Journal of Clinical Densitometry: Assessment & Management of Musculoskeletal Health, vol. 17, no. 1, 121−128, 2014

1094-6950/17:121−128/$36.00
http://dx.doi.org/10.1016/j.jocd.2013.02.012

Section III: Quality Issues

Dual-Energy X-Ray Absorptiometry Measured Regional Body Composition Least Significant Change: Effect of Region of Interest and Gender in Athletes

Bjoern Buehring,[1] Diane Krueger,[1] Jessie Libber,[1] Bryan Heiderscheit,[2,3] Jennifer Sanfilippo,[3] Brian Johnson,[4] Irina Haller,[4] and Neil Binkley*,[1]

[1]Osteoporosis Clinical Research Program, University of Wisconsin-Madison, Madison, WI, USA; [2]Orthopedics and Rehabilitation, University of Wisconsin-Madison, Madison, WI, USA; [3]Intercollegiate Athletics, University of Wisconsin-Madison, Madison, WI, USA; and [4]Essentia Institute of Rural Health, Duluth, MN, USA

Abstract

Dual-energy X-ray absorptiometry (DXA) is widely used to evaluate body composition in athletes. Knowledge of measurement precision is essential for monitoring body composition changes over time. This study begins characterizing DXA body composition precision in 60 (30 males and 30 females) Division 1 athletes focusing on gender, regional, and tissue type differences. Two total body scans with repositioning between were performed on the same day. Least significant change (LSC) for the root-mean-square deviation (LSC_{RMSD}) and the percent coefficient of variation ($LSC_{\%CV}$) for total, lean, and fat mass was calculated for 6 regions of interest. The effect of gender, region, tissue type, and mass on the standard deviation (SD) and percent coefficient of variation (%CV) between the 2 scans was evaluated using repeated measures regression analysis. Statistically significant effects of gender, region, tissue type, and mass on SD and %CV were noted. To generalize, a nonlinear positive relationship between LSC_{RMSD} and mass and a nonlinear negative relationship between $LSC_{\%CV}$ and mass were observed. In conclusion, DXA body composition LSC varies among genders, regions, tissues, and mass. As such, when evaluating serial body composition in athletes, especially if assessing regional change, knowledge of precision in individuals of similar body size and gender to the population of interest is needed.

Key Words: Body composition; DXA; precision; sports performance.

Introduction

Dual-energy X-ray absorptiometry (DXA) is increasingly being used to measure body composition in various settings *(1)*, including obesity/bariatric surgery *(2,3)*, lipodystrophy assessment in individuals with HIV *(4−7)*, sarcopenia *(8−11)*, and athletic training/performance *(12−16)*. This methodology is rapid, relatively inexpensive, and uses only a small amount of ionizing radiation. Importantly, it allows regional composition measurements, which have primarily received interest for assessing fat distribution (i.e., android/gynoid fat) *(17)* and appendicular lean mass as part of sarcopenia definition *(8,9,11)*. However, the ability to evaluate regional lean mass carries substantial potential for assessing athletes to evaluate training regimens and also rehabilitation after sports injuries. This ability to evaluate not only total fat and lean mass but also mass in specific regions such as the extremities is a distinct advantage of DXA compared with other measures of body composition, such as bioelectrical impedance or hydrodensitometry *(18,19)*.

In general, a high lean mass-to-fat mass ratio is beneficial for most athletes because high body fat mass leads to less efficient energy utilization *(20)*. However, too little fat mass might negatively impact health as seen in women with female athlete triad (disordered eating, amenorrhea, and low bone mineral density) *(21)*. Despite the potential advantages noted

Received 01/15/13; Accepted 02/20/13.

*Address correspondence to: Neil Binkley, MD, Osteoporosis Research Program, University of Wisconsin, 2870 University Avenue, Suite 100, Madison, WI 53705. E-mail: nbinkley@wisc.edu

previously, only a limited number of studies have used DXA body composition in athletes. Some reports find a high correlation between DXA and other measures of body composition *(12,21−24)*. However, other studies comparing athletes with controls observe differences in body composition, for example, among different Cricketing skill groups and Rugby player positions *(14,16)*. Importantly, serial DXA scans may be used to assess body composition changes over time to monitor training regimens or during the course of a season *(13)*. One can speculate that such serial DXA body composition evaluation in athletes might be most beneficial as it can provide information about not only conditioning status, training regimens, or rehabilitation process but also negative developments that might impact the athletes' health, such as excessive loss of fat or lean mass.

In serial measurements, however, it is necessary to appreciate and account for method variability to determine if an intervention has altered fat and/or lean mass over time. The International Society for Clinical Densitometry (ISCD) recommends performance of a precision assessment to determine what constitutes a change in the measured parameters with 95% confidence interval *(25−27)*. Importantly, such a precision assessment should be performed ''using patients representative of the clinic's patient population'' *(26)*. Because diverse populations with markedly differing body composition may be evaluated depending on the clinical circumstance, it is necessary to understand if variations in body composition, body size, and fat/lean distribution affect reproducibility of these measurements. One obvious example of differences is gender, with males typically being larger with different fat/lean distribution compared with females *(28,29)*. Moreover, although the reproducibility of total body bone, fat, and lean mass has been reported and appears to be excellent in adults with and without disease *(6,30−32)*, there is, to our knowledge, only limited information available regarding the reproducibility of these measurements in athletes *(12)*. Furthermore, only very limited data exist regarding the reproducibility of regional measurements in this population. As elite athletes are very specialized and have widely differing body compositions, we hypothesized that the size and body composition of Division 1 college athletes might be variable enough to warrant separate precision assessments. The goal of this study was to do an initial evaluation of total and regional body composition in Division 1 athletes with focus on gender, tissue, and regional differences.

Methods

Participants

As recommended by the ISCD, precision assessments consisting of 2 total body DXA scans were performed in 60 student athletes (30 females and 30 males) from the University of Wisconsin selected based on the ability to fit within the densitometer scan field. Mean (± standard deviation [SD]) age was 20.6 (±1.3) yr (range, 18.3−23.4 yr) and 19.9 (±1.3) yr (range, 18.1−22.7 yr) for men and women, respectively. These athletes participated in various sports including hockey (17 women and 16 men), basketball (5 women and 4 men), golf (8 women), and wrestling (10 men). This study was determined to be exempt by the University of Wisconsin-Madison Institutional Review Board. All participants provided written consent before undergoing DXA assessment.

DXA Acquisition, Analysis, and Precision Assessment

A GE Healthcare (Madison, WI) Lunar iDXA densitometer was used for all examinations. ISCD-certified technologists performed all scan acquisition and analyses in routine clinical manner following research facility standard operating procedures. All scans were acquired using enCORE software versions 11.0−13.31; version 13.4 was used for analysis. One technologist analyzed all scans using the software autoanalysis feature followed by manual correction of analysis markers when necessary.

Precision assessment was performed in routine clinical manner following ISCD recommendations *(26)*; specifically, each athlete was scanned twice by the same technologist with repositioning between scans. Both scans were conducted at the same scanning session.

DXA Regional Analysis

Total body and regional analyses were performed in routine clinical manner. Six standard regions of interest (ROI) were used for this analysis (Fig. 1). These regions were defined as follows: Total body ROI consisting of the entire body including the head; trunk ROI defined at the upper boundary by the mandible line including the chest, abdomen, and pelvic triangle; the arm ROIs (right and left) were defined by a line bisecting the shoulder joint of the right and left arm; and the leg ROIs (right and left) were defined by a line bisecting the hip joint aligned with the iliac crest and pubis.

Statistical Analyses

The gender differences in age and body mass index (BMI) were evaluated using Student's *t*-test. The mean mass, variance and SD between the measurements, and percent coefficient of variation (%CV) were calculated for each subject based on the 2 scans, resulting in 18 observations of each parameter (mean, variance, SD, and %CV) that corresponds to the region (total, trunk, left arm, right arm, left leg, and right leg) and tissue type (total, fat, and lean) combinations. The mean square error (MSE) and least significant change (LSC) with 95% confidence interval based on both the MSE (least significant change for the root-mean-square deviation [LSC_{RMSD}]) and %CV (least significant change for the percent coefficient of variation [$LSC_{\%CV}$]) were calculated for each region and tissue type for males and females using the ISCD precision calculator available online (http://www.iscd.org/visitors/resources/calc.cfm). The LSC values are a multiple of either the RMSD or root-mean-square %CV; hence, inferences based on the SD or %CV are applicable to the LSC