**ONLINE RESEOURCE**

**Journal**

**British Journal of Nutrition**

**Title**

***FTO* genotype, dietary intakes and anthropometric measures in European adults: The Food4Me Study**

**Author names**

Katherine M. Livingstone\*, Carlos Celis-Morales\*, Santiago Navas-Carretero, Rodrigo San-Cristobal, Hannah Forster, Clare B. O’Donovan, Clara Woolhead, Cyril F.M. Marsaux, Anna L. Macready, Rosalind Fallaize, Silvia Kolossa, Lydia Tsirigoti, Christina P. Lambrinou, George Moschonis, Magdalena Godlewska, Agnieszka Surwiłło, Christian A. Drevon, Yannis Manios, Iwona Traczyk, Eileen R. Gibney, Lorraine Brennan, Marianne C. Walsh, Julie A. Lovegrove, J. Alfredo Martinez, Wim H. Saris, Hannelore Daniel, Mike Gibney, John C. Mathers, on behalf of the Food4Me Study.

**Author affiliations**

Human Nutrition Research Centre, Institute of Cellular Medicine, Newcastle University, Newcastle Upon Tyne, UK (KML, katherine.livingstone@newcastle.ac.uk; CCM, carlos.celis@newcastle.ac.uk; JCM, John.Mathers@newcastle.ac.uk)

Center for Nutrition Research, University of Navarra, Pamplona, Spain; CIBER Fisiopatología Obesidad y Nutrición (CIBERobn), Instituto de Salud Carlos III, Madrid, Spain (SNC, snavas@unav.es; RSC, rsan.1@alumni.unav.es; JAM, jalfmtz@unav.es)

UCD Institute of Food and Health, University College Dublin, Belfield, Dublin 4, Republic of Ireland (CBD, clare.odonovan@ucdconnect.ie; HF, hannah.forster@ucdconnect.ie; CW, clara.woolhead@ucdconnect.ie; EG, eileen.gibney@ucd.ie; LB, lorraine.brennan@ucd.ie; MCW, marianne.walsh@ucd.ie; MG, mike.gibney@ucd.ie)

Department of Human Biology, NUTRIM School of Nutrition and Translational Research in Metabolism, Maastricht University Medical Centre, Maastricht, the Netherlands (CFMM, c.marsaux@maastrichtuniversity.nl; WHS, w.saris@maastrichtuniversity.nl)

Hugh Sinclair Unit of Human Nutrition and Institute for Cardiovascular and Metabolic Research, University of Reading, Reading, UK (ALM, a.l.macready@reading.ac.uk; RF, r.fallaize@reading.ac.uk; JAL, j.a.lovegrove@reading.ac.uk)

ZIEL Research Center of Nutrition and Food Sciences, Biochemistry Unit, Technische Universität München, Germany (SK, silvia.kolossa@tum.de; HD, hannelore.daniel@tum.de)

Department of Nutrition and Dietetics, Harokopio University, Athens, Greece (LT, tsirigoti.lydia@gmail.com; CPL, cplambrinos@gmail.com; GM, gmoschi@hua.gr; YM, manios@hua.gr)

National Food & Nutrition Institute (IZZ), Poland (MG, mgodlewska@izz.waw.pl; AS, asurwillo@izz.waw.pl; IT, itraczyk@izz.waw.pl)

Department of Nutrition, Institute of Basic Medical Sciences, Faculty of Medicine, University of Oslo, Oslo, Norway (CAD, c.a.drevon@medisin.uio.no)

\*KML and CCM contributed equally and are joint first-authors

**Corresponding author; request for reprints**

Professor John C. Mathers

Human Nutrition Research Centre

Institute of Cellular Medicine

Newcastle University

Biomedical Research Building

Campus for Ageing and Vitality

Newcastle upon Tyne

NE4 5PL

UK

john.mathers@newcastle.ac.uk

Tel: +44 (0) 1912081133 Fax: +44 (0) 1912081101

**Running title:** *FTO*, dietary intakes and BMI

**Ethical Approval:** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards

**Acknowledgments:** This work was supported by the European Commission under the Food, Agriculture, Fisheries and Biotechnology Theme of the 7th Framework Programme for Research and Technological Development [265494].

**Trial registration** – Clinicaltrials.gov NCT01530139 (<http://clinicaltrials.gov/show/NCT01530139>)

**Key Words** – Fat mass and obesity-associated gene, *FTO*, BMI, fried food, dietary intakes

**Table 1 Estimation of Mediterranean diet score based on PREDIMED criteriaa**

|  |  |  |  |
| --- | --- | --- | --- |
| No | PREDIMED  Dietary component | PREDIMED Recommendation | Food4Me study equivalent component and recommendation |
| 1 | Olive oil preference | Consume more olive oil than other culinary fat | Higher olive oil intake than butter or other vegetable oils (>0g/day) |
| 2 | Olive oil intake | ≥4 tbsp/day | Olive oil (≥59.2g/day) |
| 3 | Vegetables | ≥2 servings/day | Vegetables (≥160g/day) |
| 4 | Fresh fruits (including natural fruit juice) | ≥3 servings/day | Fresh fruit and juice (≥240g/day; juice was capped at 150g/day) |
| 5 | Red and processed meats | <1 serving/day | Red and processed meat (<150gday) |
| 6 | Spread fats | <1 serving/day | Fats and spreads (<12g/day) |
| 7 | Soda drinks | <1 drink/day | Fizzy soft drinks (<250g/day) |
| 8 | Wine with meals (optionally,  only for habitual drinkers) | ≥7 glasses/wk | Wine (≥175ml/day) |
| 9 | Legumes | ≥3 servings/wk | Legumes (≥64.3g/day) |
| 10 | Fish (especially fatty fish), seafood | ≥3 servings/wk | Oily, non-oily, smoked and fish products (≥64.3g/day) |
| 11 | Commercial bakery goods, sweets, and pastries | <3 servings/wk | Sweets and snacks (<25.7g/day) |
| 12 | Tree nuts and peanuts | ≥3 servings/wk | Nuts and seeds (≥12.9g/day) |
| 13 | Meat preference | Consume white meat Instead of red meat | Higher intake of white meat than red meat (>0g/day) |
| 14 | Sofrito (tomato and onion sauce, with leek, or garlic, simmered with olive oil) | ≥2 servings/wk | Tomato-based sauce (≥90g/day) |

a, A score of 1 was given when individuals met the target and 0 when they did not (range 0-14) ([1](#_ENREF_1))

**Table 2** **Total energy and macronutrient intakes of participants by BMI category**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **BMI category** | | | **Pa** |
| **Normal** | **Overweight** | **Obese** |
| Total (n) |  |  |  |  |
| Total energy intake (kJ) | 10404 (4179) | 10647 (4297) | 11986 (5434) | **<0.001** |
| Fat (% energy) | 35.5 (5.8) | 36.2 (6.0) | 37.0 (5.6) | **<0.001** |
| Saturated fat (% energy) | 14.0 (3.1) | 14.2 (3.1) | 14.5 (3.1) | **0.005** |
| Trans fat (% energy) | 0.5 (0.2) | 0.5 (0.2) | 0.5 (0.2) | **<0.001** |
| Mono-unsaturated fat (% energy) | 13.4 (3.0) | 14.0 (3.3) | 14.3 (2.9) | **<0.001** |
| Poly-unsaturated fat (% energy) | 5.8 (1.6) | 5.6 (1.3) | 5.9 (1.4) | 0.566 |
| Omega 3 (% energy) | 0.7 (0.2) | 0.7 (0.3) | 0.7 (0.4) | 0.685 |
| Carbohydrates (% energy) | 46.8 (7.5) | 44.8 (7.5) | 44.8 (7.3) | **0.001** |
| Sugar (% energy) | 21.6 (5.8) | 20.6 (5.9) | 19.6 (5.9) | **<0.001** |
| Protein (% energy) | 16.7 (3.5) | 17.6 (4.0) | 17.5 (3.7) | **<0.001** |
| Alcohol (% energy) | 3.1 (3.3) | 3.8 (4.2) | 3.1 (3.9) | 0.148 |
| Salt (g/day) | 7.1 (3.4) | 7.2 (3.3) | 8.7 (4.7) | **<0.001** |
| Contribution from sweets and snacks | |  |  |  |
| Total energy | 14.5 (9.1) | 15.1 (9.7) | 16.8 (11.2) | **0.001** |
| % energy from fat | 18.1 (11.3) | 17.6 (11.5) | 19.1 (12.8) | 0.152 |
| % energy from saturated fat | 20.0 (13.0) | 20.1 (13.6) | 21.7 (14.3) | **0.039** |
| % energy from sugars | 22.5 (14.6) | 25.4 (15.6) | 28.4 (16.4) | **<0.001** |
| % energy from salt | 7.6 (5.7) | 8.1 (6.4) | 9.1 (7.6) | **0.001** |

Values represent means and SDs; a, Multiple linear regression was used to test for significant differences across BMI categories. Analyses were adjusted for age, sex, physical activity, country and smoking

**Table 3 Dietary intakes by BMI category**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **BMI category** | | | **Pa** |
| **Normal** | **Overweight** | **Obese** |
| Foods (g/day) |  |  |  |  |
| Fruit | 288 (254) | 258 (223) | 260 (238) | 0.072 |
| Vegetables | 217 (151) | 214 (134) | 212 (115) | 0.737 |
| Fruit Juice | 108 (160) | 102 (145) | 90 (150) | **0.023** |
| Legumes | 35 (47) | 38 (39) | 36 (32) | 0.604 |
| Wholegrain | 182 (181) | 134 (139) | 142 (142) | **<0.001** |
| Non-wholegrain | 159 (129) | 179 (155) | 217 (217) | **<0.001** |
| Eggs | 30 (42) | 32 (39) | 34 (37) | 0.064 |
| Red, processed meat | 70 (72) | 90 (67) | 119 (110) | **<0.001** |
| Chicken, grilled or roast | 23 (30) | 27 (27) | 34 (30) | **<0.001** |
| Oily fish | 22 (29) | 22 (26) | 19 (22) | 0.071 |
| White fish | 15 (19) | 18 (21) | 15 (18) | 0.674 |
| Fish products | 13 (23) | 16 (20) | 15 (20) | 0.346 |
| Butter | 5 (11) | 6 (12) | 7 (18) | 0.248 |
| Low fat spreads | 1 (5) | 1 (4) | 2 (7) | 0.331 |
| Low fat dairy | 243 (261) | 235 (226) | 215 (223) | 0.686 |
| High fat dairy | 74 (130) | 64 (116) | 76 (175) | 0.423 |
| Sugar sweetened beverages | 28 (104) | 29 (70) | 50 (245) | **0.016** |
| Low calorie soft drinks | 44 (144) | 66 (199) | 125 (286) | **<0.001** |
| Added sugar | 4 (10) | 5 (12) | 5 (14) | 0.054 |
| Chocolate and sweets | 19 (28) | 20 (33) | 22 (27) | 0.117 |
| Cakes | 22 (28) | 24 (30) | 23 (26) | 0.440 |
| Biscuits | 23 (45) | 29 (47) | 44 (110) | **<0.001** |
| Ice-cream | 6 (11) | 7 (19) | 8 (15) | **0.005** |
| Pastries | 12 (15) | 14 (40) | 17 (39) | **0.006** |
| Crisps | 4 (7) | 3 (6) | 7 (13) | **<0.001** |
| Chips and pizza | 27 (28) | 33 (40) | 33 (34) | **<0.001** |
| Fried foods | 40.5 (42.3) | 48.9 (53.4) | 52.2 (49.7) | **<0.001** |
| Dietary scores2 | | | | |
| Healthy eating index-2010b | 50.3 (9.3) | 49.2 (9.9) | 47.4 (9.9) | **<0.001** |
| Mediterranean diet scoreb | 5.2 (1.7) | 5.1 (1.7) | 4.8 (1.7) | **<0.001** |
| Dietary habits |  |  |  |  |
| Add salt while cooking |  |  |  |  |
| High | 53.6 | 58.2 | 65.2 | 0.695 |
| Medium | 15.3 | 15.3 | 8.6 | 0.085 |
| Low | 31.2 | 26.5 | 26.3 | 0.167 |
| Add salt at the table |  |  |  |  |
| High | 10.1 | 12.7 | 14.4 | 0.131 |
| Medium | 15.0 | 15.9 | 22.0 | 0.096 |
| Low | 75.0 | 71.4 | 63.6 | **0.015** |
| Consume fried foods |  |  |  |  |
| High | 5.2 | 5.0 | 2.9 | 0.387 |
| Medium | 38.0 | 46.3 | 53.6 | **<0.001** |
| Low | 56.8 | 48.7 | 43.5 | **<0.001** |
| Consume visible fat on meat |  |  |  |  |
| High | 10.4 | 5.8 | 2.4 | **<0.001** |
| Medium | 60.0 | 55.0 | 58.9 | 0.967 |
| Low | 29.6 | 39.2 | 38.8 | **0.029** |

Values represent means and SDs; a, Multinomial logistic regression and multiple linear regression were used to test for significant differences across BMI categories; Analyses were adjusted for age, sex, physical activity, country and smoking; b, Healthy Eating Index and Mediterranean diet score were calculated based on an established criteria ([1](#_ENREF_1), [2](#_ENREF_2))

**Fig 1 Dietary intake by BMI category and *FTO* risk allele**

Values represent least squares means and SE adjusted for age, sex, country, physical activity and smoking; Normal: BMI 18.5-24.9kg/m2; Overweight: BMI 25-29.9kg/m2; Obese: BMI >30kg/m2. No significant P values for trends or interactions were observed

**References**

1. Estruch R, Ros E, Salas-Salvadó J, Covas M-I, Corella D, Arós F, et al. (2013) Primary Prevention of Cardiovascular Disease with a Mediterranean Diet. New Engl J Med. 368(14):1279-90.

2. Guenther PM, Casavale KO, Reedy J, Kirkpatrick SI, Hiza HAB, Kuczynski KJ, et al. (2013) Update of the Healthy Eating Index: HEI-2010. Journal of the Academy of Nutrition and Dietetics. 113(4):569-80.