 doi:10.20944/preprints202008.0004.v1

Article

Frequency of restaurant, delivery and takeaway usage is not related to BMI among adults in Scotland

Ahmad Albalawi [1], Catherine Hambly [1] and John R. Speakman [1,2,3]*

[1] School of Biological Sciences, University of Aberdeen, Tillydrone Ave, Aberdeen, AB24 2TZ, UK;
[2] State key laboratory of Molecular Developmental biology, Institute of Genetics and Development Biology, Chinese Academy of Sciences, Beijing 100101, China
[3] Centre of Excellence in Animal Evolution and Genetics, Chinese Academy of Sciences, Yunnan 650223; China
* Correspondence: j.speakman@abdn.ac.uk; Tel.: +44 (0)1224 272879

Abstract: Background: The frequency of visits to restaurants has been suggested to contribute to the pandemic of obesity. However, few studies have examined how individual use of these restaurants is related to BMI using new technology of reminding to avoid memory error. **Aim**: To investigate the association between the usage of different types of food outlets and BMI among adults in Scotland. **Method**: The study was cross-sectional. Participants (n = 681) completed an online survey for seven consecutive days where all food purchased at food outlets was reported each day. We explored the relationship between BMI and usage of these restaurants using auto-reminder text system. **Results**: Body Mass Index (BMI) of both males and females was not related to frequency of use of Full-Service Restaurants (FSRs), Fast Food Restaurants (FFRs), delivery or takeaways, when assessed individually, or combined (TFO= Total Food Outlet). **Conclusion**: These data do not support the widespread belief that consumption of food out of the home at fast-food and full-service restaurants, combined with that derived from deliveries and takeaways, is a major driver of obesity in UK.

Keywords: food outlet usage; obesity; energy intake; energy contents

1. INTRODUCTION:

Obesity is a major driver of morbidity and chronic illnesses like type 2 diabetes, cardiovascular and musculoskeletal diseases, certain cancers and adverse psychological well-being[1]. In developed countries, the combined prevalence of overweight and obesity among adults ranges from 40% to 60%[2]. The UK health survey in 2018 indicated 63% of adults aged over 18 were overweight or had obesity [3]. In Scotland, men with Body Mass Index more than 25, increased from 65% in 2003 to 68% in 2018, and females from 60% to 63% over the same period[4].

The substantial health and financial burdens that result from overweight and obesity are expected to escalate in the future[5]. Overweight and obesity result from a positive energy balance where intake exceeds expenditure[6]. Unhealthy eating behaviours and/ or low levels of exercise are thought to both contribute to the pandemic of obesity[7], although the impact of diet is generally presumed to be greater[8].

In terms of dietary factors, frequent intake of foods that are high in fat, processed carbohydrates and that are energy dense are hypothesised to lead to excess weight gain[9], [10].

The frequency of visits to fast-food restaurants has been suggested to contribute to obesity due to the high energy density, low micronutrient density and large portion sizes in meals from such establishments[11], [12]. It has been estimated that in the USA, adults obtain 11.3% of their daily energy intake from fast food meals[13], [14], while in the UK adults may obtain approximately 10% of their daily energy intake from this source[15]. These studies suggest that fast food restaurants could be risk factors contributing to increasing obesity in the population. However, this relationship could also be influenced by many factors such as socioeconomic factors which may distort the association[16]-[18]. Moreover, access to healthy options in some types of restaurants could be

 doi:10.20944/preprints202008.0004.v1

beneficial for consumers' health[19]. A study in the US showed the prevalence of obesity had no association with the density of fast food or full-service restaurant restaurants after adjusting for a various socioeconomic factors[16]. Moreover, our previous work showed that obesity among UK adults, based on the UK Biobank data, was not associated with the local density of fast-food or full-service restaurants, apart from fish and chip shops[20].

Relatively few studies, have considered the frequency of usage of diverse aspects of the retail food environment including takeaway outlets, delivery services and full-service restaurants, and how such usage may be a driver of adiposity. In the present study, we aimed to investigate the association between the usage of different types of food outlets and BMI among adults living the UK.

2. METHODOLOGY

2.1. Study design

This was a cross-sectional study. Ethical approval was obtained from the Ethics Review Board of the College of Life Sciences and Medicine from the University of Aberdeen (CERB/2018/08/1601). Volunteers were invited to participate in the study through social media, encountering individuals in the main street of Aberdeen city and inviting them to participate and by distributing flyers to postal addresses in Aberdeen. The 2000 distributed postal flyers yielded no participants. Once verbal consent was obtained, they were sent a link to the initial Socio-demographic survey: (supplementary 3). This survey included an electronic consent statement prior to commencing the questions. There was a further statement of agreed participation before each daily food outlet use questionnaire.

In the sociodemographic survey, BMI was estimated based on participants' self-reported weight in kilograms divided by their self-reported height in meters, squared. Data on potential confounding variables was also collected. This included the participants postcode district which allows an estimate of their deprivation level based on the Carstairs index. The Carstairs index is based on four factors from the UK Census: poor social class, lack of vehicle ownership, overcrowding and male unemployment, and the general index represents the material deprivation of a region compared to the remainder of Scotland. Indices may be positive or negative, with negative results indicating a greater affluence in the region and positive scores suggesting a comparatively greater level of deprivation. Participants were asked to disclose additional demographic information including sex, age, ethnicity (White, Asian, Black or mixed), number of people living at their household, workplace and employment status (employed, unemployed or student). In this survey, we also asked the participants about their dietary habits with 6 options and one open choice (regular diet, vegetarian, vegetarian but avoid eggs, vegetarian but avoid eggs and milk, fruitarian, pescatarian and other). We asked if there were any food allergies as this might affect their use of food outlets and one final question asked about their physical activity with four options: inactive, slightly active, moderately active and highly active. One question regarding pregnancy was included for the exclusion criteria.

Once they submited their responses to survey 1, which collected basic demographic data, they were sent a link to survey 2 each day over 7 consecutive days. (Food Outlet Usage survey: supplementary 4). In this survey, we asked the participants whether they used any of food outlets or services over the previous 24hrs with five options of Fast food restaurant (FFR), Full-service restaurant (FSR), delivery, takeaways or none. To stimulate participants' adherence with survey 2, an auto-reminder with a link to survey 2 was automatically generated at 8.30 P.M for 7 consecutive days. For those who wished to stop their participation, they were able to send the word "NO" and they then stopped receiving further reminders.

If the participant indicated that they had visited a food outlet in the previous 24 hrs, they were provided with a table that included the types of the four restaurants and services and beside each type there were options of whether they were visited for breakfast, lunch, dinner or snack.

In this study, we only included males and females who were 18 years old or above, healthy and with no mental or physical illnesses. We excluded females who were pregnant. One hundred and

 doi:10.20944/preprints202008.0004.v1

ninety-nine participants were removed due to incomplete 7-day surveys. The total number of participants who dropped out with no reason was 42, and one participant withdrew due to pregnancy. The final number of participants who completed all seven days of the survey was 681 (Figure 1).

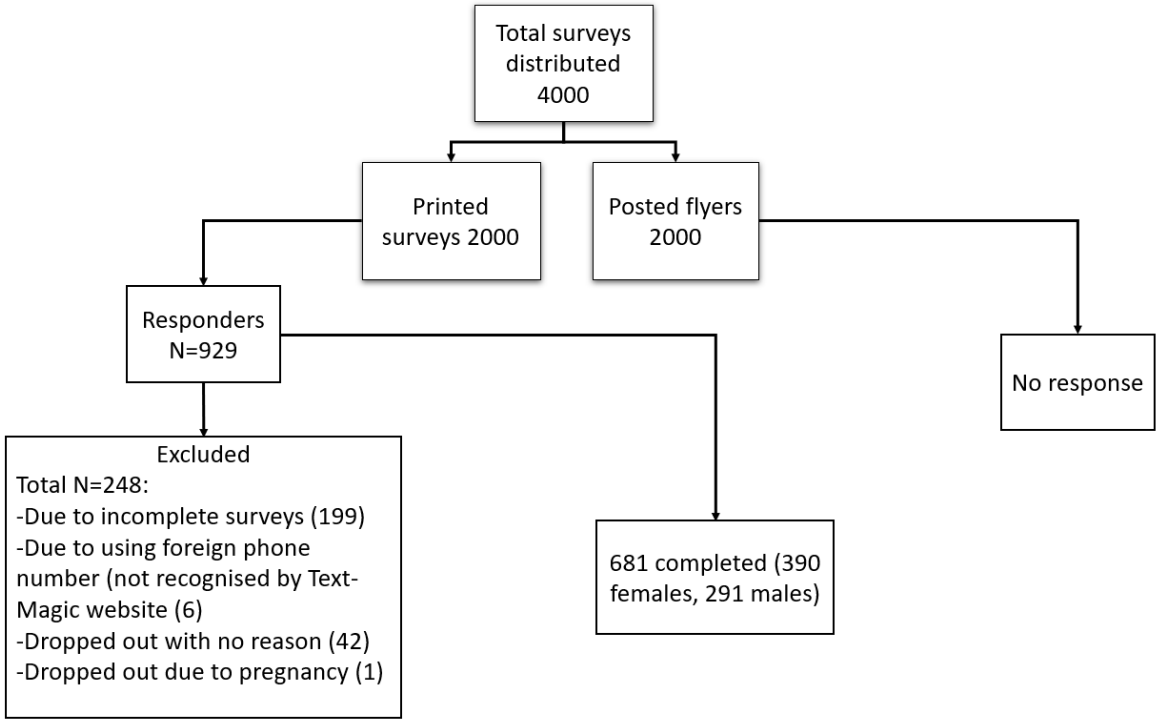


Figure 1. Flow chart of inclusion and exclusion of participants .

2.3. Statistical analysis

All the participant responses were anonymised and coded using Microsoft Excel in preparation for data analysis. Information on socio-demographic descriptive data were collected and translated into mean, standard deviation and total percentage. The socio-demographic variables are shown in Table. 1. We corrected the BMI for potential confounding factors (age, sex, ethnicity, household size, employment, workplace, dietary habits, place of living, physical activity and deprivation level). The correction of the BMI was by deriving the residuals from General Linear Model (GLM) and adding back to the mean BMI.

We counted the number of meals consumed at different types of food outlets or services (FSRs, FFRs, delivery services and takeaways) and we combined the total number of meals consumed at these premises (Total Food Outlet usage) (TFOs). We explored the relationship between the unadjusted and adjusted mean BMI and the food outlet usage using Analysis of Variance (ANOVA). In addition, we reanalysed our data after excluding the participants who reported that they were students to investigate whether this changed the pattern of the relationship.

We segregated the data based on sex to investigate the association between the frequent usage of food outlets and BMI within males and females. To reduce the familywise error rate due to multiple testing for ANOVA, we used the Bonferroni correction for the P-value. The familywise error rate was $\alpha_{fw} = 1 - (0.95)^5 * 100 = 22.6\%$ and the corrected P-value was 0.01 to maintain the confidence in our set of analyses. SPSS version 24 was used for analysis.

3. RESULTS

 doi:10.20944/preprints202008.0004.v1

3.1. Characteristics of the participants

The descriptive data of the participants are presented in Table. 1. The mean age was 25.6± 9.8 years old. Females represented 57.3% (391) of the study population. The mean household size was 2.9 and the proportion of houses that included people under 17 years old was 0.25. Regarding employment status, 64.2% of the participants reported that they were employed, 5.1% unemployed and 30.6% were students (Table. 1). With respect to workplace, 88.9% reported that they worked in Aberdeen and those who reported that they worked in Aberdeenshire represented 1.6% and in flexible premises 5.1% (Table. 1). The percent of participants who worked from home was 4.4%. The deprivation level in the study area averaged -1.3. This equalled six out of ten on the decile scale (Carstairs Index). Ethnicities in our data were divided into four categories, Asian, Black, White and mixed, where the Whites were dominant 72%, Asian, 8.8%, mixed 15.7% and Black was the lowest 2.2% (Table. 1).

Regarding dietary habits, 81.7% reported that they followed a regular diet with no specific restrictions, while 13% were vegetarians (Table. 1). Eighty-eight percent of participants had no food allergy and 11.9% indicated they had an allergy. Out of 681, 48.3% reported that they were moderately active, those who reported that they were slightly active represented 34% and 12% said they were highly active. Inactive participants only represented 5%. The mean BMI in our study was was 26.2 ± 4.16 kg.m^2.

3.2. Food outlet usage versus sex

We explored the difference between males and females in their usage of food outlets. We found that males used FSRs significantly more than females (Mean difference per week = 0.21 times, T = 2.49, P<0.01). Also, males used FFRs significantly more frequently than females (Mean difference per week = 0.33, T = 3.40, P<0.001).

Table 1. Descriptive Statistics: sociodemographic characteristics of the study participants.

Age: Mean (Standard Deviation)	25.6 (9.8)
Sex: number (%)	
Females	391 (57.3)
Males	291 (42.7)
BMI: Mean (Standard Deviation)	
Females	25.4 (4.14)
Males	27.1 (3.99)
Household size: Mean (Standard Deviation)	2.9 (1.7)
People under 17 in a household: Mean (Standard Deviation)	0.25 (0.65)
Employment: number (%)	
Employed	438 (64.2%)
Unemployed	35 (5.1%)
Student	209: (30.6%)
Workplace: number (%)	
Work in Aberdeen	606 (88.9%)
Work in Aberdeen-shire	11 (1.6%)
Work from home in Aberdeen	23 (3.4%)
Work from home in Aberdeen-shire	7 (1.0%)
Flexible premises (working places change daily)	35 (5.1%)
Deprivation level (Carstairs Index): mean (decile scale)	-1.3 (6)
Race: number (%)	
White	497 (72.9%)

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2020 doi:10.20944/preprints202008.0004.v1

Asian	60 (8.8%)
Black	18 (2.6%)
Mixed	107(15.7%)
Dietary habits: numbers (%)	
Regular diet	557 (81.7%)
Vegetarian	89 (13%)
Vegetarian but avoid eggs	1 (0.1%)
Vegetarian but avoid eggs and milk	10 (1.5%)
Fruitarian	1 (0.1%)
Pescatarian	24 (3.5%)
Allergy	
Yes (%)	81 (11.9%)
No (%)	599 (88%)
Physical activity: number (%)	
Highly active	85 (12.5%)
Moderately Active	330 (48.4%)
Slightly active	232 (34%)
Inactive	35 (5.1%)

However, no significant difference between the sexes in the use of delivery and takeaways was observed (Delivery: Difference = 0.11, T = 1.78, P = 0.07; Takeaways: Difference = 0.01, T= 0.24, P = 0.80). The total food outlet usage was significantly higher among males than females (Difference = 0.67, T = 3.67, P < 0.0001) (Figure 2).

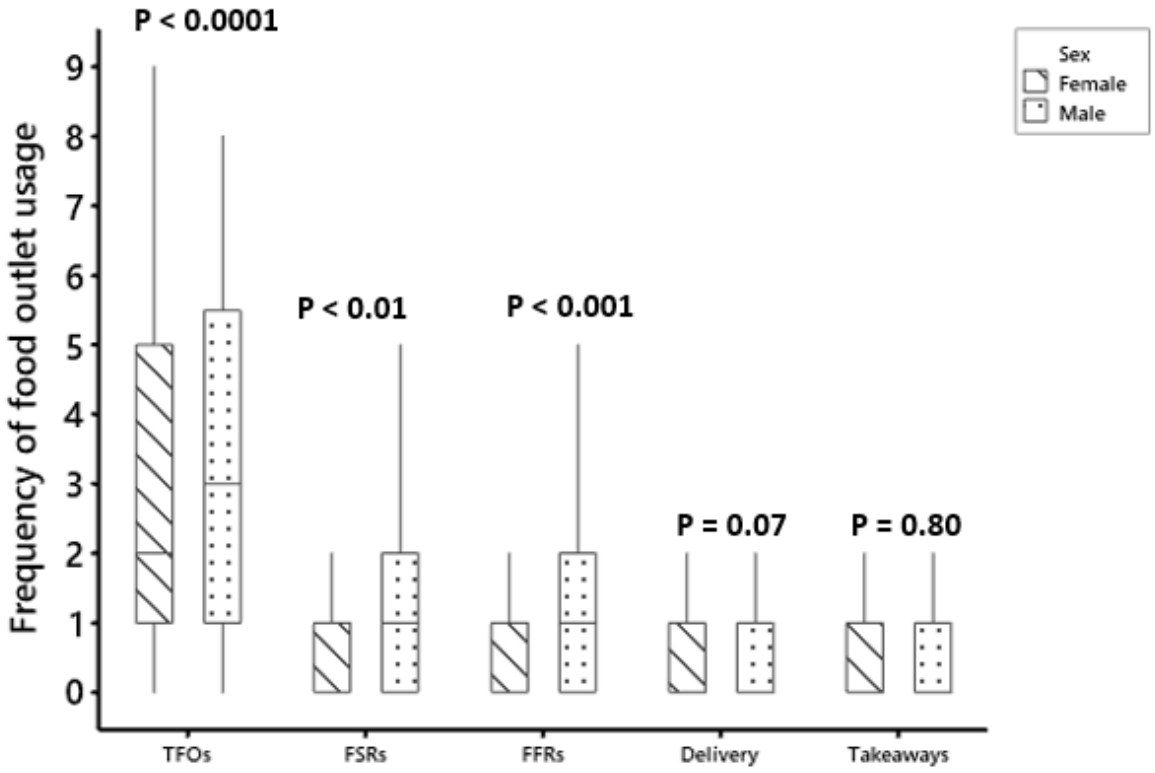


Figure 2. Comparison between the usage of different types of food outlets among males and females, FSR= Full-Service Restaurants, FFR= Fast Food Restaurants, TFO= Total Food Outlets.

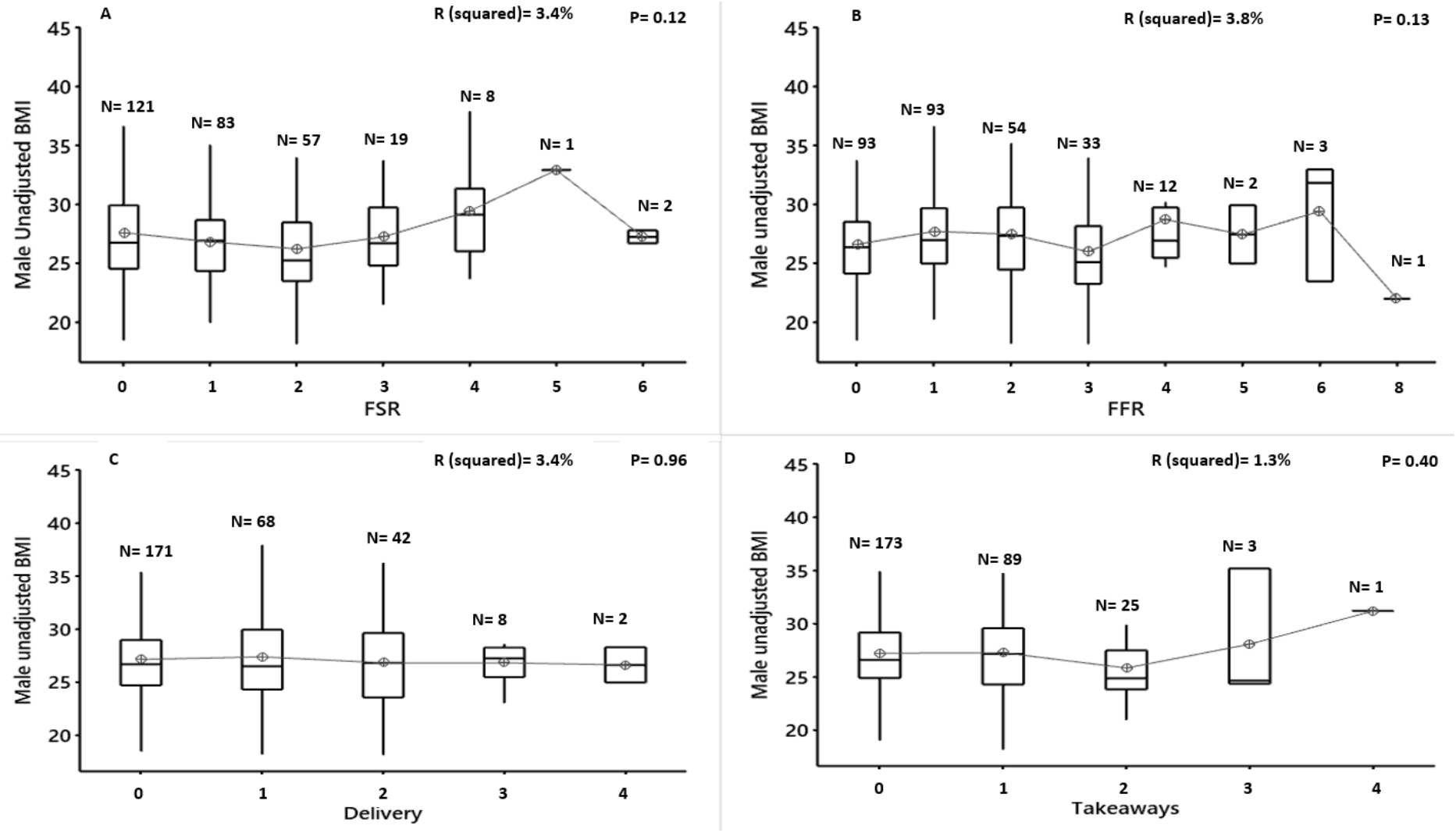
Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2020 doi:10.20944/preprints202008.0004.v1

3.3. Food outlet usage and unadjusted BMI based on sex

Males' frequency of usage of FRSs, FFRs, delivery and takeaways was not associated with unadjusted BMI (FSR; $F(6,284)= 1.67$, $P=0.12$, $R^2= 3.41\%$; FFR; $F(7,283)= 1.61$, $P=0.13$, $R^2= 3.84\%$; Delivery; $F(4,286)= 0.15$, $P=0.96$, $R^2= 0.21\%$;or Takeaways; $F(4,286)= 1.01$, $P=0.40$, $R^2= 1.39\%$) (Supplementary 1. Figure 3: A-D). When the frequency of usage was combined across all outlets there was also no association (TFO; $F (8, 282) = 0.75$, $P=0.64$, $R^2=2.08\%$) (Supplementary 1. Figure 3: E).

Among females, the usage of FSRs, FFRs, delivery and takeaways was also not significantly associated with unadjusted BMI (FSR; $F(5,384)= 2.34$, $P=0.04$, $R^2= 2.9\%$; FFR; $F(6,383)= 2.48$, $P=0.02$, $R^2= 3.7\%$; Delivery; $F(4,385)= 1.98$, $P=0.09$, $R^2= 2.01\%$;Takeaways; $F(5,384)= 1.17$, $P=0.32$, $R^2= 1.50\%$) (Supplementary 1. Figure 4: A-D) or TFO (TFO; $F (9,380) = 1.03$, $P=0.41$, $R^2=2.2\%$) (Supplementary 1. Figure 4: E).

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2020 doi:10.20944/preprints202008.0004.v1



Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2020 doi:10.20944/preprints202008.0004.v1

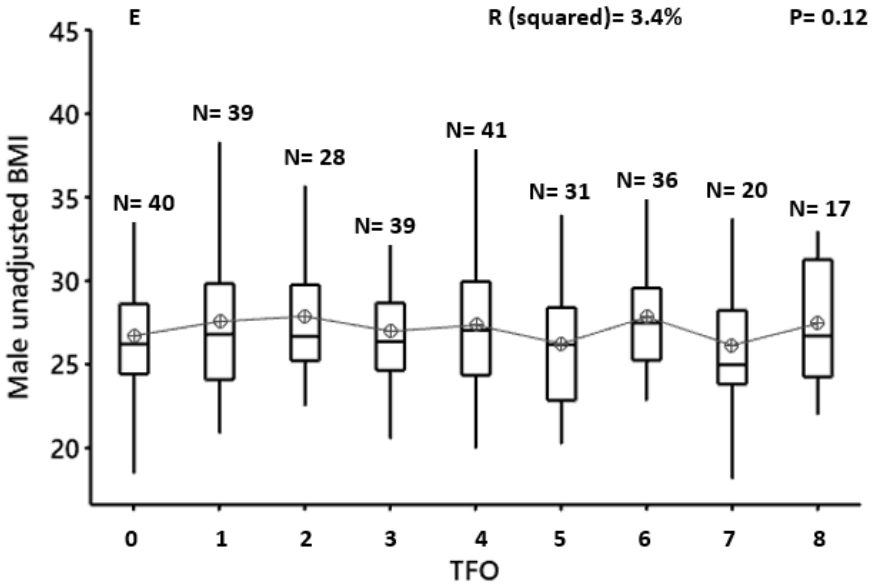
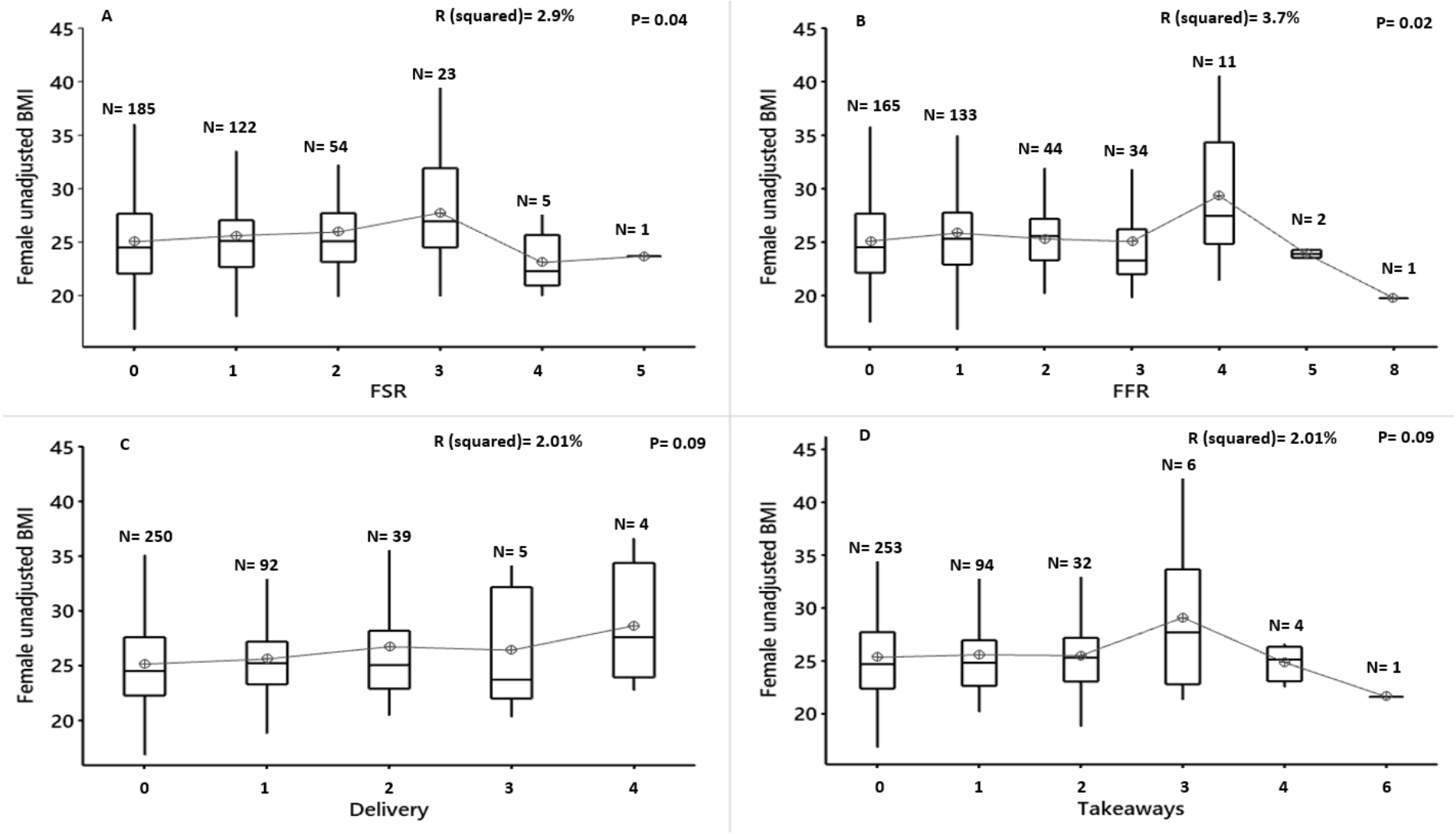


Figure 3. Male unadjusted BMI vs the frequency of food outlet usage for 7-consecutive days. FSR= Full-Service Restaurant, FFR= Fast-Food Restaurants, TFO= Total Food Outlets, N= number of participants in each group. Results of the ANOVA are shown. Significance is where P< 0.01 (after Bonferroni correction).

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2020 doi:10.20944/preprints202008.0004.v1



Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2020 doi:10.20944/preprints202008.0004.v1

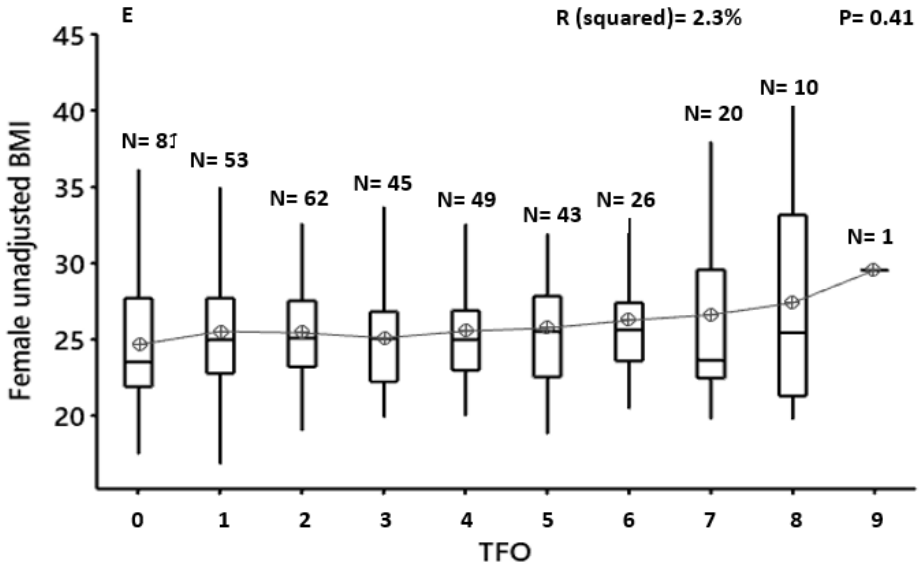


Figure 4. Female unadjusted BMI vs the frequency of food outlet usage for 7-consecutive days. FSR= Full-Service Restaurant, FFR= Fast-Food Restaurants, TFO= Total Food Outlets, N= number of participants in each group. Results of the ANOVA are shown. Significance is where $P< 0.01$ (after Bonferroni correction).

 doi:10.20944/preprints202008.0004.v1

3.4. BMI versus socioeconomic variables (possible confounding factors)

We explored several possible confounding factors that may influence the BMI of the participants (Table. 2). The variables were included individually in a GLM model and the BMI was adjusted for those that were significant. There was a significant positive association between BMI and age (β= 0.08 P<0.0001, R^2 = 4.2%); the older the subject the higher BMI. Sex was also significantly associated BMI; with males having higher BMI than females (β= 0.84 P<0.0001, R2 = 4.01%). No association was noticed between ethnicity and BMI (P= 0.17, R^2 = 0.73%). There was no significant relation between the number of people per household and BMI (P= 0.33, R^2 = 0.14%). However, we found the mean BMI was significantly associated with employment status, where unemployed participants showed a positive association (β = 0.96, P< 0.04) while students were negatively related (β = -1.1, P< 0.0001) and employed had no association (β = 0.15, P = 0.5). The whole model for employment explained 2.3% of the variation in BMI.

Regarding place of work, there was no association between the mean BMI and the workplace whether working in Aberdeen City, rurally in Aberdeenshire, or in flexible premises that changed from day to day, or whether they travelled to work or work from home (online) (Table. 2). The mean BMI was slightly but significantly higher among participants who reported that they do not follow any specific diet regime (β = 1.09, P<0.01), whilst those who reported that they are vegetarians had lower mean BMI (β = -0.05 (P<0.02). The explained variation in BMI by dietary habits was 1.4%.

Regarding place of living, we did not find a difference in the mean BMI between those who lived in Aberdeen City or the surrounding area (Table. 2). Moreover, no significant difference in mean BMI was found among self-reported physical activity groups (Inactive, Slightly active, Moderately active and Highly active (Table. 2). The mean BMI was negatively associated with the level of deprivation based on the Carstairs Index (β = -0.15, P<0.005, R^2= 1.5%).

We adjusted the BMI using stepwise regression to include all the factors mentioned previously in the model. The variation explained by the GLM model was 8.1%. The most significant factors that the BMI was adjusted for were age, sex, dietary habits and deprivation level.

Table 2. General Linear Model analysis: BMI versus socioeconomic factors.

Factors	B	BMI (SD)	P-value	R^2 (%)
Age	0.08	26.2 (4.1)	0.0001	4.26
Sex				4.01
Females	-0.84	25.4 (4.1)	0.0001	
Males	0.84	27.1 (3.9)	0.0001	
Ethnicity				0.73
White	-0.18	26.1 (4.2)	0.17	
Asian	-1.047	25.3 (4.2)	0.03	
Black	1.050	27.4 (4.3)	0.16	
Mixed	0.179	26.5 (3.7)	0.66	
Household size	-0.0905	26.2 (4.1)	0.33	0.14
Employment				2.34
Employed	0.151	26.5 (4.1)	0.594	
Unemployed	0.964	27.3 (4.7)	0.044	
Students	-1.11	25.2 (3.8)	0.0001	
Workplace				0.71
Work in Aberdeen City	-0.386	26.1 (4.09)	0.421	
Work in Aberdeenshire	1.18	27.7 (5.2)	0.271	
Flexible premises	-1.215	25.3 (3.3)	0.089	
Work from home in Aberdeen City	0.819	27.3 (5.3)	0.316	
Work from home in Aberdeenshire	-0.40	26.1 (6.5)	0.30	
Dietary habits				1.43
Avoid milk and eggs	-1.60	23.1 (2.8)	0.114	
Pescatarian	0.561	25.8 (3.7)	0.438	
Regular diet (no restrictions)	1.093	26.4 (4.1)	0.010	
Vegetarian	-0.05	25.3 (4.08)	0.02	
Physical activity				0.18
Inactive	0.155	26.3 (4.1)	0.777	

 doi:10.20944/preprints202008.0004.v1

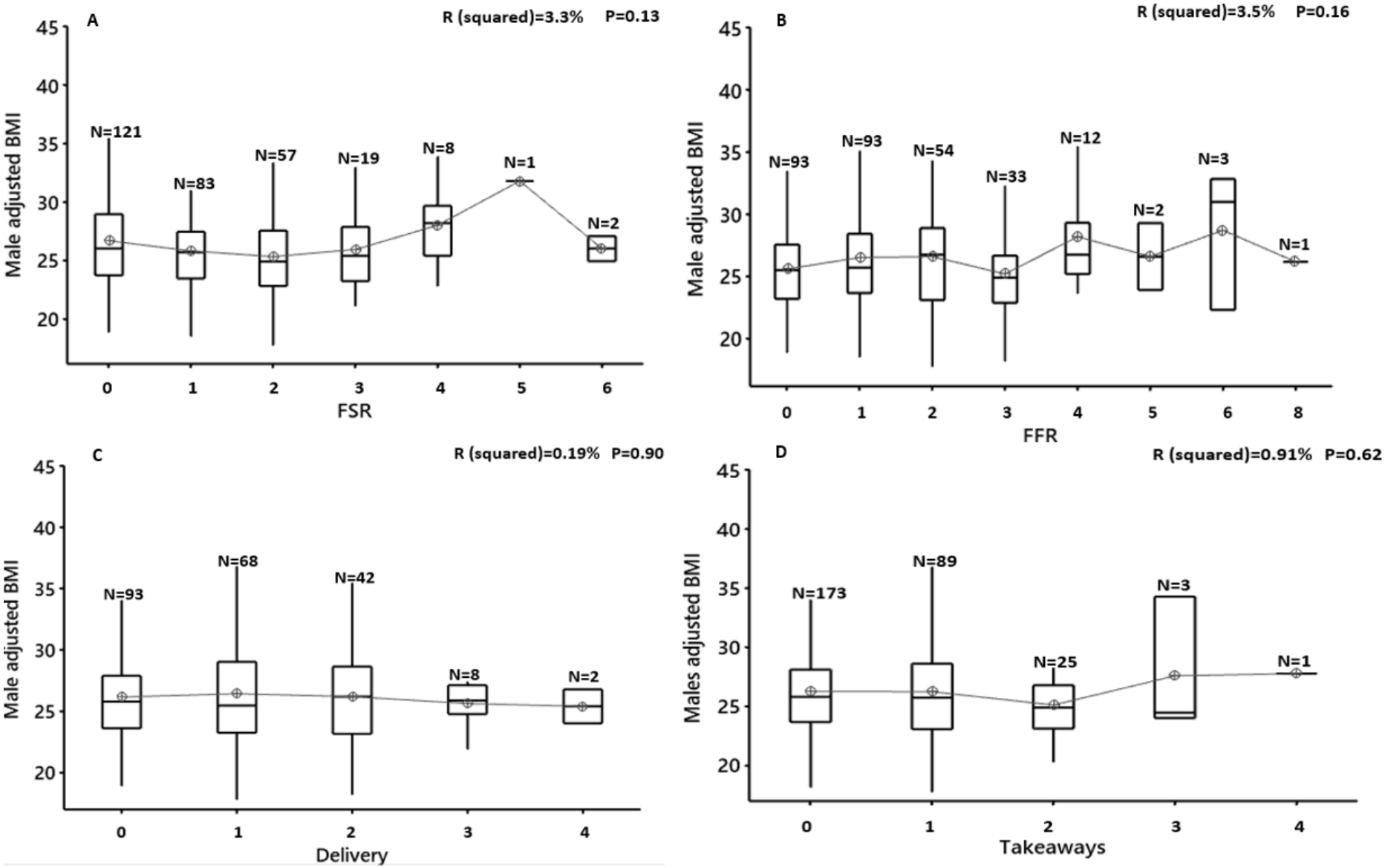
Slightly active	0.10	26.2 (4.5)	0.74	
Moderately Active	0.149	26.2 (4.01)	0.595	
Highly active	-0.405	25.7 (3.7)	0.302	
Place of living				0.03
Aberdeen City	-0.07	26.1 (4.2)	0.673	
Aberdeenshire	0.07	26.3 (4.08)	0.673	
Deprivation level	-0.15	26.2 (4.1)	0.005	1.15
β = Coefficient, BMI= Body Mass Index, SD= Standard Deviation				

 doi:10.20944/preprints202008.0004.v1

3.5. Food outlet usage and adjusted BMI based on sex

In males, the frequency of use of FSRs, FFRs, delivery or takeaways when assessed individually, or combined (TFOs) was not associated with increases in the adjusted BMI (FSR; $F(6,284)= 1.65$, $P=0.13$, $R^2= 3.36\%$; FFR; $F(7,283)= 1.65$, $P=0.16$, $R^2= 3.59\%$; Delivery; $F(4,286)= 0.24$, $P=0.90$, $R^2= 0.19\%$;Takeaways; $F(4,286)= 0.65$, $P=0.62$, $R^2= 0.91\%$; TFO; $F(8,282)= 0.85$, $P=0.56$, $R^2=2.2\%$) (Supplementary 2. Figure 5: A, B, C, D, E). The same was observed in females. There was no significant association between greater frequencies of use of FSRs, FFRs, delivery, takeaways or TFOs and the mean adjusted BMI (FSR; $F(5,384)= 1.75$, $P=0.12$, $R^2= 2.2\%$; FFR; $F(6,383)= 2.28$, $P=0.03$, $R^2= 3.4\%$; Delivery; $F(4,385)= 0.21$, $P=0.90$, $R^2= 3.07\%$;Takeaways; $F(5,384)= 1.24$, $P=0.28$, $R^2= 1.59\%$; TFO; $F(9,380)= 1.02$, $P=0.42$, $R^2=2.3\%$) (Supplementary 2. Figure 6: A, B, C, D, E).

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2020 doi:10.20944/preprints202008.0004.v1



Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2020 doi:10.20944/preprints202008.0004.v1

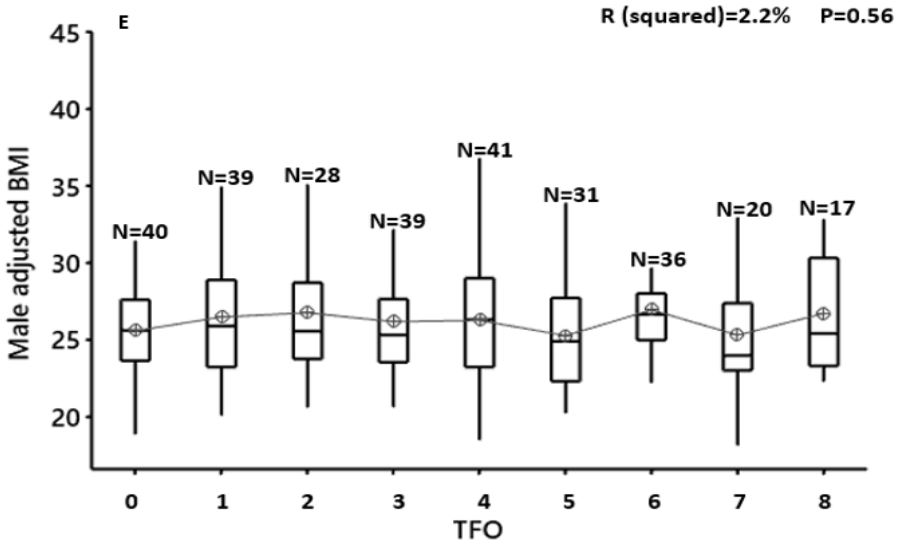
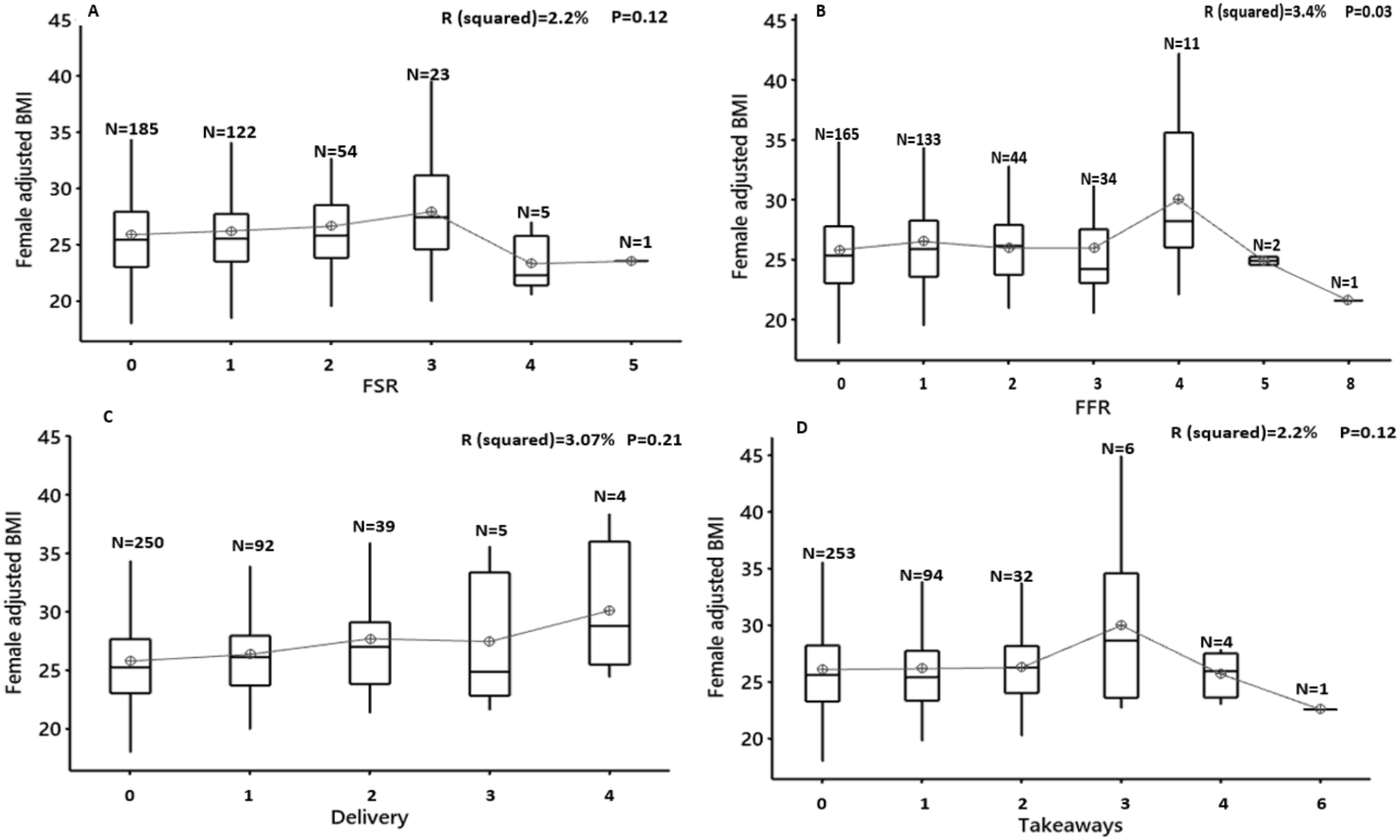


Figure 5. Male adjusted BMI vs the frequency of food outlet usage for 7-consecutive days. FSR= Full-Service Restaurant, FFR= Fast-Food Restaurants, TFO= Total Food Outlets, N= number of participants in each group. Results of the ANOVA are shown. Significance is where P< 0.01 (after Bonferroni correction).

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2020 doi:10.20944/preprints202008.0004.v1



Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 2 August 2020 doi:10.20944/preprints202008.0004.v1

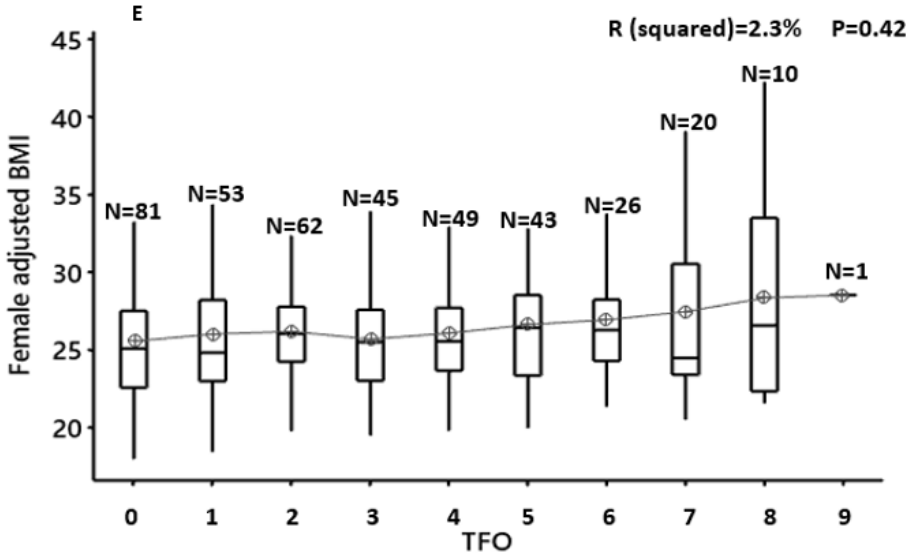


Figure 6. Female adjusted BMI vs the frequency of food outlet usage for 7-consecutive days. FSR= Full-Service Restaurant, FFR= Fast-Food Restaurants, TFO= Total Food Outlets, N= number of participants in each group. Results of the ANOVA are shown. Significance is where P< 0.01 (after Bonferroni correction).

 doi:10.20944/preprints202008.0004.v1

3.6. Food outlet usage vs unadjusted and adjusted BMI based on sex, excluding students

We reanalysed the data after excluding the students to investigate whether changed the pattern of the relationship between the frequency of usage of different types of food outlets and the unadjusted and adjusted BMI. We found no significant association between the frequent usage of the included food outlets and the unadjusted or adjusted BMI after excluding the students from the dataset.

 doi:10.20944/preprints202008.0004.v1

DISCUSSION

Our analysis shows that male and female usage of FSRs, FFRs, delivery, takeaways and TFOs was not associated with unadjusted BMI. After adjusting the BMI for several possible confounding socioeconomic factors, there was still no significant association. Our work is consistent with several previous studies. A study in the U.S found there was no association between fast food consumed out of the home and obesity. This latter study estimated the average energy content in the top five meals purchased from FFRs and FSRs in the USA combined with the number of meals consumed by individuals during a year[16]. This showed the contribution of the energy intake at these restaurants covered 15.9% of energy requirements[16]. Another study in Brazilian urban areas showed 18% of the total energy requirements came from food purchased out of the home [21], and consistent with our study, there was no difference in body weight among the participants whether they ate more frequently inside their homes or outside[21]. Moreover, in the USA a study of 2156 adults showed that out of home food consumption was not associated with BMI[22]. Also, living closer to restaurants was not related to body weight among 10199 Canadian participants, and did not necessarily increase their consumption at these outlets[23]. In the U.K there was no significant association between living near fast food restaurants and BMI among four hundred thousand participants, using Biobank data[24].

The absence of such a relationship between BMI and fast-food restaurant usage may occur for several reasons. First, since the above studies [19,24] suggest that less than 1/5th of energy intake are consumed in these establishments the main dietary habits that drive overweight and obesity may in fact reside in what people consume for the remaining 80% of their requirements[15]. Second, when they visit food outlets, consumers may choose more healthy options than what they eat at home[19], [25]. Some behavioural studies that have focussed on restaurant customers, have indicated that patrons often tend to select healthier menu items and enjoy visiting restaurants offering healthy options such as brown rice, vegetarian or vegan meals[19], [25], [26]. The absence of an association does not support the suggestion that consumption of poor food out of the home is amplified by at home food habits[12], [23], [27], [28].

The finding that individuals who visit these establishments more frequently do not have greater overweight or obesity is also consistent with studies which indicate the population levels of obesity are not greater in areas where there is a higher density of such establishments. This has been demonstrated by analysis at the level of county across the USA [16] as well as using the UK Biobank data at the level of postcode district in the UK[20].

However, other studies have suggested such associations do exist. In Cambridgeshire, an investigation found that people who live nearer to takeaways have higher intake of food by 5.3 grams per day in comparison with the ones who are less exposed[29]. Although 5.3 grams increase in the total food weight might be statistically significant in a large sample, it represents only about 50 kJ of additional energy (assuming a water content of 50% and an energy density of the remainder of 20 kJ/g) which is less than 1% of daily energy requirements and unlikely to be responsible for an increase in BMI. Moreover, the 5.3g value itself was based on extrapolation from food frequency questionnaires which are extremely inaccurate[30]-[32]. It was also noted in a UK based study that food consumption at restaurants, cafes and takeaways may increase daily energy intake between 3.2% to 4.4% in adults[33]. However, this research depended on four-day food records selected from UK National Diet and Nutrition Survey without reporting whether these percentages were also related to increased BMI.

Previous studies have suggested that the association between the frequency of food outlet use and obesity could be different in males and females[29], [30], [33], [34]. Some of these studies concluded that the association between food outlets and BMI was only significant for women[35],whilst other investigations noted that the associations between fast food restaurants and diet[36] and BMI were more observable in men[37]. Our study is consistent with a previous UK based investigation that concluded that there is no indication for sex differences in the association between BMI in males and females and their use of restaurants[38].

 doi:10.20944/preprints202008.0004.v1

Finally, a factor contributing to the contradictory results in the literature are factors that influence the relationship such as age, ethnicity, household size, employment, workplace, dietary habits, place of living, physical activity and deprivation level, and how these are accounted for in the analysis. It was noted in a systematic review in 2009 that when considering the relationship between eating out and weight gain, it is important to investigate if food intake at restaurants is causal to overweight or merely a proxy for other unhealthy lifestyle factors that may cluster, such as physical activity and neighbourhood sociodemographic status[39]. In our study the lack of an association was evident when we used unadjusted data and data adjusted for these potentials confounds.

Strengths and limitations

We used the Text-Magic website to generate automated text-survey messaging. The benefit of using such a technique is to reduce the risk of memory dependent error. By reminding individuals every day to complete the survey the possibility of forgetting an event (eating at a restaurant or ordering takeaway and delivery over the previous 24h) was likely reduced compared to asking people to recall visits to restaurants over the previous week – requiring recall of events up to seven days previously.

We counted the number of meals consumed from several different types of restaurants and food services which strengthen the investigation of the association between BMI and frequency of usage of food outlets. However, this study also has some limitations that need to be recognised. First, the weight and height were self-reported and are subject to potential bias and error[40]. However, a study conducted in Scotland to assess the validity of self-report weights and heights in the Scottish population which included 865 men and 971 women reported that the Scottish population have a low error and unbiased reporting of their weight and height which would be satisfactory for monitoring prevalence of overweight and obesity[41]. Finally, we emphasise that not finding associations does not necessarily mean individuals could eat high quantity of meals from these outlets without health consequences.

CONCLUSION

In this study, we evaluated the association between the frequency of use of different types of food outlets and BMI in males and females in the UK. No association was found between FSRs, FFRs, delivery, takeaways and TFOs and BMI in both males and females. These data do not support the widespread belief that consumption of food out of the home at fast-food and full-service restaurants, combined with that derived from deliveries and takeaways, is a major driver of obesity.

Author contributions: Conceptualization, AA, JRS and CH; methodology, AA, JRS and CH; Software, AA and JRS, validation; JRS, CH. and AA; formal analysis, AA., JRS and CH; investigation, AA, JRS and CH; data curation, AA and JRS; writing—original draft preparation, AA; writing—review and editing, JRS and CH; visualization, AA. supervision, JRS. and CH; All authors have read and agreed to the published version of the manuscript.

Funding: AA was supported by a studentship from the University of Tabuk, Saudi Arabia (KSA) project code CF10434-63. JRS was supported by a Wolfson merit award from the Royal Society.

Acknowledgments: we thank Mr. Vasileios Kyparissis and Ms. Florina Birkert for their help in distributing and collecting surveys with us.

Competing interests: No financial competing interests related to the work.

References

1. [1] J. B. Dixon, "The effect of obesity on health outcomes," *Mol. Cell. Endocrinol.,* vol. 316, *(2),* pp. 104-108, 2010.
2. [2] M. Agha and R. Agha, "The rising prevalence of obesity: part A: impact on public health," *Int. J. Surg. Oncol. (N. Y),* vol. 2, *(7),* pp. e17, Aug, 2017.
3. [3] (2018). *Health Surveys for England* [NHS]. Available: https://digital.nhs.uk/data-and-information/publications/statistical/health-survey-for-england.

4. [4] (21/02/2020). *Main report 2020* [SHS]. Available: https://www.gov.scot/publications/scottish-health-survey.
5. [5] T. Lehnert *et al*, "Economic costs of overweight and obesity," *Best Practice & Research Clinical Endocrinology & Metabolism,* vol. 27, *(2),* pp. 105-115, 2013.
6. [6] K. Giskes *et al*, "A systematic review of environmental factors and obesogenic dietary intakes among adults: are we getting closer to understanding obesogenic environments?" *Obesity Reviews,* vol. 12, *(5),* pp. e95-e106, 2011.
7. [7] M. Mu *et al*, "Dietary Patterns and Overweight/Obesity: A Review Article," *Iran. J. Public. Health.,* vol. 46, *(7),* pp. 869-876, Jul, 2017.
8. [8] K. D. Hall *et al*, "Quantification of the effect of energy imbalance on bodyweight," *The Lancet,* vol. 378, *(9793),* pp. 826-837, 2011.
9. [9] J. E. Todd, L. Mancino and B. Lin, "The impact of food away from home on adult diet quality," *USDA-ERS Economic Research Report Paper, (90),* 2010.
10. [10] K. D. Hall *et al*, "Ultra-processed diets cause excess calorie intake and weight gain: an inpatient randomized controlled trial of ad libitum food intake," *Cell Metabolism,* vol. 30, *(1),* pp. 67-77. e3, 2019.
11. [11] S. A. French, M. Story and R. W. Jeffery, "Environmental influences on eating and physical activity," *Annu. Rev. Public Health,* vol. 22, *(1),* pp. 309-335, 2001.
12. [12] E. S. Nago *et al*, "Association of out-of-home eating with anthropometric changes: a systematic review of prospective studies," *Crit. Rev. Food Sci. Nutr.,* vol. 54, *(9),* pp. 1103-1116, 2014.
13. [13] C. D. Fryar and R. B. Ervin, *Caloric Intake from Fast Food among Adults: United States, 2007-2010.* US Department of Health and Human Services, Centers for Disease Control and Prevention, 2013*(114).*
14. [14] R. An, "Fast-food and full-service restaurant consumption and daily energy and nutrient intakes in US adults," *Eur. J. Clin. Nutr.,* vol. 70, *(1),* pp. 97-103, 2016.
15. [15] J. Adams *et al*, "Frequency and socio-demographic correlates of eating meals out and take-away meals at home: cross-sectional analysis of the UK national diet and nutrition survey, waves 1–4 (2008–12)," *International Journal of Behavioral Nutrition and Physical Activity,* vol. 12, *(1),* pp. 51, 2015.
16. [16] M. Mazidi and J. R. Speakman, "Higher densities of fast-food and full-service restaurants are not associated with obesity prevalence," *Am. J. Clin. Nutr.,* vol. 106, *(2),* pp. 603-613, 2017.
17. [17] M. Stafford *et al*, "Deprivation and the development of obesity: a multilevel, longitudinal study in England," *Am. J. Prev. Med.,* vol. 39, *(2),* pp. 130-139, 2010.
18. [18] M. S. Wong *et al*, "The neighborhood environment and obesity: Understanding variation by race/ethnicity," *Prev. Med.,* vol. 111, pp. 371-377, 2018.
19. [19] C. S. Jones, "Taking up space? How customers react to health information and health icons on restaurant menus," *Journal of Foodservice Business Research,* vol. 12, *(4),* pp. 344-363, 2009.
20. [20] A. Albalawi, C. Hambly and J. Speakman, "Associations of Food Outlet Densities with Obesity Measures Identify Fish and Chip Shops as a Uniquely Important Problem," *Nutrients,* vol. 12, *(4),* pp. 890, 2020.
21. [21] I. N. Bezerra *et al*, "Contribution of foods consumed away from home to energy intake in Brazilian urban areas: the 2008–9 Nationwide Dietary Survey," *Br. J. Nutr.,* vol. 109, *(7),* pp. 1276-1283, 2013.
22. [22] A. M. Adachi-Mejia *et al*, "Geographic variation in the relationship between body mass index and the built environment," *Prev. Med.,* vol. 100, pp. 33-40, 2017.
23. [23] J. Y. Polsky *et al*, "Absolute and relative densities of fast-food versus other restaurants in relation to weight status: Does restaurant mix matter?" *Prev. Med.,* vol. 82, pp. 28-34, 2016.

24. [24] K. E. Mason, N. Pearce and S. Cummins, "Associations between fast food and physical activity environments and adiposity in mid-life: cross-sectional, observational evidence from UK Biobank," *The Lancet Public Health,* vol. 3, *(1),* pp. e24-e33, 2018.
25. [25] H. J. Kim *et al*, "Does perceived restaurant food healthiness matter? Its influence on value, satisfaction and revisit intentions in restaurant operations in South Korea," *International Journal of Hospitality Management,* vol. 33, pp. 397-405, 2013.
26. [26] J. Kang, J. Jun and S. W. Arendt, "Understanding customers' healthy food choices at casual dining restaurants: Using the Value–Attitude–Behavior model," *International Journal of Hospitality Management,* vol. 48, pp. 12-21, 2015.
27. [27] B. M. Popkin, L. S. Adair and S. W. Ng, "Global nutrition transition and the pandemic of obesity in developing countries," *Nutr. Rev.,* vol. 70, *(1),* pp. 3-21, 2012.
28. [28] G. Garcia, T. S. Sunil and P. Hinojosa, "The fast food and obesity link: consumption patterns and severity of obesity," *Obesity Surg.,* vol. 22, *(5),* pp. 810-818, 2012.
29. [29] T. Burgoine *et al*, "Associations between exposure to takeaway food outlets, takeaway food consumption, and body weight in Cambridgeshire, UK: population based, cross sectional study," *Bmj,* vol. 348, pp. g1464, Mar 13, 2014.
30. [30] J. E. Cade *et al*, "DIET@ NET: Best Practice Guidelines for dietary assessment in health research," *BMC Medicine,* vol. 15, *(1),* pp. 202, 2017.
31. [31] A. de la Hunty, "The COMA report on nutritional aspects of cardiovascular disease," *Br. Food J.,* 1995.
32. [32] Scientific Advisory Committee on Nutrition, *Dietary Reference Values for Energy*. The Stationery Office, 2012.
33. [33] L. Goffe *et al*, "Relationship between mean daily energy intake and frequency of consumption of out-of-home meals in the UK National Diet and Nutrition Survey," *International Journal of Behavioral Nutrition and Physical Activity,* vol. 14, *(1),* pp. 131, 2017.
34. [34] A. S. Richardson *et al*, "Neighborhood fast food restaurants and fast food consumption: a national study," *BMC Public Health,* vol. 11, *(1),* pp. 543, 2011.
35. [35] J. Boone-Heinonen *et al*, "Fast food restaurants and food stores: longitudinal associations with diet in young to middle-aged adults: the CARDIA study," *Arch. Intern. Med.,* vol. 171, *(13),* pp. 1162-1170, 2011.
36. [36] J. S. Volek *et al*, "Comparison of a very low-carbohydrate and low-fat diet on fasting lipids, LDL subclasses, insulin resistance, and postprandial lipemic responses in overweight women," *J. Am. Coll. Nutr.,* vol. 23, *(2),* pp. 177-184, 2004.
37. [37] L. Pieroni and L. Salmasi, "Fast-food consumption and body weight. Evidence from the UK," *Food Policy,* vol. 46, pp. 94-105, 2014.
38. [38] R. W. Jeffery *et al*, "Are fast food restaurants an environmental risk factor for obesity?" *International Journal of Behavioral Nutrition and Physical Activity,* vol. 3, *(1),* pp. 2, 2006.
39. [39] J. E. Holsten, "Obesity and the community food environment: a systematic review," *Public Health Nutr.,* vol. 12, *(3),* pp. 397-405, 2009.
40. [40] Y. M. Powell-Young, "The validity of self-report weight and height as a surrogate method for direct measurement," *Applied Nursing Research,* vol. 25, *(1),* pp. 25-30, 2012.

 doi:10.20944/preprints202008.0004.v1

41. [41] C. Bolton-Smith *et al*, "Accuracy of the estimated prevalence of obesity from self reported height and weight in an adult Scottish population," *J. Epidemiol. Community Health*, vol. 54, *(2)*, pp. 143-148, Feb, 2000.