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Original Research

Longitudinal Changes in Fat and Lean Mass: Comparisons between 3D-Infrared and Dual-Energy X-ray Absorptiometry Scans in Athletes

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ABSTRACT

International Journal of Exercise Science 15(4): 1587-1599, 2022. The low cost and portability of three-dimensional (3D) infrared body scanners make them an attractive tool for body composition measurement in athletes. The main purpose of this study was to compare total body fat percentage (BF%) and total lean mass (LM in kg), in a cohort of collegiate athletes, using a 3D infrared body scanner versus a dual energy x-ray absorptiometry (DXA) scanner. Phase I was a pre-season cross-sectional analysis of 61 (39 male) athletes while Phase II was a longitudinal subset analysis of 38 (27 male) student-athletes who returned to the laboratory for post-season scans (Post minus pre-season change). Both the 3D and DXA scans were performed within 20-minutes of one another in the same room, wearing the same clothing. Paired t-tests were used to compare the mean values (BF% and LM) between measurement devices with estimated effects size calculated using Cohen's d. Data reported as mean±SD. Mean difference (DXA minus 3D) in LM were significantly higher using the 3D scan (5.84 ± 3.55kg; $p < 0.001$; $d = 0.90$) compared to the DXA scan, while significantly underestimating BF% (-4.57 ± 4.67%; $p < 0.001$; $d = 1.6$) in Phase I analyses. In Phase II analyses, significant differences in the change (post-season minus pre-season change) values were found between methods for LM (4.45 ± 5.04; $p < 0.001$; $d = 0.90$), while BF% (-0.41 ± 2.06; $p = 0.223$; $d = 0.2$) showed no significant differences. In summary, the 3D and DXA scan values for LM and BF% were not interchangeable in cross-sectional nor longitudinal body composition analyses in collegiate athletes. Close agreement was only observed in longitudinal analyses of BF% and requires further validation with larger cohorts.

KEY WORDS: Naked™ scanner, body composition, collegiate athlete

INTRODUCTION

Collegiate athletes are constantly striving for improvements in physical strength and training to maximize performance in sport. The margins of success at the elite level are incremental, with small changes in body composition potentially having large effects on both athlete metabolism (26) and performance (2). Body fat is one component of body composition which is often prioritized, with lower percent body fat (%BF) measurements associated with better athletic performance in weight-bearing sports such as hockey, lacrosse, basketball, football, and soccer

(5, 7, 8, 21-23). Although many studies demonstrate an inverse relationship between %BF and performance, the wide array of measurement techniques undermines the application and comparison of body composition results (15).

Three-dimensional (3D) photonic (infrared) scanners represent an emerging technology that utilizes body volume to estimate fat and fat free mass (24). One such 3D infrared scanner, the Naked Labs™ 3D Fitness Tracker (Redwood City, CA, U.S.A.) scanner, uses algorithms derived from dual energy x-ray absorptiometry (DXA) scan images to convert segmental (body) volumes into fat and fat-free (lean) mass (27). The International Olympic Committee (IOC) recommends using DXA scans for measurement of body composition measurement in elite athletes (13). However, studies comparing body composition results between the 3D infrared versus DXA scans and/or other methodologies remain sparse and conflicting (16, 20, 29).

Comparison of longitudinal (i.e., post- minus pre-training) changes in fat and fat-free mass, between body composition measurement techniques, remains equally sparse. Cross-sectional comparisons using the DXA scan versus air plethysmography (6), hydrodensitometry (14) skinfolds (17, 18), and 3D infrared scanners (10) (all 2-compartment models) generally confirm lower absolute %BF values when compared with DXA scan values (a 3-compartment model technique). Comparison of longitudinal changes in %BF would offer practical information for coaches, athletes, and sports specialists (over cross-sectional analyses) because DXA scanners are expensive, required trained operators, and involve small doses of radiation which prohibit the frequency of measurement (13, 15). Therefore, if interchangeable, a 3D infrared body scanner could offer a cost effective, radiation-free, and more frequent body composition measurement option for use in collegiate athlete populations.

The two primary aims of this study are to compare body composition measurement using a 3D infrared (Naked™) versus DXA scanner in both a: 1) cross-sectional analyses and 2) longitudinal (POST- minus PRE-season change) analyses of body composition in collegiate athletes. For the Naked™ scanner to be considered a surrogate body composition measurement technique for the DXA scan, we would expect equivalent values for BF%, lean mass and fat mass in both cross-sectional and longitudinal analyses.

METHODS

Prior to measurements, participants were informed of the benefits and risks of the investigation before signing written informed consent (IRB#073919M1E) to participate in the study. All researchers complied with the stated ethical statements and requirements set forth by the International Journal of Exercise Science's official Position Stand (19)

PHASE I – Cross-sectional Analyses

Participants

In a cross-sectional design, 61 individuals (39 male and 22 females) from a midwestern National Collegiate Athletic Association Division II (NCAA D2) university underwent total body composition assessments, to assess total body fat percentage (BF %), lean mass (LM) and fat mass (FM), using two different commercially available systems: 1) a dual-energy x-ray absorptiometry (DXA) and 2) infrared (Naked™) scanner. Prior to measurements, participants were informed of the benefits and risks of the investigation before signing written informed consent (IRB#073919M1E) to participate in the study. Additionally, all female participants were required to sign a DXA pregnancy attestation form before the DXA scan, providing written confirmation that they were not pregnant (or think they would be pregnant). Data were collected between August 2019 and February 2020. Descriptive statistics can be seen in Table 1.

Table 1. Descriptive statistics for cross-sectional population.

	Females (n = 22)		Males (n = 39)		Total (N = 61)	
	Mean ± SD	Min-Max	Mean ± SD	Min-Max	Mean ± SD	Min-Max
Age (yr)	19.73 ± 1.69	18 - 24	19.31 ± 1.26	17 - 23	19.46 ± 1.43	17 - 24
Height (m)	1.69 ± 0.07*	1.59 - 1.83	1.79 ± 0.06*	1.66 - 1.92	1.76 ± 0.08	1.59 - 1.92
Weight (kg)	67.71 ± 10.54*	55.26 - 92.04	83.80 ± 21.04*	54.97 - 135.91	78.00 ± 19.50	54.97 - 135.91
BMI (Kg/m^2)	23.38 ± 2.45	19.78 - 29.05	25.91 ± 5.50	19.33 - 41.33	25.00 ± 4.77	19.33 - 41.33

	Females (n = 22)		Males (n = 39)		Total (N = 61)	
	Naked™	DXA	Naked™	DXA	Naked™	DXA
Body Fat %	23.54 ± 8.00	25.44 ± 4.72	15.25 ± 6.42**	21.32 ± 3.87**	18.24 ± 8.26**	22.80 ± 4.61**
Lean Mass	51.82 ± 11.63**	48.46 ± 9.47**	70.43 ± 11.69**	63.19 ± 12.9**	63.72 ± 14.67**	57.88 ± 13.7**
Fat Mass	15.75 ± 5.81	17.16 ± 3.84	25.00 ± 24.49*	18.69 ± 8.21*	21.67± 20.09	18.15 ± 6.96

Note: Demographic information for cross-sectional population. Mean ± standard deviation comparing cross-sectional body composition measures of body fat percent (%), lean mass (kg), and fat mass (kg) in Naked™ body scanner v. DXA Scanner in females, males, and total population. BMI, Body Mass Index. *Indicates significant difference between sex or device ($p < 0.05$) **Indicates significant difference between sex or device ($p < 0.001$)

Protocol

Anthropometrics - Participants were asked to change into tight-fitting clothing (without any metal, such as buttons or zippers), such as training spandex or a swimsuit and remove shoes, jewelry, and glasses. Then, each participant had height and body mass measured using a stadiometer and electronic scale (Seca, Germany, USA). Participants were asked to try and refrain from exercise and food 4-hours prior to the best of their ability.

DXA scan - Participant's whole-body composition data were obtained using the DXA scan (Hologic™ Horizon A, APEX System Software Version 5.6.0.5, TBAR1209 NHANES BCA calibration, Marlborough, MA, USA). Standardized procedure for patient positioning and utilization of the system software were used to analyze all body scans. Calibration procedures for the DXA system were completed daily, as per manufacturer instructions, prior to all scans.

Naked™ scan - After completion of the DXA scan, participants remained in the same clothing to obtain body composition data using the infrared Naked Labs™ 3D Fitness Tracker (Redwood City, CA, U.S.A.). Participants were instructed to step on the Naked™ platform and maintain an upright posture in the anatomical position for the duration of the scan. Participants followed the prompts given forth by Naked™ body scanner. No daily calibration is required prior to body composition measurement using the infrared Naked™ scan. Both scans were completed, in the same laboratory, within 20 minutes.

PHASE II – Longitudinal Analyses

Participants

In this longitudinal assessment, a small subset (38 athletes - 27 males, 11 females) returned to the laboratory for POST-season body composition assessment, to specifically evaluate changes in BF%, LM, and FM (Δ: POST-season minus PRE-season change) between the DXA and Naked™ scanners. Data collection for the PRE-season occurred in August 2019 while POST-season data collection occurred in January 2020. Descriptive statistics can be seen in Table 2.

Table 2. Descriptive statistics for longitudinal population.

	Females (*n* = 11)	Males (*n* = 27)	Total (*N* = 38)
	Mean ± SD	Mean ± SD	Mean ± SD
Age (yr)	20.27 ± 1.35	19.11 ± 1.12	19.45 ± 1.28
Height (m)	1.74 ± 0.07*	1.80 ± 0.06*	1.78 ± 0.07
Weight (kg)	74.93 ± 9.98*	85.64 ± 20.22*	85.64 ± 20.22
BMI (Kg/m^2)	24.69 ± 2.52	27.57 ± 5.77	26.73 ± 5.18
	Mean Diff. ± SD	Mean Diff. ± SD	Mean Diff. ± SD
Body Fat %	-0.34 ± 3.23	-0.44 ± 1.42*	-0.41 ± 2.06
Lean Mass	0.43 ± 2.05	6.09 ± 4.99	4.45 ± 5.04**
Fat Mass	-0.77 ± 2.25	0.89 ± 4.81**	0.41 ± 4.27

Note: Demographic information for longitudinal population. Mean Diff. ± standard deviation interpreted as PRE-to-POST change of DXA minus PRE-to-POST change of Naked™ (ΔDXA - ΔNaked™) for body composition measures of body fat percent (%), lean mass (kg), and fat mass (kg) in Naked™ body scanner v. DXA Scanner in females, males, and total population. BMI, Body Mass Index. *Indicates significant difference between sex or device ($p < 0.05$) **Indicates significant difference between sex or device ($p < 0.001$)

Protocol

Body composition assessment for Phase II followed the same protocol as described in Phase I.

Statistical Analysis

Main outcome measures included comparisons of BF%, LM, and FM between the Naked™ versus DXA scanners. For both Phase I (the cross-sectional analyses) and Phase II (the longitudinal analyses) paired t-tests were utilized to compare the mean values for the main outcome variables (BF%, LM, and FM) between the two measurement devices. Males and females were compared, using non-paired t-tests. Relationships between the Naked™ versus DXA scans for BF%, LM, and FM were analyzed using linear regression. Validity statistics including constant error ($CE = Naked^{™} - \text{DXA}$), total error ($TE = \sqrt{\frac{\sum[Naked^{™} - \text{DXA}]^2}{N}}$), and standard error of the estimate ($SEE = \sqrt{\sum[Naked^{™} - \text{DXA}\,]} \times \sqrt{(1) - r^2}$) were completed to assess the validity of the Naked™ scanner measures compared with the DXA. Heyward and Wagner standards for evaluating prediction errors were used to classify the TE and SEE for BF%, LM, and FM for DXA as ideal, excellent, very good, good, fairly good, fair, or poor (12).

Bland-Altman plots were used to illustrate the differences and biases between DXA and Naked™ body scanner. Mean differences (y-axis) denote the DXA minus Naked™ scan results while the mean (x-axis) of %BF, LM, and BF represents the average mean for the equation: (DXA + Naked™ value)/2.

For all t-tests, Cohen's d was used to evaluate the reliability of each measurement device, strength of association was determined from the following classifications: 2.0 = huge; 1.2 = very large; 0.80 = large; 0.50 = medium; 0.20 = small; 0.01 = very small (25). *A priori* power test using G*Power 3.1 with exact test family was done for correlations due to major analyses being correlational (9). Significance level were set at a conventional alpha level of 0.05 for all analyses., power ($1 - \beta$) at 0.95, and expected correlation at 0.90. The results indicate the present study was adequately powered as we were able to recruit well over a satisfactory N. All analyses were performed using SPSS Statistics 27 (IBM Japan, Ltd, Tokyo, Japan).

RESULTS

PHASE I - Cross-sectional Analyses

Both demographic (subdivided by sex) information and main outcome measure results are presented in Table 1. The Naked™ scanners' estimates of BF% were significantly lower ($p < 0.001$, $d = 1.0$) compared with BF% measured from the DXA. A moderate degree of reliability was found between The Naked™ and DXA measures of BF% (Intraclass Correlation (ICC): 0.761, 95% Confidence Interval (CI): 0.127 – 0.905; $p < 0.001$). Naked™ scan measures of FM were not significantly different ($p = 0.055$, $d = 0.2$) than the DXA. A moderate degree of reliability was found between The Naked™ and DXA measures of FM (ICC: 0.717, 95% CI: 0.529 – 0.985; $p < 0.001$). Naked™ scan measures of LM were significantly greater ($p < 0.001$, $d = 1.6$) than the DXA. A strong degree of reliability was found between the Naked™ and DXA measures of LM (ICC: 0.944, 95% CI: 0.095 – 0.985; $p < 0.001$). Compared with the DXA, The Naked™ estimates of %BF, LM, and FM resulted in poor measurement error. Analysis of CE, SEE, Pearson's correlation coefficient, and systemic bias of a DXA compared with The Naked™ scanner outcomes are presented in Table 3. Bland-Altman Plots (Figure 1) demonstrate the limits of agreement (LOA) and mean differences for BF% (Figure 1a), LM (Figure 1b), and FM (Figure 1c).

With regards to sex differences, in the male cohort ($n = 39$), the Naked™ measures of LM and FM were significantly higher ($p < 0.001$, $p = 0.025$, respectively) compared with DXA measures of LM and FM (Table 1). Compared with DXA, the Naked™ measures of BF% were significantly lower ($p < 0.001$). Compared with the DXA, The Naked™ estimates of BF%, LM, and FM resulted in poor measurement error (Table 3). In the female cohort ($n = 22$), The Naked™ measure of LM were significantly higher ($p < 0.001$) compared with DXA LM (Table 3). Compared with DXA, the Naked™ measures of BF% and FM were not significantly different ($p = 0.095$, $p = 0.088$, respectively). Compared with the DXA, The Naked™ estimates of BF% and LM resulted in poor measurement error, while FM resulted in fairly good measurement error (Table 3).

Table 3. Validity statistics comparing cross-sectional the Naked™ v. DXA body scanner measures of body fat % (BF%), lean mass (LM), and fat mass (FM) in the total sample ($N = 61$), females ($n = 22$), and males ($n = 39$).

		The Naked™ vs DXA Scan		
		Body Fat (%)	Lean Mass (kg)	Fat Mass (kg)
Total				
	CE	-4.57	5.84	3.52
	TE	6.51[g]	6.82[g]	14.4[g]
	SEE	3.84[e]	3.54[d]	7.62[g]
	R	0.887**	0.971**	0.928**
	ICC	0.761**	0.944**	0.717*
Females				
	CE	-1.9	3.36	-1.42
	TE	5.33[g]	4.96[g]	3.90[e]
	SEE	4.93[g]	3.41[f]	3.74[d]
	R	0.799**	0.958**	0.779**
	ICC	0.809**	0.945**	0.821**
Males				
	CE	-4.56	7.24	6.31
	TE	7.09[g]	7.68[g]	17.78[g]
	SEE	2.92[c]	2.20[a]	7.37[g]
	R	0.907**	0.983**	0.955**
	ICC	0.655**	0.910**	0.709**

Note: Estimates were derived as Naked™ minus DXA. CE, constant error; TE, total error; SEE, standard error of the estimate; R, Pearson's correlation coefficient; ICC, intraclass correlation coefficient; Classifications according to Heyward and Wagner 2004: [a]Ideal; [b]Excellent ; [c]Very good; [d]Good; [e]Fairly good; [f]Fair; [g]Poor. *Indicates significant difference ($p < 0.05$) **Indicates significant difference ($p < 0.001$)

Figure 1a.

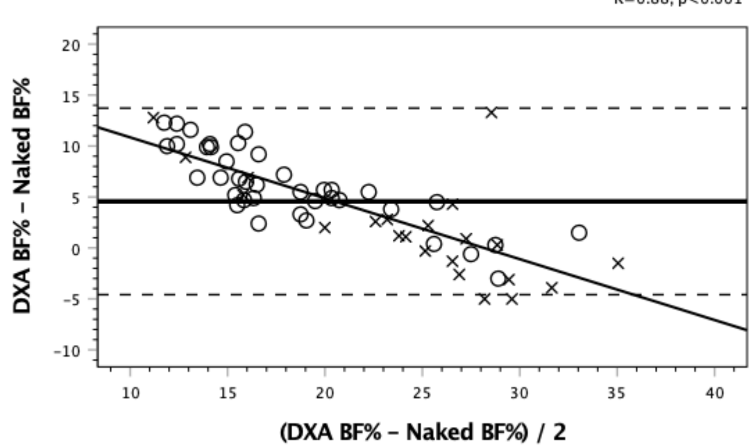


Figure 1b.

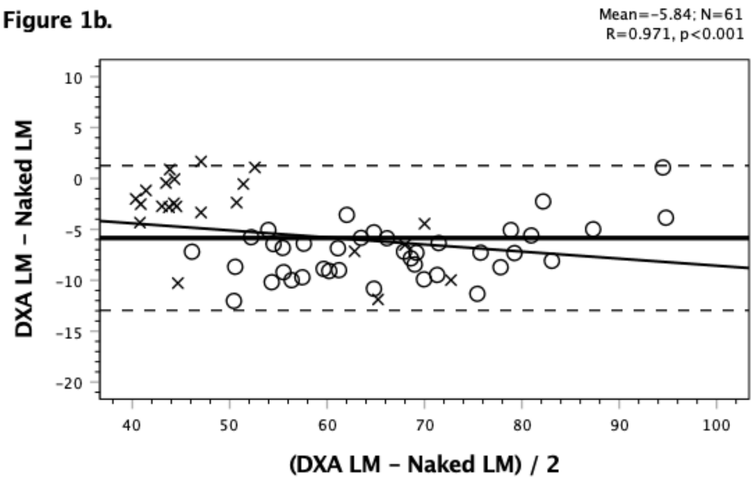
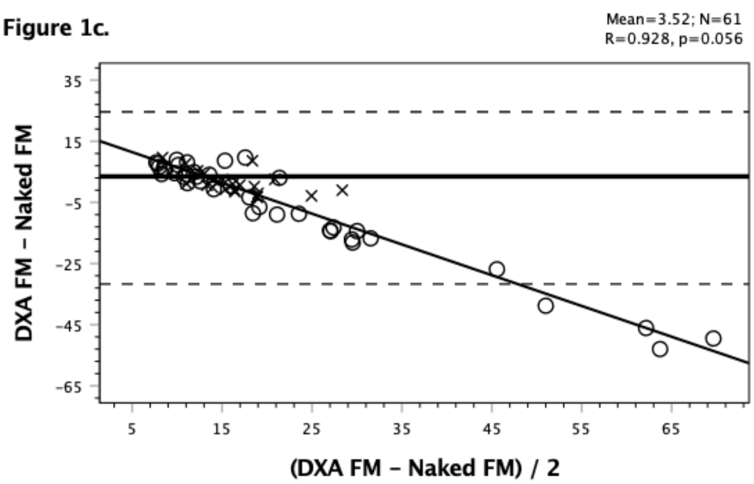


Figure 1c.



Note: Bland – Altman analyses for the Naked™ body scanner measures of (1a) percent body fat (BF%) 95% limits of agreement (LOA: Naked™ - DXA) = -4.57 to 13.71 %, (1b) lean mass (LM; -12.95 to 1.27 kg, (1c) fat mass (FM; -31.68 to 24.64 kg compared with DXA. Males denoted by "O"; Females denoted by "X"

PHASE II - Longitudinal Analyses

Both demographic (subdivided by sex) information and main outcome measure results are presented in Table 2, for this subset of student-athletes (*N* = 38) tested PRE- and POST-season. The Naked™ scanners' estimates of longitudinal changes in BF% showed no significant difference in changes ($p = 0.223$, $d = 2.0$) compared with changes in BF% measured from the DXA. A significant, but low degree of reliability was found between measures for changes in BF% (ICC: 0.450, 95% CI: -0.045 – 0.712; $p < 0.05$). Naked™ scans measures of changes in LM were significantly greater ($p < 0.001$, $d = 0.9$) than the DXA. A low degree of reliability was found between measures for LM (ICC: 0.239, 95% CI: -0.203 – 0.555; $p = 0.94$). Naked™ scan measures of changes in FM showed no significant difference in changes ($p = 0.559$, $d = 0.1$) compared with the DXA. A moderate degree of reliability was found between measures for changes (ICC: 0.609, 95% CI: 0.205 – 0.797; $p < 0.05$). Analysis of CE, SEE, Pearson's correlation coefficient, and systemic bias of longitudinal changes in DXA compared with The Naked™ scanner outcomes for the total sample are presented in Table 4. Compared with the DXA, The Naked™ estimates of %BF resulted in an ideal measurement error, while LM, and FM resulted in poor and fairly good measurement error, respectively. Bland-Altman Plots (Figure 2) demonstrate the limits of agreement (LOA) and mean differences for ΔBF% (Figure 2a), ΔLM (Figure 2b), and ΔFM (Figure 2c).

There were no statistically significant differences between males and females for any outcome variable (data not shown).

Table 4. Validity statistics comparing the Naked™ v. DXA body scanner measures of body fat %(BF%), lean mass (LM), and fat mass (FM) in the total sample (*N* = 38).

	Naked™ vs DXA Scan		
	Body Fat (%)	Lean Mass (kg)	Fat Mass (kg)
CE	-0.41	4.45	0.41
TE	2.04[a]	6.59[g]	4.18[e]
SEE	1.84[a]	2.63[c]	2.40[b]
R	0.470*	0.858**	0.831**
ICC	0.450*	0.239	0.609*

Note: Estimates were derived as Naked™ minus DXA. CE, constant error; TE, total error; SEE, standard error of the estimate; R, Pearson's correlation coefficient; ICC, intraclass correlation coefficient; Classifications according to Heyward and Wagner 2004: aIdeal; bExcellent ; cVery good; dGood; eFairly good; fFair; gPoor*. Indicates significant difference ($p < 0.05$) **Indicates significant difference ($p < 0.001$)

Figure 2a.

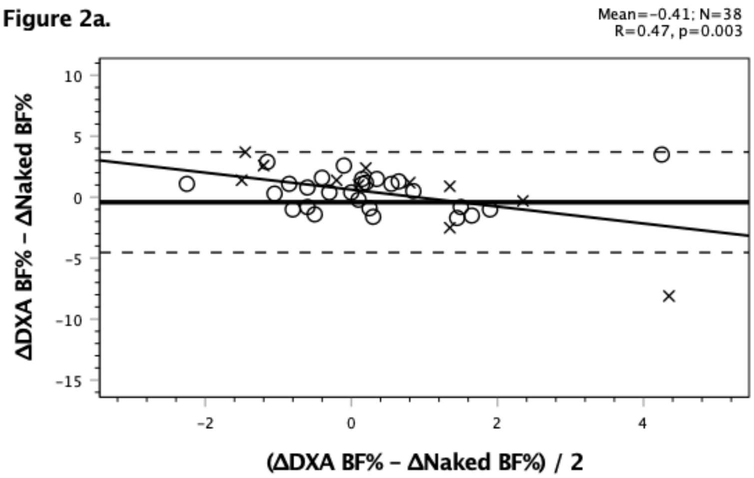


Figure 2b.

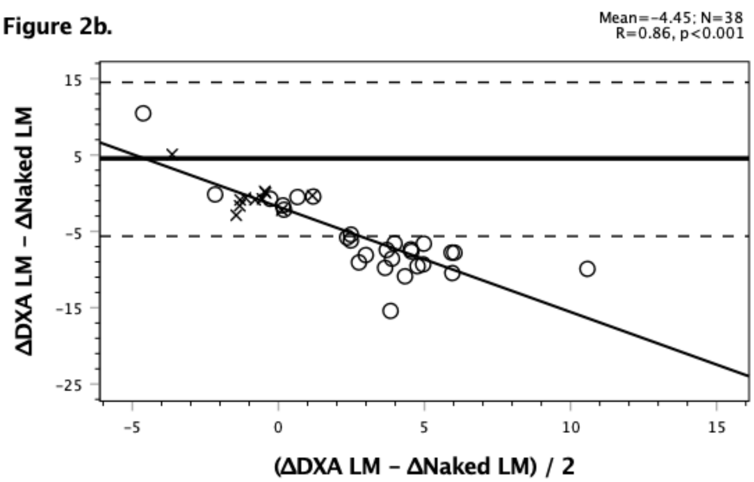
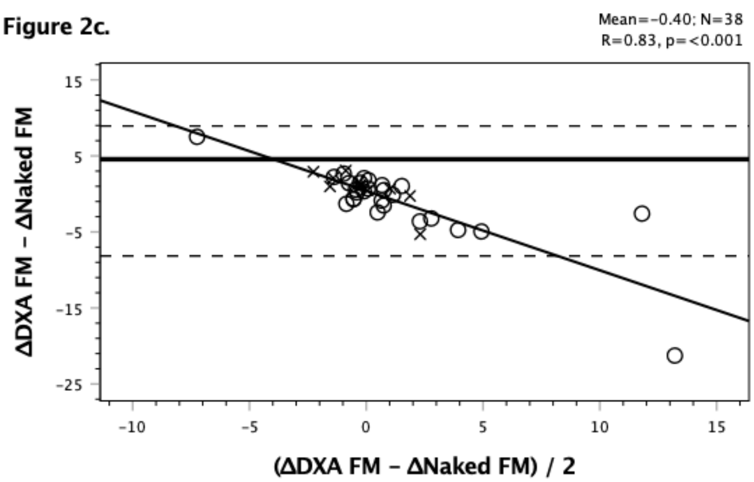


Figure 2c.



Note: Bland – Altman analyses for the Naked™ body scanner measures of (2a) changes in percent body fat (BF%) 95% limits of agreement (LOA: Naked™ - DXA) = -4.53 to 3.71 %, (2b) changes in lean mass (LM; -5.63 to 14.53 kg, (2c) changes in fat mass (FM; -8.14 to 8.94 kg compared with DXA. Males denoted by "O"; Females denoted by "X"

DISCUSSION

Examination of 3D scanners, as a novel technique to assess body composition, has seen an uptick in recent years (1) since their invention (24). Monitoring and assessing body composition in athletes for performance enhancement continues to grow, and with it so does the desire to find a cost-effective and more portable alternative to larger and more expensive methods, without sacrificing accuracy and reliability. Phase I of the present study displayed poor validity overall between the Naked™ and DXA scanner. The Naked™ assessment significantly underestimated BF% (Mean Difference (MD) (Naked™ - DXA): -4.57% ± 4.67%), while significantly overestimating LM (MD: 5.84kg ± 3.55kg). FM estimates were overestimated as well (MD: 3.52kg ± 14.08kg) but showed no significance (p = 0.056).

In Phase II, estimates of changes from PRE- to POST-season in the Naked™ compared to the DXA demonstrated better validity for all variables than in Phase I, but still demonstrated an unacceptable amount of error for LM and FM. BF% showed ideal validity, but demonstrated a poor ICC relationship (ICC = 0.450). Overall, the Naked™ estimates compared to the DXA produced unacceptable error for all body composition variables, unrelated to sex in a cross-sectional design population. The Naked™ scanner estimates from the current study do not appear to be a valid surrogate for the DXA scan; CE, TE, and SEE values demonstrated generally poor agreement for BF%, LM, and FM, with significant mean differences in BF% and LM between methods. These results differ from a recently published study comparing the Naked™ scanner, to a four-compartment (4C) model (28). In that study, the Naked™ scanner demonstrated better validity against a 4C model for estimates of BF% (TE: 4.8%), FFM (TE: 3.6kg), and FM (TE: 3.6kg).

Also, in Phase II of the present study, tracked changes in the Naked™ assessment significantly overestimated LM (MD): 4.45kg ± 5.04kg), while estimations for BF% (MD: -0.41 ± 2.06%) and FM estimates (MD: 0.41kg ± 4.27kg) showed no significance (p = 0.223 and p = 0.559 respectively). Contrary to Phase I, BF% demonstrated ideal validity (TE: 2.04%), while LM (TE: 6.59kg) and FM (TE: 4.18kg) resulted in unacceptable validity. The precision of body composition estimates assessed by 3D infrared technology is directly linked to the specific anthropometric variables that the scanner assesses, which has shown to vary in their own precision (3, 11, 27). Consequently, the more reliable the analysis software is for anthropometric variables, the more reliable the body composition estimates (28).

Still in its infancy, 3D infrared scanning systems and body composition references examined in previous studies have shown mixed results, however the validity of body composition estimates in these systems continues to improve (27). Tinsley et al. (28) examined the validity of body composition estimates produced by four scanners (Fit3D™, Naked™, Size Stream™ and Styku™) in normal-weight adults compared against a 4C model criterion, finding that three (Fit3D™, Naked™, and Size Stream™) showed equivalence with a 4C model; the Styku™ still produced fairly reliable estimates. The reported TE values of 2.3% for BF%, 0.7kg for LM, and 2.5kg are lower than the values of the present study, 6.51%, 6.82kg, and 14.4kg respectively.

Conversely, in another study, Cabre et al. (4) found that the Styku™ body composition estimates were not valid compared against a 4C model, yielding TE values for BF% of 5.61%, LM of 5.69kg, and 4.50kg for FM, all of which were higher than those reported by Tinsley et al. However, in the same study, 3D estimates compared to with DXA were found to be more acceptable (TE: BF% = 4.25%, LM = 3.86kg, FM = 2.92kg), but compared unfavorably to the present study's results.

The differences in body composition estimates across previous studies is likely a result of differences in body volume measurements between device software, resulting in consistently pronounced differences in estimates (1). Adler et al. measured body volume estimates from a 3D infrared scanner (VitusSmart XXL™) and air-displacement plethysmography (ADP) were used to predict BF% in 32 adults. They reported overestimations of BF% (7.0 ± 5.6%) in the 3D infrared scanner compared to ADP, implying that body volume estimates from a 3D infrared scanner may not translate into 2-compartment model equations without statistical adjustments being made. Wells et al., using a Hamamatsu Bodyline Scanner (HBS), documented an underestimation and poor precision of body fat percent and when compared with underwater weighing (29). Findings were in line with Lee et. al., attributing lower prediction values to inconsistent breath holding and obstruction of the inner surfaces of the limbs during the scanning process that affect the mathematical model for body fat percentage (16, 29). Conversely, Ng et al., using the Fit3D™ Proscanner (Redwood City, CA, USA), concluded that 3D body scanners offer precise and stable measurements of body composition, but noted that there were some measurement biases due to landmark positioning discrepancies (20). As mentioned previously, the results from previous and the present study suggest that results are specific to the hardware and software used in the device. As the popularity of use continues to rise, future studies should consider modification of 3D infrared scanner prediction equations for estimation of body composition.

The large limits of agreement in both, Phase I and II, in our present study reiterates the need for establishing suitable 3D infrared device algorithms and to use caution when tracking changes in body composition (28). Additionally, the present study sample population consisted of male and female college athletes, whereas the previously mentioned studies contained a randomized sample of adults. This may explain the disparity in results from our study with previous ones. Depending on sport played, athletes can be at either end of the spectrum in regards to their lean mass index (LMI: kg/m^2), which seems to have an effect on the device software, making it a poor estimator of LM (4).

In conclusion, 3D infrared body scanners represent an emerging technology with the potential for becoming a viable low cost and portable option in estimating body composition or collection of anthropometric variables. However, the poor overall validity of the scanner compared to the DXA scan (widely considered the gold standard for body composition) warrants further investigation. Further refinement of body composition prediction equations, especially for athlete populations, are warranted for the Naked™ scanner to become an interchangeable surrogate measure of body composition with the DXA scan in the future.

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