

# Body Composition Assessment: A Comparison of the Bod Pod, InBody 770, and DXA

Research Brief

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## Abstract

**Introduction:** There are several laboratory methods for assessing body composition. The purpose of this study was to compare three body composition methods in a cohort of exercise-trained men and women: air displacement plethysmography (Bod Pod®), dual energy x-ray absorptiometry (DXA) and a multi-frequency bioelectrical impedance (MF-BIA) device (InBody® 770).

**Methods:** Subjects (n=155; 42 male, 113 female) came to the laboratory for body composition assessment (i.e., percent body fat, fat-free mass and fat mass).

**Results:** There were no statistically significant differences between the Bod Pod and InBody for any measure of body composition. However, the Bod Pod and Inbody 770 overestimated fat-free mass and underestimated fat mass and percent body fat in comparison to the DXA.

**Conclusions:** In general, the Bod Pod and InBody 770 underestimate percent body fat versus the DXA. Thus, one must be cautious in the interpretation of body composition data depending on the method of assessment. It should be noted that all three methods are acceptable for body composition analysis.

**Key Words:** fat mass, fat-free mass, lean body mass, exercise

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## Introduction

Three common laboratory methods of body composition assessment include the dual energy x-ray absorptiometry (DXA), air displacement plethysmography (i.e., the Bod Pod®), and bioelectrical impedance (BIA).<sup>1-4</sup> Each of these methods has their advantages and disadvantages.<sup>1,2,5-8</sup> The BIA is a relatively simple, safe, and the most rapid of these three methods. Air displacement plethysmography (i.e., the Bod Pod®) is safe, non-invasive and as served as an alternative to underwater weighing. The DXA is quick and provides bone mass in addition to fat-free mass and fat mass. However, the primary advantage of the DXA is that it provides segmental body composition estimates.<sup>5</sup> It should be noted that all three methods are valid methods for estimating body composition. The purpose of this investigation was to compare estimates of fat mass, fat free mass, and percent body fat between the DXA, Bod Pod and BIA in exercise-trained men and women. We hypothesized that both the BIA and Bod Pod would underestimate fat mass and overestimate fat free mass in comparison to the DXA.

## Methods

### Participants

One hundred and fifty-five subjects (42 male, 113 female) came to the laboratory for body composition assessment. All subjects were self-assessed as “exercise-trained” (i.e., have been training regularly for the

past year). The University's Institutional Review Board approved all human subjects procedures. Written informed consent was obtained prior to participation.

#### Protocol

Body composition was assessed with a dual-energy X-ray absorptiometry machine (DXA) (Model: Hologic Horizon W; Hologic Inc., Danbury CT USA), the Bod Pod and the InBody 770 multi-frequency bioelectrical impedance (BIA) device. Subjects were instructed to come to the laboratory after at least a 3-hour fast and no prior exercise that day. All testing was performed between 11:00am and 4:00pm. For the DXA, quality control calibration procedures were performed on a spine phantom. Subjects wore typical athletic clothing and removed all metal jewelry. They were positioned supine on the DXA within the borders delineated by the scanning table. Each whole body scan took approximately seven minutes. For the Bod Pod, subjects were tested while wearing only tight fitting clothing (swimsuit or undergarments) and an acrylic swim cap. Thoracic gas volume was estimated for all subjects using a predictive equation integral to the Bod Pod® software. Each subject was tested at least twice. The calculated value for body density used the Siri equation to estimate body composition. The Bod Pod was calibrated the morning of the testing session as well as between each subject. For the InBody BIA, subjects stood on the platform of the device barefoot with the soles of their feet on the electrodes. Subjects then grasped the handles of the unit with their thumb and fingers to maintain direct contact with the electrodes. They stood still for ~1 minute while maintaining their elbows fully extended and their shoulder joint abducted to about a 30 degree angle.

#### Statistical Analysis

An ANOVA was used to determine differences between the three methods. Sidak's multiple comparisons test was used to determine which pairs differed. All data is presented as the mean±SD. GraphPad (Prism 6) software was used for statistical analyses.

**Table 1. Body Composition**

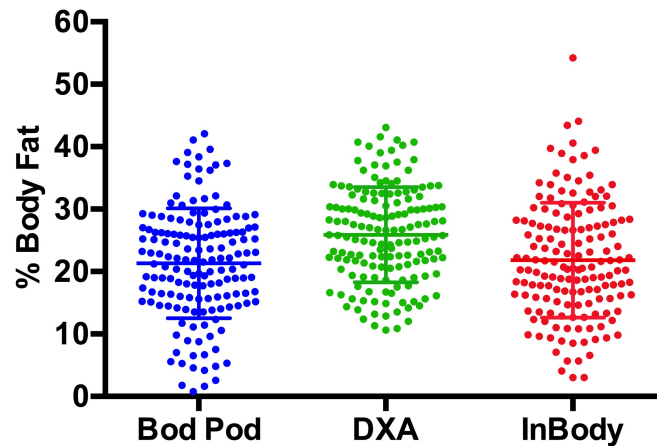
|                        | <b>Bod Pod</b> | <b>DXA</b> | <b>InBody<br/>770</b> | <i>p value<br/>Bod Pod vs<br/>InBody</i> | <i>p value<br/>DXA vs<br/>Bod Pod</i> | <i>p value<br/>DXA vs<br/>InBody</i> |
|------------------------|----------------|------------|-----------------------|--|---------------------------------------|--------------------------------------|
| % Body Fat – All       | 21.3±8.8       | 25.9±7.6   | 21.8±9.2              | 0.9394                                   | <0.0001                               | <0.0001                              |
| % Body Fat – Male      | 14.3±7.2       | 17.8±4.6   | 13.3±6.2              | 0.8300                                   | 0.0248                                | 0.0023                               |
| % Body Fat - Female    | 23.9±7.9       | 28.9±6.2   | 25.0±8.0              | 0.6310                                   | <0.0001                               | 0.0003                               |
| Fat Mass (kg)– All     | 15.3±7.6       | 18.3±6.7   | 15.6±7.6              | 0.9793                                   | 0.0008                                | 0.0029                               |
| Fat Mass (kg) – Male   | 12.6±7.8       | 15.4±5.9   | 11.8±7.6              | 0.9355                                   | 0.2206                                | 0.0688                               |
| Fat Mass (kg) - Female | 16.3±7.3       | 19.4±6.6   | 17.0±7.1              | 0.8342                                   | 0.0026                                | 0.0282                               |
| FFM (kg) – All         | 56.1±13.2      | 52.6±13.0  | 55.8±13.8             | 0.5663                                   | <0.0001                               | <0.0001                              |
| FFM (kg) - Male        | 72.9±11.0      | 69.6±11.4  | 73.7±11.1             | 0.9879                                   | 0.4583                                | 0.2869                               |
| FFM (kg) - Female      | 49.8±6.6       | 46.2±6.0   | 49.1±7.1              | 0.7740                                   | 0.0001                                | 0.0034                               |

Data are expressed as the mean±SD. n = 155 (male n=42, female n=113). Legend: kg – kilogram; FFM – fat-free mass.

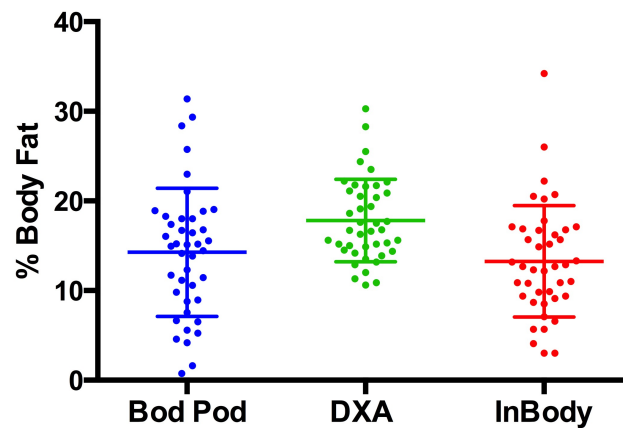
#### Results

One hundred and fifty-five subjects volunteered for this investigation (n=113 female, n=42 males; Age 27±9 years, Height 170±10 centimeters, Weight 71.4±14.7 kilograms). All subjects were self-reported to

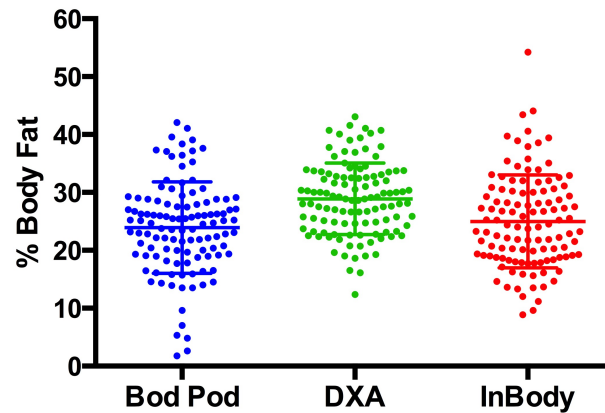
be exercise-trained. There were no significant differences between the Bod Pod and InBody for any measure (i.e., fat mass, fat-free mass, percent body fat) (See Table 1 and Figures 1-9). However, there were significant differences between the Bod Pod and InBody in comparison to the DXA (Table 1 and Figures 1-9). When male and female subjects were combined, the InBody and Bod Pod significantly underestimated fat mass and overestimated fat-free mass when compared to the DXA. However, in male subjects, the InBody and Bod Pod assessments of fat-free mass and fat mass were not different than the DXA. In female subjects, the InBody and Bod Pod underestimated fat mass and overestimated fat-free mass significantly when compared to the DXA. Additionally, the DXA had much less variability than the Bod Pod and Inbody. Note that the data in all of the figures are expressed as the mean $\pm$ SD.



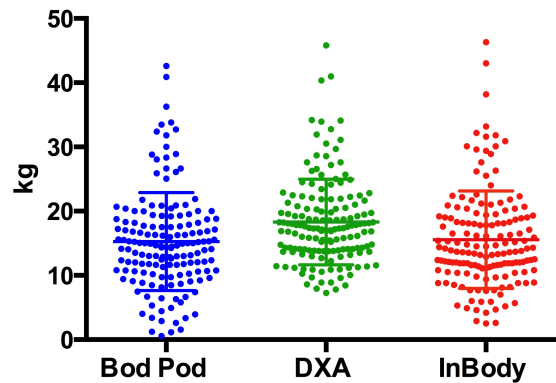
**Figure 1. Body Fat Percentage of Male and Female Combined.** The middle horizontal line represents the mean. The lines above and below the horizontal line represents the standard deviation. Each circle represents an individual data point. There was not a significant difference between the Bod Pod and Inbody. The DXA was significantly different than the Bod Pod ( $p < 0.0001$ ) and InBody ( $p < 0.001$ ).



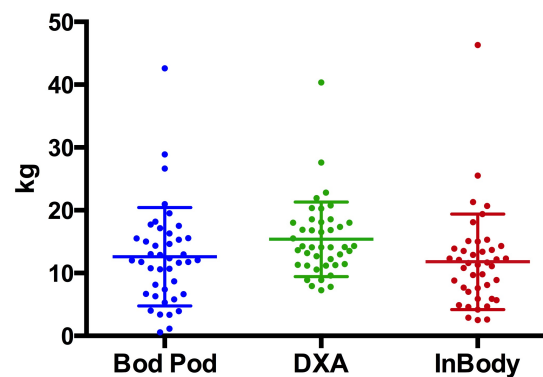
**Figure 2. Body Fat Percentage of Male Subjects.** The middle horizontal line represents the mean. The lines above and below the horizontal line represents the standard deviation. Each circle represents an individual data point. There was not a significant difference between the Bod Pod and Inbody. The DXA was significantly different than the Bod Pod ( $p = 0.0248$ ) and InBody ( $p = 0.0023$ ).



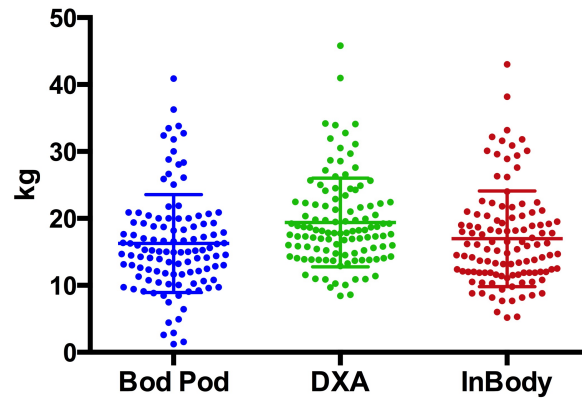
**Figure 3. Body Fat Percentage of Female Subjects.** The middle horizontal line represents the mean. The lines above and below the horizontal line represents the standard deviation. Each circle represents an individual data point. There was not a significant difference between the Bod Pod and Inbody. The DXA was significantly different than the Bod Pod ( $p < 0.0001$ ) and InBody ( $p = 0.0003$ ).



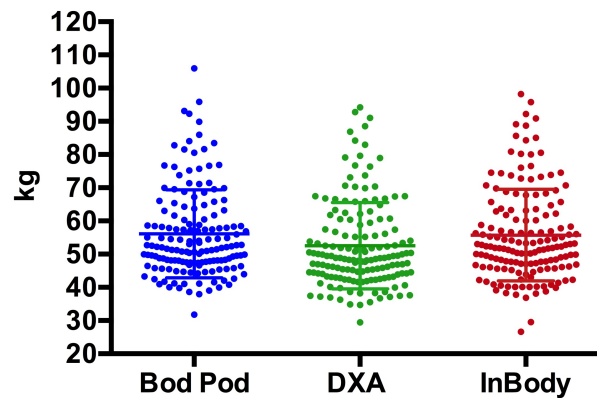
**Figure 4. Fat Mass of Male and Female Combined.** The middle horizontal line represents the mean. The lines above and below the horizontal line represents the standard deviation. Each circle represents an individual data point. There was not a significant difference between the Bod Pod and Inbody. The DXA was significantly different than the Bod Pod ( $p = 0.0008$ ) and InBody ( $p = 0.0029$ ).



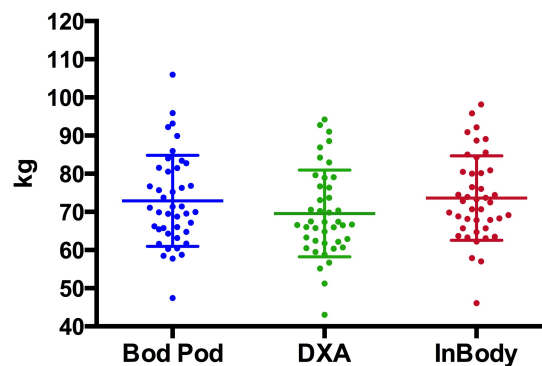
**Figure 5. Fat Mass of Male Subjects.** The middle horizontal line represents the mean. The lines above and below the horizontal line represents the standard deviation. Each circle represents an individual data point. There were no significant differences between any of the groups.



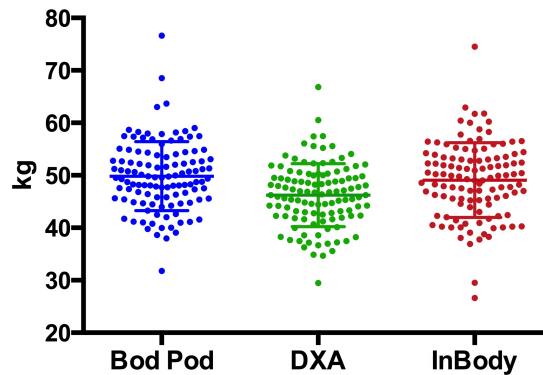
**Figure 6. Fat Mass of Female Subjects.** The middle horizontal line represents the mean. The lines above and below the horizontal line represents the standard deviation. Each circle represents an individual data point. There was not a significant difference between the Bod Pod and Inbody. The DXA was significantly different than the Bod Pod ( $p=0.0026$ ) and InBody ( $p=0.0282$ ).



**Figure 7. Fat-free Mass of Male and Female Combined.** The middle horizontal line represents the mean. The lines above and below the horizontal line represents the standard deviation. Each circle represents an individual data point. There was not a significant difference between the Bod Pod and Inbody. The DXA was significantly different than the Bod Pod ( $p<0.0001$ ) and InBody ( $p<0.0001$ ).



**Figure 8. Fat-free Mass of Male Subjects.** The middle horizontal line represents the mean. The lines above and below the horizontal line represents the standard deviation. Each circle represents an individual data point. There were no significant differences between the groups.



**Figure 9. Fat-free Mass of Female Subjects.** The middle horizontal line represents the mean. The lines above and below the horizontal line represents the standard deviation. Each circle represents an individual data point. There was not a significant difference between the Bod Pod and Inbody. The DXA was significantly different than the Bod Pod ( $p=0.0001$ ) and InBody ( $p=0.0034$ ).

### Discussion

Data from this investigation demonstrate that estimates of body composition are similar between the Inbody 770 and the Bod Pod. However, both methods report higher fat-free mass and lower fat mass estimates versus the DXA. Wingo et al. compared segmental estimates of lean and fat mass using BIA versus a DXA<sup>9</sup> and discovered that the BIA overestimated lean mass for the arm and trunk; additionally, BIA underestimated fat mass for the arm and leg. Schoenfeld et al. found that the multi-frequency BIA (MF-BIA) is similar to the DXA for tracking changes in body composition during a combined diet and exercise program in young, athletic men.<sup>10</sup> However, this study also showed a discrepancy in the absolute values for fat mass and fat-free mass when comparing the BIA to the DXA. Day et al. compared the BIA device (seca mBCA 515) to the DXA. In their study of 30 participants, the BIA underestimated fat mass and overestimated fat free mass<sup>12</sup>. In a study that compared the DXA to the Bod Pod, these investigators found that the Bod Pod had lower percent body fat and fat mass while showing a greater fat-free mass in comparison to the DXA. On the other had, the mean change in fat mass, fat-free ass and percent body fat was not significantly different between the methods<sup>13</sup>.

The primary finding from our investigation is that the InBody 770 multi-frequency bioelectrical impedance device provides similar data to the Bod Pod. On the other hand, if one is to use the DXA as the criterion method of assessing body composition, it is apparent that both the InBody and Bod Pod methods will provide absolute values for fat mass and fat-free mass that significantly differ from the DXA. Regardless of the method used, investigators must be cognizant of the advantages and disadvantages of each method.

### Conclusions

In a sample of exercise-trained individuals, both the Bod Pod and InBody 770 underestimated percent body fat and fat mass in comparison to the DXA while overestimating fat-free mass versus the DXA. Moreover, there was no difference between the Bod Pod and InBody 770. All three methods are acceptable for assessing body composition (i.e., for group data).

### Media-Friendly Summary

The InBody 770 and Bod Pod are valid methods for assessing body composition; however, both methods tend to produce underestimates of percent body fat compared to the DXA. An interesting side note is that of the hundreds of exercise-trained men and women that we have tested in our laboratory, there was not a single individual that registered less than 10% body fat on the DXA. And this

population includes professional MMA fighters, world-class distance runners, world-class stand up paddlers, physique competitors, and collegiate track and field athletes.

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**Conflicts of Interest:** The authors declare no conflict of interest.

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