIONS: Body fat percentage is important in many aspects of health and wellness. It can be a good indicator of physical fitness as well as an indicator for risk of certain diseases. It is also very important in athletic contexts and can help to create and maintain a specific diet or workout regimen based on the athlete and the sport in which they are competing. Specific body fat ranges are important in certain sports, as an athlete can compare their optimal performance when in certain ranges. Endurance sports in particular have specific lower body fat ranges that help in performance, but each sport varies depending on the type of activity and length of competition.

In this experiment it was found that the comparison of percent body fat and percent body water between the two machines was not statistically significant. The BodyStat for both water percentages from both devices were very similar. The comparison between the Tanita and physician's scale was also not significant, so the Tanita is shown to be accurate for weight. The Tanita scale costs $100, a fraction of the price of the BodyStat 1500, which is $1500. Here we find that it is not worth the money for the average person to buy the BodyStat 1500. The Tanita Innerscan will still do an excellent job.

In future studies, the Tanita and BodyStat 1500 could be compared to other methods of measuring body fat. Some of these include the air vacuum (Bod Pod), underwater weighing, skinfolds, and dual x-ray absorptiometry (DEXA). These results could be compared and statistically analyzed in the same way to see if there are any differences or how much difference there is between these methods. These results could also be used to determine and select the best method for different levels or types of athletes and if certain ones are better for inactive people.

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Figure 1. Comparison of Percent Body Fat Between BodyStat and Tanita

Figure 2. Comparison of Percent Body Water Between BodyStat and Tanita

Figure 3. Comparison of Weight Between Physicians Scale and Tanita

Figure 4. Comparison of Daily Caloric Intake Between BodyStat and Tanita