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Diet Quality as a Mediator of the Relation between Income-to-Poverty Ratio and Overweight/Obesity among Adults: Moderating Effect of Sex

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Abstract

Poverty status influences obesity and dietary quality, and dietary quality influences obesity. How these relationships differ by sex is unclear. The current study aims were to 1) determine whether dietary quality mediates the relation between income-to-poverty ratio (IPR) and overweight/obesity (OV/OB) among men and women, separately, and 2) determine whether either of the mediated paths differs by sex. Four cycles of NHANES (2007-2014) were merged to obtain an unweighted study sample of 12,768 adults with complete data. Exposure variables included self-reported measures of IPR, Healthy Eating index (HEI) total score to measure diet quality, and sex. Direct assessment of height and weight was used to create OV/OB vs. normal weight categories of interest. A multiple-group moderated mediation model was conducted to evaluate the moderating effect of sex on the association between IPR and OV/OB through HEI. Covariates included age, race, marital status, education, employment, meeting physical activity recommendations, and daily sedentary time. A greater proportion of females experienced OV/OB, lower IPR, and higher HEI. The association between IPR and HEI did not differ by sex. Greater IPR was associated with lower odds of experiencing OV/OB for women and higher odds of experiencing OV/OB among men. For both males and females, HEI partially mediated the relationship between IPR and OV/OB ($p < .05$). While efforts to improve dietary quality of all adults regardless of income and sex is needed, improving the dietary quality of higher income men may assist with reducing their experiences with OV/OB.

Keywords

Healthy eating index, poverty, overweight/obesity, moderated mediation model, sex differences

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Abstract

Poverty status influences obesity and dietary quality, and dietary quality influences obesity. How these relationships differ by sex is unclear. The current study aims were to 1) determine whether dietary quality mediates the relation between income-to-poverty ratio (IPR) and overweight/obesity (OV/OB) among men and women, separately, and 2) determine whether either of the mediated paths differs by sex**.** Four cycles of NHANES (2007-2014) were merged to obtain an unweighted study sample of 12,768 adults with complete data. Exposure variables included self-reported measures of IPR, Healthy Eating index (HEI) total score to measure diet quality, and sex. Direct assessment of height and weight was used to create OV/OB vs. normal weight categories of interest. A multiple-group moderated mediation model was conducted to evaluate the moderating effect of sex on the association between IPR and OV/OB through HEI. Covariates included age, race, marital status, education, employment, meeting physical activity recommendations, and daily sedentary time. A greater proportion of females experienced OV/OB, lower IPR, and higher HEI. The association between IPR and HEI did not differ by sex. Greater IPR was associated with lower odds of experiencing OV/OB for women and higher odds of experiencing OV/OB among men. For both males and females, HEI partially mediated the relationship between IPR and OV/OB ($p < .05$). While efforts to improve dietary quality of all adults regardless of income and sex is needed, improving the dietary quality of higher income men may assist with reducing their experiences with OV/OB.

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Introduction

Almost 40% of U.S. adults experience obesity (Hales, Carroll, Fryar, & Ogden, 2017). Opportunities for reducing overweight/obesity (OV/OB) among U.S. adults are needed as obesity is associated with chronic diseases, such as diabetes, hypertension, hyperlipidemia, asthma, and arthritis (Mokdad et al., 2003). Researchers have consistently identified differences in obesity prevalence between lower and higher income groups (Scharoun-Lee, Kaufman, Popkin, & Gordon-Larsen, 2009). This inequity may be related to dietary quality (Drewnowski & Specter, 2004). The degree to which an individual's diet adheres to U.S. Department of Agriculture's dietary recommendations is based on the Healthy Eating Index (HEI) scale (Krebs-Smith et al., 2018). Foods with a lower HEI score have a tendency to be energy dense (i.e., higher in sugar and fat). Energy dense foods are often highly palatable, which may lead to a preference and overconsumption.

Consistent with inequities in obesity by income status, diet quality inequities are also related to income status. Compared to higher income families, lower income families are more likely to purchase energy-dense foods (Drewnowski & Eichelsdoerfer, 2010) and consume fewer vegetables and whole grains, which places them at risk for a lower HEI score (Drewnowski & Eichelsdoerfer, 2010). Prior studies using the HEI have identified income-HEI inequities, with lower HEI scores being associated with lower incomes. (Drewnowski & Specter, 2004). This income-dietary quality inequity has also been found in several European countries (Irala-Estevez et al., 2000; Michaud et al., 1998; Mooney, 1990). However, evidence is lacking on whether diet quality is a potential link between poverty and adult weight status. Therefore, the first aim of the current study was to determine whether dietary quality (as measured by HEI total score) mediates the relation between income-to-poverty ratio and overweight/obesity.

There is also evidence that the association between income and weight status differs by sex (Bruce, Sims, Miller, Elliott, & Ladipo, 2007). Specifically, the inequities observed between income and obesity appear to be particularly apparent among women (Hernandez & Pressler, 2014). Among women, the difference in the prevalence of obesity within lower income brackets (e.g., 45.2% for women ≤ 130% FPL) and higher income brackets (e.g., 29.7% for women with ≥ 350% FPL) is significantly different. Among men, these differences are minimal (32.6% versus 31.5%, respectively) (Ogden et al., 2017).

The associations between poverty and obesity (Ogden et al., 2017), poverty and poor dietary quality (Drewnowski & Eichelsdoerfer, 2010), and poor diet quality and obesity have been established (Drewnowski & Specter, 2004). However, the condition sex places on the relationship between: 1) income and dietary quality, and 2) dietary quality and weight status is less clear. In general, women appear to have higher HEI scores compared to men (Hiza, Casavale, Guenther, & Davis, 2013). Prior research has revealed that the correlation between HEI and obesity-related outcomes differ by sex (Guo, Warden, Paeratakul, & Bray, 2004; Tande, Magel, & Strand, 2010). According to Tande et al. (2010), the correlation between higher HEI score and lower risk of abdominal adiposity was stronger in men compared to women, and Drenowatz, Shook, Hand, Hébert, and Blair (2014) also reported that the association between higher HEI and lower body fat percent was significant only among men. Prior research also indicates that dietary quality is lower in food insufficient households (Drewnowski & Specter, 2004), and women in food insufficient households were more likely to be overweight; this relationship did not exist for men (Basiotis & Lino, 2003). Thus, it seems reasonable that there might be some moderating effect of sex on the relationship between: 1) income-to-poverty ratio and dietary quality, and 2) dietary quality and weight status. If HEI is a link between income-to-poverty ratio and OV/OB, this mediation effect might also differ by sex. Therefore, our second aim is to investigate whether the mediation effect is moderated by sex and to determine which of the mediated paths differ by sex.

Methods

Study Sample

Four cycles of NHANES (2007-2014) were merged to obtain an adequate sample size (N = 33,574). The NHANES' sampling design and data collection procedures have been previously described (Johnson, Dohrmann, Burt, & Mohadjer, 2014). The sample inclusion criteria for the current study involved adult participants (18 - 64 years of age) and excluded

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children, older adults, pregnant women, underweight adults, and adults of other race (18,516 excluded). Participants with missing data on weight status (n = 1,122), income-to-poverty ratio (n = 1,122), and covariates (n = 46) were excluded. The final study sample consisted of 12,768 (unweighted count) adults who completed the NHANES in-home family interview, private interview, and physical examination. Multi-year sample weights were computed by dividing the 2-year sample weights by the number of 2-year cycles and used for all analyses.

Compared with the sample excluded due to missing values (N = 2,290), the participants in the analytical sample were older (t = 15.94, $p < .001$), more likely to report an income-to-poverty ratio equal to or greater than three ($\chi^2 = 37.17$, $p < .001$), less likely to have an education less than high school ($\chi^2 = 29.51$, $p < .001$), and less likely to be Hispanic ($\chi^2 = 54.75$, $p < .001$) or non-Hispanic Black ($\chi^2 = 15.69$, $p < .001$). In addition, the analytic sample was more likely to include non-Hispanic white adults ($\chi^2 = 66.65$, p < .001), employed adults ($\chi^2 = 64.53$, $p < .001$), adults with a college degree or greater level of education ($\chi^2 = 36.96$, $p < .001$), and females ($\chi^2 = 4.69$, $p = .034$).

Measures

Weight status. Height and weight measurement procedures used to calculate Body Mass Index (BMI) that have been previously described (National Center for Health Statistics, 2013). A dichotomous variable was created to indicate overweight/obese vs. normal weight status (1 = overweight/obese, 0 = normal weight).

Income-to-poverty ratio (IPR) index. IPR is an indicator of socio-economic status (Okosun, Annor, Seale, & Eriksen, 2014). Compared to income, IPR is a better indicator of the household wealth as it takes into account the poverty guidelines specific to the household size, the residence state, and the year. It is a more robust measure of socio-economic status compared to education and occupation (Okosun et al., 2014). The IPR index was calculated by dividing self-reported family income by the poverty guidelines, specific to family size, and the appropriate year and state. (U.S. Department of Health & Human Services, 2011). While it is common to use IPR as a categorical variable, for the purpose of the multiple-group moderated mediation analysis, a continuous measure of IPR ranging from zero to five was used. Lower IPR indicates higher degree of poverty.

Diet quality. Diet quality was measured using the 2015 HEI total score. The process through which dietary assessments were collected, along with the content validity, construct validity, and reliability have been reported elsewhere (Guenther et al., 2014; Krebs-Smith et al., 2018; Reedy et al., 2018). Scores range from 0-100, with greater scores indicating a higher quality diet (Bowman, Lino, Gerrior, & Basiotis, 1998; Kennedy, Ohls, Carlson, & Fleming, 1995).

Sex. Participants self-reported their sex as male [reference] or female.

Covariates. A range of self-reported socio-demographic and physical activity (PA) characteristics were identified as potential confounders of the hypothesized model. Socio-demographic covariates included: age (years), race/ethnicity (Hispanic [reference], non-Hispanic white, non-Hispanic black), marital status (single [reference] vs. married/cohabitating), education (high school or greater [reference] vs. less than high school diploma), and employment status (unemployed [reference] vs. employed). Participants were classified as meeting PA recommendations (U.S. Department of Health & Human Services, 2018) if they reported ≥ 150 minutes/week of moderate to vigorous physical activity based on their leisure time PA, work-related PA, and transport PA (IPAQ Research Committee, 2005). Daily sedentary activity time (minutes/day) was assessed through a single questionnaire item about time spent sitting, except when sleeping. Daily sedentary activity time was converted to hours of sedentary time (hours/day) and used in the mediation models.

Statistical Analysis

All data were analyzed using Mplus version 8.2. Weighted descriptive analyses were performed for the total sample, by sex, and by weight status. Weighted mediation analysis controlling for covariates was performed using the total analytic sample to determine whether HEI mediates the association between IPR and OV/OB. Total effect of IPR on OV/OB (path c), effect of IPR on HEI (path a), effect of HEI on OV/OB (path b), and direct effect of IPR on OV/OB controlling for HEI (path c') were determined as significant if $p < 0.05$. The indirect effect of IPR on OV/OB through HEI was computed as the product of the two paths a and b (Figure 1). A significant indirect effect was evidenced by a biased corrected 95% bootstrap confidence interval (CI) not containing zero. The mediation effect was defined as a “full mediation” if inclusion of the mediation variable (HEI) drops the direct effect to zero and the path is no longer significant, or a “partial mediation” if the direct effect becomes weaker, yet still a significant path.

Since the research evidence suggests the relations among the variables differ for men and women (Bruce et al., 2007; Tande et al., 2010), to test the potential moderating effect of sex on the association between IPR and the risk of OV/OB through dietary quality, multiple-group comparison was conducted using sex as the grouping variable. In the multiple-group analysis, instead of using sex as a predictor, a set of two hypothesized models were specified and estimated simultaneously as explained by Ryu and Cheong (2017). Coefficients for path a (effect of IPR on HEI), b (effect of HEI on OV/OB), c (effect of IPR on OV/OB), and c' (effect of IPR on OV/OB controlling for HEI) were determined for males and females and the sex differences in each path were assess (e.g., aF –aM). A significant moderation effect of sex on the mediation path was evident if the 95% bootstrapped CI for the sex difference in the indirect effect did not include zero. All statistical analyses accounted for the complex sampling design of NHANES in the weighted models, along with covariates listed above.

Results

Participant Characteristics

Participant characteristics, significant bivariate differences between males and females, and differences among BMI categories are shown in Table 1. A greater proportion of female participants were obese compared to male participants. Females had a significantly lower mean IPR compared to males. Males had significantly lower HEI total score compared to females. Within- and between-sex comparisons indicate that there are significant differences in the socio-demographic and physical activity characteristics among the normal weight and OV/OB participants.

Table 1

Characteristics of the Full Study Sample Overall and by Sex and Weight Status (Mean (SE) or Percentage)

Sample characteristic	Total sample (N = 12,768)	Male (N = 6,292) Male total	Normal Weight	Overweight	Obese	Female (N = 6,476) Female total	Normal Weight	Overweight	Obese	Sex Comparison[d]
Weight status as body mass index (BMI)										
Normal weight (BMI 18.5 -24.9)	28.68%	25.27%	100%	-	-	32.06%	100%	-	-	37.93***
Overweight (BMI 25.0-29.9)	33.53%	38.99%	-	100%	-	28.12%	-	100%	-	81.11***
Obese (BMI ≥ 30)	37.79%	35.74%	-	-	100%	39.82%	-	-	100%	14.51***
Family income-to-poverty ratio	3.01 (0.05)	3.08 (0.05)	2.81 (0.08)[a,b]	3.23 (0.06)[c]	3.11 (0.05)	2.94 (0.05)	3.26 (0.06)[a,b]	2.98 (0.07)[c]	2.64 (0.06)	5.53***
Diet quality										
2015 Healthy Eating Index	52.61 (0.25)	51.13 (0.26)	50.84 (0.55)[a]	52.27 (0.39)[c]	50.09 (0.31)	54.07 (0.33)	56.43 (0.55)[a,b]	54.73 (0.50)[c]	51.71 (0.35)	-9.94***
Socio-demographic characteristics										
Age	41.98 (0.24)	41.65 (0.27)	37.40 (0.56)[a,b]	42.75 (0.33)	43.44 (0.30)	42.32 (0.27)	39.84 (0.48)[a,b]	43.19 (0.40)	43.70 (0.31)	-2.74**
Race/ethnicity										
Hispanic	15.64%	16.42%	13.06%[a,b]	17.33%	17.80%	14.88%	11.36%[a,b]	16.51%	16.55%	10.15**
Non-Hispanic White	72.05%	72.37%	73.72%[b]	73.71%[c]	69.95%	71.74%	81.57%[a,b]	71.31%[c]	64.13%	0.93
Non-Hispanic Black	12.30%	11.21%	13.22%[a]	8.95%[c]	12.25%	13.39%	7.07%[a,b]	12.18%[c]	19.32%	25.49***
Marital Status										
Married or cohabitating	63.51%	64.93%	51.84%[a,b]	69.66%	69.01%	62.12%	64.18[b]	63.76%[c]	59.29%	10.98**
Single	36.49%	35.07%	48.16%[a,b]	30.34%	30.99%	37.88%	35.82%[b]	36.24%[c]	40.71%	
Education										
Less than high school diploma	15.64%	16.68%	17.94%	16.43%	16.06%	14.62%	10.05%[a,b]	15.02%[c]	18.00%	10.20**
High school diploma or greater	84.36%	83.32%	82.06%	83.57%	83.94%	85.38%	89.95%[a,b]	84.98%[c]	82.00%	
Employment status										
Employed	70.63%	76.60%	73.30%[a]	80.31%[c]	74.87%	64.73%	67.49%[b]	66.14%[c]	61.50%	93.74***
Unemployed	29.37%	23.40%	26.70%[a]	19.69%[c]	25.13%	35.27%	32.51%[b]	33.86%[c]	38.50%	

Table 1 (Continued)

Characteristics of the Full Study Sample Overall and by Sex and Weight Status (Mean (SE) or Percentage)

Sample characteristic	Total sample (N = 12,768)	Male (N = 6,292) Male total	Normal Weight	Overweight	Obese	Female (N = 6,476) Female total	Normal Weight	Overweight	Obese	Sex Comparison[d]
Weight status as body mass index (BMI)										
Physical Activity										
Meets PA recommendation[e]	60.98%	69.04%	70.73%[b]	72.61%[c]	63.95%	53.00%	62.17%[a,b]	55.35%[c]	43.96%	171.57***
Sedentary activity time (hrs/day)	6.16 (0.06)	6.15 (0.08)	5.83 (0.12)[a,b]	6.20 (0.12)	6.33 (0.10)	6.13 (0.07)	5.76 (0.11)[b]	5.96 (0.12)[c]	6.55 (0.10)	0.78

*$p < .05$, **$p < .01$, ***$p <.001$

[a] $p < .05$, normal weight vs. overweight within the same sex

[b] $p < .05$, normal weight vs. obese within the same sex

[c] $p < .05$, overweight vs. obese within the same sex

[d] Chi-square test or t-test

[e] The physical activity (PA) recommendation is ≥ 150 minutes of moderate to vigorous physical activity per week

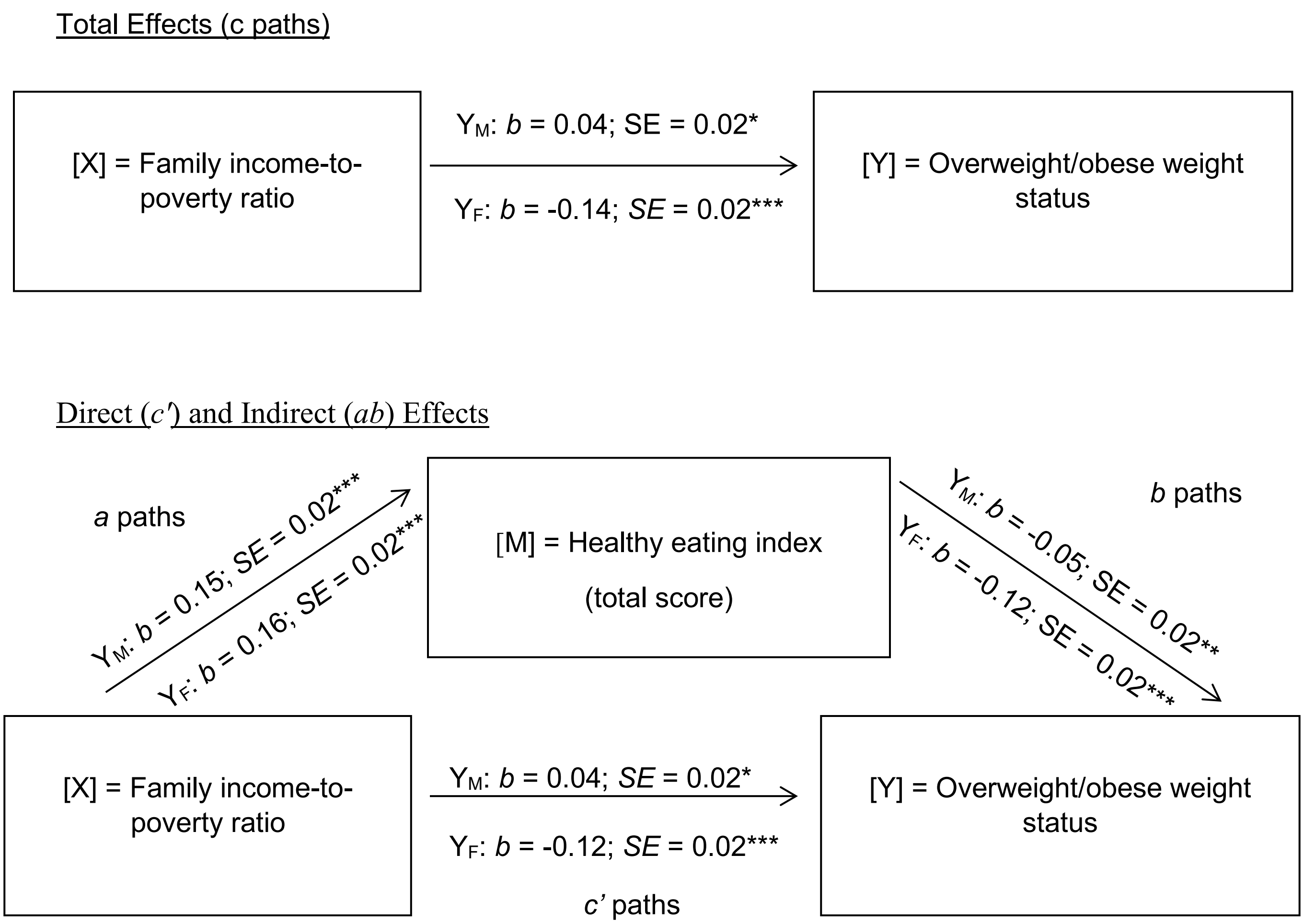

Figure 1. Covariate-adjusted multiple-group moderated mediation model of the indirect effect (*ab*) of income-to-poverty ratio on overweight and obesity status through healthy eating index by sex (Subscript M=male, Subscript F=female). *Note*: *** $p < .001$, ** $p < .01$, * $p < .05$. a path = Effect of X on M; b paths = Effect of M on Y; c paths = Total effect of X on Y; c' paths = Direct effect of X on Y controlling for M. Higher scores on the Healthy Eating Index indicate greater dietary quality.

Mediation Effect of HEI (Total Sample)

After controlling for the covariates, there is a significant positive association between IPR and HEI score (path a; $\beta = 0.157$, SE = 0.016, $p < .001$), and a negative association between HEI score and experiencing OV/OB (path b; $\beta = -0.116$, SE = 0.016, $p < .001$). The total effect indicates that IPR was inversely associated with experiencing OV/OB (path c; $\beta = -0.080$, SE = 0.020, $p < .001$). The direct effect of IPR on OV/OB was negative and statistically significant (path c'; $\beta = -0.061$, SE = 0.020, $p = .002$).

The indirect association between IPR on OV/OB through HEI was also statistically significant (path ab; $\beta = -0.018$, SE = 0.003, 95% bootstrap CI = -0.024, -0.0012, $p < .001$), indicating that among adults HEI mediates the relationship between IPR and experiencing OV/OB. Since the direct effect is still significant after addition of the mediator, HEI only partially mediates this relationship.

Multiple-group Moderated Mediation Model by Sex

Among males, the total effect of IPR indicates that IPR was positively associated with experiencing OV/OB (Figure 1, above the arrow). In the covariate-adjusted model, the direct effect of IPR on OV/OB was positive and statistically significant. In contrast to the total sample, among men higher IPR was associated with higher likelihood of experiencing OV/OB. The indirect association between IPR and OV/OB through HEI was negative and statistically significant (β = -0.008, SE = 0.003, 95% bootstrap CI = -0.012, -0.003, p = .009), indicating that for males HEI mediates this relationship. Since the direct effect is also statistically significant, HEI partially mediates the association between IPR and experiencing OV/OB. In other words, with higher HEI total scores, higher IPR was associated with a lower likelihood of experiencing OV/OB. As the direct effect and indirect effects are in the opposing direction for men, the association between IPR and OV/OB through HEI is an "inconsistent mediation" (MacKinnon, Fairchild, & Fritz, 2007).

Among females, the total effect of IPR on OV/OB status indicates IPR was inversely associated with the likelihood of being categorized as OV/OB (Figure 1, below the arrow). In the covariate-adjusted model, the direct effect of IPR on OV/OB was statistically significant; these variables were inversely related for females. The indirect association between IPR on OV/OB through HEI was also statistically significant for females (β = -0.019, SE = 0.004, 95% bootstrap CI = -0.025, -0.012, $p < .001$), indicating that HEI mediates this relation. Since the direct effect is statistically significant, HEI partially mediates the relation. Among women with higher HEI total scores, higher IPR was associated with lower likelihood of experiencing OV/OB. The results for the mediation effect and each path of the relationship for women were similar to the total sample.

Sex Differences

The total and direct effects of IPR on OV/OB were significant among both men and women. However, this association was negative among men and was positive among women.

The difference in the influence of IPR on HEI total score (path a) between males and females was 0.069 (SE = 0.195, 95% bootstrap CI = -0.256, 0.396, p = .724) and was not statistically significant. Thus, sex does not affect how IPR influences HEI, when controlling for the covariates. The difference in the influence of HEI total score on OV/OB (path b) between males and females was -0.002 (SE = 0.001, 95% bootstrap CI = -0.004, -0.001, p =.011). Thus, sex affects how HEI influences OV/OB, when controlling for IPR and covariates. The difference in the indirect effect of IPR on OV/OB through HEI between males and females was -0.003 (SE = 0.001, 95% bootstrap CI = -0.006, -0.001, p = .022). Thus, the sex difference in the mediation effect is statistically significant, indicating a moderated mediation.

Discussion

Similar to previous research, the current study found the associations between IPR and dietary quality, and dietary quality and OV/OB, in the expected directions for the total sample and for women (Drewnowski & Eichelsdoerfer, 2010; Drewnowski & Specter, 2004). However, among men higher IPR is related to increased risk of experiencing OV/OB, while for women higher IPR is related to decreased risk. The differences could be related to Western appearance ideals. For men, the ideal appearance focuses on size and muscularity, with these traits being linked to power and status (O'Neil, 2008); this is the opposite for women (Schaefer et al., 2018). Our findings also indicate that when men consume a high-quality diet, they are less likely to be OV/OB.

While our findings are consistent with prior literature showing that individuals with lower incomes have lower HEI scores than individuals with higher incomes (Drewnowski & Specter, 2004), this study contributes to the literature by demonstrating that the relationship is not moderated by sex. Irrespective of sex, greater IPR (indicating higher income) is associated with greater dietary quality. A moderating effect of sex on the other paths of the mediated model was observed. Specifically, the relationships between IPR and OV/OB as well as diet quality and OV/OB were particularly strong among women (each increment in IPR or HEI scores was associated with greater reduction in the risk of OV/OB compared to men). These findings are consistent with prior research showing that the relationship between income and obesity is most apparent among women (Bruce et al., 2007; Chang & Lauderdale, 2005; Hernandez & Pressler, 2014). Basiotis and Lino (2003) hypothesized that limited financial resources have an adverse effect on women's dietary quality rather than dietary energy. This type of effect could lead to a pattern of consuming energy dense, weight-promoting diets.

Among both men and women, diet quality partially mediates the association between income and weight status. Specifically, HEI accounts for some of the relationship between IPR and OV/OB. However, among men the direct effect is positive while the indirect effect is negative, indicating an inconsistent mediation. Therefore, the dietary quality is particularly important for men. As income increases, among men the risk of obesity is not reduced unless they engage in a diet that is higher in quality. Among women the direct and indirect effect are positive, indicating it is not an inconsistent mediation. Therefore for women, higher income reduces the risk of obesity and higher dietary quality partially contributes to the reduction in the risk. Additional research is needed to better understand the underlying mechanisms for the identified relationships.

While a large national data set was used to conduct this research, this study has several limitations. First, the data are cross-sectional in nature, not allowing for causal inference. Differences in demographic characteristics between the analytical sample and those excluded from the study must be taken into account when considering generalizability of the study findings.

In conclusion, the study findings indicate that among both men and women, dietary quality partially mediates the relationship between IPR and odds of experiencing OV/OB status. Specifically, among men with higher incomes, the risk of obesity is not reduced unless they engage in a diet that is higher in quality. Thus, improving the diet quality of men with higher incomes may be particularly beneficial to reducing their weight status. Health professionals should work with men to encourage a high-quality diet as a strategy for weight management.

Finally, improving diet quality of men and women is needed in lower income brackets as suggested by the null sex finding between income and diet quality.

Discussion Questions

1. Findings suggest that among men, there is a positive association between greater income-to-poverty ratio and experiencing obesity. This relationship is partial mediated by dietary quality. Thus, higher income men may see a reduction in overweight/obese status if they also engage in eating a healthy diet. What are other behavioral mechanisms that could be contributing to the relationship differing by sex?

2. In addition to the behavioral mechanisms, could there be physiological changes resulting from the behaviors that further influence this relationship? If so, what could they be?

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