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Energy and macronutrient intake over the course of the day of German adults: A DEDIPAC-study

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ABSTRACT

The aim of the study was to analyze the energy and macronutrient intake over the course of the day of selected population groups in Germany defined by sex, age, BMI, SES, and diet quality. The study was based on food consumption data from the German National Nutrition Survey II (2005–2007) assessed by two 4-day dietary weighing records of 662 women and men aged between 18 and 80 years. Energy and macronutrient intake were calculated using the German Nutrient Database 3.02 and summarized for the periods 'morning', 'midday', 'afternoon', 'evening', and 'night'. Generalized estimating equation models were used to examine differences in energy and macronutrient intake. For women and men, a three-main-meal pattern ('morning', 'midday', and 'evening') was observed, indicated as peaks in energy intake at 08:00 to 09:00, 13:00 and 19:00 o'clock. The distributions of carbohydrate, protein, and fat intake mirror the distribution of energy intake over the course of the day. The highest energy intake was found in the 'evening' period, especially in young adults, overweight persons, persons with a high SES, and men with a low diet quality. Women of the oldest age group showed a similar energy intake across the three-main-meals in contrast to young adults, who had lower peaks in the 'morning' and 'midday' periods as well as a shift to later meal times. Young adults seem to have a higher variability in energy intake and a less distinct meal pattern, while seniors have a more structured day. Because a high energy intake in the 'evening' period is associated with negative health-related factors, the distribution of energy intake should be considered by recommendations for a healthy nutritional behavior.

1. Introduction

Consumption of food and beverages, and thus energy and macronutrient intake, is usually distributed over several meals and snacks over the course of the day. This can also be described as meal pattern (de Castro, 2004). Currently, there is a controversial discussion about an increasing preference for snacks (examples: Duffey, Pereira, & Popkin, 2013; Mestdag, 2005; Ovaskainen et al., 2006) leading to a disadvantage of main meals (examples: Cutler, Glaeser, & Shapiro, 2003; Lund & Gronow, 2014; Ovaskainen, Tapanainen, & Pakkala, 2010). Wang et al. (2014, p. 255) described that "the timing of energy intake is a modifiable behavior". Therefore, data on meal patterns over the course of the day are important for the development of recommendations for a healthy diet. Bellisle (2014) showed that snacking may have negative health affects for example as a result of a higher total energy intake. However, data on meal patterns over the course of the day are scarce and need to be explored.

In many countries, meal patterns are still traditionally structured into the three-main-meals in the morning, midday, and evening (Bellisle et al., 2003; de Graaf, 2000; Huseinovic et al., 2016; Kant & Graubard, 2015; Riou, Lefevre, Parizot, Lhuissier, & Chauvin, 2015; Tani et al., 2015; Winkler, Doring, & Keil, 1999). But few studies compared different population groups regarding their energy intake of main meals or over the course of the day. The results of these studies suggest that the distribution or timing of energy intake over the course of the day differs between sexes (examples: Ovaskainen et al., 2006; Roos & Prättälä, 1997; Tani et al., 2015), age groups (examples: Ma et al., 2005; Striegel-Moore & Franko, 2006; Wang et al., 2014), SES (socioeconomic status) groups (example: Almoosawi, Prynne, Hardy, & Stephen, 2013b; Kant, Schatzkin, & Ballard-Barbash, 1997), and BMI (body mass index) groups (examples: Bertéus Forslund, Lindroos, Sjostrom, & Lissner, 2002; Wang et al., 2014), and may influence BMI (examples: de Castro, 2004; Garaulet et al., 2013). For the

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German population it is unknown whether the three-main-meal-pattern still exists and whether there are differences within population groups e.g. defined by different age.

The importance of the topic of meal structure is also stressed by current research within the framework of the 'DEterminants of DIet and Physical ACtivity - Knowledge Hub' (DEDIPAC KH), the first action of the European Union's joint programming initiative (JPI). One of the objectives of DEDIPAC is to improve the understanding of the determinants of dietary behavior, physical activity, and sedentary behavior (Lakerveld et al., 2014) and to find knowledge gaps in this field. Meal pattern was identified as a determinant of dietary behavior (Stok et al., 2017).

Thus, the purpose of the present study, which was undertaken within the framework of the DEDIPAC KH, was to analyze energy and macronutrient intake over the course of day of German adults based on the data of the German National Nutrition Survey (NVS) II. Information on food consumption was given for several days, including different weekdays and the time when foods were consumed. The following questions were approached:

How are energy and macronutrient intake distributed over the course of the day in selected population groups defined by sex, age, BMI, SES and dietary quality (measured by a Healthy Eating Index)? Is there still a traditional three-main-meal pattern in Germany? Are there differences in energy intake at and between defined periods?

2. Material and methods

2.1. Study design

The NVS II is a representative study conducted in Germany between November 2005 and January 2007. Dietary intake was assessed with three dietary assessment methods (Heuer, Krems, Moon, Brombach, & Hoffmann, 2015). From a sub-sample of the NVS II, a 4-day dietary weighing record was conducted twice. Food and beverage consumption was protocolled in detail, including time of consumption. The participants were instructed in handling the weighing protocol in the study center and received a digital kitchen scale. Non-consumed residues had to be reweighed in order to obtain most accurate indication of the consumed quantities (Krems et al., 2006). Additionally, an excerpt of the EPIC-SOFT picture book (Slimani et al., 1999) could be used to estimate the consumed amount of foods eaten outside of the home (proportion about 25%). Three weekdays and one weekend day were included in each 4-day dietary weighing record to consider possible different dietary habits on weekdays and weekend days (Krems et al., 2006). Energy and macronutrient intake were calculated with the German nutrient database (BLS) version 3.02 (Hartmann, Heuer, & Hoffmann, 2015). Computer-assisted personal interviews (CAPI) were applied to obtain information on socio-demographic factors like sex, age, and SES. Anthropometric measurements (body height and body weight) were determined in a standardized way. Details of the NVS II have been previously reported (Heuer et al., 2015; MRI, 2008).

The NVS II was approved by the German Federal Data Protection Office. Respondents were informed in detail about the study objectives, interview, examination procedures, and the handling of data records and analyses under pseudonymous conditions. It was made clear that participation was voluntary and could be terminated at any time.

2.2. Study population

In the NVS II, 914 participants aged 18–80 years completed two 4-day dietary weighing records. Recorded days that were incomplete because time of consumption were not considered. Recorded days with only water, tea, or coffee consumption (and therefore non-energy intake) were excluded from the analysis. As participants completed two 4-day dietary weighing records, they had one or in rare cases more than one double weekday. To achieve an equal distribution of all weekdays, the chronological later day(s) of the doubling day(s) were excluded from the analysis. The later day was excluded under the assumption that fatigue or boredom may increase with the duration of the recording (van Staveren, Ocké, & de Vries, 2012; Yannakoulia et al., 2012). Furthermore, participants with missing BMI-values could not be included in the analysis.

Underreporters were excluded from the analysis, as underreporting deranges the information on energy intake. On the basis of the ratio of energy intake and calculated resting energy expenditure, underreporting was defined by the cut-off ≤ 1.053 using the cut-off 2 formula derived by Goldberg et al. (1991) and adopted by Black (2000). Resting energy expenditure was calculated using the formula of Müller et al. (2004), considering age, sex, and individually measured body weight. A total of 201 participants (129 women and 72 men) were identified as underreporters.

Altogether, 662 participants and 3997 recorded days, with an overall of 19985 observations, remained for analysis. All analyses described in this paper were performed with this dataset.

2.3. Periods

To investigate energy and macronutrient intake over the course of the day, five periods were defined: 'morning' (05:30 to 11:29), 'midday' (11:30 to 14:29), 'afternoon' (14:30 to 17:29), 'evening' (17:30 to 23:29), and 'night' (23:30 to 5:29). To take into account the afternoon snack, the time from 11:30 to 17:29 was subdivided into two 3 h-intervals (11:30 to 14:29 and 14:30 to 17:29). The five periods were defined after a first descriptive data analysis and visual examination of the graphs showing energy intake over the course of the day of the study population. The cuts between the periods were set according to the minima in the course of the day curve and were aligned with the meal times in literature concerning meal pattern (examples: Bellisle et al., 2003; Bertéus Forslund et al., 2002; de Castro, 1987, 2004, 2007; Kant & Graubard, 2014; Leech, Worsley, Timperio, & McNaughton, 2015; Lhuissier et al., 2013; Lund & Gronow, 2014; Meyer, 2002; Tani et al., 2015; Winkler et al., 1999).

2.4. Selected population groups

Four **age groups** were formed, pooling together 18–34 years, 35–50 years, 51–64 years, and 65–80 years. **BMI** was classified into underweight, normal weight, overweight and obese, according to the WHO definition (WHO, 2000). **SES** was defined as an index based on the "Winkler-Index" (Winkler & Stolzenberg, 1999) and encompassed the monthly net income of the household (nine categories, based on a monthly income from <750 € to 5000 € or higher), employment status of the household's principle earner (eight categories ranging from unskilled worker to executive employee/senior official), and school education level of the participant (five categories ranging from no qualification to baccalaureate; additional points were given for vocational training and university education). By using this index, the participants were classified to the low, medium, or high SES class (MRI, 2008). The combination of these three factors income of household, education level and employment status provides a comprehensive picture of the social status. The overall dietary quality was examined by the Healthy Eating Index of the NVS II **(HEI-NVS II)** (Wittig & Hoffmann, 2010). The consumed amounts of foods out of nine food groups (fruits, vegetables, bread, milk, fish, meat, eggs, fat, and non-alcoholic beverages) and alcohol as a nutrient were compared