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Associations Between Ultra-Processed Food Consumption and BMI, Sedentary Time, and Adverse Dietary Habits in Active Young Adults

Original Research

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Abstract

Introduction: Ultra-processed foods (UPF), or packaged foods defined by industrial processing and food additives, are associated with poor nutrient quality of the diet, weight gain, and may impact physical activity levels. Young active populations are understudied with respect to UPF. The purpose of this study is to explore relationships between UPF and BMI, dietary habits, and physical activity in young active adults.

Methods: Healthy college students (n=42) completed two 24-hr dietary recalls and physical activity surveys. Data were median split into the top 50^{th} percentile (HIGHUPF) and low 50^{th} percentile (LOWUPF) groups based on UPF intake (%). Independent samples t-tests were used to analyze differences between groups.

Results: No significant differences in BMI (kg/m^2) were seen between HIGHUPF (25.5) and LOWUPF (23.7) (p=0.055). A significantly higher BMI was seen in HIGHUPF after controlling for physical activity (p=0.04). Compared to LOWUPF, HIGHUPF exhibited lower protein (%) intake (p=0.04), lower fiber intake (p=0.05), higher added sugar (tsp/1000kcal) intake (p=0.05), higher refined grains (oz/1,000kcal) intake (p=0.001), and higher sedentary time (mins/day) (p=0.001).

Conclusions: The results suggest that ≥476 mins/week of recreational physical activity diminishes the relationship between UPF and BMI. Greater UPF intake is associated with greater sedentary time, and adverse dietary makeup.

Key Words: Nutrition, Physical Activity, Obesity

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Introduction

Ultra-processed Foods (UPF) are foods derived from whole foods but contain little or no whole foods themselves, and commonly contain added colors, flavors, sweeteners, and emulsifiers. These foods are typically highly profitable, convenient, shelf-stable, highly palatable, energy-dense, with a high glycemic load, and low satiety potential[1]. In the United States (US), UPF are associated with greater intake of added sugar and fat, lower intake of fiber, protein, micronutrients, and increased all-cause mortality[2]. Steele et al. (2016) suggest that UPF comprises about 58% of the average American diet[3]. Increasing the dietary share of UPF is associated with poor nutritional quality of the diet, obesity, hypertension, cardiovascular diseases, metabolic disorders, gastrointestinal disorders, and some cancers[1].

In a randomized control trial, Hall et al., (2019) showed that UPF may lead to hypercaloric intake and subsequent weight gain in healthy adults[4]. This weight gain associated with UPF consumption may also be attributed to an altered gut microbiome that favors the development of obesity, as well as metabolic and inflammatory diseases[5]. Recent reviews show that an ultra-processed diet can lead to the genesis of Reactive Oxygen Species (ROS) and inflammation in adults[6]. Excess inflammation may potentially generate feelings of fatigue[7], which may impact physical activity in those with and without preexisting health issues; something not previously studied in the context of UPF.

In the US, mean BMI has increased from 23kg/m^2 in 1980 to 28kg/m^2 in 2018[8], illustrating the increasing trends of overweight and obesity in adults. Among U.S dietary guidelines, only the American Heart Association's 2021 Dietary Guidance to Improve Cardiovascular Health[9], the American Cancer Society (ACS) guidelines[10], and in the American Diabetes Association (ADA) Consensus Report[11] address UPF. Furthermore, few studies examine UPF in exclusively young, active populations. Thus, it is important to explore potential adverse relationships with UPF in this population which may set the stage for disease states later in life. The primary purpose of this study is to test for relationships between UPF intake, BMI, physical activity, sedentary time, and dietary nutrients (protein, fiber, sodium, fat, added sugar, and refined grains) in young adults without any underlying health conditions.

Scientific Methods

This research was conducted during the Covid-19 Pandemic; thus, all data collection was completed in a virtual format.

Participants

We recruited healthy college-age participants from Exercise Science and other Allied Health Science majors from several colleges and universities in the Mid-Atlantic region of the United States. Subjects were excluded based upon any pre-existing condition that might directly affect their level of physical activity (athletic commitments, injuries) and those with major dietary restrictions (i.e., vegetarian, vegan, celiac disease, lactose intolerance). All subjects completed a virtual screening survey to determine eligibility, followed by a virtual informed consent document, both distributed through Qualtrics survey software. This study was approved by Montclair State University Institutional Review Board.

Protocol

Initial interviews were conducted virtually in which each survey was displayed on the screen and read aloud to the subject. The interviewer would then record the subject's response. All subjects first completed a medical history questionnaire to determine any factors that may impact the validity of our data (conditions or medications that may affect dietary intake, physical activity, etc.). Subjects also reported their height and weight in this questionnaire, which was used to determine BMI. To determine physical activity levels, the Global Physical Activity Questionnaire (GPAQ) was administered, which has been validated for estimating levels of physical activity[12].

Following initial surveys, subjects were given access to the ASA24 dietary recall system, which has been previously validated for estimating energy intake[13]. Because dietary intake varies based upon the day of the week, subjects were asked to complete two dietary recalls with one being on a weekend and the other being a weekday[14]. Dietary recalls were exported in the "items" view for analysis. Dietary components were then categorized using the NOVA classification system, which categorizes foods into four groups; unprocessed or minimally processed foods, processed culinary ingredients, processed foods, and ultra-processed foods[1]. The NOVA food classification was applied to each daily dietary recall individually, categorizing foods as "ultra-processed" (NOVA group four) or "not ultra-processed" (NOVA groups one-three). After the two dietary recalls were fully categorized, they were averaged together. The average percentage of calories from UPF was determined by averaging the percentage of calories from UPF for both recalls.

Statistical Analysis

JASP (version 0.14.1) was used for all statistical analyses. We median split our subjects into two groups based on UPF intake (% of total calories). The lower 50th percentile group (LOWUPF, n=21) had a UPF consumption range of 18.5-40.4%. The upper 50th percentile (HIGHUPF, n=21) had a range of 40.5-76.7% UPF intake. Independent samples t-tests were used to test for differences in the dependent variables between LOWUPF and HIGHUPF. To assess the difference in BMI between LOWUPF and HIGHUPF while controlling for physical activity, an Analysis of Covariance (ANCOVA) was used with total recreational METs/week as a covariate. Additionally, a Pearson's Correlation Coefficient was used to test for relationships between UPF and our dependent variables. Lastly, a multiple linear regression with UPF (%) as the dependent variable and BMI, average caloric intake (kcal), protein (%), sugar (%), saturated fat (%), added sugar (tsp/1000kcal), fiber (g/1000kcal), sodium (mg/1000kcal), and refined grains (oz/1000kcal) as the predictor variables was used to determine which dietary variables create the best predictive model for UPF intake. These predictor variables were chosen because they have previously been shown to be significantly different with greater UPF intake. More specifically, BMI, average calorie intake, saturated fat, added sugar, and refined grains are significantly greater with greater UPF intake, while protein, fiber, and sodium are significantly lower with greater UPF intake[1,2,15–17].

Results

A total of 48 subjects were enrolled in the study. Four subjects were excluded because they did not complete both dietary recalls and contact was lost. Box plots identified two subjects as outliers and their data were excluded from the analysis. 42 subjects (28 females and 14 males) were included in the final analysis of the study (Age = 22.0±2.5 years, BMI = 24.6±3.1 kg/m^2, Height = 1.7±0.1m, Average kcal = 2,033.1±833.0kcal). The average total daily calorie consumption was 2,033.1±833.0kcals. The average UPF consumption of our sample was 44.5±15.8%.

The independent samples t-test between LOWUPF and HIGHUPF are shown in table 1. No significant differences in BMI (kg/m^2) were seen between HIGHUPF and LOWUPF, however, our ANCOVA showed that BMI was significantly greater in HIGHUPF (p=0.04) after controlling for recreational physical activity (total recreational METs). In HIGHUPF, protein (%), sodium (mg/100kcal), and fiber (g/1000kcal) were significantly lower, and added sugar (tsp/1000kcal), refined grains (oz/1,000kcal), and sedentary time (mins/day) were significantly higher compared to LOWUPF.

Table 1. T-test analysis between LOWUPF and HIGHUPF.

	LOWUPF (n = 21)	**HIGHUPF (n = 21)**	**P-Value**	**Cohen's D**
Protein (%)	23.0±5.5	18.8±5.8	p=0.042*	0.74
Added Sugar (tsp/1,000kcal)	3.8±2.5	5.8±3.7	p=0.048*	-0.63
Sodium (mg/1,000kcal)	1997.9± 535.9	1702.2± 312.4	p=0.035*	0.67
Refined grains (oz/1,000kcal)	1.7±0.7	3.1±1.0	p=0.001**	-1.67
Fiber (g/1,000kcal)	10.5+3.4	8.5±3.0	p=0.053*	0.62
Sedentary time (mins/day)	360.0± 180.0	592.9± 249.0	p=0.001**	-1.07
BMI (kg/m^2)	23.7±2.4	25.5±3.4	p=0.055	-0.61

Data are Means ± SD

Table 2 shows the correlation analysis. We observed a significant correlation between UPF (%) and each of the following: Protein (%), Added sugar (tsp/1000kcal), Refined grains (oz/1000kcal), and Sedentary time (mins).

	%UPF	**P-Value**
Protein (%)	r=-0.49	p≤0.001**
Added sugar (tsp/1,000kcal)	r=0.39	p=0.01*
Sodium (mg/1,000kcal)	r=-0.32	p=0.04*
Refined grains (oz/1,000kcal)	r=0.61	p≤0.001**
Fiber (g/1000kcal)	r=-0.23	p=0.14
Sedentary time (mins/day)	r=0.36	p=0.01*
BMI (kg/m^2)	r=0.04	p=0.82

Our multiple linear regression with UPF as the dependent variable and BMI, average kcal, protein (%), sugar (%), saturated fat (%), added sugar (tsp/1000kcal), fiber (g/1000kcal), sodium (mg/1000kcal), and refined grains (oz/1000kcal) as the predictor variables produced a R^2 of 0.49 (p=≤0.001), showing that refined grains (oz/1000kcal), protein (%), and average kcal were the strongest predictors of %UPF predicting 49% of the variance in UPF.

Discussion

Previous research indicates that UPF are associated with various chronic health conditions, weight gain, and inflammation[1,4,6]. Active young populations are understudied with respect to UPF. Associations between UPF and poor health in this population may be indicative of disease states later in life. We found that greater UPF intake was associated with 18% lower protein intake, 53% higher added sugar intake, 82% higher refined grains intake, 19% lower fiber intake, and 65% higher sedentary time. BMI was significantly higher with greater intake of UPF after controlling for recreational physical activity. Average recreational METs in our sample was 476 (mins/week).

In our sample, UPF comprises 44.5% of the average diet, which is lower than the 58% that is reported in previous studies[3]. This could be because our subjects were recruited from Exercise Science and other Allied Health Science majors which may tend to avoid certain foods considered to be "unhealthy". Research suggests that UPF intake may contribute to weight gain[4], thus we hypothesized a significantly lower BMI in the low UPF group compared to high UPF. The results of the t-test were not significant for BMI between LOW- and HIGHUPF groups although a moderate effect size and p-value trend (p=0.055) was found. However, our ANCOVA showed a significantly lower BMI in the low UPF group after controlling for recreational physical activity. This was chosen as a covariate because our sample was likely more active than the general population which may be protective against UPF induced weight gain, especially in a young adult population. Previous work on US adult populations has observed a significant relationship between UPF consumption and BMI[15], while that is not always the case in non-US populations[18,19]. Our findings support that UPF intake is associated with elevated BMI in a young, active group when controlling for recreational activity. Due to the ubiquitous nature of UPF in our food supply[1], our results suggest that promoting recreational physical activity may be an important factor in offsetting the adverse health effects of high UPF intake.

Research suggests that UPF are associated with inflammatory responses[5,6,20]. Chronic low-grade inflammation may cause feelings of fatigue and decrease willingness to exert effort[7]. To date, no research has studied relationships between UPF and exercise-related variables. Thus, we examined relationships between UPF, physical activity, and sedentary time. While we observed no significant associations between UPF and total physical activity, we did observed a significant association between UPF (%) and sedentary time (mins). Therefore, individuals who consume more UPF are more likely to engage in greater sedentary time, which may lead to adverse health effects over time such as lower cardiorespiratory fitness[21]. This could simply be due to a healthy user bias (individuals who make one unhealthy choice may be more likely to make another unhealthy choice). A theoretical mechanism to explain this relationship could be explained by inflammation-induced fatigue, posing several considerations for those who are physically active. High glycemic load diets have been shown to cause greater post-prandial glycemic variation, which may increase fatigue, depression, and total mood disturbance, as mediated through pro-inflammatory cytokines[22].

The Dietary Guidelines for Americans (DGA) suggest including a variety of protein from plant and animal sources in the diet and limiting added sugar intake to less than 10% of total calories[24]. Our t-test and multiple linear regression results show that greater UPF intake is associated with lower protein and sodium intake, and greater added sugar and refined grain intake. These findings are consistent with other U.S-based research that showed that greater UPF intake is associated with greater intake of added sugar, and lower intake of protein and sodium[2]. Kim et al., (2019) noted that the sodium finding was unexpected and explained that this association could be because sodium in food preparation may have been unaccounted for[2]. However, research on the ASA24 dietary recall system shows that there are no significant differences between true and reported sodium intake[25]. Other non-US studies show greater sodium intake with greater UPF, therefore, further research should examine the relationship between UPF and sodium[26]. Inconsistent with Kim et al., (2019), we found no associations between UPF and fat intake[2]. The lack of significant association between UPF and fat intake could be due to our smaller sample size and novel population. Non-obese college students who participate in physical activity tend to have better dietary quality measured by Healthy Eating Index (HEI)[27]. Because our population was recruited from university exercise science departments, it is likely that they have greater diet quality compared to American adults. Overall, our findings suggest that limiting UPF in a young active population may lead to dietary patterns that more closely represent the DGA recommendations.

Our research poses several limitations. Firstly, because this research was conducted during the Covid-19 pandemic, height, and weight (used to calculate BMI) were self-reported. Secondly, our sample was largely drawn from an Exercise Science and Physical Education department. This could have resulted in lower than average UPF consumption and higher than average physical activity, as such, these findings may not be applicable to the general population. Future research should address these limitations by utilizing lab visits to gather anthropometric and physiological data.

Conclusions

This research is the first to examine relationships between UPF and BMI in an exclusively young, active population. We saw no associations with UPF and BMI, however, a significantly higher BMI was seen with a high intake of UPF after controlling for recreational exercise. These results suggest that physical activity can nullify the expected relationship between recreational UPF and BMI, and that future research should assess causal effects of physical activity on UPF-associated increases in BMI. Additionally, we observed significantly greater sedentary time with a higher intake of UPF. UPF is also strongly associated with adverse dietary habits. Notably, higher refined grains, added sugar, and lower protein. As such, these findings support the need for the US dietary guidelines to address the adverse health effects of UPFs in greater detail.

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