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Predicted Versus Measured Thoracic Gas Volume on Body Fat Percentage in Male College Athletes

Direct Original Research

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Abstract

Introduction: Accurate body composition is important for a variety of reasons including health and fitness. The purposes of this study were to compare predicted thoracic gas volumes (TGVp) and measured thoracic gas volumes (TGVm) and to compare percentage body fat (%BF) from the Bod Pod using TGVp and TGVm.

Methods: Participants included 31 male college athletes (18-22 years) on the basketball, soccer, tennis, baseball, or track teams. Each participant completed both a predicted and measured TGV using the Bod Pod.

Results: TGVm was significantly higher (4.59 ± 0.88 L) than TGVp (4.11 ±0.45 L, $p<0.001$). %BF derived by TGVm was significantly higher than %BF derived by TGVp (13.8% vs. 12.6%; $p<0.001$). Individually, %BF derived from TGVm vs. TGVp differed within ± 2.0% BF for 58% of the participants.

Conclusions: The results indicate that measuring TGV is recommended in male college athletes.

Key Words: body composition, fat mass, air-displacement plethysmography.

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Introduction

Many body composition assessment methods exist. The Bod Pod® (COSMED USA Inc., Concord, CA) is a standard method. This device is found in many settings, such as clinics, research, athletic and wellness centers. The Bod Pod is a reliable and valid measure of body composition.[1–3]

The Bod Pod is an air displacement plethysmograph and uses the inverse relationship between pressure and volume to determine body volume (BV) in order to estimate percentage body fat.[4] To determine BV, thoracic gas volume (TGV) can either be predicted or measured. Measured thoracic gas volume can be challenging; thus, predicted TGV is often utilized. The accuracy of predicted versus measured has shown mixed results. Some studies show no differences between the two.[3,5,6] Other studies have reported differences.[7,8] Thus, the purposes of this study were to compare predicted (TGVp) and measured (TGVm) thoracic gas volumes and to compare percentage body fat (%BF) from the Bod Pod using TGVp and TGVm.

Scientific Methods

Participants

Thirty-four male college athletes were recruited from the basketball, soccer, tennis, baseball, or track teams. Of those 34, three participants were unable to perform the measured TGV correctly. Thus, their data was not included, leaving 31 participants. Participants were asked to refrain from eating, drinking, or exercising two hours before testing and to void their bladder prior to testing. Before testing each participant read and signed informed consent which explained the purpose, method, benefits, and risks of the study. The Huntington University Institutional Review Board (IRB) approved the study before testing.

Protocol

Testing took place on the university campus in the Human Performance Lab. Upon arriving at the lab, each participant was asked prior to testing whether they refrained from eating, drinking (other than water), and exercising for at least the past two hours. If they did not, they were not tested and instructed to reschedule. After following the pre-testing instructions, the participant's height was measured by a stadiometer. Body composition was then assessed using the Bod Pod, using the published standards.[9] The Bod Pod was calibrated using a 50.28-L cylinder prior to testing. Participants were required to wear clothing according to the manufacturer's guidelines. Participants were weighed on the calibrated scale connected to the Bod Pod. After being weighed, participants were instructed to sit in the Bod Pod chamber. Each participant performed two Bod Pod tests. The first test used the predicted TGV. The device measured Body volume twice; however, if there was more than a 150 ml difference between the first two measures, a third measurement was taken. Body fat was then obtained by the Bod Pod using the Siri equation. The second test was similar, except participants' TGV was measured at the end of the body volume measures. The measured TGV involved participants breathing via a disposable breathing tube, plugging their nose, and performing a "huffing" maneuver mid-expiration against a shutter valve. Then, at the end the Bod Pod provides a %BF using the TGVm.

Statistical Analysis

Analyses were performed in Excel. Descriptive statistics included means, standard deviations, minimum and maximum values. Mean differences between TGVm and TGVp and between %BF derived from TGVm and TGVp were determined by paired samples t-tests. Bland-Altman plots with 95% limits of agreement were used to evaluate mean differences in %BF derived from predicted and measured TGV at the individual level.[10] Statistical significance was set at $p \leq 0.05$.

Results

The participants' characteristics are presented in Table 1.

Table 1. Characteristics of the participants (n = 31)

	Mean ± SD	Min - Max
Age (y)	20.3 ± 1.42	18.3 - 22.7
Height (cm)	182.5 ± 9.52	160.0 - 203.2
Body Mass (kg)	78.8 ± 9.43	61.9 - 102.1
TGVm (L)	4.59 ± 0.88*	2.95 - 6.46
TGVp (L)	4.11 ± 0.45	3.03 - 5.08
BVm (L)	73.78 ± 8.97	58.3 - 96.65
BVp (L)	73.59 ± 8.97	57.98 - 96.73
BFm (%)	13.8 ± 5.07	7.3 - 23.9
BFp (%)	12.58 ± 5.21	5.0 - 24.1

Note: TGVm = Thoracic gas volume measured; TGVp = Thoracic gas volume predicted; BVm = Body volume measured; BVp = Body volume predicted; BFm = body fat derived from TGVm; BFp = Body fat derived from TGVp

The t-test revealed a significant difference ($p \leq 0.001$) between TGVm and TGVp. There was also a significant difference ($p \leq 0.001$) between %BF derived from TGVm and TGVp. On an individual basis, 58% of the sample (18 participants) were within ± 2.0% BF when comparing %BF derived from TGVm and TGVp. The maximum differences of %BF were -4.7 to 2.1. The Bland-Altman plot (Figure 1) revealed a constant bias of -1.2%.

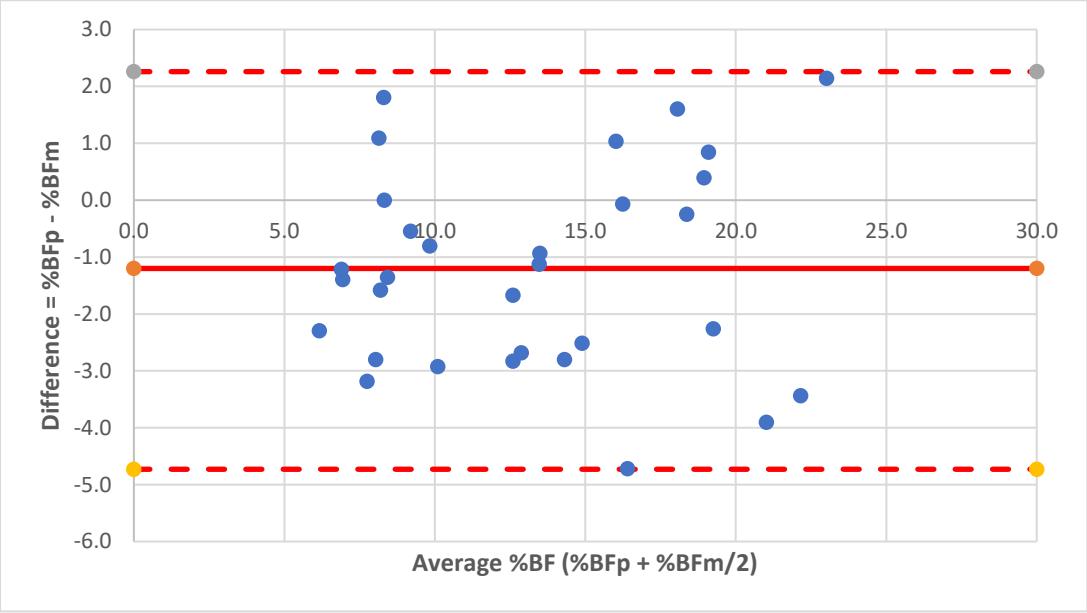

Figure 1. Bland-Altman Plot of individual %BF differences. The solid line represents the constant bias (-1.2%). The dashed lines are the 95% confidence interval (-4.73 to +2.26%). %BFp = percent body fat derived from predicted TGV; %BFm = percent body fat derived from measured TGV.

Discussion

The purposes of this study were to compare predicted (TGVp) and measured (TGVm) thoracic gas volumes and to compare percentage body fat (%BF) from the Bod Pod using TGVp and TGVm. The measured TGV was significantly higher than the predicted TGV (4.59 vs. 4.11 L). The %BF derived from measured TGV was also significantly higher than %BF derived from predicted TGV (13.8 vs. 12.58 %).

In contrast to this study's findings, several studies[3,5,9] found no significant difference between measured and predicted TGV. For instance, Wagner[3] found no significant differences in measured and predicted thoracic gas volumes in 33 lean university athletes. Like Wagner, McCrory et al.[9] found no differences in measured and predicted TGV in 50 adults ages 18-56 years. However, both studies still recommend using measured TGV as standard practice. Conversely and similar to the present study, other studies[7,8] have reported significant differences in measured and predicted TGV and %BF derived from TGV. For example, Blaney[8] found a significant difference in measured and predicted TGV in 113 college freshmen. Ducharme et al.[7] found predicted TGV significantly lower than measured TGV in 95 men ages 18-30 years. Furthermore, he reported %BF derived from predicted TGV was lower than %BF derived from measured TGV by 1.3%. This finding was similar to the present study %BF derived by predicted TGV in being 1.22% lower than %BF derived from measured TGV.

Further analysis revealed that on an individual basis, the current study found only 58% of the sample participants' %BF fell within ± 2% BF when comparing %BF derived from TGVm and TGVp. This finding was lower than reported by previous studies[3,9]. For instance, McCrory et al.[9] reported that 82% of the subjects fell within ± 2% BF and maximum individual differences ranged between -2.9 to +3.0%. Wagner reported that 76% of his study's sample were within ± 2% BF when comparing %BF derived from TGVp and TGVm.

This study had two known limitations. First, the population consisted of young male college athletes, so the findings cannot be generalized to other populations. For example, non-athletes, athletes in other sports, females, or older participants may show different results. Second, there is the uncertainty that participants followed the pre-testing requirements of fasting and exercise 2-3 hours prior to the test. Although each participant was asked prior to testing, there is no guarantee and thus a possibility that the participant did not follow the pre-testing instructions. This study has two major strengths. First, this study compared both measured and predicted TGV and %BF derived from measured and predicted TGV. Some studies only compared measured and predicted TGV, not the effects on %BF.

Second, this study included two separate Bod Pod tests for each participant, providing a more "real world" assessment protocol.

Conclusions

This study found predicted TGV underestimates when compared to measured TGV, leading to underestimates of %BF. Even though predicted TGV takes less time and is easier to perform, we recommend measuring TGV when possible, especially in male college athletes.

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The authors have no conflicts of interest to disclose.

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