ALINEA
NUTRITION

APRIL 2020

www.alineanutrition.com

TABLE OF
CONTENTS

Huseinovic E, Winkvist A, Freisling H, Slimani N, Boeing H, Buckland G, Schwingshackl L...Bertéus Forslund H. Timing of eating across ten European countries - results from the European Prospective Investigation into Cancer and Nutrition (EPIC) calibration study. Public Health Nutr. 2019 Feb;22(2):324-335.

What We Know, Think We Know, or Are Starting to Know

Meal patterns are not a simple variable to study in humans. The gold standard of dietary assessment in nutritional epidemiology, the food frequency questionnaire [FFQ] is designed to capture average intake over time as the exposure of interest, and generally do not contain an inherent time component [(1)]. As FFQ are not designed to capture time, most studies to date have used 24-recalls, or diet diaries where the meal labels are pre-defined [(1)].

These methods present their own difficulties, however, because there is still a lack of operational definitions for what the term ‘meal’ means. While we typically prescribe labels to meals, the definitions ‘breakfast’, ‘lunch’, and ‘dinner’, have distinct socio-cultural-economic influences, and therefore what constitutes, for example, ‘breakfast’ in France in terms of energy content, timing, and food choices, is not the same as the meaning of ‘breakfast’ in the UK [(2)].

Another major issue for meal pattern research in epidemiology has been that, while meals retain culturally-laden definitions, the definition for ’snack’ ranges from any energy intake whatsoever, to recently some research groups ascribing a minimum energy criteria and timing between calorie intake to define a ’snack’ [(3)]. Gibney & Wolever proposed a definition for snacks, including a minimum energy criteria of 50kcals and a minimum 15-minute period between eating episodes [(3)]. In addition, Makala et al. proposed the term ‘eating occasion’ as a neutral adjective to encompass any occasion at which energy is ingested, therefore capturing any social, cultural definitions in ‘meal’ and ’snack’ [(2)].

From a methodological perspective, these issues are important to resolve: the associations between temporal [i.e., time] distribution, later timing of food intake, irregular meal patterns, and evening energy intake, and increased cardiometabolic disease risk, have continued to emerge [(4)]. Thus, patterns of energy intake in, and across, populations, are an important exposure to adequately capture, in order to further examine these associations.

The present study aimed to describe meal timing and the association with with sociodemographic, lifestyle and health-related characteristics across ten European countries.

The Study

The European Prospective Investigation into Cancer and Nutrition [EPIC] Study, is a large scale prospective cohort study with cohorts recruited across nine countries; the UK, Netherlands, Denmark, Germany, Norway, Sweden, Spain, Greece, and Italy.

The EPIC cohort used country-specific dietary assessment, which were validated in the specific population which the dietary assessment method would be used [mostly FFQ]. The present study is based on data collected during the EPIC calibration study, which was designed to account for measurement error in the FFQ.

In order to calibrate the validity of the country-specific FFQ, a random sample of 36,994 participants [constituting 8% of the overall cohort] across all centres completed a computerised 24-hour dietary recall interview, which was compared to the FFQ completed by the same people in the calibration study. The 24-hour recall was standardised across all countries. The interview was administered by trained interviewers through face-to-face interviews [except in Norway, where interviews were conducted by telephone].

Each cohort contributed a random sample of 1,200-5,000 individuals. The aim was to use the 24-hour recall interview to adjust for over-estimation or under-estimation of food intake in the FFQ, and to ensure that measurement error was similar in the different cohorts.

The authors labelled meals as 'food consumption occasions' [FCO], and used 11 pre-defined (FCO) were asked for by interviewers:

(i) before breakfast; (ii) breakfast; (iii) during morning; (iv) before lunch; (v) lunch; (vi) after lunch; (vii) during afternoon; (viii) before dinner; (ix) dinner; (x) after dinner, and; xi) during evening.

The actual clock time of consumption was recorded in hourly integers [e.g., 08.00 h, 09.00 h, etc.]. Breakfast, lunch and dinner, could only be selected once. However, other FCO could be elected several times during the pre-defined period, e.g., the FCO 'during afternoon' could have two times of consumption at 14.00 h and 16.30 h. All FCO were included in the analysis except tap water.

The primary outcomes were temporal distribution, as proportion of FCO per hour across the day, and the ratio of later:earlier energy intake [earlier defined as 06.00-14.00 h; later defined as 15.00 h -24.00 h]. This was expressed as <1.0 indicating greater earlier energy intake and >1.0 indicating greater later energy intake. The variables adjusted for were country, age, educational level, marital status, smoking status, physical activity, BMI, elevated cholesterol, diabetes, day of recall and season.

*Geek Box: Measurement Errors

Measurement error is a reality of any epidemiological study. In nutritional epidemiology, the goal is to capture dietary intake as accurately as possible; the extent to which an instrument achieves this is known as 'validity'. To ascertain the validity of a dietary assessment method, validation studies are conducted, by taken a subsample of the cohort and conducting a 7-day measured food record, which is then used to compare the accuracy of the FFQ against. There are two main types of error: random and systematic. Random error results from difficult or inconsistencies in taking a measurement [for example, different styles of questionnaire, or human memory]. Systematic errors result from predictable inaccuracies in the measurement instrument used, that are consistent in the direction of the error. For example, in nutritional epidemiology, the systematic error from FFQ is to underestimate true dietary intake. The random error potential in nutritional epidemiology is generally human memory. The overall effect, in a prospective cohort study, any measurement errors tend to bias the associations between diet and a given outcome towards the null (i.e., 'no association). One way to overcome the potential influence of measurement error is with very large sample sizes. Therefore, for prospective cohort studies in nutrition science, 'bigger is better'. In any cohort study, however, the most important means of dealing with potential error is validation and calibration studies: this allows for systematic error to be addressed, by understanding the size of the error, and being able to correct for this measurement error in statistical analysis.

Results: 36,020 participants [22,985 women and 13, 035 men] were included in the analysis. In the overall cohort, breakfast was most often consumed the earlier at 07.00 h in Sweden, Norway and France, and latest at 09.00 h in Spain. All remaining countries averaged 08.00 h for breakfast.

Lunch was consumed earliest at 12.00 h in France and the Nordic countries [Denmark, Sweden, Norway], and latest at 14.00 h in Spain and Greece [all remaining countries 13.00 h].

The greatest differences between countries was in relation to dinner, which was earliest at 16.00 in Norway and latest at 21.00 h in Spain and Greece. The Nordic countries, Germany, and the UK, consumed dinner between 16.00-19.00 h, compared to 20.00-21.00 in the Mediterranean countries.

However, a significant North-South regional division was observed in the distribution of energy intake, with Mediterranean countries having significantly greater early:later energy intake [0.76] compared to Central European [1.13] and Northern European countries [1.15]. FCO for the 'during afternoon' definition had a wide range of time of consumption, with the earliest at 14.00 h in Norway compared to 24.00 in Spain.

The Critical Breakdown

Pros: Each cohort contributed significant numbers to the calibration study, which may have attenuated the within-person variability in a 24-hour recall. Interviews were conducted across different seasons and days of the week, to try and capture day-to-day and seasonal variability in dietary intake. The 24-hour recall was standardised, so that the format was the same across all populations, minimising potential for random error from the interview. The actual clock time at which FCO occurred was captured, which allowed for linking the meal label, i.e., 'breakfast', with the actual timing of that meal. This allowed for clear comparisons between, and within, populations.

Cons: 24-hour recalls remain prone to within-person variability. The duration between a participant completing the baseline FFQ and the calibration 24-hour recall ranged from as little as 1 day [a 'Pro'] to up to 3-years [a 'Con']. The data presented was for all FCO, with no minimum energy criteria applied in the main analysis, and the supplementary material, where analysis was conducted with a 50kcal minimum, resulted in peak energy intake occasions were more distinct. Thus, not applying a minimum energy criteria may have resulted in an overestimation of eating occasions, and underestimation of timing of peak energy intake across the day.

Key Characteristic

The calibration study in itself is a defining characteristic of the EPIC cohort. The use of calibration studies nested within large, multi-centre cohorts remains a relatively emerging methodology, and large multi-centre cohort studies face particular logistical and methodological issues.

The logistical issues are obvious: diverse populations with different cultural food habits, languages, and socio-demographic characteristics.

The methodological issues include the potential for the population-specific FFQs to result in measurement errors that vary from population to population, making comparisons in risk related to diet a practical impossibility.

By applying a second, highly standardised dietary assessment in a subsample of each cohort in the EPIC countries, this provided a common instrument to assess measurement error that was consistent across the EPIC populations.

Another key point about the calibration study relates to regression dilution bias, which is where random errors [i.e., human memory] bias the results toward a lack of association. By comparing the 24-hour dietary recall completed by a participant to the FFQ completed by the same participant, regression dilution could be estimated and corrected for [although a degree of error always remains].

Interesting Finding

The differences in the ration of early:later energy intake provides fascinating insight into the differences both between populations, and within populations. The first somewhat anomaly is that despite eating later defined by clock time, Mediterranean countries consumed a greater proportion of daily energy early in the day between 06.00-14.00 h.

There was also within-country variance, with two centres in Spain - Navarra and Granada - exhibiting wide variance: the ratio of early:later energy in Navarra was 0.66 and 0.72 for women and men, respectively, compared to 2.04 and 2.58, respectively, in Granada.

Thus, the North-South divide in terms of temporal distribution is not a uniform characteristic of the various diet patterns in the EPIC study.

What is particularly interesting is that of the variables analysed in relation to early:later energy intake, conducting the 24-hour recall on a weekend day was associated with later energy intake scores in both men and women, particularly in Northern European countries. We know that timing of dietary intake often varies between weekends and weekdays, and this may have relevance for emerging risk factors like social jetlag, i.e., differences between sleep timing and duration on work days vs. free days, and the influence on dietary intake [5].

Relevance

From a health perspective, it is important to recognise that no inferences can be made from this study alone, as cardiometabolic risk factors or disease events were not included in the analysis. This is because the data presented in this study is based on the calibration study, not the actual follow-up period of the EPIC cohort themselves. Thus, we await further analysis specifically analysing the relationship between timing of food intake and temporal distribution of energy, on specific health outcomes.

However, there is wider data we can contextualise the findings with, particularly the ratio of early:later energy intake. For example, the Spanish population in this study exhibited a tendency toward very later energy intake - 21.00 h dinner, 23.00 'after dinner' FCO, and 24.00 'during evening' FCO. In a Spanish population, consumption of the main daily meal [defined as greatest EI during the day] after 15.00hrs was associated with significantly less weight lost during a weight-loss intervention, compared to participants consuming the main meal before 15.00hrs [6].

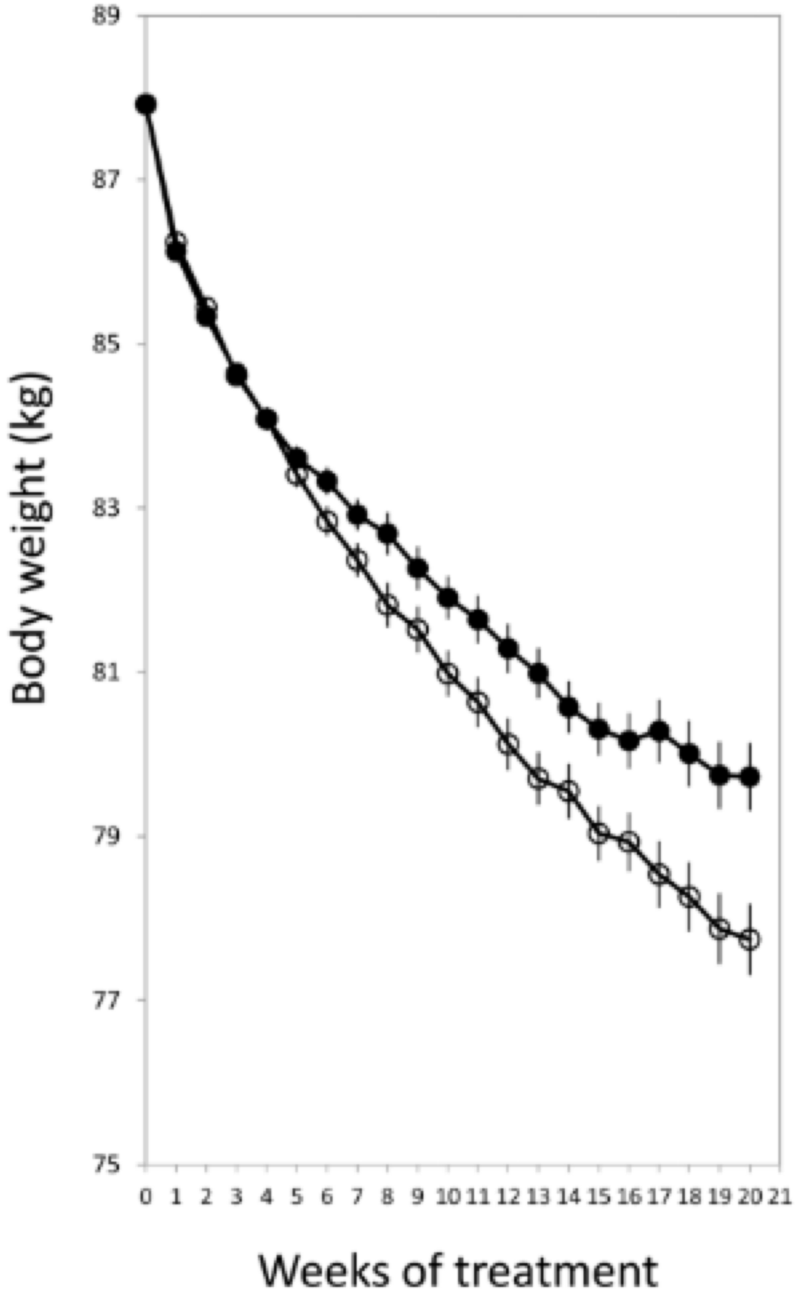

Figure *taken from Garaulet et al.* [6] *indicating the difference in weight loss over 20-weeks comparing early vs. later lunch eaters in a Spanish study.*

In the UCLA Energetics Study, participants consuming >33% of total daily energy intake between 17.00-00.00 h were twice as likely to have obesity compared to those consuming <33% [7]. And in the US Adventist Health Study 2, consumption of the majority of daily energy in breakfast and lunch meals [before 15.00 h] was associated with significant protective effects against increasing BMI before 60yo [8].

A number of recent studies have suggested that it is not necessarily the clock time at which eating occurs, but the proximity of eating to the nocturnal elevation in melatonin, and consumption of a greater proportion of energy in close proximity to melatonin onset has been associated with increased body fat (9,10).

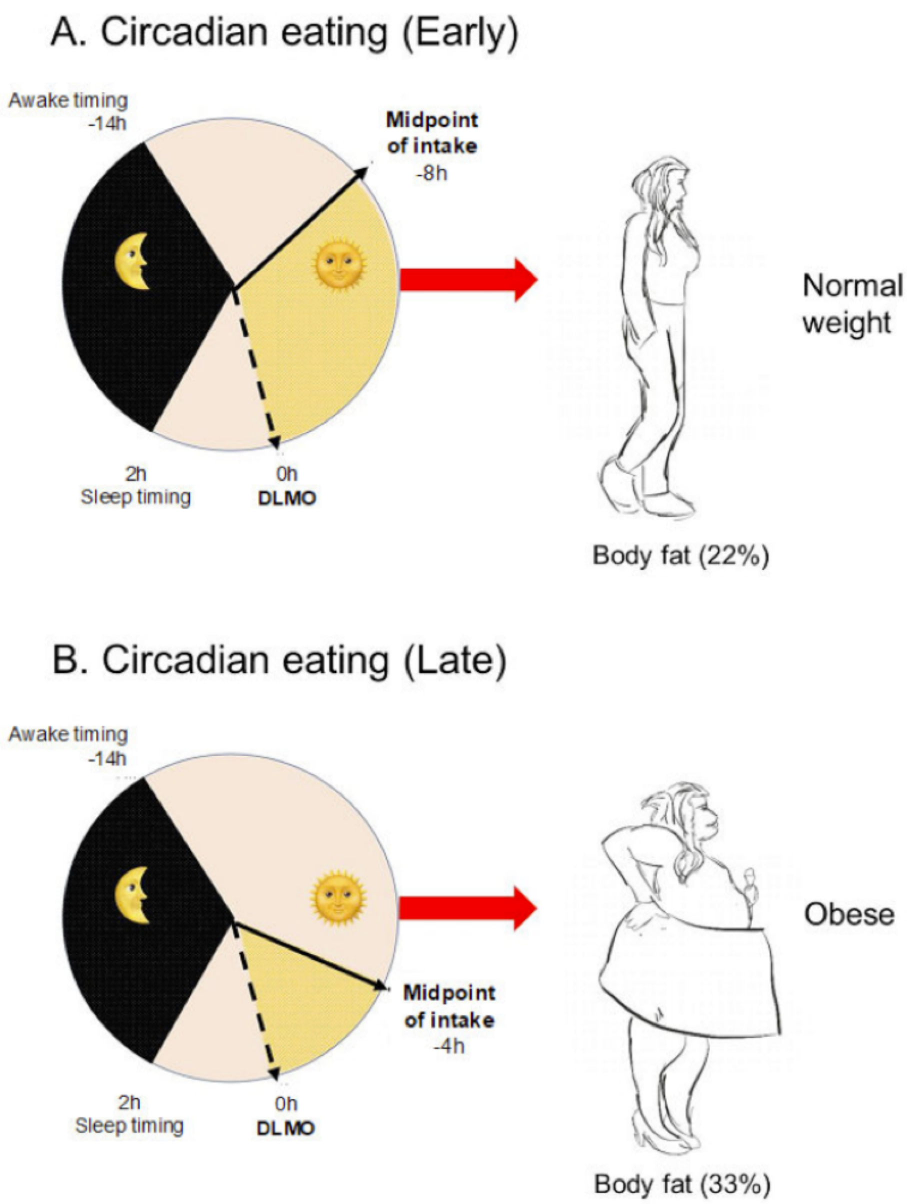

***Figure** aken from Lopez-Minguez et al. (4), indicating associations between proximity of food intake to melatonin onset and body fat found in reference (9). Please excuse the stigmatising imagery: sometimes I wonder if researchers are thinking about this stuff.*

However, what is most evident from the present study is that meal patterns are complex and differ both between and within populations. The relationships between these various eating patterns and health outcomes remain the focus of the emerging area of chrono-nutrition.

Application to Practice

Is there a 'healthiest eating pattern' in humans? If there is, we don't know exactly what it is yet. However, based on the wider data available, it remains prudent to avoid later eating into the biological night. Thus, it may be beneficial to think in terms of overall energy distribution across the day, and the evidence suggest that the main meal and majority of daily energy occurring across the first two meals of the day, i.e., before 16.00 h, may result in favourable health outcomes. This may be particularly important given evidence from other population research to suggest that less than 25% of daily energy is consumed before noon [(11)].

References

1. Leech R, Worsley A, Timperio A, McNaughton S. Understanding meal patterns: definitions, methodology and impact on nutrient intake and diet quality. Nutrition Research Reviews. 2015;28(1):1-21.

2. Mäkalä J, Kjærnes U, Pipping Ekström M, L' Orange Fürst E, Gronow J, Holm L. Nordic Meals: Methodological Notes on a Comparative Survey. Appetite. 1999;32(1):73-79.

3. Gibney MJ, Wolever TM. Periodicity of eating and human health: present perspective and future directions. Br J Nutr 1997;77(Suppl 1): S3–5.

4. Lopez-Minguez J, Gómez-Abellán P, Garaulet M. Timing of Breakfast, Lunch, and Dinner. Effects on Obesity and Metabolic Risk. Nutrients. 2019;11(11):2624.

5. Parsons M, Moffitt T, Gregory A, Goldman-Mellor S, Nolan P, Poulton R et al. Social jetlag, obesity and metabolic disorder: investigation in a cohort study. International Journal of Obesity. 2014;39(5):842-848.

6. Garaulet M, Gómez-Abellán P, Alburquerque-Béjar J, Lee Y, Ordovás J, Scheer F. Timing of food intake predicts weight loss effectiveness. International Journal of Obesity. 2013;37(4):604-611.

7. Wang J, Patterson R, Ang A, Emond J, Shetty N, Arab L. Timing of energy intake during the day is associated with the risk of obesity in adults. Journal of Human Nutrition and Dietetics. 2013;27:255-262.

8. Kahleova H, Lloren J, Mashchak A, Hill M, Fraser G. Meal Frequency and Timing Are Associated with Changes in Body Mass Index in Adventist Health Study 2. The Journal of Nutrition. 2017;(147):1722-8.

9. McHill A, Phillips A, Czeisler C, Keating L, Yee K, Barger L et al. Later circadian timing of food intake is associated with increased body fat. The American Journal of Clinical Nutrition. 2017;:ajcn161588.

10. McHill A, Czeisler C, Phillips A, Keating L, Barger L, Garaulet M et al. Caloric and Macronutrient Intake Differ with Circadian Phase and between Lean and Overweight Young Adults. Nutrients. 2019;11(3):587.

11. Gill S, Panda S. A Smartphone App Reveals Erratic Diurnal Eating Patterns in Humans that Can Be Modulated for Health Benefits. Cell Metabolism. 2015;22(5):789-798.