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Change in Body Mass Index is a Stronger Predictor of Change in Fat Mass than Lean Mass in Elderly Black and White Women

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Abstract

The aim of this study was to determine the relation between change in body mass index (BMI) and changes in fat mass (FM), lean soft tissue (LST), and percentage body fat (%Fat) in elderly (67.6±6.0yrs) women varying in race (53 black, 144 white) who underwent measurements of BMI, FM, LST, and %Fat at baseline and after two years. The group did not markedly change body composition over two years (BMI = $-0.1 \pm 1.5 \text{ kg/m}^2$, $p=0.53$; FM = $0.0 \pm 2.8 \text{ kg}$, $p=0.95$; LST = $-0.4 \pm 1.7 \text{ kg}$, $p<0.001$; %Fat = $0.3 \pm 2.0\%$, $p=0.06$). Change in BMI predicted change in FM ($r=0.90$, $\text{SEE}=1.19 \text{ kg FM}$, $p<0.001$) but was less predictive of change in %Fat ($r=0.64$, $\text{SEE}=1.54\% \text{ Fat}$, $p<0.001$). Change in BMI was curvilinearly related to change in LST adjusted for change in height ($R=0.76$, $\text{SEE}=1.10 \text{ kg LST}$, $p<0.001$). Change in BMI more strongly predicts change in FM than LST, and could be used to monitor change in FM in community-dwelling women.

Introduction

Overweight and obesity are associated with increased morbidity (Shankuan et al. 2003) and mortality (Troiano et al. 1996), whereas weight loss and especially fat loss are related to decreased morbidity and mortality (Allison et al. 1999; Rosenfalck et al. 2002). Older adults tend to lose relatively more lean mass with weight loss than they gain with weight gain and the opposite is true for fat mass (FM) (Newman et al. 2005). This loss of lean mass is associated with morbidity and mortality in the elderly (Janssen et al. 2002), and may explain the increased mortality risk in people with normal BMI in this age group (Wannamethee et al. 2007). Nevertheless, loss of lean mass does not adversely affect disease risk among those with high BMI (Allison et al. 1999), and high BMI is indicative of increased body fatness and infiltration of the muscle with fat (Goodpaster et al. 2001). Fat loss among overweight older adults should, therefore, decrease disease risk especially if lean mass is maintained.

Although not without limitations, BMI is the best simple indicator of fatness (Calle et al. 1999) and is an effective method for individual self-monitoring (Blew et al. 2002). BMI has a moderate-to-strong correlation with FM and percentage body fat (%Fat) (Blew et al. 2002; Evans et al. 2006; Bedogni et al. 2001) but much lower correlation with lean soft tissue (LST) (Bedogni et al. 2001) in postmenopausal women. However, neither the ability of

change in BMI to predict changes in FM, %Fat, and LST nor whether that relation is modified by race or age has been investigated in community-dwelling older females.

Methods

Participants

Data were obtained from 197 (67.6 ± 6.0 yrs, 53 black, 144 white) community-dwelling women participating in a two-year longitudinal study in a relatively rural setting in the Midwestern region of the United States. The University Human Subjects Review Board approved the study and all participants signed an informed consent.

Body composition

Standing height and body mass were measured to the nearest mm (Seca 242, Seca Ltd., Hamburg, Germany) and 0.1 kg (Tanita, BWB-627A, Tokyo, Japan), respectively, and were used to calculate BMI (kg/m^2). Precision (CV%) of height and weight measures in our laboratory are on the order of 0.1% and 0.05%, respectively. Relative body fatness (%Fat), FM, and LST were measured via dual energy X-ray absorptiometry (DXA, Hologic QDR 4500A, software version 11.2, Bedford, MA). Precision for DXA measurements of interest are ~1% in our laboratory with standard deviation (SD) of repeated measurements of FM and LST ~0.5kg (Evans et al. 2006).

Statistical analyses

The data were analyzed with SPSS 15.0 (SPSS Inc., Chicago, IL) and are presented as means $\pm$ SD. The data were assessed for normality and change in %Fat was negatively skewed because of three outliers that were subsequently removed from the analysis. The relationship between change in BMI and changes in %Fat, FM, and LST was examined using multiple linear regression to determine whether the relations were linear or curvilinear and whether they were moderated by race, age, hormone replacement therapy (HRT) use (29% of sample), or age at last menstrual period (LMP). The relation between change in BMI and change in LST was adjusted for change in height due to a significant correlation between change in these variables and change in height. The differences between the regression coefficients were assessed as described by Pallant (2006).

Results

The cohort did not markedly change in body composition on average over the two years; however, there was considerable individual variability in the changes (Table 1). The ranges for changes in BMI and %Fat were from -4.6 to $4.2 \text{ kg}/\text{m}^2$ and -6.6 to 5.1% , respectively. Similarly, the ranges for changes in LST and FM were from -5.5 to 4.4 kg and -8.8 to 8.0 kg , respectively. The number and percentage of women who changed more than $1 \text{ kg}/\text{m}^2$ BMI, 1.5% Fat, or more than 2 kg LST and FM were 77 (39.1%), 77 (39.7%), 47 (23.9%), and 74 (37.6%), respectively.

Change in weight was strongly correlated with changes in BMI ($r=0.98$) and FM ($r=0.90$), moderately correlated with changes in LST ($r=0.76$) and %Fat ($r=0.64$, all $p<0.001$), and was weakly correlated with change in height ($r=0.15$, $p=0.034$). On the contrary, change in height was only weakly related to change in LST ($r=0.15$, $p=0.034$).

Change in %Fat was moderately predicted by change in BMI ($r=0.64$, $\text{SEE}=1.54\%$ Fat, $p<0.001$, Figure 1A) and the addition of a quadratic function to the model (change in BMI²) did not improve the prediction of %Fat ($p=0.239$). Similarly, race, age, HRT, or LMP did not contribute to the model (all $p>0.05$). Conversely, change in BMI strongly predicted

change in FM ($r=0.90$, $SEE=1.19\text{kg FM}$, $p<0.001$, Figure 1B), but adding a quadratic function, race, age, HRT, or LMP to the model did not enhance the prediction of FM (all $p>0.05$). After controlling for change in height, change in BMI moderately predicted change in LST ($R=0.75$, $SEE=1.12\text{kg LST}$, $p<0.001$), although the relation was slightly curvilinear as evident by the addition of a quadratic function ($p=0.005$) to the model ($R=0.76$, $SEE=1.10\text{kg LST}$, Figure 1C). Further additions of race, age, HRT, or LMP did not improve the model ($p>0.05$). Notably, change in BMI was a significantly better predictor of change in FM than of change in LST ($p<0.01$).

Discussion

The major findings of this study indicate that change in BMI strongly predicts change in FM in elderly women; that the prediction is linear and not moderated by age, race, HRT, or LMP. Change in BMI does not predict changes in LST and %Fat as well as change in FM, although the strength of these relations was moderate. Furthermore, the prediction of change in LST from change in BMI is modified by a quadratic component (change in BMI^2) and change in height, which complicates the prediction. Our findings are important from a public health perspective because fat loss is strongly related to decreased disease risk and mortality (Allison et al. 1999; Rosenfalck et al. 2002).

The stronger relation between change in BMI and change in FM compared to change in BMI and change in LST is not completely unexpected. Previous studies have reported a stronger relation between BMI and FM than BMI and LST in older women (Bedogni et al. 2001). In addition, twice as much FM compared to lean mass is proportionally lost during weight loss and four times as much FM compared to lean mass is proportionally gained during weight gain in elderly women (Newman et al. 2005). Therefore, it appears that in adulthood, more of weight change is due to changes in FM. Thus, change in BMI should be more reflective of change in FM than change in LST as supported by the present results.

Notably, race and age did not modify any of the relations although the latter may have been impacted by the restricted age range in this sample (59 to 82 yrs). Race has also previously been shown to affect the relation between BMI and %Fat in elderly women (Evans et al. 2006). Similarly, a quadratic function did not improve the prediction of changes in %Fat and FM from change in BMI despite the BMI-%Fat relation being curvilinear in postmenopausal women (Evans et al. 2006; Blew et al. 2002). In contrast, a curvilinear relationship was found between change in BMI and change in LST in this study but a linear relation between BMI and LST has been reported previously (Bedogni et al. 2001); however, that study did not investigate whether a quadratic function would improve their prediction. Consequently, although the relations between BMI and %Fat may be affected by race and not linear, our results suggest that the relations between change in BMI and changes in FM and %Fat are linear and the same among black and white women from the sixth to eighth decade of life.

In the elderly, a great concern is loss of lean mass even among those who are weight stable (Hughes et al. 2002). It is commonly believed that lean mass loss contributes to physical disability, morbidity and mortality (Janssen et al. 2002), whereas others have found that high body fatness and not low fat-free mass predicts disability in the elderly (Visser et al. 1998). Unpublished findings from our laboratory on elderly women also suggest that fat loss improves physical performance, whereas changes in LST do not affect it. Regardless of the primary body composition variable for physical performance, it is accepted that fat loss improves risk of morbidity and mortality (Allison et al. 1999; Rosenfalck et al. 2002), and lean mass should be retained (Janssen et al. 2002).

In conclusion, change in BMI more strongly predicts change in FM than change in %Fat and LST. Older women could use change in BMI to monitor their change in FM, which should be indicative of increased/decreased morbidity and mortality risk.

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Figure 1.

The relation between change in body mass index and changes in A) percentage body fat, B) fat mass, and C) lean soft tissue. Δ = change, %Fat = percentage body fat, BMI = body mass index, FM = fat mass, LST = lean soft tissue.

Table 1
Subject characteristics (n=197)

	Baseline	Final	Change	P value
Height (cm)	161.5±5.8	161.0±5.8	-0.4±0.6	<0.001
Weight (kg)	74.1±14.8	73.5±14.7	-0.6±3.9	0.042
Body mass index (kg/m ²)	28.4±5.2	28.3±5.2	-0.1±1.5	0.529
Lean soft tissue (kg)	43.9±6.4	43.5±6.2	-0.4±1.7	0.001
Fat mass (kg)	28.9±9.4	28.9±9.6	0.0±2.8	0.948
Body fat (%) [*]	37.8±6.1	38.1±6.3	0.3±2.0	0.060

^{*}
n=194