


# Weight stigma and acculturation in relation to hair cortisol among Asian Americans with overweight and obesity: A cross-sectional study

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## Abstract

Weight stigma is a pervasive problem for Americans, but little is known about its impact on the health of Asian Americans. Authors examined the relationship between weight stigma and cortisol and whether acculturation moderated this relationship. Asian Americans ( $n = 166$ ) with overweight or obesity completed questionnaires and provided a 50-mg hair sample to assay cortisol. Results revealed a negative correlation between weight stigma and cortisol. However, this was no longer significant after controlling of relevant covariates. The level of acculturation did not significantly moderate this relationship. The non-significant relationships among weight stigma, cortisol, and acculturation are discussed along with future directions.

## Keywords

acculturation, Asian Americans, hair cortisol, obesity, weight stigma

## Introduction

The prevalence of overweight and obesity is increasing rapidly among Asian Americans living in the United States (Centers for Disease Control and Prevention (CDC), 2016). Currently, 40.3 percent of Asian Americans are either overweight or obese (CDC, 2016). The increasing number of Asian Americans with overweight or obesity raises concerns about the potential negative impact of weight stigma on this population. Weight stigma is defined as individuals with overweight and obesity experiencing negative comments, physical harassment, being mistreated, being labeled or stereotyped as lazy, unintelligent, and lacking self-discipline because of their weight (Hatzenbuehler et al., 2013; Puhl and Heuer, 2010). Weight stigma can be present in the media, school, work and healthcare settings and can be perpetrated by educators, healthcare providers, family, and even strangers (Ata and Thompson, 2010; Sutin and Terracciano, 2017).

Previous research has characterized weight stigma as a chronic psychological stressor (Tomiya, 2014). The social depreciation and personal condemnation from weight stigma toward an individual with higher body

weight can be psychologically stressful (Brewis et al., 2017). Moreover, those with higher body weight may experience weight stigma repeatedly over their lifetime, and the long-term stress from experiencing weight stigma and maladaptive coping may produce differences in health outcomes (Puhl and Heuer, 2010). Of note, only the frequency of experiencing weight stigma was measured in the current study, but weight stigma can be observed and measured in other formats, including internalized weight stigma (Durso and Latner, 2008). Internalized weight stigma is a measure of an individual's belief in stereotypes relating to negative self-evaluations (Durso and Latner, 2008). After experiencing weight-related discrimination, an individual may internalize weight stigma and self-stigmatize (Pearl et al., 2015). Perceived experiences of weight stigma and internalized weight stigma may create different

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stress levels and may have a different effect on health behaviors (Pearl et al., 2015).

There is mounting evidence that weight stigma uniquely contributes to adverse health via stress such as increased binge eating (Palmeira et al., 2017), depression (Robinson et al., 2017), and anxiety (Savoy et al., 2012). Adults experiencing higher weight stigma report increased weight gain (Jackson et al., 2014), reduced interest in physical activity (Nolan and Eshleman, 2016), and a higher risk of developing type 2 diabetes (Tsenkova et al., 2011). Among Asian Americans, higher weight discrimination was also associated with higher body mass index (BMI; Gee et al., 2008). Weight stigma has been linked to negative physiological and behavioral consequences. Although a previous study showed that there were no race differences between White, Latino/Hispanic, African American, and Asian or Pacific Islanders from experiencing weight stigma (Himmelstein et al., 2017), the impact of weight stigma on Asian Americans' health outcomes has been understudied.

### *Chronic stress of weight stigma and hair cortisol*

Recent studies have demonstrated a relationship between weight stigma and short-term hypothalamic–pituitary–adrenocortical (HPA) axis response by analyzing salivary cortisol samples (Himmelstein et al., 2014; Schvey et al., 2014). The HPA axis coordinates the human body's stress response, and cortisol is the end product of the HPA axis activity (Elder et al., 2014). Cortisol levels reflect the HPA axis activation in responding to acute or chronic stress. Cortisol levels in blood, urine, or saliva indicate only the current status of HPA axis activity in responding to acute stress and are susceptible to a variety of influences such as circadian rhythm, physical activity, and sleep (Kudielka et al., 2009). Repeating measures of blood, urine, or saliva to measure long-term cortisol increases burden and discomfort for study participants (Wright et al., 2015). In contrast, hair cortisol analysis may offer a novel approach to measure HPA axis activity in response to chronic stressors such as long-term weight stigma experiences (Wright et al., 2015). Hair cortisol measurement provides a retrospective timeline of cortisol secretion over the past months by a one-time, non-invasive collection of hair samples and offers information about long-term HPA axis activity (Stalder and Kirschbaum, 2012). Unbound cortisol (i.e. cortisol is not bound to specific carrier protein) is assumed to enter the hair shaft through passive diffusion, and its concentration represents cumulative free circulating cortisol levels (Wester and van Rossum, 2015). The growth rate of hair is approximately 1 cm per month (Stalder and Kirschbaum, 2012). The 1-cm segment of hair most proximal to the scalp represents the cortisol level of the prior month, with the second-most proximal 1-cm segment of hair representing the level of the month before that (Stalder and Kirschbaum, 2012). Hair cortisol may be affected by cosmetic hair

treatments, such as bleaching, as well as by smoking, shift work, ultraviolet sun exposure, repeated shampooing, hot water, and hair discoloration from swimming in chlorinated pools (Hoffman et al., 2014; Manenschijn et al., 2011; Nanko et al., 2000; Wosu et al., 2015).

Previous research reported that the higher the weight stigma, the higher the serum (i.e. the liquid portion of the blood without cells and clotting factors) and salivary cortisol levels (Himmelstein et al., 2014; Schvey et al., 2014; Tomiyama et al., 2014; Tuck et al., 2009). However, studies on the relationship between hair cortisol levels and weight stigma or chronic stress are conflicting. Jackson et al. (2016) found a significant positive association between perceived weight discrimination and hair cortisol concentration after controlling for age, sex, socioeconomic status, ethnicity, hair treatment, and BMI among 563 non-smoking adults in England. Stalder et al. (2014) investigated the association between chronic stress of caregiving burden and hair cortisol concentration and found that hair cortisol concentration was elevated in dementia caregivers compared to non-caregivers. Stalder et al. (2017) then conducted a meta-analysis of hair cortisol findings using 72 studies and found that chronic stress-exposed groups exposed to caregiver stress, unemployment, and natural disasters exhibited a 22 percent higher median hair cortisol concentration. However, other evidence showed a negative relationship between chronic stress and hair cortisol levels (Morris et al., 2017; Ouellette et al., 2015). For example, Ouellette et al. (2015) examined the relationship between hair cortisol and maternal chronic stress using a longitudinal study design with 60 mother–daughter dyads and found that mothers with higher stress had significantly lower hair cortisol levels compared to mothers with lower stress. Morris et al. (2017) conducted a preliminary study to examine associations between hair cortisol and the stress exposure of interpersonal violence from baseline to 3-month follow-up among young adult women and found that lower hair cortisol levels predicted greater stress exposure in women with a history of significant childhood abuse compared to women with no history of maltreatment. Moreover, a hypothesis of a curvilinear relationship between chronic stress and hair cortisol level has begun to be tested (Wells et al., 2014). Wells et al. (2014) tested curvilinear associations of self-reported perceived stress with hair cortisol levels among 324 community participants and found that hair cortisol levels increased when participants had lower perceived stress scale ranges of 0–8 to 17–24, but it decreased when participants had higher levels of perceived stress scores ranging from 33–40. Given the divergence of current research results, the relationship between chronic stress and HPA axis function requires additional research. Hair cortisol levels can reflect the HPA axis function in response to chronic stress. Therefore, we were intrigued by its potential as a biomarker for chronic stress response of the HPA axis among individuals experiencing weight stigma situations.

## *Acculturation and body image of Asian Americans*

When Asian immigrants transition from an Asian lifestyle to an American lifestyle, they start the process of acculturation (Bharmal et al., 2014). Acculturation is a series of actions by which members of one cultural group adopt the beliefs and behaviors of another group (Bharmal et al., 2014). Compared to first-generation Asian immigrants (i.e. an individual was born in Asia or country other than the United States), second-generation Asian immigrants (i.e. an individual was born in the United States and either parent was born in Asia or country other than the United States) are more likely to identify with US culture (i.e. high acculturated) (Murray et al., 2014). Also, wanting to integrate into American society may affect the eating habits of Asian Americans (Guendelman et al., 2011). Asian Americans might eat more unhealthy American foods and consume more calories and fat when their American identity was questioned (Guendelman et al., 2011). Approximately 70 percent of the US population meets the criteria for overweight and obesity (National Center for Health Statistics, 2016). A review study reported that Asian individuals who were overweight were perceived as significantly more American than those who were at a healthy weight, indicating that being overweight may have a consequence of how Asian Americans are recognized as a part of American society (Handron et al., 2017). Taken together, these studies demonstrate that the transition from an Asian to an American lifestyle and the pressure of being accepted and recognized by American society may influence the diet and body shape of Asian Americans. Since weight stigma is strongly related to perceptions of body shape (Pearl et al., 2014), we were intrigued by how the level of acculturation mitigated or exacerbated the effects of weight stigma on health outcomes.

### *Aims*

The Weight Stigma for Asian Americans study was conducted to examine (1) the relationship between self-reported weight stigma frequency and hair cortisol levels and (2) whether the level of acculturation moderated the relationship between weight stigma and hair cortisol among Asian Americans ( $\geq 21$  years of age) with overweight or obesity using a cross-sectional study design. Other life-related stressful events or the stress from race-related discrimination may also affect the result of hair cortisol (Busse et al., 2017). Therefore, this study considered the levels of perceived stress and perceived racism for Asian Americans as potentially confounding variables. We expected to find a significant positive association between weight stigma and hair cortisol. We also expected that the level of acculturation would significantly moderate the relationship between weight stigma and hair cortisol, such that the effect of

weight stigma on hair cortisol would be exacerbated for participants with higher acculturation score (i.e. high Western identity).

## **Methods**

### *Study design and setting*

The Weight Stigma for Asian Americans study used a cross-sectional design with a convenience sample to explore the relationship among weight stigma, hair cortisol, and acculturation among Asian Americans who were overweight or obese in North Carolina. The study was conducted in the four cities in North Carolina with high Asian populations (i.e. Chapel Hill, Durham, Raleigh, and Cary). The size of the Asian American population of North Carolina was 287,640 in 2016 (North Carolina Office of State Budget and Management, 2016). Although there is no precise data on the prevalence of overweight and obesity in Asian Americans in North Carolina, approximately 33 percent of adults in the other races category (i.e. other races include Asians and multi-race categories but not White, African American, American Indian, and Hispanic) in North Carolina are categorized as overweight and 16 percent as obese (North Carolina Department of Health and Human Services, 2018). The data collection was conducted from 20 April to 11 November 2016. The research materials supporting this publication can be accessed by contacting Dr. Ya-Ke Wu.

### *Sample size*

To determine the sample size for this study, G\*Power 3, a software developed by a G\*Power Team at Heinrich-Heine-Universität Düsseldorf, Düsseldorf, German, was used for power analysis (Faul et al., 2007). Using values based on a study conducted by Himmelstein et al. (2014), this study sets the effect size at 0.12,  $\alpha$  at 0.05, statistical power at 0.8, and the number of explanatory factors at 8 based on the number of independent and confounding variables (described in the “Statistical analyses” section) in this study. A total of 140 participants were needed to achieve a power of 0.8. The percentage of participants contributing incomplete data (and, hence, excluded from analysis) was projected to be 20 percent (Polit and Beck, 2008). Therefore, a total of 168 participants were needed in the study.

### *Participants*

Participants' inclusion criteria were as follows: (1) US-born or foreign-born Asian Americans living in North Carolina; (2) between 21 and 65 years of age; (3) could read and write in English at a sixth-grade level or above (Lynn, 1989); and (4) had a BMI of  $\geq 23$  kg/m<sup>2</sup>. The rationale to include both US-born and foreign-born Asian Americans in the current

study was that the level of acculturation may have differed between these populations (Murray et al., 2014). Also, we decided to choose the BMI cut-off points of 23 to 27.5 kg/m<sup>2</sup> for overweight and greater than 27.5 kg/m<sup>2</sup> for obesity, based on the suggestions of World Health Organization Expert Consultation for the appropriate BMI for Asian populations for public health action (World Health Organization (WHO), 2004). We understand that the WHO's recommendations of the BMI cut-off points were based on the findings of the Asian population, not Asian Americans. However, because 94 percent of our sample were first-generation immigrants (i.e. participant was born in Asia or country other than the United States) and lived in Asia for an average ( $\pm$  standard deviation (SD)) of  $26.6 \pm 9.4$  years, we decided to use the WHO (2004) criteria. Although the weight stigma study in Asian population is limited, a previous Asian weight stigma study showed that the primary source of weight stigma for the Asian population was parents or relatives (Wu and Liu, 2015). The majority of first-generation immigrants in our study kept a close relationship with their parents and relatives who still lived in Asia. An Asian immigrant with a BMI of 23 kg/m<sup>2</sup> is still perceived to be at a healthy weight in the US society; however, he or she may be perceived as overweight and receive stigmatizing comment by family in Asia. The exclusion criteria were as follows: (1) mental illness, such as schizophrenia or Alzheimer's disease, which would have made it difficult to complete the surveys (Arango et al., 2014; Pearman, 2013); (2) regular recreational drug use, such as cannabis or any other recreational drugs, secondary to the potential influence on cortisol activity (Granger et al., 2012); (3) regular use of seizure medication, estrogen, hydrocortisone, prednisone, or androgen within the past year, which may have affected the results of cortisol testing (Granger et al., 2012); (4) disease that would affect cortisol activity, such as Cushing's disease, Addison's disease, or hypopituitarism (Granger et al., 2012); (5) shift work within the preceding year (Manenshijn et al., 2011); (6) current smoker (Wosu et al., 2015); and/or (7) pregnant (Garcia-Blanco et al., 2017). Participants were asked questions via telephone to determine inclusion/exclusion during eligibility screening. If potential participants met the inclusion criteria and had used hair dye within the past year, they were asked not to dye their hair for 1 month to allow for new 1-cm hair growth. Data were then collected 1 month later. During eligibility screening, 180 participants expressed an interest in participating. One of the participants was excluded for having Cushing's syndrome, one was excluded for smoking, three were excluded for being older than age 65 years, three were excluded for using estrogen (e.g. birth control pills), and four were excluded for having a BMI below 23 kg/m<sup>2</sup>. A total of 168 adults were recruited for the study, but two participants did not complete the surveys. Therefore, complete data were available for 166 participants.

## Measures

**Demographic and hair-related variables.** Participants were asked to report their age, gender, education level, marital status, occupation, country of birth, number of years lived in the United States and Asia, the frequency of swimming and hair-washing per week during the prior month, and usual water temperature used for hair-washing based on participants' judgment. The participants' hair color and hair weight (in mg) were documented for hair cortisol analysis.

**Anthropometric measurements.** The participants' height and weight were measured. All participants were dressed in lightweight indoor clothes, without socks and shoes. Weight was measured twice with a portable digital scale and was averaged and recorded to the nearest 0.1 kg. Height was measured twice, using a portable Martin stadiometer, which was averaged and recorded to the nearest 0.5 cm. BMIs were calculated by entering mean weight and height data into a BMI computerized formula.

**Hair cortisol collection and measurements.** Hair samples were taken from the participants; however, only the 1-cm segment of hair that was most proximal to the scalp was analyzed in this study. Hair was separated at the back of the head using a hair clip and a hair strand of about 3 to 5 mm in diameter (approximately 50 mg of hair) at the posterior vertex was collected. A hair band was used to secure the hair as close as possible to the scalp. The hair sample was placed in aluminum foil and folded without bending the sample. The participant's study identification number was attached, and the sample was placed in a padded envelope. We avoided pulling out hair from the scalp. All of the hair samples were stored at room temperature and then analyzed using commercially available high-sensitivity enzyme immunoassay kits and a hair analysis protocol as described by Meyer et al. (2014) at The University of North Carolina at Chapel Hill Biobehavioral Lab to obtain cortisol levels. Because the high-sensitivity enzyme immunoassay kits that we used were designed to measure cortisol values in liquid samples such as saliva, the assay output was converted from micrograms cortisol per deciliter ( $\mu\text{g/dL}$ ) to picograms cortisol per milligrams hair (pg/mg) based on the Meyer et al. (2014) formula. All of the hair samples were analyzed in duplicate. The intra-assay and inter-assay coefficients of variation of this assay were <5 percent in this study.

**Weight stigma frequency.** The participant's self-reported weight stigma frequency over their lifetime was measured using the Stigmatizing Situations Inventory (SSI; Myers and Rosen, 1999). The English version of the SSI has been used in the United States for Asian populations (Tomiyama et al., 2014) and the Chinese version of the SSI has been used in Taiwan for the Taiwanese population (Wu and Liu, 2015),

with the Cronbach's alpha of 0.95 and 0.94, respectively. The original SSI has 50 items with 10-point scale (0=*never*, 1=*once in your life*, 5=*about once a month*, 9=*daily*). Puhl and Brownell (2006) modified the response scale to a 4-point scale to streamline response (0=*never experienced the weight stigma situation in question*, 1=*experienced one instance*, 2=*experienced more than one instance*, 3=*experienced multiple instances*). The English version of the SSI with the 4-point scale was used in this study. The overall score of the SSI was computed by adding all of the questions and dividing by 50 to create a mean score of weight-related stigmatizing experiences (Myers and Rosen, 1999). Average scores range from 0 to 3 with higher scores indicating higher weight-related stigmatizing experiences (Puhl and Brownell, 2006). A sample item includes "Friends, acquaintances, co-workers, etc. making fun of your appearance" (Myers and Rosen, 1999). Cronbach's alpha for the overall inventory was 0.94 in this study.

**Level of acculturation.** The level of acculturation of the participants was measured using the Suinn–Lew Asian Self-Identity Acculturation Scale, a 21-item instrument with a 5-point scale (1=*low acculturation*, 3=*bicultural*, 5=*high acculturation*) to assess both actual behaviors and assessed ideals or preferences (Suinn et al., 1992). A sample item includes "What is your music preference?" and the response options are as follows: (1) only Asian music (e.g. Chinese, Japanese, Korean, and Vietnamese); (2) mostly Asian; (3) equally Asian and English; (4) mostly English; and (5) English only. The response option 1 represents 1 point, and the response option 5 represents 5 points. A total score was computed by summing across the answers for all 21 items (Suinn et al., 1992). A final acculturation score was calculated by then dividing the total value by 21 (Suinn et al., 1992). The overall score ranges from a low of 1, indicative of low acculturation (i.e. high Asian identity), to a high of 5, indicative of high acculturation (i.e. high Western identity) (Suinn et al., 1992). In addition, item 12 of the scale was used to measure participants' generation: first generation="I was born in Asia or a country other than the US"; second generation="I was born in the US, either parent was born in Asia or a country other than the US"; or "I don't know what generation best fits me since I lack some information" (Suinn et al., 1992). Cronbach's alpha for the overall scale was 0.86 in this study.

**Level of perceived racism.** The level of perceived racism of the participants was measured using the Subtle and Blatant Racism Scale for Asian Americans, a 10-item instrument with a 5-point scale (1=*almost never*, 2=*once in a while*, 3=*sometimes*, 4=*often or frequent*, 5=*almost always*) to measure the extent to which one believes he or she has personally encountered racial discrimination (Yoo et al., 2010). Higher scores represent higher perceived personal racial discrimination (Yoo et al., 2010). A sample item includes

the following: "In America, I am called names such as, 'chink, gook, etc.' because I'm Asian." In this study, the total score of the Racism Scale was treated as one of the control variables in the multiple regression models for all study aims. Cronbach's alpha for the overall Racism Scale was 0.79 in this study.

**Level of perceived stress.** The level of perceived stress was measured using the Perceived Stress Scale, a 10-item instrument with a 5-point scale ranging from 0 (*never*) to 4 (*very often*) to measure the degree to which situations in one's life are perceived as stressful within the past month and is not bound to any specific situation or event (Cohen et al., 1983). The overall score ranges from 0 to 40, with higher composite scores indicative of higher perceived stress (Cohen et al., 1983). A sample item includes the following: "In the last month, how often have you felt nervous and stressed?" Both English and Chinese versions of the scale have been validated in the Asian population in different countries, including Singapore (Kouk et al., 2013), Korea (Lee et al., 2015), and China (Leung et al., 2010) with Cronbach's alpha ranging from 0.74 to 0.83. The English version of the scale was used in this study. The overall score of the scale served as a control variable in the multiple regression models. Cronbach's alpha for the overall scale was 0.75 in this study.

### Procedure and ethical considerations

This study was approved by the Institutional Review Board (approval no. 16-0412) for the Protection of Human Subjects at The University of North Carolina at Chapel Hill. Patients reviewed the consent and asked questions before they were asked to consent. Participants were recruited from local communities and churches through recruitment ads, flyers, and brochures, and screened over the phone for eligibility. Following the initial phone screening, interested participants were invited to a local church or the Biobehavioral Lab and were evaluated in person for eligibility. At this visit, all potential participants' height and weight were measured in a private room before enrollment. Written informed consent was obtained if the study criteria were met. Hair samples were collected and the participants completed paper questionnaires in the private room.

### Statistical analyses

Descriptive statistics (mean and standard deviation, or frequency and percentage, as appropriate) were computed for demographic variables, body weight and height, BMI, hair cortisol, hair-related characteristics, and scores of the four questionnaires. Median and inter-quartile range were provided for hair cortisol data. Independent-groups two-sample *t*-tests were used to compare each of the means of hair cortisol and the four questionnaires between participants

with overweight and obesity. The means of hair cortisol was also compared between hot and warm water temperatures for hair-washing; only one participant reported using cold water for hair-washing, so this was excluded from the *t*-test. The natural log transformation was applied to the hair cortisol data in *t*-test, correlation and multiple regression analyses due to its non-normal distribution. Pearson's correlation analysis was used to determine the bivariate relationships between pairs of continuous variables.

Multiple linear regression analyses were performed for study aim 1 to determine the association between weight stigma (as the independent variable) and hair cortisol (as the dependent variable), controlling for covariates (model I,  $n=166$ ). Multiple linear regression coefficient estimates ( $\beta$ ), confidence intervals (CIs), coefficient of determination ( $R^2$ ), and *p*-values were noted. We adjusted for the covariates of age, BMI, level of perceived racism for Asian Americans, and level of perceived stress because those variables were significantly correlated with weight stigma or hair cortisol. For regression model diagnostics, Shapiro-Wilk, Kolmogorov-Smirnov, Cramer-von Mises, and Anderson-Darling statistics were performed to evaluate whether residuals were normally distributed, and plots of the residuals versus predicted values were generated to assess the assumption of homogeneity of variances for all models. The result of the diagnostics showed that the assumptions of normality and homogeneity of variance were violated in model I. We examined the model distribution and probability plots for the studentized residual and removed six extreme hair cortisol observations based on the value of the residuals; we refit the models without those outliers to improve model diagnostics (model II,  $n=160$ ). For study aim 2, the level of acculturation was introduced into this multiple linear regression model as a moderator through its pairwise interaction with weight stigma. In addition to adjusting for the five potential covariates specified for study aim 1, we further adjusted for the number of years lived in Asia in study aim 2 because it was significantly correlated with the level of acculturation (model III,  $n=166$ ). The result of the diagnostics showed that the assumptions of normality and homogeneity of variance were also violated in model III. We again removed six extreme hair cortisol cases to improve model diagnostics (model IV,  $n=160$ ). All data were analyzed using SAS 9.3 software (SAS, 2014). *p*-values of 0.05 or less were considered statistically significant, and no adjustment was made for multiple testing.

## Results

### Participant characteristics

Table 1 presents the characteristics of the full sample. The 166 participants, who primarily identified as first-generation Asian Americans (94%), had a mean  $\pm$  SD age

**Table 1.** Sample characteristics ( $n=166$ ).

Characteristics	Mean $\cdot$ SD or $n$ (%)
Age (years)	45.7 $\cdot$ 9.8
Gender	
Male	92 (55.4)
Female	74 (44.6)
Body height (cm)	166.9 $\cdot$ 8.7
Body weight (kg)	74.4 $\cdot$ 12.3
BMI (kg/m <sup>2</sup> )	26.6 $\cdot$ 3.1
Weight status	
Overweight (23.0–27.5 kg/m <sup>2</sup> )	114 $\cdot$ 68.7
Obese (>27.5 kg/m <sup>2</sup> )	52 $\cdot$ 31.3
Education	
Graduate school	117 (70.5)
College/university	46 (27.7)
High school	3 (1.8)
Marital status	
Single	18 (10.9)
Divorced	1 (0.6)
Widowed	3 (1.8)
Unmarried but in a relationship without living with partner	4 (2.4)
Married and living with a spouse	139 (83.7)
Married but separated	1 (0.6)
Occupation ( $n=162$ )	
Business/market/financial	20 (12.4)
Computer/information technology	53 (32.7)
Research/education	32 (19.6)
Healthcare practitioners	5 (3.2)
Self-employment	7 (4.3)
Housewife/student/unemployment	26 (16.1)
Retired	7 (4.3)
Other <sup>a</sup>	12 (7.4)
Place of birth	
Taiwan	73 (44.0)
Hong Kong	7 (4.2)
China	74 (44.6)
Malaysia	1 (0.6)
South Korea	2 (1.2)
United States	9 (5.4)
Generation	
First generation	156 (94.0)
Second generation	9 (5.4)
Don't know	1 (0.6)
Years lived in Asia	26.6 $\cdot$ 9.4
Years lived in the United States	18.6 $\cdot$ 9.8
Average swimming during last month (per week)	0.5 $\cdot$ 1.1
Average hair wash during last month (per week)	5.2 $\cdot$ 2.6
Water temperature for washing hair <sup>b</sup>	
Hot water	39 (23.5)
Warm water	126 (75.9)
Cold water	1 (0.6)

**Table 1.** (Continued)

Characteristics	Mean · SD or <i>n</i> (%)
Hair color	
Black	119 (71.7)
Mix (black, gray, and white)	47 (28.3)
Weight of hair subjected to extraction (mg)	35.67 · 12.58

First generation: participant was born in Asia or country other than the United States; second generation: participant was born in the United States and either parent was born in Asia or country other than the United States; SD: standard deviation; *n*: number of participants; mg: milligram.

<sup>a</sup>Other in "Occupation" includes religious workers, lawyers, artists, food preparation workers and wait service-related occupations, sales and related occupations, and translator.

<sup>b</sup>Based on subjects' own judgment.

of  $45.7 \pm 9.8$  years. The average years lived in Asia was  $26.6 \pm 9.4$  years and in the United States was  $18.6 \pm 9.8$  years. The mean BMI of all participants was  $26.6 \pm 3.1$  kg/m<sup>2</sup>, with 68.7 percent overweight and 31.3 percent obese. Most of the participants had black hair (71.7%) and used warm water to wash their hair (75.9%) an average of  $5.2 \pm 2.6$  times per week.

Table 2 shows the results of weight stigma, hair cortisol, acculturation, perceived racism, and perceived stress by total sample and weight status. The mean hair cortisol of all participants was  $23.43 \pm 30.47$  pg/mg, with the median and inter-quartile range of 16.21 and 14.57 pg/mg, respectively. The means of log hair cortisol were not significantly different between participants with overweight and obesity ( $t(164) = -0.55, p = 0.59$ ) or between hot and warm water temperatures for hair-washing ( $t(163) = -1.01, p = 0.31$ ). A majority (89.8%) of the participants had faced weight-based stigmatization in their lifetime. However, a low frequency of weight stigma was noted (mean:  $0.28 \pm 0.33$  of 3 points). Participants with obesity reported more weight stigma experiences (mean:  $0.40 \pm 0.36$  of 3 points) than participants with overweight (mean:  $0.22 \pm 0.30$  of 3 points) ( $t(164) = 3.28, p < 0.01$ ). The mean acculturation score was  $2.21 \pm 0.42$ , indicating that participants perceived themselves as having "Asian identity" (score of 1 or 2) or "bicultural" (score of 3) (Suinn et al., 1992). Participants showed low levels on the Racism Scale (mean:  $20.07 \pm 5.68$  of 50 points) and the Perceived Stress Scale (mean:  $16.20 \pm 5.62$  of 40 points).

### Correlation analysis results

Table 3 displays the correlation analysis results for continuous variables. Weight stigma was negatively correlated with hair cortisol ( $r = -0.19, p < 0.05$ ) and with age, and positively correlated with each of BMI, the level of acculturation, the level of perceived racism, and the level of perceived stress. In addition to being negatively correlated with weight

stigma, hair cortisol was positively correlated with age, but was not correlated with the level of acculturation, perceived racism, or perceived stress. In addition to being positively correlated with weight stigma, the level of acculturation was also positively correlated with each of the BMI levels, years lived in the United States, the level of perceived racism, and the level of perceived stress and was negatively correlated with each of age and years lived in Asia.

### Relationship between weight stigma and hair cortisol

Table 4 shows the multiple linear regression analysis results for the association between weight stigma and log hair cortisol. Both models I and II indicated a non-significant trend for higher weight stigma frequency to be associated with lower log hair cortisol level, whether with ( $\beta = -0.34, t = -1.56, p = 0.12$ ) or without ( $\beta = -0.16, t = -0.83, p = 0.41$ ) the outliers, after adjusting for age, BMI, level of perceived racism for Asian Americans, and level of perceived stress.

### Moderator role of acculturation

Table 5 presents the multiple linear regression analysis results for the moderator role of acculturation in the relationship between weight stigma and log hair cortisol. In both models III and IV, the regression coefficients were small and non-significant for the interaction term between weight stigma and acculturation, whether with ( $\beta = 0.03, t = 0.12, p = 0.90$ ) or without ( $\beta = -0.01, t = -0.03, p = 0.97$ ) the outliers, after adjusting for age, BMI, level of perceived racism for Asian Americans, level of perceived stress, and years lived in the United States and Asia.

### Discussion

This study found no statistically significant association between weight stigma and hair cortisol when controlling for age, BMI, perceived racism, and perceived stress. These findings were different from what we expected. Our results appeared dissimilar to the study by Jackson et al. (2016), who found a significant positive association between self-reported perceived weight discrimination and hair cortisol. Jackson et al.'s (2016) study had a larger sample size (563 participants) compared to this study. Also, participants who had a low prevalence of perceived weight discrimination were excluded from Jackson et al.'s (2016) study. Finally, 2-cm hair samples were used in Jackson et al.'s (2016) study to reflect cumulative cortisol in the hair over the preceding 2 months, whereas 1-cm hair samples were used in this study, which represented a 1 month of cumulative cortisol level. Moreover, in two previous studies, a lack of association of stress with hair cortisol has been reported (Boesch et al., 2015; Milam et al., 2014). Boesch et al.

**Table 2.** Results of weight stigma, hair cortisol, acculturation, perceived racism, and perceived stress by total sample and weight status.

Measures	Total group ( <i>n</i> = 166)	Overweight ( <i>n</i> = 114)	Obese ( <i>n</i> = 52)	<i>t</i>	<i>p</i> -value
	Mean · SD (range)	Mean · SD	Mean · SD		
Hair cortisol (pg/mg)	23.43 · 30.47 (3.37–215.05)	23.82 · 31.59	22.59 · 28.12	−0.55 <sup>a</sup>	0.5853
Stigmatizing Situations Inventory	0.28 · 0.33 (0–2.4)	0.22 · 0.30	0.40 · 0.36	3.28	0.0013
Suinn–Lew Asian Self-Identity Acculturation Scale	2.21 · 0.42 (1.43–4.57)	2.20 · 0.37	2.24 · 0.51	0.55	0.5859
Subtle and Blatant Racism Scale	20.07 · 5.68 (0–36)	20.44 · 5.02	19.25 · 6.88	−1.12	0.2672
Perceived Stress Scale	16.20 · 5.62 (2–30)	15.82 · 5.42	17.04 · 6.03	1.30	0.1948

SD: standard deviation; overweight: BMI = 23.0–27.5 kg/m<sup>2</sup>; obese: BMI > 27.5 kg/m<sup>2</sup>; *t*: *t*-value for independent groups *t*-test; degrees of freedom = 164; pg/mg: picograms per milligram.

<sup>a</sup>The natural log transformation was applied to the hair cortisol data in *t*-test.

**Table 3.** Pearson's correlation coefficients for pairs of continuous variables for total sample (*n* = 166).

Measures	$\alpha^a$	$\alpha^b$	1	2	3	4	5	6	7	8	9	10
1. Age	–	–										
2. BMI	–	–	0.02									
3. Years lived in Asia	–	–	0.47**	−0.11								
4. Years lived in the United States	–	–	0.51**	0.13	−0.46**							
5. Frequency of swimming	–	–	0.05	0.27**	−0.06	0.09						
6. Frequency of hair wash	–	–	−0.08	0.08	−0.10	0.01	0.17*					
7. Hair cortisol (log)	–	–	0.23**	−0.05	0.05	0.11	0.01	−0.02				
8. Weight stigma	0.94	0.94	−0.18*	0.40**	−0.12	−0.06	0.11	0.08	−0.19*			
9. Acculturation	0.91	0.86	−0.29**	0.23**	−0.66**	0.33**	0.06	0.03	−0.06	0.27**		
10. Perceived racism	0.84	0.79	−0.17*	0.01	−0.14	−0.04	0.14	0.07	−0.12	0.41**	0.19*	
11. Perceived stress	0.74	0.75	−0.22**	0.12	−0.06	−0.16*	0.07	−0.07	−0.04	0.30**	0.17*	0.31**

$\alpha^a$ : Cronbach's alpha from previous studies with Asian participants;  $\alpha^b$ : Cronbach's alpha from this study; frequency of swimming: average swimming during last month (per week); frequency of hair wash: average hair wash during last month (per week).

\**p* < 0.05; \*\**p* < 0.01.

(2015) used a longitudinal study to examine the association between the perceived stress from a 11-week military training and hair cortisol level among 105 male adults. The result from Boesch et al.'s (2015) study showed that the military training increased the perceived stress level, but no significant association between the perceived stress and hair cortisol level was found. A pilot study was conducted by Milam et al. (2014) to test the relationships between self-reported perceived stress, stressful life events, depressive symptoms, dispositional optimism, and hair cortisol levels among 28 adolescents aged between 12 and 18 years. Milam et al. (2014) found that none of the perceived stress, stressful life events, or depressive symptoms significantly associated with hair cortisol level. There were various possible explanations for the non-significant relationship between hair cortisol and self-reported stress in both

studies noted above, such as small sample size and lack of other potential influence factors. Nevertheless, the absence of significant associations between weight stigma and hair cortisol in this study confirms the findings of Boesch's (2015) and Milam's (2014) studies but does not provide evidence about the effect of weight stigma on physiological function.

The non-significant relationship between weight stigma and hair cortisol in this study may be explained as follows. Our regression analysis demonstrated that weight stigma was not a significant factor in relation to hair cortisol, which necessitated us to examine more closely weight stigma in our sample. The frequency of weight stigma observed in this study was low, indicating our participants did not often encounter weight stigma or the items from the SSI (Myers and Rosen, 1999) were not well endorsed by



**Table 4.** Multiple linear regression results for association of weight stigma and log-transformed hair cortisol adjusting for control variables, with and without extreme hair cortisol observations.

	Model I (n = 166)			Model II (n = 160)		
	Hair cortisol (log)			Hair cortisol (log)		
	$\beta$	95% CI	$R^2$	$\beta$	95% CI	$R^2$
			0.08*			0.06
Weight stigma	-0.344	(-0.780, 0.093)		-0.157	(-0.530, 0.217)	
Age (years)	0.016	(0.004, 0.029)**		0.012	(0.001, 0.022)*	
BMI (kg/m <sup>2</sup> )	-0.002	(-0.043, 0.039)		-0.001	(-0.036, 0.034)	
Perceived racism	-0.007	(-0.030, 0.017)		0.001	(-0.020, 0.021)	
Perceived stress	0.007	(-0.013, 0.031)		-0.009	(-0.029, 0.011)	

Control variables for both models: age, BMI, perceived racism for Asian Americans, and perceived stress; model I: adjusted for the five control variables with the total sample; model II: adjusted for the five control variables without six extreme hair cortisol observations;  $\beta$ : linear regression coefficient estimate; CI: confidence interval;  $R^2$ : coefficient of determination.

\* $p < 0.05$ ; \*\* $p < 0.01$ .

**Table 5.** Multiple linear regression results for testing the moderating role of acculturation in the association between weight stigma and log-transformed hair cortisol adjusting for control variables, with and without extreme hair cortisol observations.

	Model III (n = 166)			Model IV (n = 160)		
	Hair cortisol (log)			Hair cortisol (log)		
	$\beta$	95% CI	$R^2$	$\beta$	95% CI	$R^2$
			0.11*			0.06
Weight stigma	-0.393	(-1.652, 0.866)		-0.114	(-1.199, 0.971)	
Acculturation	-0.014	(-0.465, 0.436)		-0.099	(-0.491, 0.293)	
Weight stigma $\times$ acculturation	0.027	(-0.412, 0.466)		-0.006	(-0.386, 0.373)	
Age (years)	0.055	(0.020, 0.091)**		0.0003	(-0.048, 0.049)	
BMI (kg/m <sup>2</sup> )	-0.005	(-0.046, 0.036)		-0.001	(-0.037, 0.035)	
Perceived racism	-0.009	(-0.032, 0.014)		0.001	(-0.020, 0.021)	
Perceived stress	0.010	(-0.013, 0.032)		-0.009	(-0.029, 0.0116)	
Years lived in the United States	-0.038	(-0.073, -0.003)*		0.013	(-0.035, 0.061)	
Years lived in Asia	-0.043	(-0.080, -0.006)*		0.007	(-0.042, 0.056)	

Control variables for both models: age, BMI, perceived racism for Asian Americans, perceived stress, and years lived in the United States and Asia; model III: adjusted for the six control variables with the total sample; model IV: adjusted for the six control variables without six extreme hair cortisol observations;  $\beta$ : linear regression coefficient estimates; CI: confidence interval;  $R^2$ : coefficient of determination.

\* $p < 0.05$ ; \*\* $p < 0.01$ .

our participants. The SSI may need to be tailored for this population. For example, item 13 of the SSI is “*Being singled out as a child by a teacher, school nurse, etc. because of your size.*” Some of our participants reported that item 13 confused them because they were normal weight when they were children and became overweight as an adult. Items in the questionnaire may not have truly reflected our participants’ weight stigma experience and may be one reason that they had low weight stigma scores in this study. Also, a lower mean BMI was observed in this study compared to previous weight stigma research (Wu and Berry, 2017). A recent review of the literature reported that the mean BMI of participants from 33 weight stigma studies was  $33.6 \pm 7.6 \text{ kg/m}^2$  (Wu and Berry, 2017), where the mean

BMI in this study was  $26.6 \pm 3.1 \text{ kg/m}^2$ . The lower mean BMI of our participants may also lead to the lower weight stigma since the higher the BMI, the greater the weight stigma (Tomiyama, 2014). The low weight stigma scores may have contributed to the non-significant association with hair cortisol in our study. Furthermore, it is noteworthy that there was a temporal mismatch between accumulated cortisol in our hair samples and the timespan of the SSI (Myers and Rosen, 1999). The SSI asks about frequency of weight stigma over their lifetime, where our 1-cm hair cortisol measurement reflected accumulated cortisol as well as the level of stress in the past month. Therefore, the frequency of weight stigma we measured may not have represented the stress that participants

experienced in the past month. In future studies, we will ask participants about their weight stigma frequency in the past month to more closely match the 1-cm hair cortisol measurements. In addition, hair cortisol and perceived stress were not significantly correlated, even they were both measured over the past month. The overall score of the Perceived Stress Scale (Cohen et al., 1983) ranges from 0 to 40. However, our sample reported a low mean score of perceived stress with a range from 2 to 30, and 71.1 percent ( $n=118$ ) of our participants reported a score below 20. The level of perceived stress we observed from our sample may have a rather low-intensity range that only had minor effects on integrated long-term hair cortisol level (Stalder et al., 2017).

This study did not find evidence of moderation by acculturation independent of controls, meaning that the relationship between weight stigma and hair cortisol was not influenced by participants' cultural identity. This finding is similar to Shim and Schwartz's (2008) study, which investigated the association of acculturation and adherence to Asian values with psychological distress among 118 Korean immigrants living in the Midwestern United States. Shim and Schwartz (2008) found that the level of acculturation and adherence to Asian values did not significantly associate with psychological distress after adjusting for sex and years of living in the United States or educational levels. The non-significant influence of acculturation on the relationship between weight stigma and hair cortisol found in our study could be explained in two ways. First, our study did not have enough participants to represent a wide range of levels of acculturation. Also, both our study and Shim and Schwartz's (2008) study used the Suinn–Lew Asian Self-Identity Acculturation Scale (Suinn et al., 1992) to determine the level of acculturation. This scale focuses on actual practice and behaviors that are adopted when immigrants arrive in the United States, such as speaking English and music and food preferences, but does not contain questions that could determine the degree of beliefs and attitudes about stigmatization (Suinn et al., 1992), which may reduce the applicability of this questionnaire for weight stigmatization.

### **Study strengths and limitations**

Our study had several limitations. First, our study did not include a measure of internalized weight stigma. Individuals who experienced weight stigma did not necessarily internalize the stigma and self-stigmatize themselves (Pearl et al., 2015). Individuals with and without internalized weight stigma may have different levels of stress. Second, most of the participants in this study were recruited from local Asian churches and spiritual support from the churches may affect one's perception of weight discrimination (Saad and de Medeiros, 2016). Third, the sample was almost exclusively Chinese-speaking Asian Americans, so the

findings cannot be generalized to include other Asian Americans. Fourth, little variability in the scores reflecting weight stigma and acculturation was observed in our samples, and the results may not be generalizable across the entire spectrum of these measures in Asian Americans. Finally, causality was unattainable because the exposure and outcome were simultaneously assessed for each of our subjects, so we do not have temporal precedence of the exposure to show causality for the outcome in this cross-sectional study (Carlson and Morrison, 2009). Despite its limitations, this study targeted population of Asian Americans with overweight and obesity and used hair cortisol as a novel and non-invasive indicator to examine HPA axis activity under long-term exposure to weight stigma.

### **Future research directions**

Weight stigma research is understudied in Asian Americans. Future weight stigma research should include various Asian American groups, such as Filipino and Japanese Americans, to understand the impact of weight stigma across different Asian ethnic groups. Also, the impact of internalized weight stigma versus the effect of experienced weight stigma on health outcomes needs further exploration. Future research is needed to examine whether the SSI can accurately measure weight stigma experiences of Asian Americans. Focus groups could be conducted to gather information from Asian Americans' perspectives and experiences about weight stigma and to compare those perspectives and experiences with the items of the SSI. Future longitudinal studies could demonstrate the long-term effects of weight stigma on hair cortisol and reveal the possible relationship between the chronic stress of weight stigma and HPA axis activity. Finally, our study demonstrated that the method of collecting hair samples for cortisol was acceptable for a community sample of Asian Americans. Future research could consider using hair cortisol as a biomarker of chronic stress for Asian Americans.

### **Conclusion**

Conclusions from this study are limited by not finding sufficient evidence to support the relationship between weight stigma and hair cortisol and the moderating role of acculturation. Future research should unmask the effects of weight stigma on hair cortisol using longitudinal evidence with different Asian American groups and proper measurements of weight stigma.

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