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Association between chronotype and diet in adolescents based on food logs

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ABSTRACT

Recent research revealed an association between chronotype and psychological constructs of eating behaviour. Here, we used food logs in adolescents and assessed their chronotype. We found that later bed and rise times were associated with the tendency to drink caffeinated drinks and eat fast food and to consume less dairy products. No relationship existed between chronotype and sweets, vegetables and salad, and meat consumption. These results suggest a healthier lifestyle in morning oriented adolescents (or late chronotypes). Breakfast times differed between weekdays and weekend while lunch and dinner times were similar. Mean breakfast time at the weekend was later in late chronotypes which was a result of later rise times of late chronotypes. The study showed that morning oriented pupils exhibit a healthier and more regular lifestyle.

Individual differences in chronotype are a striking aspect of human behaviour. These differences are usually viewed as continuous between the two ends: morning types are labeled 'larks' while evening types were named 'owls' (Cavallera & Giudici, 2008; Natale & Cicogna, 2002). Morning larks perform best in morning hours and have less trouble getting out of bed while evening owls have more difficulties in getting up in the morning but perform best in late afternoon or evening hours (Fabbri, Antonietti, Giorgetti, Tonetti, & Natale, 2007; Goldstein, Hahn, Hasher, Wiprzycka, & Zelazo 2007). Although dichotomizing 'larks' and 'owls' as both ends of the continuum is an easy-to-understand picture, the distribution resembles a normal distribution and morningness–eveningness preferences represent a continuum (Randler, 2008a). In this study, chronotype was defined according to Roenneberg, Kuehnle, Pramstaller, Ricken, and Havel 2004 as the midpoint of sleep on free days, i.e. based on a clock time measurement. The midpoint of sleep is calculated from bed time and rise time, e.g. when a person goes to sleep at 24:00 and gets up at 6:00, midpoint of sleep is 3:00. Assume, two persons both sleep 6 h, one may have the midpoint of sleep at 3:00, and the other at 4:00. The later the midpoint of sleep, the more a person is an evening type.

These individual differences are in part heritable (Katzenberg, Young, Finn, Lin, & King, 1998) but additional factors, such as social, cultural and environmental zeitgeber, also significantly modulate chronotype (e.g. Randler & Díaz-Morales, 2007). For example, people in the tropics are earlier chronotypes than in the subtropics and people living further east are earlier chronotypes given the same time zone (Randler, 2008b,c). Despite the heritability of chronotype, age shows one of the most pronounced relationships to chronotype. During the age of puberty adolescents shift from morningness to eveningness (e.g. Díaz-Morales, Davila de Leon, & Sorroche, 2007; Randler 2008a,c) and back towards morningness at the end of adolescence (Roenneberg et al., 2004). During later years of life, aged people, turn towards morning activity again (Park, Matsumoto, Seo, Kang, & Nagashima, 2002). At a similar age, boys and men are more evening oriented than girls and women (Adan & Natale, 2002; Randler, 2007).

The relationship between chronotype and eating behaviour has been largely unexplored. Costa, Lievore, Ferrari and Gaffuri (1987), e.g. focused on the timing of meals in adults and compared weekdays with weekend days. Lunch time and evening dinner had a high stability with similar times on weekdays and on free days, while breakfast times differed, and there is a progressive advance in breakfast times with age. Morning people exhibit a more regular lifestyle compared to evening types (Monk, Buysse, Potts, De Grazia, & Kupfer, 2004). These results were obtained by using the Social Rhythm Metric, an instrument that measures daily lifetime regularity (i.e. clock times for each day). Meal times are one aspect of this instrument, and data are collected over a period of some weeks and each subject receives a regularity score. The smaller the variance for each measure (e.g. breakfast) is, the higher is the lifestyle regularity. Lifestyle regularity was higher in morning oriented persons. Further, morning oriented people have been found to show a healthier lifestyle and they reported less morbidity and a higher physical mobility (Taillard, Philip, Chastang, Diefenbach, & Bioulac, 2001). Early chronotypes or morning oriented adults further consumed less alcohol, fewer caffeinated drinks and comprised fewer smokers (Randler, 2008d; Wittmann, Dinich, Merrow, & Roenneberg, 2006). Eating disorders were linked with chronotype (Kasof, 2001; Natale, Ballardini, Schumann, Mencarelli, & Magelli, 2008). Kasof (2001) found correlational evidence

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between eveningness and two different measures of bulimic behaviour suggesting that evening types are higher at risk. In the study of Natale et al. (2008), evening types were as twice as high in their clinical sample with eating disorders compared to the control group, and it seems that especially activity during the evening is linked with eating disorders (Kasof, 2001; Natale et al., 2008).

But also in a non-clinical sample, all three constructs of the Three Factor Eating Questionnaire of Stunkard and Messick (1985) were associated with chronotype (Schubert & Randler, 2008). Morning oriented persons scored higher on dietary restraint and lower on disinhibition and perceived hunger. Further, there was an association between morningness and flexible control. These data further suggest that staying awake late in the evening may lead to overeating.

However, most – if not all – these studies are concerned with adults and not with adolescents. Also, food logs have not been examined in association with chronotype, therefore, the study is new. Studies focusing on children and adolescents identified a relationship between sleep length and obesity (measured by the Body Mass Index): short sleep duration was identified as one risk factor for obesity (Snell, Adam, & Duncan, 2007). As obesity becomes an increasing problem emerging in childhood/adolescence, we need a closer look at what happens during these developmental stages, and at the association of diet and chronotype. Here, we studied adolescent chronotypes and used food logs for a detailed analysis. We hypothesise that late chronotypes should differ in meal times from earlier chronotypes at the weekend and that food intake quantitatively should be associated with chronotype, presumably by healthier diet in morning oriented adolescents. We expected a higher caloric intake in sweets, fast food, and caffeinated drinks in late chronotypes.

1. Methods

1.1. Participants

Data were collected from 152 girls and boys in Germany between 11.1.2008 and 16.1.2008. Participants were recruited from a school in a middle sized town (13 600 inhabitants). After the principals of the school agreed, parents and pupils were informed. Parents and adolescents gave informed consent and had the possibility to refuse participation. The study was under the oversight of the IRB of the University of Education Heidelberg ("Forschungskommission"). There were 96 girls (=64.0%) and 54 boys. The mean age was 13.23 years (SD = 1.54, range = 11–17). The pupils attended classes with a schedule between 7:40 a.m. and 12:50 p.m. Teachers informed pupils about the nature of the study, e.g. by introducing the researcher, informing about the University where DF made the study. This point is important because teachers showed that they supported the study which has a motivating effect on the pupils. All detailed information regarding the study was then given by DF who was present in the classrooms. The questionnaires about chronotype were completed during the usual classes in the presence of one researcher (DF). Pupils were introduced in the handling of the food log using one artificial example by DF, e.g. how to report quantities was discussed with the pupils and examples were given to aid them by filling in the food logs. Teachers and pupils were not aware of the hypothesis. The food logs were then distributed initially among 281 pupils, but only 152 (54%) responded to the logs. Participation was voluntary, unpaid and anonymous.

1.2. Measurement instruments

Chronotype: Midpoint of sleep. The pupils were asked for their habitual rise time and bed time on weekdays and on free days (weekend) to calculate the midpoint of sleep on free days (see details of format and calculations in Roenneberg et al., 2004). Please note that our measurement differed because we used bed times and rise times instead of sleep onset and wake time. Chronotype is defined as the midpoint of sleep on free days without any obligations on the next day because this measures the internal biological clock or preference. Because many people (adolescents and adults) acquire some sleep deficit during the school/work week, they sleep longer on the weekends. To account for this sleep debt acquired during the week, we used the algorithm proposed in Roenneberg et al. (2004) to calculate the midpoint of sleep on free days corrected for sleep debt. This algorithm corrects for weekend oversleep.[1]

1.3. Food logs

Our subjects kept food logs for a total number of seven days. In these food logs, subjects reported everything they ate during the respective days and the approximate quantity and the meal times for breakfast, lunch and dinner. These data were sometimes rather precise, e.g. a specific branded product in a given quantity, sometimes the pupils reported it in a format like "two glasses of milk". The quality of such food logs is considered good since Tremblay, Sévigny, Leblanc, and Bouchard (1983) showed that three days of recording are sufficient for a valid analysis. To homogenize the data, we applied a standardisation procedure (see Methods).

To assess the caloric intake, we transformed the data obtained by the food logs into calories. Three sources were used: a) Bayerisches Staatsministerium für Gesundheit, Ernährung und Verbraucherschutz, b) Barmer Ersatzkasse, and c) an internet-based resource (www.fettrechner.de) which is based on the Bundeslebensmittelschlüssel. Additionally, original data from the different brand products were inspected directly. The data were counterchecked between these sources and with the original data from the producers. The mean between the sources was used.

We grouped the foods into six groups which were most interesting with respect to chronotype and healthy nutrition. These were 1) fast food consumption, 2) cola and other caffeinated drinks, 3) dairy products, 4) sweets, 5) vegetables and salad, 6) meat. The basic categories were obtained from a food frequency list (Winkler & Döring, 1998), additionally, we used the fast food category. Fast food, cola/caffeine consumption and sweets may be considered as some kind of unhealthy "stimulants" in adolescents (compared e.g. to alcohol or smoking in adults; see Wittmann et al., 2006). Vegetables and fruits were merged into one category (and not in two as in Winkler & Döring, 1998), because they represent – more or less unequivocal – a healthy diet.

1.4. Additional measurement

We asked for body weight and height to calculate the Body Mass Index (BMI).

1.5. Statistical analysis

We used complex linear regressions to account for confounding variables. Dependent variables were the six different groups of food (see above). First, we used the total caloric intake of an individual during the week and regressed it against e.g. the total caloric intake of sweets, vegetables, and so on. This kind of regression accounts for individual differences in reporting details about diet (assume, e.g. an individual fills out only six of the seven days, then it is possible to compare this individual with the others by this standardisation procedure). Second, chronotype, BMI, age and sex were also computed in this regression analysis, since chronotype is dependent on age, and BMI, in turn, also is associated with age or caloric intake. Sex, of course, is related to both diet and chronotype, with girls usually consuming

[1] $MSF_{sc} = MSF - 0.5*(SDF - (5*SDW + 2*SDF)/7)$. MSF is midpoint of sleep on free days, SDF = sleep duration on free days, and SDW = sleep duration on week days.