Clinical Nutrition xxx (2017) 1–7

Contents lists available at ScienceDirect

Clinical Nutrition

journal homepage: http://www.elsevier.com/locate/clnu

Original article

The associations between carbohydrate and protein intakes with habitual sleep duration among adults living in urban and rural areas

Q2 Q1 Xin Liu [a,*], Di Wu [b,c], Xin Qi [a], Yulin Niu [a], Wenyuan Li [d], Yichen Lu [d], Jie Chang [e]

[a] Department of Epidemiology and Health Statistics, School of Public Health, Xi'an Jiaotong University Health Science Center, Xi'an, Shaanxi, People's Republic of China
[b] Department of Periodontology, UNC-Chapel Hill School of Dentistry, NC, USA
[c] Department of Biostatistics, UNC Gillings School of Global Public Health, NC, USA
[d] Xi'an Jiaotong University Health Science Center, Xi'an, Shaanxi, People's Republic of China
[e] Department of Pharmacy Administration and Clinical Pharmacy, School of Pharmacy, Health Science Center, Center for Drug Safety and Policy Research, Xi'an Jiaotong University, Xi'an, Shaanxi, People's Republic of China

ARTICLE INFO

Article history:
Received 6 March 2017
Accepted 31 July 2017

Keywords:
Macronutrient
Sleep duration
Urbanicity

SUMMARY

Background & aims: Macronutrient intake was associated with habitual sleep duration, a recognized metabolic risk factor. However, results are not clear for populations with large diversities in dietary habits and urbanization levels. In this study, we aimed to evaluate the associations between relative macronutrient intakes and sleep duration, and the potential modification effect of urban–rural residence among adult Chinese population.
Methods: We analyzed data from the China Health and Nutrition Survey 2009. In total, 9239 men and women aged 18 years or older were included. Dietary intakes were measured using a combination of a 3-day recall and household-based food weighing approach. Sleep duration was self-reported as hours of sleeping every 24 h.
Results: Our participants have a mean sleep duration of 7.9 ± 1.2 h. After multivariate adjustment, higher intake of carbohydrate as percentage of total energy was associated with longer sleep duration ($\beta \pm SE = 0.43 \pm 0.12$, $P < 0.001$); and an inverse association was observed for the relative protein intake ($\beta \pm SE = -2.12 \pm 0.47$, $P < 0.001$). After stratification, the inverse association for protein was only detected in rural residents ($\beta \pm SE = -3.30 \pm 0.66$, $P < 0.001$), but not in urban participants ($\beta \pm SE = -0.44 \pm 0.74$, $P = 0.55$) (P for interaction = 0.002). Similarly, a marginal interaction with residence was observed for carbohydrate–sleep association.
Conclusions: Our study suggested that the relative intakes of protein/carbohydrate were associated with sleep duration among adult Chinese, especially those in rural areas.

1. Introduction

Sleep is a natural resting state, during which people tend to be mentally and physically less active [1]. Short and (or) long sleep durations have been associated with higher risks of obesity [2], hypertension [3], type 2 diabetes [4], and other cardiometabolic risk factors [5,6]. Therefore, it is of importance to determine what factors may influence sleep durations. However, sleep practice could not be purely controlled by willed behavior. It is also affected by multiple factors including environmental pollution [7], socio-economic status [8], employment [9], physical activity [10], psychiatric problems [11], and dietary habits [1]. At the individual level, dietary intake could be one of the most modifiable factors. Several epidemiological studies with relatively limited sample size supported the relationships between the intakes of fat/carbohydrate or total energy and sleep durations [12–16]. Nevertheless, the reported associations were not entirely consistent in directions or

Abbreviations: BMI, body mass index; CHNS, China Health and Nutrition Survey; FFQ, food frequency questionnaires; HSD, habitual sleep durations; LNAA, large neutral amino acid; NHANES, National Health and Nutrition Examination Survey; TRP, tryptophan.

* Corresponding author. Department of Epidemiology and Health Statistics, School of Public Health, Xi'an Jiaotong University Health Science Center, 76 West Yanta Road, Xi'an, Shaanxi 710061, People's Republic of China. Fax: +86 29 82655101.
E-mail address: xinliu@xjtu.edu.cn (X. Liu).

http://dx.doi.org/10.1016/j.clnu.2017.07.024
0261-5614/

strengths. Meanwhile, most of the previous studies were conducted among developed countries [17].

In the China Sub-Optimal Health Survey conducted among 18,316 adult citizens from six provinces, 5.93% of the participants reported a short sleep duration (<6 h) [18]. This survey was conducted in 2008. With rapid economic development during the very early 21st century, the Chinese population experienced substantial changes in macronutrient intake levels, according to China Health and Nutrition Survey (CHNS) [19]. Little is known on the relationship between macronutrient intake and sleep duration in this population.

In the Chinese Longitudinal Healthy Longevity Survey, participants living in rural areas showed a better sleep quality and a trend of longer sleep duration, compared to urban residents [8]. In China, there used to be huge differences in dietary sources, and lifestyle patterns between rural and urban areas in the past decades, and the rapid urbanization may have contributed to the nutrition transition, changes in lifestyles, and thereafter metabolic status [19]. However, it is unclear whether people in rural and urban areas share a common relationship between dietary intake and sleeping habits.

We hereby investigated the associations between the relative macronutrient intakes and habitual sleep duration, and explored the potential modification effects of urban–rural residence among adult Chinese, using a national-wide survey sample.

2. Methods

2.1. Study population

The CHNS was an ongoing open longitudinal study to learn how social, economic, demographic changes affect health behaviors in China. The study design has been published elsewhere [20]. In brief, it initiated in 1989, and has finished eight follow-up surveys up to 2011. Individuals from 228 communities of nine provinces participated the survey (Supplementary Fig. 1) (Liaoning, Heilongjiang, Jiangsu, Shandong, Henan, Hubei, Hunan, Guangxi, and Guizhou) with socio-economic and geographical diversity [20]. Using a multi-stage, random cluster sampling approach, both urban and rural residents were included from each province. The study protocol was jointly approved by the institutional review committees of the University of North Carolina at Chapel Hill, the National Institute of Nutrition and Food Safety, the Chinese Center for Disease Control and Prevention, and the China–Japan Friendship Hospital, Ministry of Health, China [20]. Written informed consents were acquired from all the participants.

The sample of current study was from the CHNS 2009. In this wave of survey, a total of 10,829 participants have available data of food intake and physical examination. We excluded those aged less than 18 years ($n = 1453$), those without data of sleep duration ($n = 121$), and those reported a daily energy intake less than 500 kcal or above 5000 kcal ($n = 16$). Finally, data from 9239 participants were included in this study.

2.2. Data collection

Questionnaires were used to collect demographical information and lifestyle habits [20]. Sleep duration was obtained by asking "How many hours do you sleep every day, including day and night?", and was classified into five groups: $\leq$6 h, 7 h, 8 h, 9 h, and $\geq$10 h. Education attainment was grouped into three levels based on a six-category primary question: low (uneducated, primary school, or junior middle school), medium (upper middle school or technical or vocational degree), or High (university, college, master or higher degree). Occupational physical activities were grouped into three levels based on 5 categories recorded by the interviewers: low (light or very light), moderate (moderate), and high (heavy or very heavy) [21,22]. Smoking status (current smoking, former or never) and drinking habits (current drinking, or not) were also recorded in the questionnaire. Urbanization index has been described elsewhere previously [20]. Twelve components related to urbanization were combined, including community measures of infrastructure, services, and population. At each follow-up visit, weight and height were collected by trained health workers according to standard protocol recommended by the World Health Organization. With participants wearing light clothes without shoes, body weight was measured to the nearest 0.1 kg on a calibrated beam scale, and height was measured to the nearest 0.1 cm, with a portable stadiometer (SECA; Hamburg, Germany). Body mass index (BMI) was calculated as weight in kilogram divided by the squared height in meters.

2.3. Macronutrient measurement

In the CHNS, information on dietary intake were obtained in a combination manner of 24-h recalls of 3 consecutive days at individual level and a food weighing record at household level performed during the same period [23]. At the individual level, all the food types and amount during the previous days were documented by trained interviewers, with food models and pictures. Food consumption at the household level was assessed using a weighing approach previously described [24]. A comparison between the individual level data and the household level data was conducted to control the data quality. Any discrepancies were resolved by revisiting at both levels [24]. Daily intakes of carbohydrate (g), protein (g), and fat (g), and total energy intake (kcal) were analyzed from the dietary intake data using the Chinese Food Composition Table [25]. Percentage of total energy was calculated by multiplying the amount of each nutrient with its corresponding energy value (4 kcal for 1 g carbohydrate or 1 g protein, and 9 kcal for 1 g fat), and then divided by total energy consumption. Total energy intake was converted from kcal to kJ (1 kcal = 4.18 kJ) [25].

2.4. Statistical analyses

Data are presented as mean ± SD or percentage where appropriate. Differences between groups were tested using general linear model for continuous response variables and Chi-square test for categorical response variables. The associations between the macronutrient in percentage of energy consumption and sleep duration (response variable) were analyzed using general linear model, adjusted for age, sex, residence (urban or rural), current alcohol drinking (yes or no), current smoking (yes or no), physical activity level (low, moderate, or high), and education attainment (low, medium, or high). Stratified analyses were also conducted by age group (above or lower than median), sex, residence, and BMI status (above or lower than 24 kg/m^2, the Chinese-specific cut-off point for normal weight/overweight [26]). To understand the contribution of the relative macronutrient intake on their associations with habitual sleep duration (response variable), multivariable substitution models were used [27]. In our models, the unit of sleep duration was transferred to minute. For each macronutrient, two other macronutrients, total energy consumption, as well as other covariates were left in the model, and we calculated the coefficient of 5% energy substituted by one macronutrient with another in each model [16]. All the statistical analyses were performed using SAS 9.3. $P < 0.05$ (two-sided) was regarded as statistically significant.

Please cite this article in press as: Liu X, et al., The associations between carbohydrate and protein intakes with habitual sleep duration among adults living in urban and rural areas, Clinical Nutrition (2017), http://dx.doi.org/10.1016/j.clnu.2017.07.024