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An Examination of Whether Perceived Stress Mediates the Effects of Income on Engagement and Weight Loss Outcomes in an Online Behavioral Weight Loss Intervention

Kristen Volz
kristen.volz@uconn.edu

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An Examination of Whether Perceived Stress Mediates the Effects of Income on Engagement and Weight Loss Outcomes in an Online Behavioral Weight Loss Intervention

Kristen A. Volz
Bachelor of Science
University of Connecticut
2017

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Abstract

Individuals with lower income have higher rates of obesity and are underrepresented in weight loss treatment. Moreover, when individuals with lower income do enroll in face-to-face interventions, their adherence and weight loss outcomes are worse due to known treatment barriers, including unreliable transportation, lack of childcare, and scheduling constraints associated with multiple jobs and unconventional work hours. Because online interventions are asynchronous and can be accessed any time of day, they hold significant promise for reducing treatment barriers and improving adherence and weight loss outcomes in lower income populations. However, one drawback of online interventions is that they are self-directed, which, in the context of multiple life stressors, may be particularly challenging. This study examined whether income is in fact associated with engagement and weight loss outcomes in an online weight loss program, and whether perceived stress mediates these effects. We hypothesized that lower income would be associated with less engagement with the weight loss program and poorer weight losses and that stress would mediate these effects.

Participants (N=260, 79% female, 71.9% White/Non-Hispanic/Latino, age 50.7±11.9 years, 331 ± 129.6% above the poverty line, BMI 35±5.7kg/m²) received a 16-week DPP-based online behavioral weight loss intervention. Income was assessed via self-reported data. Engagement (weeks lesson viewed and weight entered) was obtained from the intervention website. Weight loss was calculated using objective measurement when available, or, when unavailable, last weight reported on the website. Stress was measured with the Perceived Stress Scale.

Our mediation analyses indicated perceived stress mediated the relationship between income on engagement [β = 0.001, 95% CI = 0.02-0.3]. Through the mediator of stress, lower
income was associated with lower stress scores ($\beta = -0.37$, $p = 0.01$, 95% CI = -0.66-(-0.08)) and lower engagement was associated with higher stress scores ($\beta = -0.369$, $p = 0.001$, 95% CI = -0.58-(-0.16)). Additionally, higher levels of stress partially mediated the relationship between income and percent weight loss [$\beta = -0.1$, 95% CI = -0.3-(-0.03)]. Through the mediator of perceived stress, lower income was associated with less weight loss ($\beta = -0.352$, $p = 0.001$, 95% CI = 0.14-0.56).

These findings demonstrate that perceived stress mediates, in part, the relationship between income and obesity treatment outcomes in an online intervention. Thus, stress reduction interventions may be critical to effectively engage individuals with lower income and improve weight loss in obesity treatments.
Overweight and obesity are prevalent, particularly among individuals from lower income backgrounds (commonly defined by the federal poverty line, which accounts for household income divided by household size [The George Washington University, 2018]). Whereas two-thirds of American adults are overweight or obese (CDC, 2018), nearly 85% of adults from low-income backgrounds suffer from overweight or obesity and associated health ailments (Ogden et al., 2014; Beckles et al., 2016). Likewise, individuals from lower income backgrounds are more likely to develop costly and debilitating obesity-related health conditions, such as type 2 diabetes and cardiovascular disease (American Diabetes Association, 2011; World Health Organization, 2018).

Despite their high risk, individuals with lower income are alarmingly underrepresented in obesity treatment programs (Diabetes Prevention Program Research Group, 2002; Svetkey et al., 2008). Moreover, when they do enroll, they tend to achieve poorer weight loss outcomes relative to individuals of higher income (Kalarchian et al., 2011). One common barrier to treatment and treatment engagement among individuals with lower income is the need to attend in-person sessions, which require transportation and childcare (Warner et al., 2013; Bennett et al., 2012). Thus, interventions are needed that reduce barriers to treatment.

Individuals with low income have high (85%) internet access (Perrin & Duggan, 2015), thus, web-based interventions may reduce barriers to treatment for individuals with lower income. That is, web-based interventions eliminate the need for in-person visits, which can be costly and burdensome (e.g., transportation, childcare). Further, the asynchrony of web-based programs (accessible any time of day / night) may eliminate adherence barriers among low-income populations by making treatment accessible to individuals working multiple jobs or
unconventional hours (Davis et al., 2006; Kumanyika, 2006; Graffagnino et al. 2006). Taken together, web interventions may be applicable and attractive to individuals from lower income.

While web-based obesity treatments may be particularly appealing and relevant for individuals with lower incomes, previous studies have shown suboptimal adherence among lower income individuals enrolled in web-based programs (Harvey-Berino et al., 2010). A study by Leahey and colleagues (2018) compared adherence among lower income individuals vs. higher income individuals enrolled in an online behavioral weight loss program. Lower income individuals logged into the platform less often (Lower Income: 70.2%, Higher Income: 82.1%), viewed fewer lessons (Lower Income: 47.1%, Higher Income: 59.6%), and submitted fewer self-monitoring records (weight, diet, activity logs), (Lower Income: 23.6% of days, Higher Income: 48.7% of days). Further, lower income individuals lost significantly less weight compared to their higher income counterparts (Lower Income: 3.4 ±4.2%, Higher Income: 4.9 ±4.0%), (Leahey et al., 2018). This data suggests that while web-based obesity treatments hold promise for reaching individuals with lower income by reducing treatment barriers, developing a better understanding of factors that may impede adherence and undermine weight loss in web interventions is needed.

Stress, often defined as an individual’s response to events that disturb equilibrium and tax his/her ability to cope (American Psychiatric Association, 2013), may be an important factor that impedes adherence and attenuates weight loss outcomes among individuals with lower income. Stress is commonly assessed with objective and self-report measures. Common objective measures include serum cortisol, allostatic load, HPA, and heart rate variability (HRV) (Walvekar et al., 2015; Epet et al., 2018; Ryan, 2014; Föhr et al., 2015). One of the benefits of these measures is that they yield a pure physiological response and objective outcome data (Epet
et al., 2018; Föhr et al., 2015). However, there are also some limitations to objective assessments of stress. For example, cortisol may not be predictive of long-term outcomes because reactivity is highly influenced by a variety of contextual factors (conscious or unconscious) and reactivity alone is a weak predictor of outcomes (Epet et al., 2018). Similarly, HRV has very high inter- and intra-individual variability, sometimes making it difficult to interpret as a measure of stress (Epet et al., 2018). In weight loss and other studies, stress has been commonly measured using self-report instruments, which assess perceived stress (Trief et al., 2014; Payne et al, 2018; Kim et al., 2009). Common self-reported measures include the perceived stress scale (PSS), the State-Trait Anxiety Inventory (STAI), the Profile of Mood States (POMS), the Positive and Negative Affect Schedule (PANAS), or a combination of these measures (Harrer et al., 2013; Brinkworth et al., 2009; Tomiyama et al, 2010; Imayamma et al., 2011; Green et al, 2005; Wing et al., 1991).

The benefits to using self-reported measures of perceived stress are the ability to capture a mix of affective states and cognitions in response to a situation, the ability to measure one’s perceived stress, and the brevity and reliability of these measures (Epet et al., 2018; Warttig et al, 2013). However there are also limitations to self-report measures, including scores that do not always correspond to physiological or biological measures of stress, participants’ inability to accurately report levels of stress, and cultural factors influencing one’s willingness to express emotion/feelings of stress (Epet et al., 2018).

Individuals with lower income have been shown to experience more stressful life events (Brondolo et al., 2017). This increased stress is likely due to a variety of factors including competing life demands (e.g., working multiple jobs and caring for family), income insecurity, and discrimination (due to income, race, ethnicity) (Sinha et al., 2013; Cozier et al., 2014). Studies have shown that increased stress levels are linked to weight gain through both
behavioral, physiological, and biological factors, via objective measures of stress (hormones) (Institute of Medicine (US), 2001; Ryan, 2014). That is, high levels of perceived psychological stress (i.e., self-report stress) are associated with factors related to unhealthy lifestyles such as a greater incidence of physical inactivity, emotional eating, and stimulating appetite (cortisol) for foods that are energy dense (Rod et al., 2009; Torres et al., 2007). Evidence suggests that these higher levels of stress may impede weight loss during treatment. In comparison to other weight loss studies using the PSS, score averages were 10.5, 14.2, and 17.4 using the 40 point scale, which when scaled are comparable to the PSS-4 marker for “stressed” participants (Payne et al., 2018; Morin et al., 2018; Trief et al., 2014). In a study by Trief and colleagues (2014), individuals with high stress, measured via the PSS-14, lost significantly less weight during a behavioral weight loss program (Trief et al., 2014). Further, individuals with higher stress also completed fewer intervention sessions (High Stress: 7.1 sessions; Low Stress: 9.2 sessions), fewer self-monitoring records (High Stress: 18.3%; Low Stress: 47.3%), and were less likely to complete treatment (High Stress: 39.3% completed; Low Stress: 62.0% completed). These data suggest that stress may negatively impact obesity treatment program adherence and outcomes.

The current study examined the influence of income on website engagement and percent weight loss among adults enrolled in an online weight loss program. Further, the mediating role of stress was examined. It was hypothesized that lower income would be associated with poorer engagement and poorer weight losses and that stress would mediate these effects.
Methods

Study design.

Participants (N=260) were recruited via mass mailings and email listservs. Study exclusion criteria were BMI < 25 kg/m$^2$ or >50 kg/m$^2$, age <18 or >70 years, a health condition that would make changes to diet or exercise unsafe (e.g., pregnancy, uncontrolled heart condition), current participation in another weight loss program, unreliable Internet access, history of bariatric surgery, planned relocation during the study period, ≥ 5% weight loss in the past 6 months, or deemed unlikely to follow the study protocol. All participants completed a one-time, in-person, group-based “Weight Loss 101” session during which they received their weight loss goal (lose 5-10% of initial body weight), their calorie goal (1200-1800 kcal/day and 30% of calories from fat), and exercise goal (gradually increase to 250 minutes of moderate intensity physical activity per week). Participants were also instructed how to accurately self-monitor their weight, diet, and activity using MyFitnessPal (smartphone app) or paper/pencil diaries and a calorie reference book. Following the one-time in person session, participants received access to the 16-week online behavioral weight loss program. The online program was based on the
Diabetes Prevention Program (Diabetes Prevention Program et al., 2002) and involved weekly multimedia lessons focused on reducing calories, increasing physical activity, goal setting, stimulus control, and problem solving. It also included a self-monitoring platform where participants submitted their weekly weight, diet, and activity information and received personalized, automated feedback on their progress. The website also included supplemental materials to help participants reach their weight loss goals (e.g., meal plans). Assessments were conducted at baseline and post-treatment.

**Measures.**

*Demographics:* Participants self-reported basic demographic information including sex, age, race, and ethnicity.

*Income:* Annual income was collected, along with household size. Income was calculated based on percent of the federal poverty line, which is dependent on household size. An income of 100% indicates an income at the federal poverty line, an income of greater than 100% is indicative of above the federal poverty line, and in income of less than 100% is indicative of less than the federal poverty line. Of note, federal benefits (e.g., WIC, housing, healthcare) are typically available to individuals ≤200% of the federal poverty line (Widor, 2019; Cochran, 2017).

*Engagement:* Engagement with an online intervention is commonly measured as both viewing weekly video lessons and submitting self-monitoring information into the online platform (Leahey et al., 2014). As such, website engagement was calculated by number of weeks participants interacted (“clicked”) on the site and input self-monitoring data (weight, diet, and activity) into the program website at least once per week. This variable was dichotomized; participants received a 1 for each week they completed both tasks (interacted with website and...
imputed self-monitoring data) and a 0 for each week in which they did not complete both tasks. Given that the online program was 16 weeks in duration, possible scores range from 0 to 16.

**Weight, height, and BMI:** Weight and height were objectively assessed at baseline using a digital scale and stadiometer. BMI was calculated using the formula weight in kg / height in m$^2$. Post-treatment weight was obtained objectively or, when unavailable, last reported weight in the intervention website was used. Percent weight loss was calculated using the following formula: 

$$\left(\frac{\text{baseline weight} - \text{post-treatment weight}}{\text{baseline weight}}\right) \times 100.$$ 

**Stress:** Given that the four-item Perceived Stress Scale (PSS-4) has been successfully used in previous weight loss studies, successfully predicting weight loss outcomes (Harrer et al., 2013), the PSS-4 was used to measure stress (the proposed mediator) in this study (Cohen, 1983). Relative to its predecessors, the four-item PSS-4 has a moderate loss in internal reliability in comparison to the 14-item PSS ($r=0.60$ vs $r=0.85$); however, the brevity of the PSS-4 (4 items) lends itself well to settings in which assessment time is limited. Further, it has been shown to accurately measure general amounts of stress in one’s life, rather than one’s response to a specific stressor (Warttig et al., 2013; Cohen and Williamson, 1988; MacArthur, 2000). The PSS-4 has been successfully validated against objective measures of stress (serum cortisol, HRV) and individuals categorized as stressed scoring highly on both measures (Walvekar et al., 2015; Föhr et al., 2015). Participants in this study responded to items on a 5-point Likert Scale (e.g., “In the last month, how often have you felt nervous or ‘stressed’?” 0 [Never] to 4 [Very Often]). Possible scores range from 0 to 16. Higher scores indicate higher levels of perceived stress. Scale reliability (Cronbach’s alpha) for this study was good ($\alpha=0.81$). The PSS-4 has also been shown to be reliable in other studies (e.g., Cohen et al, 1983; Harrer et al., 2013; Walvekar et al., 2015; Föhr et al., 2015). A score of 8 or higher on the PSS-4 is deemed “stressed” (Harrer
et al., 2013). Stress scores from the current study were comparable to stress scores reported in other weight loss / obesity studies (Payne et al., 2018; Morin et al., 2018).

Statistical Analysis.

Statistical analyses were completed using SPSS version 25; significance level was set at p-value ≤0.05 with a confidence interval of 95% (Hayes, 2019). Descriptive statistics were conducted to examine participant characteristics (age, education, race, ethnicity, BMI, percent weight loss, stress, and income). Ethnicity and race were assessed as two different groups, Non-Hispanic White vs. Hispanic or racial minority. Normality of variables was assessed by the Shapiro-Wilk (engagement) or skewness and kurtosis statistic (percent weight loss) when appropriate. Pearson correlation analysis was used to test relationships between participant characteristics of stress, income, engagement, age, and percent weight loss. Independent t-tests were used to assess differences between sex (male/female), ethnicity (Non-Hispanic White vs. Hispanic), and engagement (yes/no) when appropriate to test differences between variables of interest (income, perceived stress, and percent weight loss). Association between the independent (income) and dependent variables (engagement and percent weight loss) was assessed by a linear regression. A mediation analysis using PROCESS v3.1 macro model 4 was conducted. Model 4 is a simple mediation model, which at least one casual antecedent X variable is proposed as influencing an outcome Y through a single intervening variable M (Hayes, 2019). In our models, there are two pathways by which income can influence our dependent variables, i.e., engagement and percent weight loss. (Hayes, 2019). Pathway c defined as the total effect of how much one unit of income are estimated to differ on engagement and percent weight loss. Path a quantifies how much it is estimated the increase or decrease of stress by one unit on income. Path a was
measured per 100% of income, which reflects the scale more appropriately due to the larger distribution of the income variable. Path b observes how much it is estimated the increase or decrease of stress on engagement and percent weight loss. Path c’ observes the direct effect of income on engagement and percent weight loss.

Results

Participant Characteristics.

Participants (N=260) were predominantly female (79.2%), with an average age of 50.7 ± 11.9 years. Average participant income was 331±129.6% above the poverty line (range = 31.5 - 600.5%). Average engagement (weeks of viewing lessons and submitting self-monitoring data), percent weight loss, and stress score were 8.3 ± 4.9 weeks, -6.7%±4.9 percent weight loss, and 5.6±2.9 (range = 0-15) stress score, respectively. A t-test examined the association between demographic characteristics and variables of interest. Women lost less weight than men (Females: -6.3%±4.7, Males: -8.2%±5.5, p = 0.02). Younger age was associated with lower income, higher stress, and less weight loss (r = 0.44, p = 0.01; r = -0.20, p= 0.01; r= -0.19, p=0.003, respectively). Remaining associations between demographic characteristics and outcomes of interest were non-significant.

Mediating Effect of Perceived Stress on Income and Engagement.

Mediation analysis was conducted to investigate whether perceived stress mediates the relationship between income and engagement with the online weight loss program. The direct effect between income and engagement controlling for stress was not significant (β = 0.002, 95% CI = -0.003-0.007). An indirect effect of income on engagement through perceived stress was significant [β = - 0.001, 95% CI = 0.02-0.30; Figure 3]. This pattern of results suggests that
perceived stress fully mediates the effects of income on engagement in an online weight loss program.

Figure 3: Significant pathways and beta-coefficients of the mediation model of income and perceived stress scores on engagement.

**Mediating Effect of Perceived Stress on Income and Percent Weight Loss.**

The mediating effect of perceived stress on the relationship between income and percent weight loss was also investigated. The effect of income on percent weight loss was significant, with lower income associated with less weight loss ($\beta = -0.155$, $p = 0.02$). However, the direct effect of income and percent weight loss controlling for perceived stress was not significant, ($\beta = -0.005$, 95% CI = -0.009-0.0002). Additionally, there was a significant pathway between income and perceived stress ($\beta = -0.37$, 95% CI = -0.66-(-0.08)), with lower income associated with more stress. Further, the pathway between perceived stress and percent weight loss was significant ($\beta = 0.352$, 95% CI = 0.14-0.56), with higher stress associated with less weight loss. This pattern of results suggests that stress partially mediated the relationship between income and percent weight loss [$\beta = -0.1$, 95% CI = -0.3- (-0.03)]. Please see Figure 4.
Discussion

The results from this study suggest that low income is associated with poorer obesity treatment outcomes in web-based interventions and that this relationship is accounted for, at least in part, by stress. The findings of this study are consistent with and contribute to the research on income, stress, and obesity treatment engagement and outcomes. The association between lower income and higher stress levels is supported by previous research, where lower income individuals have more stressful life events than their higher income counterparts (Brondolo et al., 2017). Our findings are also consistent with previous literature showing that stress negatively impacts engagement and treatment outcomes in-person behavioral intervention (Trief et al., 2014; Gaalema et al., 2017). Of note, the present research also extends this prior work beyond in-person sessions to online programs and, to our knowledge, is the first study to demonstrate that income is associated with treatment outcomes in such programs and that stress mediates these effects.

Figure 4: Significant pathways and beta-coefficients of the partial mediation model of income and perceived stress scores on percent weight loss.
Given these findings showing that stress impacts the effectiveness of health interventions, adding stress management strategies (e.g., deep breathing, progressive muscle relaxation, time management) to obesity treatment may improve weight loss outcomes, particularly in individuals with lower income. Such an approach could lead to better engagement, weight loss outcomes, and health effects. Indeed, previous research has shown that among adults with obesity (regardless of income), a stress management weight loss intervention consisting of a 8-week course comprised of diaphragmatic breathing, progressive muscle relaxation, and guided visualization, yields a significantly greater weight loss and reduction in stress compared to a weight management program without a stress management component (Xenaki et al., 2018). Similarly, progressive muscle relaxation has been associated with better compliance to a dietary program (Wynd, 2006).

This study had some limitations and notable strengths. Limitations of this study include a predominantly female, middle-age sample, which is consistent with most other weight loss studies (e.g., Payne et al., 2018; Crain et al., 2018). While this study had some racial and ethnic minority representation (40%), future studies should examine the effects of stress on a more diverse population. The Perceived Stress Scale was completed once; stress levels may change over time and even within each day depending on daily hassles and life events, thus, future studies may consider using more frequent assessments of stress to understand how stress impacts engagement and weight loss on a daily basis. Objective (cortisol, heart rate variability) and other multidimensional measures of stress may also be important to consider in future studies (Kim et al., 2009). Whereas 100% of participants provided objective weight at baseline, at post-treatment 49% of participants had objective weight data and 51% had self-report weight data via the study website. While self-report weight data has been shown to be accurate (Short et al., 2009), it
would have been ideal to obtain objective weight data on all participants at post-treatment. This study also had important strengths. This study demonstrated for the first time that income and stress impact engagement and obesity treatment outcomes in an online behavioral weight loss intervention and that stress mediates this effect. Future research may focus on developing and testing online stress reduction interventions (e.g., diaphragmatic breathing, progressive muscle relaxation, guided visualization [Xenaki, 2018]) in order to improve treatment outcomes in individuals with lower income, and, thus, improve obesity treatment and other health outcomes, particularly among high-risk, understudied low-income populations.

Conclusion

These findings demonstrate that the effects of income on treatment outcomes in an online obesity treatment intervention operate through perceived stress. Thus, stress reduction interventions (deep breathing, progressive muscle relaxation, exercise, counseling [American Diabetes Association, 2013]) may be critical in order to effectively engage individuals, particularly those with lower income, in online obesity treatment programs.
<table>
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<th>Table 1: Participant characteristics.</th>
<th>Percent (N) or Mean (SD)</th>
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References


Retrieved April 21, 2019, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3969538/


Hayes, Andrew F. “The PROCESS Macro for SPSS and SAS.” The PROCESS Macro for SPSS and SAS, 2019, processmacro.org/faq.html.


