Weight Concerns are Associated with Elevated C-Reactive Protein and Perceived Stress Levels in College Women

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Megan Wing

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ABSTRACT

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A thesis presented to the Department of Psychology

Graduate School of Arts and Sciences
Brandeis University
Waltham, Massachusetts

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Background: Low body esteem is linked to negative health outcomes, but the association is not well understood. However, chronic-low grade inflammation is present in these negative health outcomes. Further, chronic stress and its associated physiological stress system changes are linked to chronic low-grade inflammation. Hence, the aim of the current study was to test whether low body esteem was associated with inflammation, and whether stress mediated the relationship. Methods: Thirty-nine undergraduates (25 women) completed self-report body esteem and perceived stress measures. Cortisol awakening response and diurnal slope were assessed by twelve salivary cortisol samples. C-reactive protein (CRP) levels were measured from dried blood spots. Stepwise regressions controlling for BMI and including gender as a moderator assessed study hypotheses. Results: In both genders, appearance concerns were associated with elevated perceived stress (beta = -.61, t = -3.36, p = .002). Further, more weight concerns were linked to higher CRP (beta = -.43, t = -1.90, p = .07) and perceived stress (beta = -
.74, $t = -3.53$, $p = .001$) levels in women. No associations were found between CRP values and perceived stress or basal cortisol indices (all $p \geq .70$). Conclusions: The associations between appearance and weight concerns and perceived stress may be indicative of American societal prescriptions for success. Dieting may account for the relationship between weight concerns and low-grade chronic inflammation in women.
# Table of Contents

I. Introduction 1

A. Body Esteem and Health 1

B. Inflammation Linking Body Esteem and Health 3

C. Stress and Inflammation 4

D. Body Esteem and Stress 5

E. Aims 5

II. Method 7

A. Participants 7

B. Procedures 8

C. Measures 8

D. Analytical Plan 11

III. Results 13

A. Preliminary Analysis 13

B. Testing Hypothesis 13

C. Mediation Analysis 14
IV. Discussion

A. Weight Concerns are Gender-Dependently Linked to Chronic Low-Grade Inflammation 15

B. Weight Concerns are Gender-Dependently Linked to Perceived Stress 17

C. Appearance Concerns are Linked to Stress in Both Genders 19

D. Limitations 20

E. Conclusions and Outlook 21

V. References 22

VI. Tables 28

VII. Figures 32
List of Tables

Table 1. Characteristics of women (N=25) and men (N=14) 28

Table 2. Estimated coefficients of the regression models predicting CRP from body esteem 29

Table 3. Estimated coefficients of the regression models predicting stress measures from body esteem 30

Table 4. Estimated coefficients for the regression models predicting CRP from stress measures 31
List of Figures

Figure 1. Interaction effect of weight concerns by gender on CRP 32

Figure 2a. Main effect of appearance concerns on perceived stress 33

Figure 2b. Interaction effect of weight concerns by gender on perceived stress 34
Introduction

Low body esteem is linked to negative health outcomes such as eating disorders, obesity and depressive symptoms. However, despite extensive research efforts, to date the mechanisms underlying these associations are unclear. Interestingly, all the above conditions present with chronic low-grade inflammation as well. Hence, inflammation may be a promising pathway linking body dissatisfaction and negative health outcomes. Furthermore, given the strong evidence for chronic stress and associated biological dysfunctions playing a role in inflammation, stress may provide a mechanism underlying the elevated inflammatory risk in individuals with low body esteem. The current study aimed at testing these hypotheses by examining the relationship between body esteem and inflammation and the role of stress as a mediator.

Body Esteem and Health

Body image is a complex construct thought to be influenced by a comprehensive set of factors including an individual's history of weight fluctuation, their attitudes to weight and shape, cognitive and affective variables and cultural and social norms (Slade 1994). Thus, this concept pervades our individual and social lives; because of its far-reaching importance, it is primed to influence physiological functioning.
In fact, low body esteem is positively associated with negative health outcomes. For example, in male and female adolescents, body dissatisfaction is associated with increased depressive symptoms (Kostanski & Gullone, 1998). Furthermore, in undergraduate women, weight and appearance concerns correlate with depressive symptoms (Sabik, Lupis, & Wolf, in progress) and body dissatisfaction is associated with increased depressive symptoms in adult men (McFadden, 2000). Although these associations are usually observed over and above actual weight or shape (e.g., BMI), body esteem is linked to obesity. For example, obese adolescents report more appearance concerns when compared to their overweight or normal weight peers (Witherspoon et al., 2013). Further, the experience of being obese appears to have lasting adverse effects; compared to those who had never been obese, adolescent girls, once obese but currently of normal BMI, reported more body dissatisfaction (Mustillo et al., 2012). Lastly, body dissatisfaction mediates the relationship between obesity and self-esteem in adolescence (Mond et al., 2011). Eating disorders provide another example of a link between body esteem and negative health outcomes. Compared to healthy controls, girls in therapy and girls on diets, adolescent girls with anorexia and bulimia nervosa report greater body dissatisfaction (Gonzales, 2001). Indeed, women with eating disorders show body dissatisfaction, body checking and body preoccupation comparable to men and women with Body Dysmorphic Disorder (Rosen and Ramirez, 1997).

Because low body esteem is a factor in negative health outcomes such as eating disorders, obesity and depressive symptoms, examining the underlying mechanism linking body
esteem to negative health is of particular importance to health research. One promising candidate is thereby chronic low-grade inflammation.

**Inflammation Linking Body Esteem and Health**

Inflammation is the body’s acute immune response to pathogen or injury and as such, highly adaptive and beneficial (Dhabhar, 2014). Contrarily, chronic low-grade inflammation is characterized by chronically elevated basal concentrations of inflammatory biomarkers such as C-reactive protein. Chronic inflammation differs from an acute inflammatory response in length of onset, cells affected, degree of tissue injury, and bodily signs of activation (Kumar, Abbas, & Aster, 2012). Most importantly, however, chronic low-grade inflammation is a key indication of negative biological impact. For example, Virdis et al. (2014) reviewed recent accumulating evidence supporting chronic low-grade inflammation’s etiological role in cardiovascular disease.

Interestingly, chronic low-grade inflammation is also present in negative health outcomes linked to low body esteem. For example, a review and meta-analysis of longitudinal studies indicates an association between elevated baseline CRP levels and elevated depressive symptoms (Valkanova et al., 2013). Additionally, females with eating disorders exhibit higher concentrations of pro-inflammatory cytokines than matched controls (MacDowell et al., 2013). Lastly, elevated levels of CRP are associated with elevated BMI in adolescent and adult women and men (Brummett et al., 2013), while CRP levels decrease after weight reduction (Petelin et al., 2014).
Although these findings suggest that low body esteem may be linked to negative health outcomes via chronic low-grade inflammation, to date no study exists supporting this potential pathway. However, indirect evidence is provided by studies on chronic stress. More specifically, chronic-low grade inflammation has consistently been linked to elevated chronic stress (Miller et al., 2014; Sribanditmongkol, Neal, Patrick, Szalacha & McCarthy, 2014) and emerging evidence suggests that low body esteem may act as a chronic stressor (Murray, Byrne, & Rieger, 2011; Murray, Rieger, & Byrne, 2013; Sabik et al., in progress).

**Stress and Inflammation**

When assessing chronic stress, dysfunctions in the circadian cortisol rhythm are a widely used marker providing at the same time a physiological mechanism linking perceived stress and health-relevant physiological effects. A healthy circadian cortisol rhythm is thereby characterized by a sharp increase in levels between wake-up and the following 30-45min (cortisol awakening response: CAR), with levels subsequently decreasing over the course of the day, reaching a nadir during early sleep (cortisol slope) (Weitzman et al., 1971; Pruessner et al., 1997). Contrarily, female undergraduates who reported high levels of perceived stress over the previous month exhibited a flatter diurnal cortisol slope due to higher cortisol concentrations at 10pm than those who report low stress levels (Lovell, 2011). Furthermore, a review of the effects of chronic stress on the cortisol awakening response suggests that in most circumstances, perceived stress is linked to elevated CAR (Kudielka and Wust, 2010).

However, chronic stress and the accompanying dysfunctions in basal cortisol levels have been linked to inflammatory processes as well. As reviewed by Hansel et al. (2010), current
evidence suggests that chronically elevated stress hormone levels are pro-inflammatory and as such may contribute to a chronic low-grade inflammatory state.

**Body Esteem and Stress**

As described previously, body esteem is integral to our individual and social lives. Because of its importance, low body esteem would seem to have the potential to act as a stressor for an individual. Indeed, body dissatisfaction has been shown to be associated with increased perceived stress and to predict a longitudinal increase in perceived stress (Johnson & Wardel, 2005). Furthermore, low body esteem was found to predict dysfunctions in cortisol responses to acute stress (Sabik et al., under review). Lastly, body dissatisfaction has been reported in conjunction with elevated cortisol awaking responses (Therrien et al., 2008) and elevated afternoon cortisol concentrations (Putterman & Linden, 2006).

In summary, the above findings suggest that low body esteem may be linked to negative health outcomes via chronic low-grade inflammation and further, that chronic stress and associated changes in physiological stress systems may promote the proposed elevated inflammatory risk in individuals with low body esteem.

**Aims**

The present study set out to test these hypotheses in healthy undergraduates by examining different facets of body esteem – weight concerns, appearance concerns, perceived appearance judgments by others – and their relation to C-reactive protein (CRP) levels assessed in dried blood spot samples as well as chronic stress assessed by self-report, CAR, and diurnal
cortisol slope. Specifically, we hypothesized that (1) low body esteem will be associated with elevated CRP levels. Furthermore, based on previous findings, we hypothesized that (2) low body esteem will be associated with elevated stress measures and that (3) elevated stress measures will be associated with elevated C-reactive protein. Lastly, we hypothesized that (4) the relationship between body esteem and CRP will be accounted for by chronic stress measures (perceived chronic stress and basal cortisol rhythm indices).

It should be noted that all variables of interest vary dependent on gender. For example, a consistent finding in body esteem literature is that women report higher levels of body dissatisfaction compared to men (Henriques and Calhoun, 1999; Furnham and Greaves, 1994). In particular, weight and shape concerns appear greater for women than men (Connors and Casey, 2006). In addition, research suggests that female undergraduates report greater levels of stress compared to males (Lin and Huang, 2014; Pedersen, 2013). However, a lack of gender effect in perceived stress of undergraduates has also been reported (Pettit and DeBarr, 2011; Feldt and Updegraff, 2013). Lastly, C-reactive protein concentrations demonstrate a gender influence. For example, Le-Ha and colleagues (2014) found higher levels of CRP in females compared to males; a similar pattern was found in older women when compared to older men (Hiramoto et al., 2014). Hence, gender will be examined as a moderator in the relationship between body esteem, chronic stress, and chronic low-grade inflammation.
Method

Participants

Flyers and advertisements were used to recruit fifty-four participants (33 female; mean age 20.1 ± 2.2), from a pool of individuals who had previously participated in Health Psychology Laboratory research at Brandeis University, the at-large student population and the surrounding area of Waltham, Massachusetts. Compensation of introductory psychology class credits or $15 was provided. Only healthy participants were recruited. Healthy was defined as no current acute diseases, no current or former chronic disease or psychiatric disorder and non-smoking. Because body image is culturally influenced (Akiba, 1998; Jaeger et al., 2002), non-native English speakers were excluded.

Thirty-nine participants comprised the final sample (25 female; mean age 20.5 ± 2.3). Ten (4 female) participants were excluded from data analyses due to an insufficient dried blood sample; one male participant data was excluded because of self-report inconsistencies (straightline through questionnaire items, including reverse coded items; missing cortisol data excluded one female participant; and three female participants were excluded because of CRP levels two standard deviations above the mean, levels that may indicate an acute infection.
Procedure

The study included two visits to the Health Psychology Laboratory and two days of at home saliva sampling. On their initial visit, the study protocol and consent form was explained to participants. After informed consent was obtained, height and weight was measured. Participants then completed a demographics questionnaire, the Perceived Stress Scale and the Body Esteem Scale for Adolescents and Adults. After completion of these measures, they were provided with instructions and materials for home saliva sampling. Participants were asked to collect twelve saliva samples over the next two consecutive week days. Participants brought their saliva samples to the Health Psychology laboratory no later than two days after all had been collected.

When the samples were brought to the laboratory a trained phlebotomist collected the participant’s blood sample. After the sample was collected and the participant reported feeling well compensation was provided, and they were free to leave.

Measures

Perceived Stress Scale: This 10 item scale refers to the previous month and measures how unpredictable, uncontrollable and overwhelming individuals perceive their lives to be (Cohen, Kamarck, & Mermelstein, 1983). An example item reads: “In the last month, how often have you felt that you were unable to control the important things in your life?” Responses were measured on a 0 to 4 scale anchored by “Never” and “Very often”. A total score was
obtained by summing the individual item scores taking into account reverse scoring when applicable. Scores increase as perception of stress increases.

**Body Esteem Scale for Adults and Adolescents:** This 23 item scale measures self-evaluations and perceptions of other’s evaluations of one’s body and appearance (Mendelson, B, Mendelson, M & White, D, 2001). Self-evaluations are measured by the 8-item weight concerns subscale and the 10-item appearance concerns subscale. The 5-item attribution subscale measured other’s evaluations of one’s looks. Example items read: “I am satisfied with my weight” (weight concerns), “I am pretty happy about the way I look” (appearance concerns), and “other people consider me good looking” (attribution). Level of agreement to each item was measured on a 0 to 4 scale, 0 indicating “Never”, and 4 indicating “Always”. Scores for the three subscales were computed by averaging the responses of the appropriate items taking into account reverse scoring when applicable. Low weight body esteem scores indicate an unhappiness and a preoccupation with changing one’s weight, while low appearance body esteem subscale scores indicate an unhappiness and worry for one’s looks. Thus, low weight and appearance body esteem subscale scores indicate high concerns in these areas. Low attribution subscale scores indicate perceptions that peers judge one’s looks negatively.

**Saliva sampling:** The home sampling procedure consisted of collecting a total of twelve saliva samples over two consecutive week days as directed. On each day, the first sample was collected immediately upon awaking, the second, third and fourth were collected 30, 45 and 60 minutes later, respectively. The fifth sample was collected at 11am and the sixth at 8pm. Saliva samples were obtained using the salivette collection system (Sarstedt, Newton, NC).
Participants salivated onto the provided cotton roll for one minute, placed it in the plastic tube, and applied the provided cover to insure the sample did not dry out. Cortisol was assayed using a commercially available LIA kit (Salimetrics, Carlsbad, CA). The cortisol awakening response increase was computed as the difference between the first measurement taken upon awakening and the larger of the two measurements taken 30 and 45 minutes later. The cortisol diurnal slope was computed as the difference between the peak measurement (the highest measurement from awakening, +30 minutes and +45 minutes) and the 8pm measurement.

Blood sample: A blood sample was collected by a certified phlebotomist using a sterile, disposable lancet that produces uniform punctures. The participant’s fingertip was cleaned with a sterile alcohol pad, and the tip of the second or third finger was pricked with a 2.2 mm deep safety lancet (SurgiLance). After the first drop of blood was wiped away with sterile gauze, blood was allowed to drip onto a dried blood spot filter paper collection card (Whatman #903). The cards contain four preprinted circles to guide and standardize collection. We aimed to collect a complete card from each participant, that is a sample of 4x50ul=200ul. Collection cards were marked with the participant’s identification number, placed in a drawer to dry overnight and stored at -30C.

C-reactive protein was assayed using a Quantikine ELISA kit (catalog number DCRP00). Specifically, one 3.5mm core was taken from the dried bloodspots with a Harris Uni-Core punch. They were eluted overnight in 250µl phosphate buffered saline containing 0.1% Tween20, pH 7.2, followed by one hour at 300rpm on a microplate shaker. CRP levels were then quantified
using a commercially available CRP assay kit (R&D systems, DCRPOO). Since CRP concentrations were not normally distributed, levels were log2base transformed.

**Analytical Plan**

**Preliminary analyses.** A repeated-measures ANCOVA controlling for BMI for all six cortisol values as within subjects factor and gender as between subjects factor were computed to test for gender-dependent differences in basal cortisol rhythms. Similarly, ANCOVAs controlling for BMI assessed gender differences on all other study variables. Gender differences in age and BMI were assessed by T-tests.

**Testing hypotheses.** Stepwise regressions were employed to test study hypotheses. In more detail, to determine whether body esteem is associated with C-reactive protein, we regressed each of the three subscales of the body esteem scale separately on C-reactive protein. For that, weight, shape and attribution scores were centered, gender was dummy coded, and gender-by-subscale interaction terms were computed according to Aiken and West (1991). Regressions included C-reactive protein concentrations as the dependent variable. BMI was controlled by entering it in the first step, followed by the centered mean score for each subscale and gender in the second step, and the interaction term in the third step. Similar sets of regressions were computed to test for associations between body esteem and stress as well as stress and CRP, with stress assessed by PSS score, CAR increase, and cortisol diurnal slope.

Simple slopes analyses were conducted in cases of significant interactions according to methods described in Holmbeck (2002). In short, two conditional moderator variables and an
interaction term for each by the predictor variable were computed. Regressions were then run for each conditional moderator variable with the predictor variable and the interaction term on the outcome measure. A significant predictor variable indicates a slope significantly different from zero.

If significant associations existed between each independent and dependent variable, mediational analyses were conducted separately for males and females. Using the method described by Hayes (2013), 95% bias-corrected confidence intervals for all indirect effects and the pairwise contrasts between all indirect effects were generated using bootstrapped (N=10,000) samples. Confidence intervals excluding zero were considered indicated of significant indirect effects.
Results

Preliminary Analysis

Table 1 presents means and standard deviations separately for men and women for all study variables. No gender differences were found (all \( p \geq .07 \)). Furthermore, repeated measures ANCOVA revealed no main effect of gender on basal cortisol rhythm (\( F (1, 35) = .03, p = .86 \)). This was confirmed by a lack of gender differences for CAR increase (\( p = .98 \)) and cortisol diurnal slope (\( p = .59 \)).

Testing Hypothesis

Tables 2 and 3 present the results of regression analyses evaluating the associations between body esteem subscales and CRP values as well as between body esteem subscales and stress-related measures.

Testing hypothesis 1 regarding associations between body esteem and CRP, regression analysis revealed a trend for gender X weight concerns effect (\( \beta = .35, t = 1.9, p = .07 \)) on CRP values (see Figure 1). Simple slopes analysis confirmed a negative association between weight concerns subscale scores and CRP concentrations in women, such that more weight concerns were linked to higher CRP levels (\( \beta = -.66, SEB = .35, beta = -.43, t = -1.90, p = .07 \)). No such association was found for men (\( \beta = .45, SEB = .54, beta = .29, t = .83, p = .41 \)).
Furthermore, neither appearance concerns nor attributions were linked to CRP in either gender (all $p \geq .70$). Testing hypothesis 2 concerning links between body esteem and stress, regression analyses revealed a main effect of appearance concerns ($\beta = -.61$, $t = -3.36$, $p = .002$; see Figure 2a), and a significant gender X weight concerns effect ($\beta = .37$, $t = 2.11$, $p = .04$) on perceived stress (see Figure 2b). More specifically, a negative association between weight concerns subscale scores and perceived stress were only observed in women, such that more weight concerns were linked to higher perceived stress ($\beta = -4.71$, SEB = 1.33, $\beta = -.74$, $t = -3.53$, $p = .001$). For men, weight concerns and perceived stress were not linked ($\beta = -.00$, SEB = 2.06, $\beta = .00$, $t = .00$, $p = 1.00$), nor were attributions linked to perceived stress in either gender ($p = .10$). Lastly, repeating the above analyses for CAR increase and cortisol diurnal slope also did not reveal any associations with body esteem measures (all $p \geq .79$).

Table 4 presents the results of regression analyses evaluating the associations between stress measures and CRP values. Testing hypothesis 3, regression analysis revealed no associations between CRP values and perceived stress or basal cortisol indices (all $p \geq .70$).

**Mediation Analysis**

Although for women, weight concerns were positively linked to both CRP and perceived stress, stress and CRP were not associated in either gender. Hence, no mediation analyses were computed.
Discussion

The current study investigated whether body esteem in college students is related to inflammation and if this relationship is moderated by stress. In line with our hypotheses, we found higher weight concerns to be linked to both higher perceived stress and higher CRP levels over and above BMI. Interestingly, this was true for women only. Contrarily, our results did not suggest a link between stress measures and CRP values, thus did not support stress as a mediator between body esteem and inflammation.

Weight Concerns are Gender-Dependently Linked to Chronic Low-Grade Inflammation

One possible pathway linking weight concerns and inflammation involves eating behavior. Weight concerns are associated with initiating dieting in adolescents with no previous dieting history (Loth, MacLehose, Bucchianeri, Crow, & Neumark-Sztainer, 2014). Over time, dieters tend to gain more weight than non-dieters (Field et al., 2007; Lowe et al., 2006) and demonstrate more weight fluctuation (French, Perry, Leon, & Fulkerson, 1995). These weight fluctuations result in changes in adipocyte (fat) cell volume and may contribute to increases in adipocyte numbers (Spaulding et al., 2008; Knittle, Timmers, Ginsberg-Fellner, Brown, & Katz, 1979). However, weight loss does not result in decreases in cell numbers, thus explaining why fat cell numbers are independent of weight indices such as body mass index. Importantly, adipocytes produce and release the pro-inflammatory cytokine interleukin-6 (IL-6) (Vicennati,
Vottero, Friedman, & Papanicolaou, 2002), which, in turn, is positively associated with CRP serum concentrations (Bastard et al., 1999). As such, dieting may increase the likelihood for an individual to have elevated adipocyte numbers compared to a non-dieting person, thereby increasing the risk of being exposed to elevated levels of inflammatory markers (IL-6 and CRP).

Interestingly, dieting is consistently shown to be more prevalent in women than in men (Patton et al., 1997; Furnham & Greaves, 1994; von Soest & Wichstrom, 2009), an observation in line with the current finding of a gender specific association between weight concerns and inflammation. However, Sabiston et al. (2009), found a positive association between CRP and body discrepancy in 13- and 16-year old adolescent girls as well as boys. Similarly, Cernelic-Bizjac et al. (2014) found body dissatisfaction to be positively associated with markers of inflammation both in adult women and men. Perhaps, differences in the age range of participants assessed in the various studies may have contributed to the differential findings, i.e., weight concerns may be less salient in college aged male students compared to adolescent boys and men in their thirties. On the other hand, Sabiston et al. (2009) measured body esteem with one measure of current and ideal appearance that utilized body shape figure drawings. Figure drawings may elicit concerns related to shape that are not captured by weight concerns. In particular boys and men may want to be broader shouldered or more muscular, desires not necessary interpreted as weight, but elicited by pictorial reference. Body shape concerns were also explicit in the aggregate measure of body esteem utilized by Cernelic-Bizjac et al. (2014). Thus, perhaps the subscale used in the current study consisting primarily of statements
specifying weight did not capture shape-related body dissatisfaction relevant for CRP associations in male participants.

**Weight Concerns are Gender-Dependently Linked to Perceived Stress**

Similarly to CRP, we also found a positive association between weight concerns and perceived stress in women only. This result is in line with a previous finding demonstrating a positive association in adolescent girls (mean age 14.4) between body dissatisfaction and perceived stress (Johnson and Wardle, 2005). Given our suggestion that dieting may have increased the risk for elevated CRP levels in women with weight concerns, it is interesting that dieting is also linked to elevated stress in women and adolescent girls (Tomiyama, 2010; Rosen et al., 1989). On the other hand, weight may be a particular stressor for women compared to men. More specifically, women have more total body fat and a higher percent body fat (Chumlea et al., 2002), yet the societal prescription for women is thinness (Hesse-Biber et al., 2006). Moreover, society associates success with intellect for men and with appearance for woman (McKinley, 2002), linking women’s economic independence and status to the thinness ideal (Bordo, 1993; Goodman, 2002). Hence, given the consequences of being overweight, it is not surprising that weight concerns are linked to elevated perceptions of stress in women. For men, on the other hand, success is less contingent on weight, reducing the stressfulness of weight concerns.

Although weight concerns were related to elevated perceptions of stress, neither weight concerns nor appearance concerns or attribution body esteem were linked to diurnal cortisol indices. Thus it could be speculated that body concerns do not act as a source of chronic HPA-
axis activation. However, Putterman and Linden (2006) linked an aggregate of negative beliefs about appearance, situational body image dysphoria and body shape preoccupying cognitions to larger residualized change scores between morning peak and afternoon cortisol levels in undergraduate women. Similarly, Therrien et al. (2008) reported a positive correlation between appearance body esteem and cortisol awakening response in women (mean age 37), and a negative relationship between body dissatisfaction and CAR in women but not men. Perhaps the association between body esteem and cortisol is not yet apparent in a young and otherwise healthy undergraduate sample as changes in basal cortisol rhythms are thought to occur over time as a result of the wear and tear involved in the body repeatedly responding to stress (McEwen, 1998). Of note, weight concerns explained 13% of the variance in cortisol slopes, suggesting that future longitudinal studies may be promising in determining the role of weight concerns in diurnal cortisol.

Although weight concerns in women were positively associated with perceived stress as well as CRP levels, there was no relationship between perceived stress and CRP values. This indicates that the influence of weight concerns on inflammation is not dependent upon the experience of psychological stress, but that a direct link between weight concerns and low grade inflammation exists – possibly via health behaviors as outlined above. Although perhaps not via inflammatory processes, perceived chronic stress linked to weight concern is very likely nevertheless contributing to negative health outcomes seen in individuals with low body esteem (Grogan, 2006; Wilson, Latner, & Hayashi, 2013). As such, women highly concerned
about their weight are at increased risk for suffering from physical and mental diseases as a result of both, stress-related biological processes as well as chronic low-grade inflammation.

**Appearance Concerns are Linked to Stress in Both Genders**

Interestingly, appearance concerns were positively associated with perceived stress in women and men. For women, this may be an ‘extension’ of weight concerns in terms of economic relevance. Experimental research has demonstrated appearance biases in interview offers (Watkins & Johnston, 2000), and hiring and promotion recommendations (Marlowe, Schneider, & Nelson, 1996; Cann, Siegfried, Pearce, 1981). Further, longitudinal research suggests a positive effect of appearance on wages that is not present for education and is not accounted for by age or socioeconomic status (Seng, 1993). Thus appearance has similar socioeconomic consequences as weight and therefore may act as an additional stressor for women.

In men, the link between appearance and stress supports the earlier idea that shape may be more relevant than weight and is picked up in the appearance scale. College men endorse muscle “definition” as part of the ideal body shape (Ridgeway & Tylka, 2005). Muscularity as a sign of dominance (Frederick & Haselton, 2007) is associated with social and economic success (Cassidy, 1991). Furthermore, muscularity may be perceived as a proxy for one’s masculinity (Hunt, Gonsalkorale, K., & Murray, 2013). Hence, appearance concerns may be linked to stress due to their success and gender stereotype symbolism.
However, appearance concerns were not linked to CRP in men. This may be related to evidence that suggests men’s body dissatisfaction emerges later than women’s (Frisen & Anneheden, 2014). As such, stress associated with low body esteem may emerge earlier in girls than boys as well. The association between body esteem and stress in college may thus be a first sign of the effects of body image on men’s health and only over time, effects on biological processes such as inflammation may become apparent.

In summary, our study is the first linking weight concerns with a measure of chronic low-grade inflammation and provides a possible mechanistic explanation to the association between body esteem and negative health outcomes in women. Our results highlight the psychological and biological impact of weight concerns on women and emphasize the importance for clinical and medical care providers to consider weight concerns when treating diseases. Further, the current study demonstrates a link between appearance concerns and stress in men, a relationship that may influence future inflammatory levels.

Limitations

This study has several limitations. Because of the small sample size, results should be interpreted with caution. For example, greater statistical power may have shifted the trend level positive association between weight concerns and CRP values in women to a significant association as well as may have revealed similar associations in men. However, implementing CRP determination from dried blood spot may outweigh the fact that 18.5% of the initial sample had to be excluded due to insufficient dried blood samples, as it presents a new methodology prime for ambulatory data collection and storage. Lastly, evidence suggests that
diurnal cortisol and CRP levels are not affected by menstrual phase (Liening, Stanton, & Schultheiss 2010; Wunder et al., 2006). Thus, present analyses did not control for menstrual cycle phase. However, future studies need to confirm the lack of cycle phase effects on the association between weight concerns and cortisol or inflammation. Lastly, the study design precludes causal inferences regarding the relationships between variables.

**Conclusions and Outlook**

Women in the current study experienced weight and appearance concerns that were associated with increases in psychological stress. This relationship may be accounted for by a culturally influenced expectation of thinness and attractiveness, characteristics that appear to be advantageous in women’s transition to social and financial independence. Men too experienced appearance concerns that were linked to increased psychological stress. However, those may be primarily shape related, as for men, shape, particularly musculature, is a sign of authority and socioeconomic status. Determining the potential sociocultural factors influencing the link between body esteem and stress may be an interesting future avenue of investigation.

Women with high levels of weight concerns exhibit high levels of CRP, a marker of chronic low-grade inflammation. Chronic low-grade inflammation in otherwise healthy college women is alarming given the links between inflammation and negative health outcomes such as cardiovascular disease. Moreover the link between weight concerns and CRP may be an indication of the long-term stress effects of weight concerns that initiate for girls in childhood. Health behaviors, particularly dieting may account for the relationship between weight concerns and CRP in women.
References


**Tables**

Table 1: *Characteristics of women (N=25) and men (N=14)*

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<th>Female Mean</th>
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<td>2.7</td>
<td>2.82</td>
<td>.15</td>
</tr>
<tr>
<td>Perceived stress</td>
<td>17.7</td>
<td>6.3</td>
<td>13.5</td>
<td>6.2</td>
<td>3.37</td>
<td>.074</td>
</tr>
<tr>
<td>Cortisol awakening</td>
<td>11</td>
<td>11.2</td>
<td>10.7</td>
<td>6.8</td>
<td>0.00</td>
<td>.98</td>
</tr>
<tr>
<td>Cortisol diurnal slope</td>
<td>22.5</td>
<td>9.2</td>
<td>20.5</td>
<td>10.1</td>
<td>0.30</td>
<td>.59</td>
</tr>
</tbody>
</table>

*Note: t(df) and P values indicate the statistical significance of gender differences.*
Table 2: *Estimated coefficients for the regression models predicting CRP from body esteem*

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Beta</th>
<th>P</th>
<th>$R^2$ change</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI</td>
<td>0.08</td>
<td>.66</td>
<td>.07</td>
</tr>
<tr>
<td>Appearance body esteem</td>
<td>0.35</td>
<td>.093</td>
<td>.08</td>
</tr>
<tr>
<td>Gender</td>
<td>-0.27</td>
<td>.13</td>
<td>.04</td>
</tr>
<tr>
<td>Appearance X Gender</td>
<td>0.18</td>
<td>.34</td>
<td>.02</td>
</tr>
<tr>
<td>BMI</td>
<td>0.08</td>
<td>.85</td>
<td>.07</td>
</tr>
<tr>
<td>Weight body esteem</td>
<td>0.35</td>
<td>.066</td>
<td>.06</td>
</tr>
<tr>
<td>Gender</td>
<td>0.54</td>
<td>.072</td>
<td>.04</td>
</tr>
<tr>
<td>Weight X Gender</td>
<td>0.58</td>
<td>.066</td>
<td>.08</td>
</tr>
<tr>
<td>BMI</td>
<td>0.2</td>
<td>.24</td>
<td>.07</td>
</tr>
<tr>
<td>Attribution body esteem</td>
<td>-0.16</td>
<td>.48</td>
<td>.02</td>
</tr>
<tr>
<td>Gender</td>
<td>-0.26</td>
<td>.13</td>
<td>.06</td>
</tr>
<tr>
<td>Attribution X Gender</td>
<td>0.08</td>
<td>.70</td>
<td>.00</td>
</tr>
</tbody>
</table>

**$P \leq .001$, *$P \leq .05$**
Table 3: *Estimated coefficients for the regression models predicting stress measures from body esteem*

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Perceived stress</th>
<th>CAR</th>
<th>Diurnal slope</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Beta</td>
<td>P</td>
<td>R² change</td>
</tr>
<tr>
<td>BMI</td>
<td>-0.16</td>
<td>.33</td>
<td>.03</td>
</tr>
<tr>
<td>Appearance body esteem</td>
<td>-0.61</td>
<td>.002*</td>
<td>.30</td>
</tr>
<tr>
<td>Gender</td>
<td>-0.18</td>
<td>.25</td>
<td>.02</td>
</tr>
<tr>
<td>Appearance X Gender</td>
<td>0.07</td>
<td>.71</td>
<td>.00</td>
</tr>
<tr>
<td>BMI</td>
<td>-0.26</td>
<td>.16</td>
<td>.03</td>
</tr>
<tr>
<td>Weight body esteem</td>
<td>-0.74</td>
<td>.001**</td>
<td>.22</td>
</tr>
<tr>
<td>Gender</td>
<td>-0.27</td>
<td>.084</td>
<td>.03</td>
</tr>
<tr>
<td>Weight X Gender</td>
<td>0.37</td>
<td>.043*</td>
<td>.08</td>
</tr>
<tr>
<td>BMI</td>
<td>0.06</td>
<td>.44</td>
<td>.03</td>
</tr>
<tr>
<td>Attribution body esteem</td>
<td>-0.27</td>
<td>.59</td>
<td>.11</td>
</tr>
<tr>
<td>Gender</td>
<td>0.03</td>
<td>.18</td>
<td>.06</td>
</tr>
<tr>
<td>Attribution X Gender</td>
<td>0.08</td>
<td>.10</td>
<td>.06</td>
</tr>
</tbody>
</table>

**P ≤ .001, *P ≤ .05**
Table 4: Estimated coefficients for the regression models predicting CRP from stress measures

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Beta</th>
<th>P</th>
<th>R² change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent variable: CRP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predictor</td>
<td>Beta</td>
<td>P</td>
<td>R² change</td>
</tr>
<tr>
<td>----------------------------</td>
<td>------</td>
<td>-----</td>
<td>-----------</td>
</tr>
<tr>
<td>BMI</td>
<td>0.22</td>
<td>.19</td>
<td>.07</td>
</tr>
<tr>
<td>CAR</td>
<td>0.10</td>
<td>.57</td>
<td>.01</td>
</tr>
<tr>
<td>Gender</td>
<td>-0.26</td>
<td>.11</td>
<td>.07</td>
</tr>
<tr>
<td>CAR X Gender</td>
<td>-0.05</td>
<td>.78</td>
<td>.00</td>
</tr>
<tr>
<td>BMI</td>
<td>0.22</td>
<td>.18</td>
<td>.07</td>
</tr>
<tr>
<td>Diurnal slope</td>
<td>-0.02</td>
<td>.92</td>
<td>.00</td>
</tr>
<tr>
<td>Gender</td>
<td>-0.27</td>
<td>.11</td>
<td>.07</td>
</tr>
<tr>
<td>Diurnal slope X Gender</td>
<td>-0.02</td>
<td>.94</td>
<td>.00</td>
</tr>
<tr>
<td>BMI</td>
<td>0.18</td>
<td>.27</td>
<td>.07</td>
</tr>
<tr>
<td>Perceived stress</td>
<td>0.29</td>
<td>.17</td>
<td>.09</td>
</tr>
<tr>
<td>Gender</td>
<td>-0.21</td>
<td>.22</td>
<td>.03</td>
</tr>
<tr>
<td>Perceived stress X Gender</td>
<td>-0.08</td>
<td>.70</td>
<td>.00</td>
</tr>
</tbody>
</table>
Figures

Figure 1: Interaction effect of weight concerns by gender on CRP
Figure 2a: *Main effect of appearance concerns on perceived stress*
Figure 2b: Interaction effect of weight concerns by gender on perceived stress