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## Associations between reliable changes in depression and changes in BMI, total body fatness and visceral adiposity during a 12-month weight loss trial

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### Abstract

We investigated associations between changes in depression and body composition over a 12-month weight loss trial. Of the 298 adults (BMI > 27 m/kg<sup>2</sup>), 219 with complete depression and body composition data were included. A 10-item Center for Epidemiologic Studies Depression Scale measured depression; dual-energy x-ray absorptiometry measured body composition. Multinomial logistic regression predicted reliable changes in depression by BMI, body fat (BF) and visceral adiposity (VAT). Multiplicative interaction terms tested modification by sex and ethnicity. Participants with increases in body composition were less likely to experience improvements in depression (BMI: RRR = 0.79 (0.68 – 0.91),  $p < 0.01$ ; BF: RRR = 0.97 (0.94 – 0.99),  $p = 0.01$ ; VAT: RRR = 0.99 (0.98 – 1.00),  $p = 0.02$ ), but not worsening of depression (BMI: RRR = 1.29 (0.96 – 1.73),  $p = 0.10$ ; BF: RRR = 1.04 (0.99 – 1.09),  $p = 0.15$ ; VAT: RRR = 1.01 (1.00 – 1.03),  $p = 0.18$ ). Sex and ethnicity interaction terms were not significant. However, the relationship was only significant among females, among non-Latinos for BMI and BF, and among Latinos for VAT. Our study supports the association between depression and obesity and highlights the need for longitudinal studies investigating VAT and depression in diverse ethnic groups.

### Introduction

Obesity and depression are critical public health concerns in the United States (ref. 1–2). Both are associated with chronic disease and all-cause mortality (ref. 3–4). Observational studies report associations between depression and obesity (ref. 5–7) mediated by several factors including hypothalamic-pituitary-adrenal axis dysregulation, pro-inflammatory

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Competing Interests

The authors have no conflicts of interest to declare.

cytokine release, appetite regulation, and genetic vulnerabilities (ref. 8). Since visceral adiposity (VAT) is particularly pro-inflammatory (ref. 9), VAT may specifically mediate this relationship (ref. 10).

To our knowledge, no studies have correlated changes in VAT with changes in depression over time. Additionally, results from clinical weight loss trials correlating weight loss with depression are less consistent than those from observational studies possibly due to differences in study population and design (ref. 11–13). Therefore, the purpose of our study is to investigate associations between changes in body composition (including VAT) and changes in depression over a 12-month weight loss trial. Since several studies suggest the relationship may be strongest in non-Latino, white women (ref. 5–7, 10, 14), we also investigated the modifying effect of sex and ethnicity (Latino vs non-Latino).

## Methods

This was a secondary data analysis from a RCT investigating effects of a text-messaging program targeting weight loss ([ClinicalTrials.gov](https://clinicaltrials.gov/ct2/show/study/NCT01171586) NCT01171586). Participants provided written informed consent; the University of California San Diego IRB (Project #091040) approved the study. Participants were 298 adults (21–61 years) with BMI > 27 kg/m<sup>2</sup> from San Diego without histories of eating disorders or bariatric surgery, and not taking weight changing medications. Participants were randomized to a control, motivational text-messaging, or text-messaging plus motivational phone call group. Investigators were blinded to group allocation. We excluded 79 participants missing depression or body composition data; they did not differ from those included by age, sex, ethnicity (non-Latino vs Latino) or baseline BMI ( $p > 0.05$ ). Inclusion/exclusion criteria were pre-established.

A 10-item Center for Epidemiologic Studies Depression (CES-D) scale measured depressive symptoms (ref. 15). Scores range from 0 to 30 with 10 correlating with an increased risk for clinical depression. Body composition measures including BMI, body fat (BF) and VAT were assessed with validated dual-energy x-ray absorptiometry (DXA) scanning using CoreScan/enCORE Software (GE/Lunar, Madison, WI, USA) (ref. 16).

To predict clinically meaningful changes in depression, we determined a reliable change in depression score (ref. 12, 17). Unlike cut-off values, reliable change scores identify subjects with significant changes in depression who do not cross a clinical threshold (CESD = 10). Likewise, it excludes those who pass thresholds while experiencing minimal changes in depression. Reliable change was calculated as 3.77 using the equation  $1.96 \sqrt{2(SD_{pre}\sqrt{1-\alpha})^2}$  ( $SD_{pre}$  = SD baseline CES-D score = 3.21;  $\alpha$  = Cronbach's alpha measuring internal consistency = 0.82) (ref. 12,17). We labeled participants with change in CES-D from baseline to 12-months  $\geq 4$  as “less depressed,” change  $\leq -4$  as “more depressed” and change  $< |4|$  as experiencing “no change.”

Multinomial logistic regression predicted the probability of becoming “more depressed” or “less depressed” relative to experiencing “no change” by changes in body composition. We combined study groups for the analysis because there were no differences among groups for change in depression. To choose covariates for the model, we ran multinomial logistic

regressions to predict changes in depression by each covariate of interest. Covariates significant at the  $p < 0.2$  level included were sex ( $p = 0.01$ ), change in daily sleep time ( $p = 0.03$ ), baseline percent BF ( $p = 0.07$ ), and baseline depression score ( $p = 0.05$ ). Change in BMI, percent change in BF, and percent change in VAT were then added in separate models. Lastly, we added multiplicative interaction terms to investigate the modifying effect of sex and ethnicity. The ethnicity\*body composition and sex\*body composition interactions were not investigated for males and the “more depressed” group due to small sample sizes (Latino males:  $n = 11$ ; “more depressed”:  $n = 18$ ). Assumptions of multinomial logistic regression were met including independence of observations, mutually exclusive dependent variables, and absence of multicollinearity. P-values  $< 0.05$  level were considered significant.

## Results

Most participants were female (75%) and non-Latino (60%) with a mean age of 42 years (Table 1). Mean baseline CES-D score was  $8.8 \pm 3.2$  with an average decrease of  $3.1 \pm 4.3$ . Baseline BMI, percent BF, and VAT mass were  $32.5 \pm 3.3 \text{ kg/m}^2$ ,  $42.7 \pm 6.0\%$  and  $1318.5 \pm 646.7\text{g}$  with modest decreases of  $0.33 \pm 2.4 \text{ kg/m}^2$ ,  $2.2 \pm 13.4\%$  and  $3.2 \pm 30.9\%$ , respectively. Of the 219 participants, 108 (49.3%) became “less depressed,” 19 (8.7%) became “more depressed” and 92 (42.0%) experienced “no change.”

Regressions revealed that increases in body composition were associated with a decreased probability of becoming “less depressed” ( $p < 0.05$ ). For every  $1\text{kg/m}^2$  increase in BMI and 1% increase in BF and VAT, there was a 21%, 3% and 1% decrease in the probability of becoming “less depressed,” respectively. Increases in body composition were not associated with becoming “more depressed” (Table 2).

There were no interactions among sex, ethnicity and change in body composition in predicting reliable changes in depression. However, changes in body composition were associated with becoming “less depressed” in women only. Changes in body composition were associated with becoming “less depressed” in non-Latino women for BMI and BF only (BMI: RRR = 0.77 (0.62 – 0.96),  $p = 0.02$ ; BF: RRR = 0.96 (0.93 – 1.00),  $p = 0.05$ ), and in Latino women for VAT only (RRR: 0.96 (0.93 – 1.00),  $p = 0.03$ ) (Table 2).

## Discussion

Changes in body composition over this 12-month weight loss intervention were associated with decreases in depression, supporting numerous studies documenting associations between depression and obesity (ref. 5–7, 10, 12–14). The association was most clinically relevant for changes in BMI as 1 unit changes in BMI, BF and VAT correlated to 21%, 3% and 1% increases in the chance of becoming less depressed, respectively. Additionally, rounding to the nearest hundredth, the 95% CI for the RRR for VAT contained 1. Although we cannot infer direction of causality, our results may suggest that changes in BMI are easier for participants to monitor, and therefore, affected mood more so than BF or VAT. Interestingly, increases in body composition were not associated with increases in depression, suggesting that weight gain or increases in depression may simply impede meaningful improvements in depression or weight, respectively.

There were no interactions between sex, ethnicity, and body composition in predicting changes in depression. However, the association was only significant among women, non-Latinos for BMI and BF, and Latinos for VAT. These results support studies showing stronger associations between obesity and depression in females (ref. 5–7,10, 14).

Observational studies suggest that the relationship is stronger for non-Latino white women compared to Latino and black women, which would support our findings regarding BMI (ref. 5,6,14). However, no studies to date have investigated the relationship between changes in VAT and depression in Latinos.

Strengths of this study include the use of data from a 12-month RCT with a high proportion of Latinos compared to prior studies (ref. 6), and the use of DXA derived VAT data. To our knowledge, there have been no studies to date investigating associations between VAT and depression over time, particularly in Latino adults. In addition, using reliable change scores with multinomial logistic regression instead of cut-off values or linear modeling allowed for better characterization of clinically significant changes in depression (ref. 17).

Limitations include a modestly sized data set with a small number of male subjects ( $n = 54$ , 25% of sample). Our sample size, however, is comparable to those of similar trials (ref. 12–13). In addition, decreases in body composition over the trial were small with large standard deviations, particularly for BMI. Our data was also obtained from a study not specifically designed to investigate the contributions of sex and ethnicity in the relationship between depression and body composition. Additionally, this was a correlational study, and we therefore cannot make assumptions regarding causality. Finally, we could not control for possible effect modifiers including diet, substance abuse, menopausal status and psychiatric history.

## Conclusions

In conclusion, changes in body composition were associated with reliable decreases in depressive symptoms, but not increases in depressive symptoms during this weight loss trial. Although there was no interaction between sex and ethnicity in this relationship, subgroup analyses revealed the relationship was significant for females only and differed by ethnicity. Our study contributes to the current literature with its use of VAT data, its high proportion of Latino participants and its longitudinal design, and points to the need for further work investigating associations between changes in VAT and depression over time and across ethnic groups. Knowledge of our results and differences in the response to weight loss among ethnic groups can help clinicians practice personalized medicine and motivate those with obesity to lose weight.

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**Table 1.****Demographics**

|                                    | n = 219       |
|------------------------------------|---------------|
| Age (SD)                           | 41.88 (11.05) |
| Female (%)                         | 75.34 (n=165) |
| Latino (%)                         | 40.18 (n=88)  |
| <b>Education (%)</b>               |               |
| High School or Less                | 19.18         |
| Some College/Associate/Technical   | 33.79         |
| College                            | 23.29         |
| Graduate or Post-graduate Training | 23.74         |
| <b>Employment (%)</b>              |               |
| Unemployed                         | 20.09         |
| Part-Time                          | 18.72         |
| Full -Time                         | 61.19         |

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**Table 2.**

Multinomial logistic regression predicting reliable changes in depression by changes in body composition

| Covariates                                  | “Less Depressed” * |              |         | “More depressed”* |              |         |
|---|--------------------|--------------|---------|-------------------|--------------|---------|
|   | RRR                | (95% CI)     | P Value | RRR               | (95% CI)     | P Value |
| Sex (female vs male)                        | 2.53               | (0.98,6.54)  | 0.06    | 0.24              | (0.02,2.70)  | 0.25    |
| Change in average sleep per day (min)       | 1.01               | (1.00,1.01)  | 0.01    | 1.00              | (1.00,1.01)  | 0.29    |
| Baseline body fat (%)                       | 1.02               | (0.96,1.09)  | 0.54    | 1.01              | (0.89,1.15)  | 0.85    |
| Baseline depression score (CES-D 10)        | 1.06               | (0.97, 1.17) | 0.21    | 0.83              | (0.68,1.01)  | 0.07    |
| <b>Predictor Variables</b>                  |                    |              |         |                   |              |         |
| <b>Change in BMI</b>                        | 0.79               | (0.68,0.91)  | < 0.01  | 1.29              | (0.96, 1.73) | 0.10    |
| <i>Sex Interaction</i>                      |                    |              | 0.26    |                   |              |         |
| Male  | 0.91               | (0.66,1.25)  | 0.56    |                   |              |         |
| Female                                      | 0.75               | (0.63,0.90)  | < 0.01  | 1.24              | (0.91,1.68)  | 0.17    |
| <i>Ethnicity Interaction (Females only)</i> |                    |              | 0.55    |                   |              |         |
| Non-Latino                                  | 0.77               | (0.62,0.96)  | 0.02    |                   |              |         |
| Latino                                      | 0.68               | (0.46,1.01)  | 0.06    |                   |              |         |
| <b>Percent Change in Body Fat</b>           | 0.97               | (0.94, 0.99) | 0.01    | 1.04              | (0.99, 1.09) | 0.15    |
| <i>Sex Interaction</i>                      |                    |              | 0.15    |                   |              |         |
| Male  | 0.99               | (0.94,1.04)  | 0.63    |                   |              |         |
| Female                                      | 0.96               | (0.93,0.99)  | 0.01    | 1.04              | (0.98,1.09)  | 0.20    |
| <i>Ethnicity Interaction (Females only)</i> |                    |              | 0.32    |                   |              |         |
| Non-Latino                                  | 0.96               | (0.93,1.00)  | 0.05    |                   |              |         |
| Latino                                      | 0.94               | (0.88,1.01)  | 0.08    |                   |              |         |
| <b>Percent Change in VAT</b>                | 0.99               | (0.98, 1.00) | 0.02    | 1.01              | (1.00, 1.03) | 0.18    |
| <i>Sex Interaction</i>                      |                    |              | 0.16    |                   |              |         |
| Male  | 1.00               | (0.97,1.02)  | 0.85    |                   |              |         |
| Female                                      | 0.98               | (0.97,1.00)  | 0.01    | 1.01              | (1.00,1.03)  | 0.18    |
| <i>Ethnicity Interaction (Females only)</i> |                    |              | 0.18    |                   |              |         |
| Non-Latino                                  | 0.99               | (0.97,1.00)  | 0.08    |                   |              |         |
| Latino                                      | 0.96               | (0.93,1.00)  | 0.03    |                   |              |         |

\* Compared to “no change” in depression group