Relationships between food groups, eating time slots and diabetes status in adults from the UK National Diet and Nutrition Survey (2008–2017)

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Short running head: Time of food consumption by diabetes status.

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**Abbreviations:**

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## ABSTRACT

**Background:** Time of eating has been shown to be associated with diabetes and obesity.

**Objective:** To identify potential relationships between foods and eating time, and see whether these associations may vary by diabetes status.

**Design:** The National Diet and Nutrition Survey (NDNS) included 6802 adults (age 19) collected 749026 food recordings by a 4-day-diary. The contingency table cross-classifying 60 foods with the pre-defined 7-time slots were analyzed by Correspondence Analysis (CA). Biplots displaying the associations were generated for all adults and separately by diabetes status (self-reported, pre-, undiagnosed-, and non-diabetics). Odds ratios (OR, 99%CIs) were derived of consuming unhealthy foods at evening/night (20:00 - 06:00) vs. earlier in the day, by logistic regression with generalized estimating equation.

**Results:** The biplots suggested positive associations between evening/night and spirits, beer, ice cream, chocolate, sugar-confectionery, biscuits, crisps, and sweetened beverages. The OR of consuming these foods at evening/night were respectively 11.13 (8.37-14.80), 7.19 (5.87-8.82), 2.38 (1.79-3.15), 3.19 (2.69-3.79), 1.92 (1.38-2.69), 1.91 (1.67-2.16), and 1.55 (1.27-1.88) vs. earlier time. Stratified biplots found that sweetened beverages, sugar-confectionery were more likely to be consumed at event/night among undiagnosed diabetics.

**Conclusions:** Foods consumed in the evening/night time tend to be highly processed, easily accessible, and rich in added sugar or saturated fat. Individuals with undiagnosed diabetes are more likely to consume unhealthy foods at night. Further longitudinal studies are required to explore the causality.

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## INTRODUCTION

The timing of energy intake has been shown to be associated with obesity and diabetes. (1)

We aimed to decribe the relationship between food groups and the time of day when they were consumed, and how such relationships may vary by status of type 2 diabetes.

## METHODS

6802 adults (2810 men and 3992 women) and 749,026 food recordings collected by the UK National Diet and Nutrition Survey Rolling Programme (NDNS RP 2008-17) were analyzed in the current study (2). The sample was randomly drawn from a list of all addresses in the UK, clustered into postcode sectors. Details of the rationale, design and methods of the survey can be found in the previous published reports (3,4). Time of the day was categorized as 7 slots: 6-9 am, 9-12 noon, 12-2 pm, 2-5 pm, 5-8 pm, and 10 pm - 6 am. Foods recorded were classified into 60 standard food groups with 1 to 10 subgroups each: the details are given in Appendix R of the NDNS offical report (5). We focused on the 60 standard food groups in the current analysis. Diabetes statuses were defined as: 1) healthy if fasting glucose was lower than 6.10 (mmol/L), hemoglobin A1c (HbA1c) were less than 6.5 (%), and without self-reported diabetes or under treatment of diabetes (n = 2626); 2) pre-diabetic if fasting glucose was lower between 6.10 and 6.99 (inclusive) but without self-reported diabetes or under treatment of diabetes (n = 133); 3) undiagnosed diabetic if either fasting glucose was higher or equal to 7.00 (mmol/L) or HbA1c higher or equal to 6.5 (%) but without self-reported diabetes or under treatment of diabetes (n = 99); 4) diabetic if participant had self-reported diabetes or under treatment of diabetes (n = 227). Consequently, number of adults whose diabetes status could not be confirmed was 3717 (1519 men, 2198 women) and they were kept in the whole sample analyses.

Correspondence analysis (CA) (6,7) was used as a tool for data mining, visualisation and hypotheses generation using half of the randomly selected NDNS diary entries data. Specifically, the contingency table generated by cross-tabulating foods and time of eating were analyzed by CA. Through CA, the 60 categories of standard food and the 7 time-slot were projected on two dimensions that could jointly contain large percentage of the deviation (or inertia) of the table. Biplots that graphically showing the association between time of day and food groups were derived for all adults and seprately according to their diabetes status. To account for the hierarchy of the data (food recordings within the same individuals who lived within the same sampling units) and to calculate population marginal odds ratios (OR), logistic regression models with generalized estimating equations (GEE) were used to test associations that were suggested from biplots generated by CA using the remaining half of the diary entries data.

## RESULTS

## DISCUSSION

### Conclusions

## ACKNOWLEDGEMENT

## CONFLIT OF INTEREST (COI) STATEMENT

The authors declared no conflicts of interest.

## AUTHOR’S CONTRIBUTIONS

CW, SA, and LP: designed research and had primary responsibility for final content; CW and LP performed statistical analysis; and all authors: wrote the manuscript, read and approved the final manuscript.

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## REFERENCES

1. Almoosawi S, Vingeliene S, Karagounis L, Pot G. Chrono-nutrition: A review of current evidence from observational studies on global trends in time-of-day of energy intake and its association with obesity. Proc Nutr Soc. Cambridge University Press; 2016;75:487–500.

2. MRC Elsie Widdowson Laboratory and NatCen Social Research. National diet and nutrition survey years 1-8, 2008/09-2015/16 [data collection]. 11th Edition. UK Data Service. SN: 6533; 2018.

3. Bates B, Lennox A, Prentice A, Bates CJ, Page P, Nicholson S, Swan G. National Diet and Nutrition Survey: Results from years 1, 2, 3 and 4 (combined) of the Rolling Programme (2008/2009-2011/2012): A survey carried out on behalf of Public Health England and the Food Standards Agency. Public Health England; 2014.

4. Roberts C, Steer T, Maplethorpe N, Cox L, Meadows S, Nicholson S, Page P, Swan G. National Diet and Nutrition Survey: Results from years 7 and 8 (combined) of the Rolling Programme (2014/2015–2015/2016). Public Health England; 2018;

5.. National diet and nutrition survey years 1-8, 2008/09-2015/16. 9th Edition. 2018.

6. Greenacre M. Correspondence analysis in practice. Chapman; Hall/CRC; 2017.

7. Chapman AN, Beh EJ, Palla L. Application of correspondence analysis to graphically investigate associations between foods and eating locations. 2017;