Mining relationships between food groups, eating time slots and diabetes status in adults from UK NDNS RP

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Introduction

- The timing of energy/nutrient intake has been previously shown to be associated with obesity and diabetes [1];
- Recently derived diurnal patterns of energy/carbohydrate intake suggested the potential interplay of circadian biology and social behaviour contributing to obesity [2];
- **Aim:** To characterise the relationship between food groups and the time of day when they are eaten, and how such relationships may vary by type 2 diabetes status.

Data and Methodology

- National Diet and Nutrition Survey Rolling Programme (NDNS RP, 2008-2017) included 6802 adults (2810 men and 3992 women) aged 19 or older in the UK, and their 749,026 food recordings collected by a 4-day-diary.
- Time of the day was categorised into 7 slots: 6-9 am, 9-12 noon, 12-2 pm, 2-5 pm, 5-8 pm, 8-10 pm and 10 pm-6 am; foods recorded were categorised in one of 60 standard food groups.
- The derived contingency table cross-classifying 60 food groups with the 7 time slots were analyzed by Correspondence Analysis (CA). Biplots graphically displaying the association were derived for all adults combined and separately by diabetes status.

Table 1: Definition of Type 2 Diabetes (T2D).

Diabetes status	Self-reported	Glucose (mmol/L)		HbA1c (%)	n
No diabetes	No	< 6.10	AND	< 6.5	2626
Pre-diabetes	No	$6.10 \sim 6.99$		--	133
Undiagnosed	No	$\geqslant 7.00$	OR	$\geqslant 6.5$	99
Diagnosed	Yes	--		--	227
Missing	NA	NA		NA	3717

- The odds ratio estimate was derived of consuming unhealthy food groups selected by CA, later in the day (8pm - 6am) compared to earlier in the day, by logistic regression models with generalised estimating equation (GEE) accounting for repeated food entries from the same individual.

Results

Figure 1: Biplot for CA of food groups and time slots among **non-diabetics**.

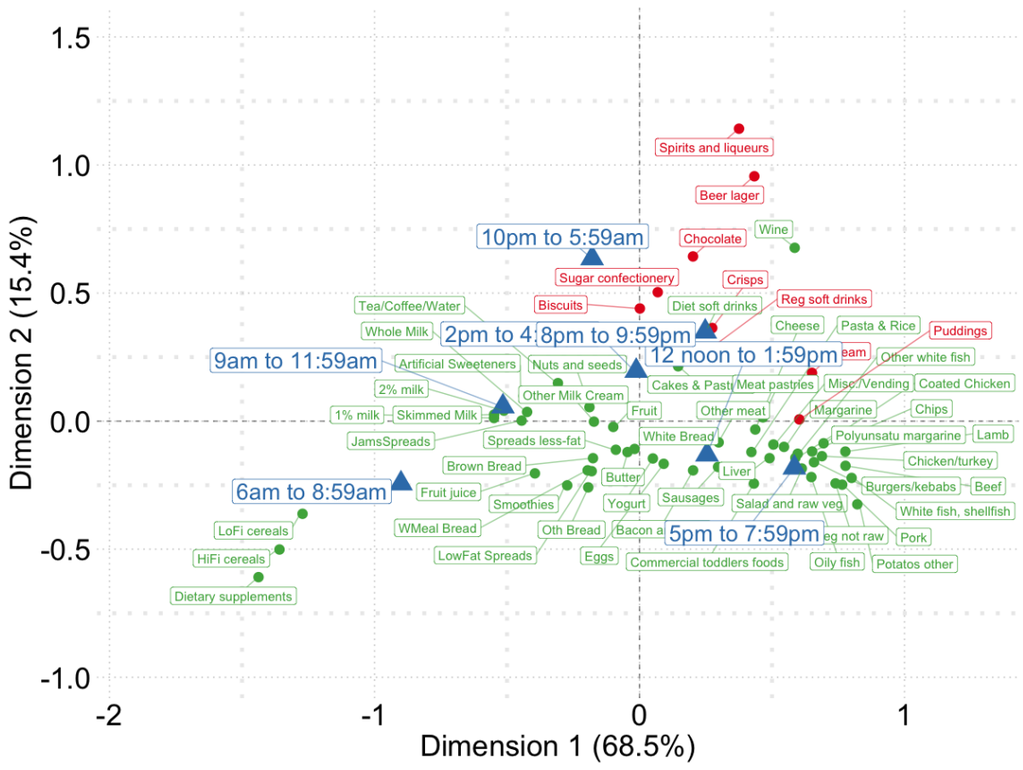

Figure 2: Biplot for CA of food groups and time slots among **diabetics**.

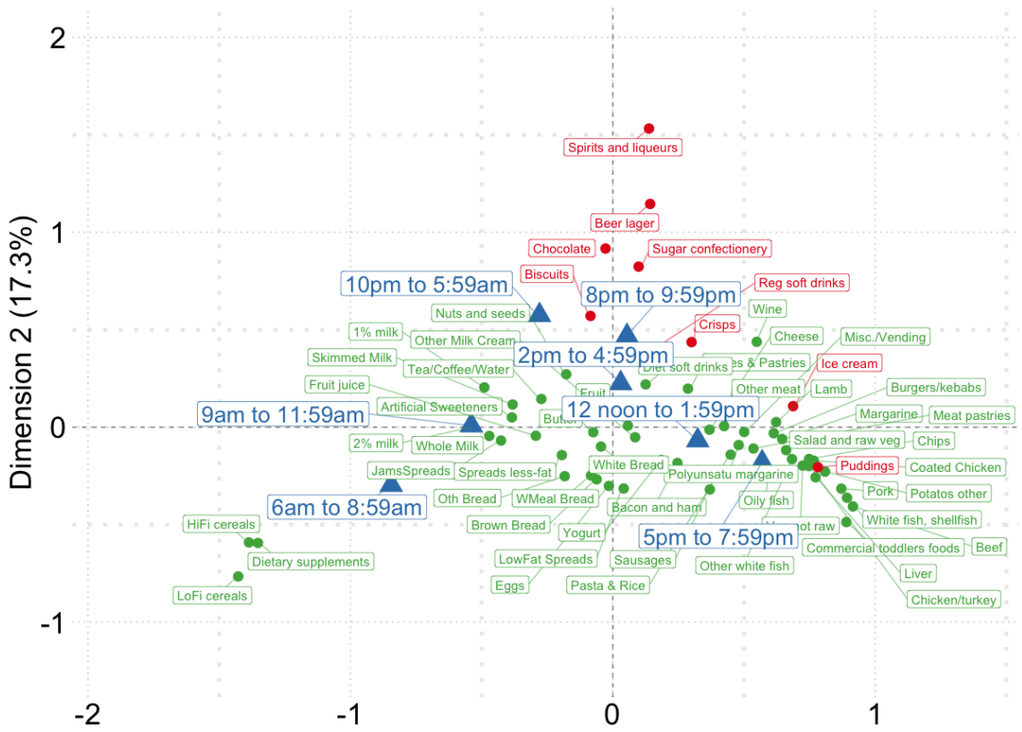

Figure 3: Biplot for CA of food groups and time slots among **undiagnosed diabetics**.

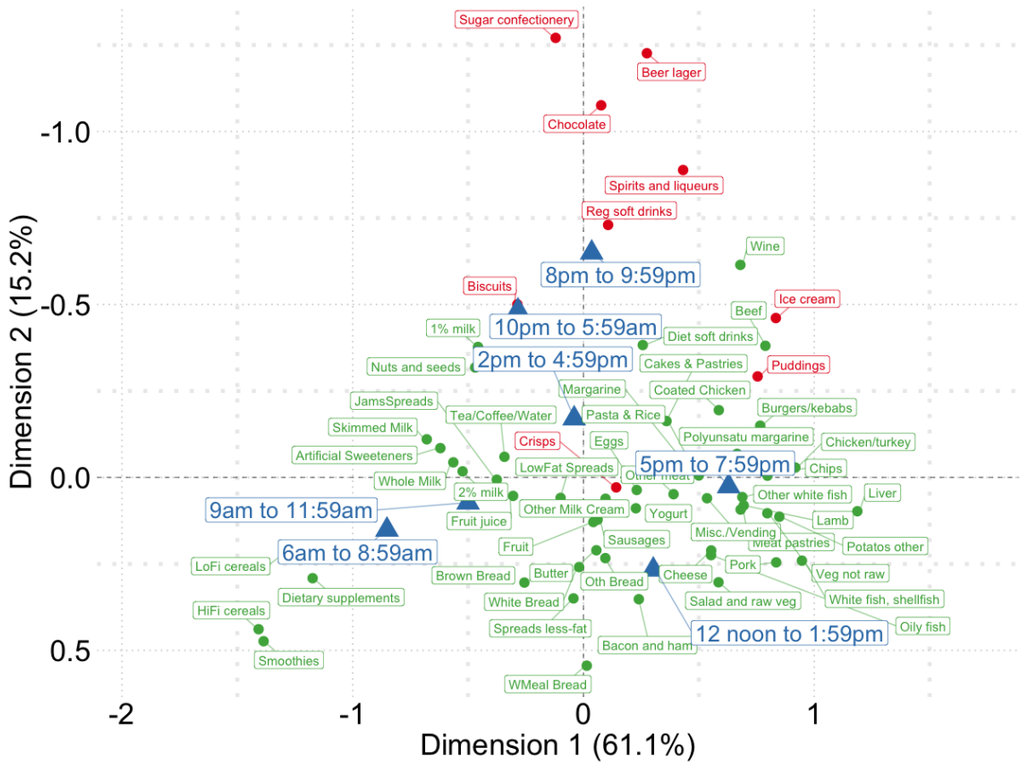

Figure 4: Biplot for CA of food groups and time slots among **pre-diabetics**.

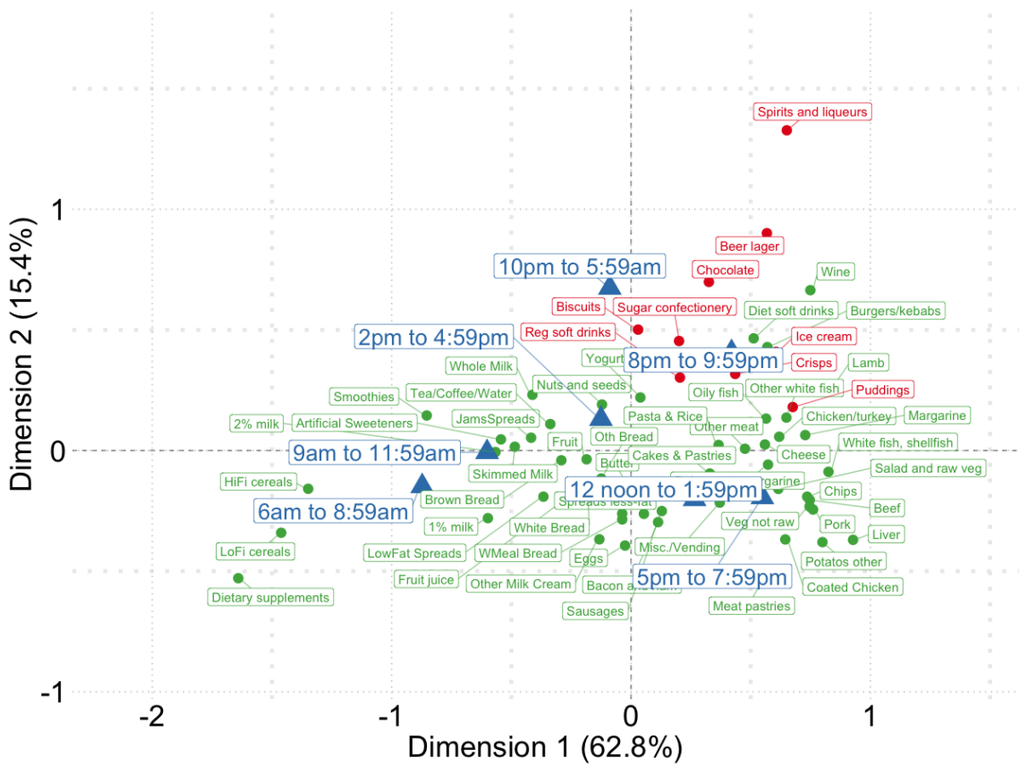

Table 2: OR (99%CI) for food groups eaten at night (8pm - 6am) vs. earlier time, among total and according to different T2D status, NDNS RP 2008-2017.

Food group	Overall	Non-DM	Pre-DM	Undiag-DM	DM
Pudding	1.38 (1.03, 1.86)	1.50 (1.10, 2.07)	0.89 (0.16, 4.87)	1.81 (0.41, 7.98)	0.58 (0.14, 2.43)
Sweetened Soft Drink	1.74 (1.47, 2.06)	1.72 (1.43, 2.06)	1.87 (0.97, 3.57)	2.72 (1.44, 5.14)	1.38 (0.65, 2.96)
Sugar Confectionery	1.92 (1.38, 2.69)	1.63 (1.14, 2.32)	2.10 (0.52, 8.46)	13.07 (4.59, 37.24)	5.10 (2.15, 12.09)
Chocolate	3.19 (2.69. 3.79)	3.10 (2.57, 3.73)	4.07 (2.58, 3.73)	2.52 (0.95, 6.66)	5.13 (2.55, 10.30)
Spirit	11.13 (8.37, 14.80)	10.86 (8.01, 14.73)	8.48 (2.26, 31.79)	7.51 (1.99, 5.21)	36.8 (7.36, 183.66)
Beer	7.19 (5.87, 8.82)	7.49 (6.02, 9.34)	4.05 (2.00, 8.20)	7.87 (3.51, 17.63)	6.32 (2.29, 17.47)
Ice Cream	2.38 (1.79, 3.15)	2.45 (1.82, 3.31)	3.32 (0.75, 14.62)	0.98 (0.14, 7.00)	1.65 (0.54, 5.07)
Biscuit	1.91 (1.67, 2.16)	1.78 (1.55, 2.03)	3.51 (2.16, 5.71)	2.75 (1.35, 5.59)	2.44 (1.54, 3.88)
Crisp	1.55 (1.27, 1.88)	1.56 (1.27, 1.92)	1.95 (0.79, 4.78)	1.37 (0.37, 5.12)	1.16 (0.49, 2.75)

Logisitic regression models with GEE were adjusted for age, sex, and social-economic status.

Discussion

- Assessing the relationships between less healthy foods and timing of eating is a first step towards identifying specific public health targets for behaviour change/modification.
- All unhealthy foods emerged from CA were significantly more likely to be eaten after 8pm. These included alcoholic/sweetened beverages, chocolates and other foods rich in added sugars and saturated fats like biscuits and ice cream.
- Foods and drinks consumed in the evening/night time slot tend to be highly processed and easily accessible.
- Undiagnosed T2D patients might be at higher risk of causing/worsening their condition as they had higher odds to consume a number of less healthy foods after 8pm (sugar confectionary, biscuits, sweetened soft drinks and puddings) than diabetics and non diabetics.
- The survey cross-sectional nature warrants further investigations by longitudinal cohort studies to establish the causal relation between time of eating of unhealthy foods and diabetes.

[1] S. Almoosawi, S. Vingeliene, F. Gachon, T. Voortman, L. Palla, J. D. Johnston, R. M. Van Dam, C. Darimont, L. G. Karagounis, Chronotype: Implications for Epidemiologic Studies on Chrono-Nutrition and Cardiometabolic Health, Advances in Nutrition 10 (1) (2018) 30--42.

[2] L. Palla, S. Almoosawi, Diurnal patterns of energy intake derived via principal component analysis and their relationship with adiposity measures in adolescents: Results from the national diet and nutrition survey rp (2008--2012), Nutrients 11 (2) (2019) 422.