An Electronic Ecological Momentary Assessment Study to Examine the Consumption of High-Fat/High-Sugar Foods, Fruits/Vegetables, and Affective States Among Women

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Abstract:

Objective: To examine the associations between high-fat/high-sugar foods (HFHS) and fruit and vegetable (FV) consumption and affective states in women.

Methods: The researchers used electronic ecological momentary assessment to capture HFHS and FV consumption in the past 2 hours (predictor) and current affective states (outcome) across 1 week among 202 women. Multilevel linear regression was conducted. Weight status was tested as a moderator.

Results: Consumption of FV in the past 2 hours was positively associated with feeling happy ($P < .05$). Women who consumed more HFHS or fewer FV than others in the study reported higher average sadness (both $P < .05$). Overweight or obese women who reported more frequent HFHS consumption than others had higher average stress than normal weight women ($P < .05$).

Conclusions and Implications: The association between HFHS consumption and stress might be stronger in overweight or obese than normal weight women. Future studies could further enhance the electronic ecological momentary assessment method to explore other time-varying moderators and mediators of food consumption and affect.

Keywords: dietary intake | free-living | overweight | smartphones | stress

Article:

Introduction

Unhealthy eating is a major modifiable lifestyle risk factor that contributes to the development of chronic conditions, such as cardiovascular diseases, diabetes, and cancer.[1] Some important components in healthy eating patterns include consuming a variety of fruits and vegetables (FV) and limiting high-fat, high-sugar foods (HFHS). However, >75% of Americans do not meet the FV recommendations, and approximately 70% exceed the recommendations for added sugars and saturated fats.[2] Furthermore, adherence to meeting the dietary guidelines has remained low for the past few decades.[2] Therefore, there is a need to help individuals improve dietary behaviors and achieve healthy eating patterns.

Previous research suggested that food consumption could lead to improved mood and positive affect as a result of its nutritional and physiological effects[3] and that eating is a pleasurable experience in itself.4, 5 Food consumption could affect affective states through several potential physiological mechanisms. For example, consumption of energy-dense foods (eg, HFHS) may increase positive affect as a result of the release of endorphins.[6] However, frequent consumption of HFHS could induce plasticity-related changes in brain reward circuitry that are associated with depressive-like phenotype.[7] Furthermore, compared with HFHS, FV are believed to be conducive to increasing levels of brain-derived neurotrophic factors, which are thought to have a central role in negative mood states and depression.[8]In addition to the physiological mechanisms, food consumption could influence affective states via cognitive expectations and perceptions of the health value of certain foods,9, 10 which might differ across gender, weight status, and cultural background. For instance, in many western cultures, there is a greater societal pressure for women to be physically attractive and thin compared with men.[11]Moreover, HFHS could be considered as a threat to being thin and are associated with negative affect, especially among overweight or obese women who are trying to lose weight.[12] Previous studies showed that overweight or obese women experience more intense negative affect than do normal weight women after consumption of HFHS.[13] A better understanding of the association between HFHS/FV consumption and affective states in women could inform nutrition educators to help women recognize the possible consequences of consuming these foods and change their eating patterns to optimize physical and mental health.

Although several feeding studies (eg, certain types of food were provided) investigated the acute relationships between food consumption and subsequent affective states,5, 13 those studies did not reflect the dynamic situations that individuals experience in their everyday lives (eg, personal choices of foods in real-world situations). Understanding the association between HFHS/FV consumption and affective states could shed light on how to motivate individuals to avoid HFHS and consume more FV. Ecological momentary assessment (EMA), a real-time data capture method that allows individuals to self-report behaviors and experiences in their daily lives,[14] is a useful method to study the acute relationships between everyday food consumption and affective states. Prior studies using this method found that eating large quantities of food subsequently led to greater negative affect in women.[15] Nevertheless, the effects of different types of food was not investigated. The current study aimed to use EMA to (1) examine the association between consumption of HFHS and FV and affective states, and (2) explore the moderating effect of weight status on these associations among middle-aged women. It was hypothesized that consumption of HFHS would associate positively with negative affect and consumption of FV would associate positively with positive affect.

Methods

Data Source

This study used data from the Mothers' and Their Children's Health (MATCH) study, a longitudinal observational dyadic study in a sample of mother–child pairs.[16] The MATCH study included a 1-week free-living EMA monitoring period, which was repeated across 6 waves separated by 6 months each. The current study used mothers' EMA data from the first wave. The MATCH study protocol was reviewed and approved by the Institutional Review Board at the University of Southern California. Reporting of this study followed guidelines from the Adapted Strengthening the Reporting of Observational Studies in Epidemiology Checklist for Reporting EMA Studies.[17]

Participants

Participants in the MATCH study were ethnically diverse mothers and their 8- to 12-year-old children recruited from public elementary schools and after-school programs in the greater Los Angeles area. Eligible participants were children in the third through sixth grade who resided with the mother at least 50% of the time; in addition, both mother and child had to be able to read English or Spanish. All study materials (eg, EMA surveys, instructions) were available in both English and Spanish. Mother–child pairs were excluded if they were taking medications for thyroid function or psychological conditions, using oral or inhalant corticosteroids for asthma, or had health issues that limited physical activity; if the child was enrolled in special education programs or classified as underweight; if mother was currently pregnant; or she worked >2 weekday evenings/wk or >8 hours on any weekend day.

Procedures

Details about the design and protocol for MATCH study were described elsewhere.[16] All mothers attended an in-person data collection session to complete anthropometric measurements and paper-and-pencil questionnaires. They also received instructions on how to use study equipment, which included the smartphone EMA app.

The EMA surveys were delivered via a custom Android app that was developed specifically for the study. Mothers who owned an Android smartphone downloaded the app on their own smartphone. For those who did not wish to use their own smartphone, whose smartphone was incompatible, or who did not have a smartphone, a MotoG (Motorola, Inc, Chicago, IL) was provided for the duration of the study period. The researchers collected EMA data over 8 days after the end of the in-person data collection session. The EMA prompts started after 5 PM on the day of the in-person data collection session (day 1) and continued for the next 6 days (days 2–7), up until 5 PM on the last day (day 8). The EMA surveys were randomly prompted 4 times/d on weekdays between 3:00 and 9:30 PM and 8 times/d on weekend days between 7 AM and 9:30 PM. The EMA data were wirelessly uploaded and stored on a secure Internet-accessible server during the monitoring period.

Electronic Ecological Momentary Assessment Measures

The researchers assessed food consumption by asking women to indicate which of the following foods they had eaten over the past 2 hours (ie, chips or fries; pastries or sweets; fast food; FV). Women were instructed to choose all that applied. Each food item was then converted into a dichotomous response of yes/no. For the purpose of the current study, selection of chips or fries, pastries or sweets, or fast food was recoded as HFHS consumption (yes/no). The researchers excluded from the analysis EMA entries that indicated both HFHS and FV consumption, to examine the effects of these 2 food groups on affect separately.

For affective state, women were asked, *Right before the phone went off, how (happy, calm/relaxed, frustrated/angry, stressed, sad/depressed) were you feeling?* Response choices were *Not at all*, *A little*, *Quite a bit*, and *Extremely*. Each affect was analyzed separately because previous research showed distinct associations between single-item affect and eating.[5, 13] Composite scores for positive and negative affect were computed to explore the effect of food consumption on the 2 fundamental dimensions of affect. Positive affect was an average of happy and calm/relaxed (average Cronbach $\alpha = .75$). Negative affect was an average of frustrated/angry, stressed, and sad/depressed (average Cronbach $\alpha = .72$).

All EMA items were thoroughly pilot-tested in the target population for comprehension and applicability. The Supplementary Data shows an example of 1 woman's EMA responses.

Anthropometric and Demographic Measures

Weight and height were measured in duplicate using an electronically calibrated digital scale (Tanita WB-110A, Tanita, Inc., Arlington Heights, IL) and professional stadiometer (PE-AIM-101, Perspective Enterprises, Portage, MI). Weight status was determined according to body mass index as normal weight vs overweight or obese.[18] Participants self-reported their age, ethnicity (*Are you Hispanic or Latino?*), highest level of education, and annual household income through a paper-and-pencil survey.

Statistical Analysis

Because each woman had multiple (≤36) EMA responses, data were nested within individuals. The intraclass correlation coefficient was small (range, .15–.33) for all outcome variables, indicating a large amount of variation within individuals.[19] Therefore, multilevel linear regression modeling (MLM) was used to adjust the SEs for the clustering of EMA responses within individuals. Between-subject (BS) and within-subject (WS) effects were separated (ie, partitioning the variance). The BS effect represents the individual mean deviation from the group mean, and the WS effect represents deviation from one's own mean (average level) at any given EMA prompt.[20] To test aim 1, MLM was fitted using current affective state (eg, positive affect, negative affect, and each individual affect item) as the outcome and past 2-hour food consumption (ie, HFHS/FV consumption vs no consumption) as the predictor. Each predictor and outcome was tested in separate models. Because responses for each individual negative affect item and the composite negative affect score were not normally distributed, a log-transformation of the data was performed for those items. To test aim 2, interactions between each predictor and weight status were created (ie, weight status × WS and weight status × BS)

and entered into all models described previously. Age, ethnicity (Hispanic vs non-Hispanic), day of the week (weekdays vs weekend days), and time of the day (morning, afternoon, and evening) were controlled for in all models.

Results

Descriptive Statistics

A total of 453 women expressed interest in the MATCH study, 299 of whom completed eligibility screening. Of those, 237 met the eligibility criteria, 202 of whom attended the initial in-person data collection session and enrolled in the study. Of those who enrolled in the study, EMA data were lost for 2 women as a result of errors in server upload/manual backup. Another 2 women answered no EMA surveys during the monitoring period. One woman answered no food consumption EMA questions. These data losses resulted in a total of 197 women in the analytical sample. Women were on average aged 40.9 years (SD, 6.2 years). A total of 49% of women were Hispanic, 43% were overweight or obese, and 60% had completed a college degree or higher with a median annual household income of $75,000.

Of the 6,895 possible EMA survey prompts, 1,136 were not prompted owing to technical problems, because they were outside the sleep schedule, the phone was powered off, there was a change in protocol, or other unknown issues. On average, women answered 81% of the prompted EMA surveys (SD, 21%), yielding 4,730 EMA records. The likelihood of missing an EMA prompt was unrelated to women's age, weight status, time of day, or day of the week (all $P > .05$); however, Hispanic women were more likely to have missed an EMA prompt than were non-Hispanic women ($P = .03$).

A total of 301 EMA records were removed from the analyses because of an indication that participants had consumed both HFHS and FV, which left an analytical sample of 4,429 EMA records from 197 women. On average, women reported HFHS consumption in the past 2 hours in 12.8% of EMA prompts (SD, 11.4%). Consumption of FV was reported in 17.6% of EMA prompts (SD, 14.4%).

High-Fat/High-Sugar Food Consumption and Affective States

The Table shows results from the MLM. Overall, the WS effect was not significant in any model, which suggests that the consumption of HFHS over the past 2 hours was not associated with feelings of being happy, calm/relaxed, frustrated/angry, stressed, or sad/depressed, or with the composite positive and negative affect scores at the end of the 2-hour window. However, at the BS level, women who reported more frequent consumption of HFHS compared with others in the study had greater overall negative affect (BS $\beta = .228$, SE = .108, $P = .04$, 95% confidence interval [CI], .015–.441), particularly from feeling more stressed (BS $\beta = .436$, SE = .159, $P < .01$, 95% CI, .123–.749) and more sad/depressed (BS $\beta = .219$, SE = .109, $P = .04$, 95% CI, .004–.434).

Table. Associations Between Consumption of High-Fat/High-Sugar Foods and Fruits/Vegetables and Affective States in a Sample of 197 Women

Outcome	Statistical measure	Predictor (Coefficient estimate [SE])			
		High-fat/High-sugar food consumption	Weight status interaction	Fruit/Vegetable consumption	Weight status interaction
Happy	WS Effect	.035 (.030)	ns	.057 (.027)*	ns
	BS Effect	−.289 (.312)	ns	.551 (.246)*	ns
	AIC	8,586.5	8,590.3	8,582.0	8,579.2
Calm/relaxed	WS Effect	.023 (.035)	ns	.039 (.032)	ns
	BS Effect	−.571 (.309)	ns	.340 (.249)	ns
	AIC	9,752.3	9,754.5	9,752.6	9,756.4
Positive affect	WS Effect	.029 (.028)	ns	.049 (.023)	ns
	BS Effect	−.426 (.294)	ns	.450 (.234)	ns
	AIC	8,083.3	8,086.7	8,079.0	8,082.8
Frustrated/angry	WS Effect	−.007 (.016)	ns	−.010 (.014)	ns
	BS Effect	.197 (.104)	ns	−.140 (.083)	ns
	AIC	3,275.5	3,276.2	3,275.8	3,277.6
Stressed	WS Effect	.015 (.019)	.003 (.035)	−.014 (.018)	ns
	BS Effect	.436 (.159)**	−.687 (.304)*	−.207 (.152)	ns
	AIC		3,524.3	3,526.8	3,528.0
Sad/depressed	WS Effect	.014 (.011)	ns	−.003 (.010)	ns
	BS Effect	.219 (.109)*	ns	−.206 (.087)*	ns
	AIC	92.6	96.6	92.9	96.2
Negative affect	WS Effect	.007 (.012)	ns	−.016 (.011)	ns
	BS Effect	.228 (.108)*	ns	−.126 (.087)	ns
	AIC	1,120.6	1,121.3	1,121.0	1,123.3

AIC indicates Akaike information criterion; BS, between-subject; ns, not significant; WS, within-subject. *$P < .05$, **$P < .01$.

Notes: Multilevel linear regression was used. All models controlled for age, ethnicity (Hispanic vs non-Hispanic), day of the week (weekdays vs weekend days), and time of the day (morning, afternoon, and evening). The study sample included 197 middle-aged women (mean age, 40.9 years; SD, 6.2 years), 49% Hispanic and 43% overweight or obese, 60% of whom completed college degree or more, with a median annual household income of $75,000.

Weight status significantly moderated the association between HFHS consumption and stress only at the BS level (BS β = −.687, SE = .304, $P = .02$, 95% CI, −1.288 to −.087), indicating a positive association between the frequency of HFHS consumption and the average stress level among only overweight or obese women.

Fruit/Vegetable Consumption and Affective States

As shown in the Table, FV consumption in the past 2 hours was positively associated with feeling happy at the end of the 2-hour window (WS β = .06, SE = .03, $P = .03$, 95% CI, .004–.111). This significant positive association was also found at the BS level. Women who reported more frequent FV consumption compared with others in the study reported feeling happier in general (BS β = .55, SE = .25, $P = .02$, 95% CI, .066–1.035). Furthermore, women who reported more frequent FV consumption compared with others reported feeling less sad in general (BS β = −.21, SE = .09, $P = .02$, 95% CI, −.377 to −.035). Weight status was not a significant moderator in any of the models.

Discussion

The current study used electronic EMA through a smartphone app to examine the associations of HFHS and FV consumption with affective states in a sample of middle-aged women's daily lives. Previous studies used EMA to capture eating episodes in obese adults[21] and binge eating.[22] However, those studies assessed only the frequency of eating, not the types of food being eaten. This study also had a high EMA compliance rate (81%) compared with the average EMA compliance rate (71%) in diet and physical activity research.[17]

The positive associations between happiness and consumption of FV but not HFHS found in this study might be partly explained by the potential mental health benefit effect of FV beyond just the intake of food. Previous studies showed that FV but not HFHS consumption was associated with a greater positive affect the next day.[23] Consumption of FV could have a positive effect on one's mental state through various physiological mechanisms via the nutrients found in FV (eg, B vitamins' effect on the synthesis of neurotransmitters, antioxidants' defense mechanism against oxidative stress).[24] Furthermore, the perception of consuming healthier foods could provoke positive emotions such as feeling satisfied, happy, or proud.[10] It is also possible that women who generally feel happier tend to choose FV over HFHS foods.

The null WS associations between the consumption of HFHS and feelings of anger or sadness were consistent with previous studies that examined affective states immediately after energy-dense food intake in laboratory settings[13] and affective states 5–90 minutes after chocolate intake in free-living settings.[5] However, it is possible that consumption of HFHS could invoke other negative affective states (eg, guilt, shame) that were not measured in this study. This study also found no association between HFHS consumption and positive affective states. There might be other unexplored time-varying or contextual moderators (eg, place, social context) that influenced the association between affective states and HFHS consumption.

The association between high-fat/high-sugar food consumption and stress could be different for overweight or obese and normal weight women.

This study showed that women who consumed more HFHS or fewer FV compared with others in the study reported feeling more depressed in general. This is consistent with previous cross-sectional findings that high frequency of snacks and fast-food intake and low frequency of FV intake were correlated with higher (trait) depression.[25, 26] Moreover, overweight or obese women who reported more frequent HFHS consumption than others in the study had higher average stress than did normal weight women. It is possible that overweight or obese women might be more emotionally vulnerable to the consequences of frequent HFHS consumption compared with normal weight women. It is also possible that on average, overweight or obese women might experience higher levels of stress than do normal weight women, which in turn may be associated with the higher likelihood of consuming HFHS for emotional comfort.

Although this study is one of the first attempts to use electronic EMA to examine the association between HFHS and FV consumption with affective states in daily lives, there were some limitations. First, the EMA questions did not measure portion size. Furthermore, some eating events might not have been captured if the participants did not think the preset food category applied to what they had consumed. Nevertheless, this study attempted to capture and distinguish between HFHS and FV broadly. Second, this study assessed eating events within the past 2 hours

but did not specify the exact time of the eating event (eg, eating a food 2 hours ago vs 10 minutes ago may have differentially influenced the affective states). Eating also could have happened at the time of the EMA prompt, resulting in the capture of affective states during eating. In addition, because the parent study focused on mother–child dyads, EMA surveys were prompted only when they were likely spending time together (ie, after-school hours on weekdays and weekend days). Third, some other affective states that might be related to food consumption (eg, guilt, energetic) were not measured. Although the current study used affect items that were from well-established scales[27] and were used in previous EMA studies,[28] it is possible that potential between-person variations exist when rating affective states. Furthermore, this study did not examine mood change before and after food consumption. Therefore, it is unclear whether food consumption altered mood states. The current study design also could not distinguish the potential effects of mood states on food consumption. Fourth, this sample included only middle-aged women; thus, findings might not be generalizable to younger or older women. Results from this study might not be applicable to men, because the relationships between food consumption and affect tend to differ by gender. Finally, because Hispanic women in the study were more likely to miss an EMA prompt than were non-Hispanic women, their experiences may have been underrepresented in this study. Nevertheless, all models controlled for the effect of Hispanic vs non-Hispanic ethnicity.

Implications for Research and Practice

The current study demonstrated that electronic EMA is a feasible tool for capturing everyday HFHS/FV consumption and related factors such as affective states. In nutrition education, findings from the WS effect could be useful for setting personalized behavioral targets (eg, eat a half serving more FV than the average intake) whereas BS findings could identify health disparities in populations (eg, overweight or obese women might have a more negative experience from frequent HFHS consumption than might normal weight women). The EMA method could be further enhanced by optimizing the prompting schedules and survey questions. Other time-varying moderators and mediators of the relationships between food consumption and affective states (eg, social context, intentions, stressful events) could also be explored.

Ecological momentary assessment (EMA) could be a useful tool to capture daily food intake and related time-varying factors that might influence consumptions.

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Supplementary Data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jneb.2018.02.003.

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