Original Article

Dietary patterns and sleep parameters in a cohort of community dwelling Australian men

Yingting Cao MBBS, MMsc[1,2], Anne W Taylor PhD[1], Gary Wittert MD[2,3], Robert Adams MD, PhD[4], Zumin Shi MD, PhD[1,2]

[1]*Population Research and Outcome Studies, School of Medicine, University of Adelaide, South Australia, Australia*
[2]*Freemasons Foundation Centre for Men's Health, Adelaide, South Australia, Australia*
[3]*Discipline of Medicine, School of Medicine, the University of Adelaide, Adelaide, South Australia, Australia*
[4]*The Health Observatory, University of Adelaide, Queen Elizabeth Hospital Campus, Woodville, South Australia, Australia*

Background and Objectives: Emerging evidence suggests potential effects of nutrients/foods on sleep parameters. However, no studies have addressed the complex interactions among nutrients/foods and relate them to sleep outcomes. To investigate the associations between dietary patterns and sleep parameters (polysomnography (PSG) measured and self-reported sleep symptoms) in a large sample of community dwelling men in South Australia. **Methods and Study Design:** Cross-sectional analysis was conducted of participants in the Men Androgen Inflammation Lifestyle Environment and Stress cohort enrolled in a sleep sub-study (n=784, age 35-80 years). Dietary intake was measured by a validated food frequency questionnaire. Dietary patterns were identified by factor analysis. Sleep was assessed by an overnight home PSG and self-reported questionnaires. **Results:** Two factors were obtained by factor analysis: Factor 1 was characterised by high intakes of vegetables, fruits, and legumes and factor 2 was characterised by processed meat, snacks, red meat and take-away foods. Three categories of the dietary patterns were defined (prudent, mixed and western) through classification of the sample according to the actual consumption higher or lower of each factor. The prudent (factor 1 dominant) and mixed dietary patterns were inversely associated with sleep onset, compared with the western dietary pattern (factor 2 dominant) (β=-6.34 (95% CI-1.11, -11.57), β=-4.34 (95% CI-8.34, -0.34) respectively)). The association was only significant with the prudent dietary pattern after multiple comparison adjustment. No associations were found with between dietary patterns and other sleep outcomes. **Conclusions:** The prudent dietary pattern was associated with a faster sleep onset, which may provide a solution for sleep management.

Key Words: dietary patterns, polysomnography, sleep onset latency, apnoea hypopnea index, men

INTRODUCTION

In line with the epidemic of sleep disturbances,[1] Australians have demonstrated a high prevalence of frequent sleep difficulties (including sleep initiating and maintenance, and inadequate sleep), daytime fatigue and daytime sleepiness (20-35%).[2] Sleep disturbances are well known to increase the risk of obesity, type 2 diabetes and inflammation.[3]

Short sleep has been shown to be associated with higher intakes of energy-rich foods mostly from fat or refined carbohydrates.[4-6] On the other hand, as the bidirectional relationship between food intake and sleep, diet may also affect sleep although findings are inconsistent.[7] Experimental studies have found that carbohydrate intake, particularly with high glycaemic index (GI) before bedtime, was associated with shortened sleep onset in healthy young men,[8] but was associated with increased arousals in toddlers.[9] In observational studies, low intake of protein (<16% of energy intake vs ≥16% of energy intake) was associated with poor sleep quality, while high protein intake (≥19% of total energy vs <19% of energy intake) was associated with difficulties of maintaining sleep.[10] Another two studies did not find any association between protein intake and sleep duration/quality.[11,12]

Most of the existing studies on diet and sleep mainly focused on specific nutrients/foods intake. However, foods are consumed in combination and neglecting the interactions among nutrients/foods may generate inconsistent results. Dietary pattern analysis can address the possible interactions among foods and nutrients, connecting diet with health outcomes.[13]

Dietary patterns have been shown to be associated with

Corresponding Author: Yingting Cao, School of Medicine, The University of Adelaide, SAHMRI, L7, North Terrace, SA5000, Australia.
Tel: +61 8 8313 1218; Fax: +61 8 8313 1228. Mobile: +61 4 20 350 060.
Email: yingting.cao@adelaide.edu.au
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metabolic syndrome,[14] depression,[15] stroke[16] and mortality[17] in adults. However, the association between dietary patterns and sleep is not well studied. Currently, only two studies have assessed the association between dietary patterns and subjective measured sleep. A dietary pattern rich in fruits and vegetables was positively associated with long sleep duration among Portuguese children.[18] A healthy dietary pattern was inversely associated with difficulty initiating sleep among Japanese adults.[19] No studies on dietary patterns and objectively measured sleep are available.

We aimed to investigate the association between dietary patterns and polysomnography (PSG) measured sleep onset latency (SOL), sleep duration and Apnoea-Hypopnea Index (AHI) and as well as self-reported sleep symptoms in a large sample of community men in South Australia.

METHODS

Study population

The Men Androgen Inflammation Lifestyle Environment and Stress (MAILES) study is an ongoing cohort study established in 2009 investigating the roles of sex steroids, inflammation, environmental and psychosocial factors in the pathogenesis of cardio-metabolic disease in men. A detailed cohort profile has been published previously.[20] Briefly, MAILES contains 2563 men aged 35-80 years old from Adelaide at baseline (MAILES stage1) from the harmonisation of two population cohort studies: all participants from the Florey Adelaide Male Ageing Study (FAMAS) (2002-05)[21] and eligible male participants from the North West Adelaide Health Study (NWHAS) (2004-06).[22] The MAILES stage 2 was an approximate five-year follow-up consisting of questionnaires and biomedical examinations. In total, 1815 men provided details on dietary intake during MAILES stage 2.

MAILES stage 3, consisting of a Computer Assisted Telephone Interview (CATI) that included sleep related questions, was conducted in August 2010 (n=1629). The 184 who answered 'yes' to the question 'Have you ever been diagnosed with obstructive sleep apnoea (OSA) with a sleep study' were excluded from participating in the sleep study, and 1445 men who answered 'no' to the question were further asked if they were willing to participant in the sleep study (75.2% agreed). Of these, a random sample of 1087 was chosen for inclusion. A total of 857 men underwent PSG (Figure 1[23]) by the end of the study period. Ethics approval was obtained from the Queens Elizabeth Hospital Human Ethics Committee for the NWHAS study (number 2010054) and the Royal

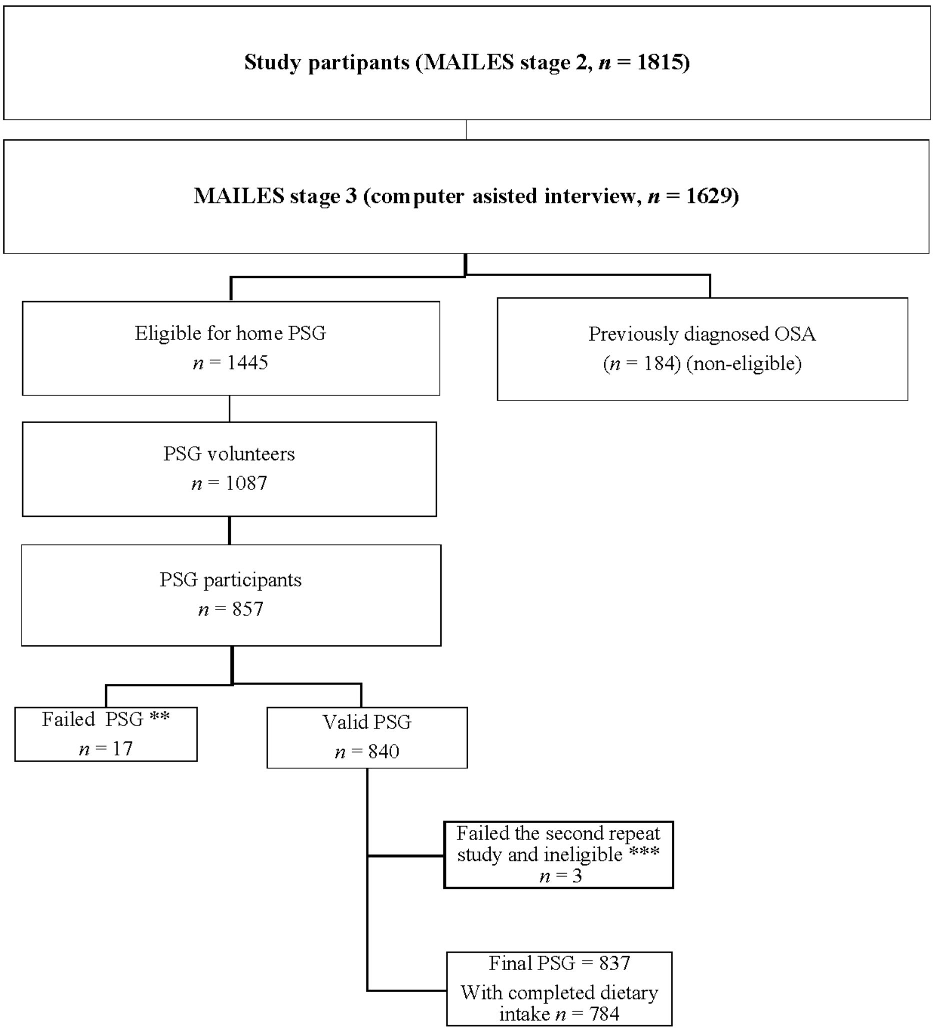

Figure 1. The flow chart of study participants with dietary intake (MAILES stage 2) and MAILES stage 3 with polysomnography (PSG) recruitment Notes: * n=17 failed and did not repeat the study (n=15 total sleep time (TST) was not ≥3.5 h from ≥5 h recording; n=1 poor respiratory signals; n=1 poor EEG); ** n=2 TST was not ≥3.5 h from ≥5 h recording, and n=1 subsequently found to be ineligible.[23]

Adelaide Hospital Human Research Ethics Committee for the FAMAS study (number 020305h).

Dietary measurements

Dietary intake was measured by the Cancer Council of Victoria Diet Questionnaire for Epidemiological Studies (DQES-V 3.0 & 3.1 (FFQ)). The FFQ has been validated in an Australian population and is widely used in epidemiological studies.[24] The questionnaire asks the participant's habitual consumption of 167 food items and six alcohol beverages over the last 12-month on a 10-point frequency scale. By using the estimated portion sizes and frequencies, the intake of each food (in grams) was converted to daily equivalents for analyses. Additional questions were asked about the type of breads, dairy products and fat spreads.

Sleep measurements

Sleep measurements consisted of subjective (CATI and self-completed questionnaires) and objective (in-home PSG) approaches. Self-reported data included: 1) the STOP questionnaire- questions of snoring, tiredness during daytime, observed apnoea and high blood pressure;[25] 2) the Pittsburgh Sleep Quality Index (PSQI)- total score of PSQI ranged from 0-21, with a score ≥5 interpreted as poor sleep quality;[26] and 3) sleepiness asked by the question 'Do you feel sleepy when sitting quietly during the day?'

Among those without previous diagnosis of OSA, an overnight in-home PSG with Emblettas X100 portable sleep device (http://www.embla.com/index.cfm/id/57/Embletta-X100/) was conducted with manual scoring undertaken by an experienced sleep technician according to the current American Academy of Sleep Medicine criteria (alternative).[27] Several detections were monitored by PSG including electroencephalography, electrooculography, electromyography, and electrocardiograms, thoracic and abdominal bands for respiratory effort, a nasal pressure cannula for nasal airflow, a body-position sensor for body posture, and a finger oximeter sensor to monitor oxygen saturation. PSG parameters used in the analysis were SOL, total sleep duration and AHI.

Other measurements

Information on education, marital status, income, work status, physical activity, smoking, shift-work and chronic diseases were collected by questionnaires.[20] Medication use was obtained from Medicare Australia by confidential unit record linkage, classified according to the Anatomical Therapeutic Chemical (ATC) Classification. The number of distinct medication classes (at the ATC third level) six months before the clinical examination were treated as covariates.

Body weight was measured in light indoor clothing without shoes to the nearest 100 grams. Height was measured without shoes to the nearest mm using a stadiometer. Waist circumference was measured to the nearest mm midway between the inferior margin of the last rib and the crest of the ilium, in the mid-axillary line in a horizontal plane. Blood pressure was measured twice by mercury sphygmomanometer on the right upper arm of the subject, who was seated for five minutes before the measurement.

Statistical analyses

The 167 food items were grouped into 41 groups, with modifications made based on a study that followed the Australian dietary guideline.[28] Dietary patterns were identified using factor analysis (principle-component method) with estimated daily intake (by grams) of the 41 food groups. Varimax rotation was used to improve interpretability and minimize the correlation between the factors. Factor solutions that contain a different number of factors were also tried. The final number of factors was determined by eigenvalue >1, screeplot, and interpretability of the factors.[29] Factor loadings for each food group were calculated and factor scores for each pattern were calculated for each participant by summing the total intake of the 41 food groups (standardised) weighted by their factor loadings. A higher score indicated greater association with the specific pattern.

Factor scores were used to categorize the sample and to carry out the statistical analysis. Chi square test was used to compare difference between categorical variables, and ANOVA was used to compare differences in continuous variables between groups. Poisson regressions were used to examine the association between dietary patterns and self-reported sleep symptoms. Linear regression models were used to examine the associations between dietary patterns and sleep parameters (SOL, AHI and PSG measured sleep duration). Tukey's honestly significant difference (HSD) was performed to adjust for multiple comparisons. A set of models were conducted: 1) adjusted for age; 2) further adjusted for education, smoking, alcohol consumption, physical activity and shift-work; 3) further adjusted for waist circumference; 4) further adjusted for diabetes, depression and medication. Sensitivity analyses were conducted using the same models between separate factors from factor analysis and sleep parameters. All of the analyses were performed using STATA 13.0 (Stata Corporation, College Station, TX, USA) with a p value of <0.05 as statistical significance.

RESULTS

At the completion of MAILES stage 2, there were 1815 participants with a complete set of data including dietary intake, of whom 82% had self-reported daytime sleepiness data. In the sleep sub study, 784 had home PSG data that was technically satisfactory, and 99% had self-reported poor sleep quality data (asked among PSG participants).

The factor analysis identified two main factors, and loadings of each factor were shown in Figure 2. Factor 1 was characterized by high intake of vegetables, fruits, and legumes while factor 2 was characterized by high intake of processed meat, snacks, red meat and take away foods. The food groups according to the two factors are presented in Supplemental Table 1, and the food groups according to three dietary patterns that were based on the differences of the quartiles of factors between the two factors are presented in Supplemental Table 2. Sensitivity analysis of the association between two factors separately with PSG sleep parameters is presented in Supplemental table 3.

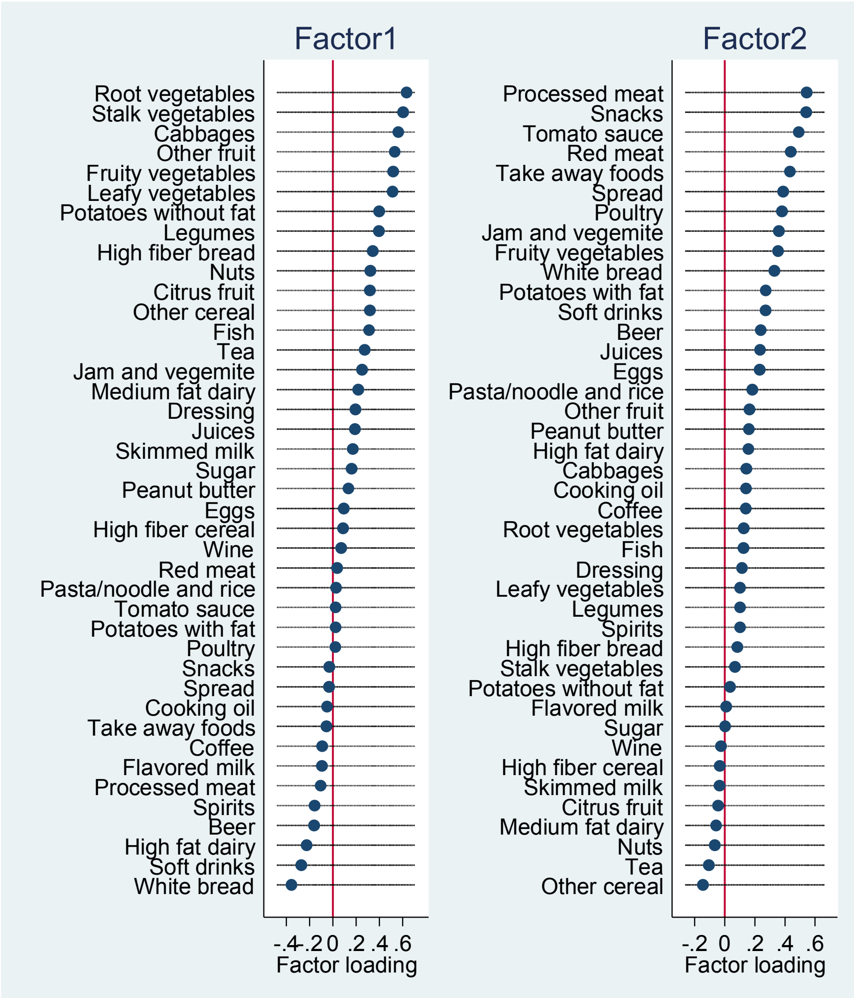

Figure 2. Factor loadings of two factor

Although the two factors were independent statistically, in reality, people with high intake of one factor may have low intake of the other. Therefore, the sample was categorised according to the difference of the quartiles of the factor scores between the two factors. If the difference of the quartiles ≥2, these subjects were grouped into either factor 1 dominant (named as the 'prudent pattern') or factor 2 dominant pattern (named as the 'western pattern'). The rest of the subjects were grouped as the 'mixed pattern'. The numbers of subjects in each group were as following: the prudent pattern, n=312 for the whole sample, and n=130 for subjects with PSG; the western dietary pattern, n=347 for the whole sample, and n=145 for subjects with PSG; the mixed dietary pattern, n=1156 for the whole sample, and n=509 for subjects with PSG.

The age adjusted sample characteristics by dietary patterns in the three categories are presented in Table 1. Subjects with the prudent dietary pattern tended to be older, lighter, less depressed, higher educated, and have lower consumption of alcohol, cigarettes, macronutrient and total energy intake and were more active.

Age adjusted sleep parameters by dietary patterns are presented in Table 2. Subjects with the prudent dietary had the shortest SOL comparing with those who had mixed or the western patterns (16.3 mins vs 19.2 mins and 22.5 mins) (p=0.024). Although without statistical significance, subjects with the prudent dietary pattern had the lowest AHI comparing with those who had mixed or the western patterns (14.4 vs 14.8 and 17.0). Total sleep duration did not differ by the three dietary patterns. For self-reported sleep measures, no differences were found in daytime sleepiness and poor sleep quality according to dietary patterns. No associations were found between dietary patterns and self-reported sleep symptoms (Table 3).

After adjusting for age, demographic and lifestyle factors, weight, as well as chronic diseases, the prudent dietary pattern was associated with about six minutes less in SOL compared with the western dietary pattern (β=-6.34, 95% CI-1.11, -11.57). Similarly, the mixed pattern was also associated with about four minutes less in SOL compared with the western dietary pattern (β=-4.34, 95% CI-8.34, -0.34). No associations were observed between the prudent dietary pattern or the western dietary pattern and other PSG outcomes (Table 4).

Multiple comparisons adjustment suggested that the prudent dietary pattern was still inversely associated with SOL (p<0.05) (data not shown), while the association between the mixed dietary pattern and SOL was not significant after adjustment.

DISCUSSION

To the best of our knowledge, this is the first study as-

Table 1. Age-adjusted sample characteristics by dietary patterns†

	Western pattern (n=347)	Mixed pattern (n=1156)	Prudent pattern (n=312)	p-value‡
Age (years)	55.8 (0.6)	59.7 (0.3)	63.6 (0.6)	<0.001
BMI (kg/m^2)	29.3 (0.3)	28.8 (0.1)	28.4 (0.3)	0.06
Waist circumference (cm)	103 (0.7)	101 (0.4)	99.1 (0.7)	<0.001
Carbohydrate (g/d)	235 (4.5)	212 (2.5)	217 (4.8)	<0.001
Protein (g/d)	110 (1.8)	98.8 (1.0)	93.0 (1.9)	<0.001
Fat (g/d)	110 (1.6)	92.8 (0.9)	79.1 (1.7)	<0.001
Energy intake (kcal)	2464 (34.4)	2157 (18.7)	2012 (36.3)	<0.001
Alcohol (standard drinks)	2.5 (0.2)	1.6 (0.1)	1.1 (0.2)	<0.001
Smokers (%)	25.0	11.4	5.9	<0.001
Depression (%)	14.2	11.3	6.8	0.01
Diabetes (%)	13.0	14.4	14.5	0.82
Physical active§ (%)	67.2	78.6	87.9	<0.001
Higher education¶ (%)	70.0	74.6	82.2	0.003
Shift worker (%)	48.9	49.6	49.2	0.97

†Results are presented in mean (SE) for such values.
‡p values were from ANOVA analysis adjusting for age.
§Physical active was defined as those who reported not being sedentary.
¶Higher education was defined as those who reported have obtained trade or bachelor degree or higher.

Table 2. Age-adjusted sleep outcomes by dietary patterns†

	Western pattern	Mixed pattern	Prudent pattern	p-value‡
PSG measured, n	145	509	130	
AHI (/h)	17.0 (1.2)	14.8 (0.6)	14.4 (1.2)	0.19
Sleep onset latency (min)	22.5 (1.6)	19.2 (0.8)	16.3 (1.7)	0.024
Total sleep duration (min)	372 (4.8)	373 (2.6)	374 (5.1)	0.96
Self-reported , n	252	940	295	
Daytime sleepiness (%)	43.6	41.6	33.6	0.07
Poor sleep quality§ (%)	52.0	47.9	37.5	0.06

†Results are presented in mean (SE) for such values.
‡p values were from ANOVA analysis adjusting for age.
§Poor sleep quality was measured in MAILES participants who participated PSG, the number of participants in each pattern refers to the numbers for PSG measured in the table.

sessing the association between dietary patterns and objectively measured sleep parameters in a relatively large community cohort. The prudent and the mixed dietary pattern were associated with a reduced SOL. No associations were observed between the dietary patterns and any other sleep outcomes.

We have divided the sample according to the real consumption of two factors obtained by factor analysis. Similarly, San-Cristobal et al[30] have previously categorized the sample into four groups (prudent, healthy, western and compensatory) based on the adherence to the two factors that derived from factory analysis. We compared the results using the original two factors as two patterns separately in the analysis and the results remained (Supplemental table 3).

Previous studies have suggested that dietary factors could affect sleep architecture such as shortening sleep latency and increasing non rapid eye movement sleep.[31-33] Afaghi's group has reported that a meal with high glycaemic index resulted in a reduced SOL compared with low glycaemic meal in 12 healthy young men.[8] They indicated the main mechanism was to do with the increased insulin response and the ratio of tryptophan to large neutral amino acid. This experimental result is in line with our study showing that the prudent dietary pattern was associated with a shortened SOL. As root vegetables are highly loaded on the prudent dietary pattern, the reduced SOL may also be explained by high glycaemic index. However, as dietary patterns do not reveal the timing of food intake, the direct effect of the prudent dietary pattern on SOL is unclear. In a Japanese study of adult workers, healthy dietary pattern was inversely associated with difficulty in initiating sleep.[19] Although they did not measure SOL, the inverse association between a healthy dietary pattern and difficulty in sleep initiation was in line with our findings. Although the biological mechanisms linking dietary patterns and SOL are yet to be explored, depression may be one of the possible mediators. A systematic review has found that a healthy dietary pattern was associated with reduced odds of depression[34] possibly due to its anti-inflammatory properties.[35-37] It is known that sleep quality is influenced by psychological factors such as anxiety[38] and depression.[39] We speculate that the antidepressant/anti-inflammatory effect of the prudent dietary pattern may partly explain the reduced SOL. It is noted that when we tested the association between two separate factors and SOL, factor 1 was inversely associated with SOL across quartiles (Supplemental table 3). This is consistent with categorizing into three patterns (prudent, mixed and western) in the current analysis, which highlighted the dominant patterns consumed in the sample.

Trakada et al[40] assessed the role of a fatty meal on OSA in 19 subjects and reported that a fatty meal was

Table 3. Prevalence ratio of self-reported sleep outcomes by dietary patterns†

	Western pattern (ref) (n=295)	Mixed pattern (n=940)	Prudent pattern (n=252)	N
Daytime sleepiness				
Model 1	1.00	0.95 (0.78-1.17)	0.78 (0.59-1.02)	1,487
Model 2	1.00	0.94 (0.75-1.19)	0.80 (0.59-1.09)	1,255
Model 3	1.00	0.96 (0.77-1.21)	0.83 (0.61-1.13)	1,255
Model 4	1.00	0.97 (0.77-1.22)	0.86 (0.63-1.17)	1,220
Poor sleep quality‡				
Model 1	1.00	0.94 (0.71-1.23)	0.79 (0.54-1.15)	751
Model 2	1.00	1.00 (0.73-1.37)	0.85 (0.55-1.30)	620
Model 3	1.00	1.01 (0.73-1.38)	0.86 (0.56-1.32)	620
Model 4	1.00	1.03 (0.75-1.42)	0.94 (0.61-1.47)	601

†Poisson regression was performed for the association between dietary patterns and self-reported sleep outcomes.
‡Poor sleep quality was measured in MAILES participants who participated PSG, the number of participants in each pattern refers to the numbers for PSG measured in Table 2.
Model 1 adjusted for age.
Model 2 further adjusted for education, smoking, alcohol, physical activity and shift work.
Model 3 further adjusted for waist circumference.
Model 4 further adjusted for depression, diabetes and medication.

Table 4. Associations between dietary patterns and PSG sleep outcomes†

PSG sleep parameters	Western pattern (ref) (n=145)	Mixed pattern (n=509)	Prudent pattern (n=130)	N
Sleep onset latency (min)				
Model 1	0	-3.27 (-6.83, 0.29)	-6.20 (-10.83, -1.56)**	784
Model 2	0	-4.02 (-8.03, -0.00)*	-6.12 (-11.32, -0.92)*	650
Model 3	0	-4.09 (-8.11, 0.06)	-6.25 (-11.47, -1.04)*	650
Model 4	0	-4.34 (-8.34, -0.34)*	-6.34 (-11.57, -1.11)*	630
Apnoea hypopnea index (/hour)				
Model 1	0	-2.14 (-4.71, 0.43)	-2.54 (-5.89, 0.81)	784
Model 2	0	-2.33 (-5.23, 0.57)	-1.82 (-5.58, 1.93)	650
Model 3	0	-1.80 (-4.60, 1.01)	-0.82 (-4.46, 2.82)	650
Model 4	0	-2.14 (-4.71, 0.43)	-2.54 (-5.89, 0.81)	630
Total sleep duration (min)				
Model 1	0	1.61 (-9.14, 12.4)	2.41 (-11.6, 16.4)	784
Model 2	0	-1.56 (-13.9, 10.7)	-4.88 (-20.8, 11.0)	650
Model 3	0	-1.81(-14.1, 10.5)	-5.34 (-21.3, 10.6)	650
Model 4	0	-2.26 (-14.7, 10.2)	-4.63 (-21.0, 11.7)	630

†Coefficients (95% CI) were presented from multivariable linear regression models.
Model 1 adjusted for age.
Model 2 extra adjusted for education, smoking, alcohol, physical activity and shift work.
Model 3 extra adjusted for waist circumference.
Model 4 extra adjusted for depression, diabetes and medication.
*p<0.05; **p<0.01.

associated with increased AHI. However, the small sample size and non-randomised control study design were the main limitations to that study. In our study, there was a positive association between factor 2 (high intake of processed meat, snacks, red meat and take away foods) and AHI after adjusting for demographic and lifestyle factors (Supplemental table 3). This is consistent with our previous finding that a high intake of fat was associated with an increased number of AHI.[41]

Self-reported total sleep duration has been suggested to be inversely associated with high fat/energy intake[4,42] and high fat intake has been shown to be associated with short sleep although the association was weaker.[4] However, dietary patterns were not associated with PSG measured total sleep duration in our data. A possible reason could be the differences between actual measured and self-reported sleep duration.

No association was found between daytime sleepiness and the dietary patterns. Postprandial sleepiness has been suggested in early experimental studies,[43] which could be explained by the interactions with the gut neuro hormones and promoting hypnogenesis.[44] A healthy dietary pattern that is characterised by vegetables, mushrooms, potatoes, seaweeds, soy products and eggs was associated with a decreased risk of difficulty of initiating sleep among Japanese workers,[19] However it is unknown how such dietary patterns would be associated with daytime sleepiness as it was not assessed in that study. Moreover, despite the existence of common elements, dietary patterns vary among populations, and the differences in relation to sleep parameters should be taken into account.

The strengths of this study are the use of validated dietary questionnaire, large size of the cohort, detailed information related to potential confounding factors and the objective measurements of sleep. There are a number of limitations in this study. Firstly, as the study is cross-sectional, casual effect cannot be indicated. Secondly, although we derived two factors from the factor analysis, we arbitrarily divided them into three groups according to the distribution of the sample. However, the result is consistent with using two factors separately. Finally, we only conducted one overnight PSG assessment as it is not practical to have multiple night PSG assessments in large epidemiological studies. Because the data was limited to males, we do not know what the associations are in females.

In conclusion, a prudent dietary pattern with high intake of vegetables, fruits, and legumes was associated with reduced SOL. Although this may assist in promoting diet interventions to improve sleep for clinicians, further prospective studies are needed to confirm these findings.

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The authors declared that there are no conflicts of interest.

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Supplemental table 1. Food intakes (in food groups) across qualities of factor 1 and factor 2 according to factor analysis.

a) Factor1 (food groups were ordered by factor scores in factor 1 from high to low)

Food groups (g)	Factor 1				*p*-value†
	Q1	Q2	Q3	Q4	
Root vegetables, mean (SD)	7.7 (6.4)	12.5 (9.4)	19.1 (12.3)	34.1 (19.5)	<0.001
Stalk vegetables, mean (SD)	3.9 (3.5)	7.0 (5.7)	9.9 (6.9)	16.6 (10.6)	<0.001
Cabbages, mean (SD)	14.2 (12.2)	20.9 (17.7)	33.5 (24.0)	54.6 (37.3)	<0.001
Other fruit, mean (SD)	130 (84.4)	204 (138)	264 (160)	360 (211)	<0.001
Fruity vegetables, mean (SD)	72.7 (70.1)	116 (85.6)	163 (116.4)	234 (161.4)	<0.001
Leafy vegetables, mean (SD)	10.4 (12.1)	18.2 (15.0)	28.1 (25.8)	45.8 (37.9)	<0.001
Potatoes without fat, mean (SD)	9.7 (12.3)	14.6 (15.7)	21.4 (23.0)	34.7 (31.8)	<0.001
Legumes, mean (SD)	26.5 (27.5)	39.0 (36.9)	51.7 (42.7)	71.6 (61.2)	<0.001
High fibre bread, mean (SD)	29.0 (40.5)	53.6 (45.0)	62.2 (48.0)	76.3 (51.9)	<0.001
Nuts, mean (SD)	2.8 (4.7)	5.0 (7.0)	7.2 (10.3)	11.4 (14.6)	<0.001
Citrus fruit, mean (SD)	8.5 (12.9)	13.8 (21.8)	20.8 (29.2)	31.1 (37.1)	<0.001
Other cereal, mean (SD)	37.3 (49.2)	56.1 (60.4)	67.7 (65.1)	91.6 (76.9)	<0.001
Fish, mean (SD)	14.0 (18.6)	23.9 (26.1)	29.0 (28.9)	37.8 (41.2)	<0.001
Tea, mean (SD)	203 (320)	276 (330)	333 (349)	480 (417)	<0.001
Jam vegemite, mean (SD)	5.8 (6.7)	8.4 (9.7)	9.1 (8.6)	12.4 (13.4)	<0.001
Medium fat dairy, mean (SD)	64.5 (134)	115 (182)	162 (227)	182.3 (219)	<0.001
Dressing, mean (SD)	9.4 (9.4)	12.4 (11.2)	13.5 (10.3)	14.5 (12.7)	<0.001
Juices, mean (SD)	62.7 (91.8)	88.6 (126)	116 (144)	133.3 (185)	<0.001
Skim milk, mean (SD)	34.6 (103)	92.0 (176)	110 (201)	115.4 (197)	<0.001
Other bread, mean (SD)	0.9 (6.4)	2.2 (9.9)	3.5 (13.1)	6.2 (19.3)	<0.001
Peanut butter, mean (SD)	6.2 (11.6)	6.4 (9.8)	9.0 (16.4)	10.1 (15.1)	<0.001
Eggs, mean (SD)	21.8 (17.5)	23.0 (16.9)	24.4 (17.4)	26.4 (20.4)	<0.001
High fibre cereal, mean (SD)	1.8 (7.1)	3.3 (9.4)	4.0 (11.1)	4.3 (10.7)	<0.001
Wine, mean (SD)	55.7 (115)	87.8 (167)	98.3 (198)	91.0 (147)	<0.001
Red meat, mean (SD)	87.2 (74.0)	82.6 (57.5)	87.6 (53.5)	93.6 (81.9)	0.11
Pasta/noodleand rice, mean (SD)	45.4 (55.2)	51.6 (47.5)	52.7 (45.6)	50.5 (47.2)	0.11
Tomato sauce, mean (SD)	7.1 (10.4)	7.1 (10.3)	7.9 (11.3)	7.6 (11.5)	0.64
Potatoes with fat, mean (SD)	8.4 (13.7)	9.2 (14.8)	10.1 (13.9)	9.3 (14.0)	0.36
Poultry, mean (SD)	38.6 (37.6)	39.8 (33.1)	37.6 (23.2)	42.5 (40.8)	0.17
Snacks, mean (SD)	86.1 (76.1)	80.0 (58.5)	79.0 (56.8)	81.7 (60.1)	0.35
Spread, mean (SD)	20.3 (19.2)	17.5 (15.7)	18.3 (16.5)	19.0 (17.2)	0.09
Cooking oil, mean (SD)	9.1 (9.3)	8.2 (8.9)	7.9 (9.2)	8.1 (9.3)	0.16
Take away foods, mean (SD)	21.1 (16.9)	19.6 (16.8)	21.0 (21.2)	17.5 (26.0)	0.03
Coffee, mean (SD)	430 (366)	428 (328)	383 (310)	355 (311)	<0.001
Flavoured milk, mean (SD)	19.3 (82.6)	11.0 (58.7)	5.2 (35.1)	6.5 (39.6)	<0.001
Processed meat, mean (SD)	34.4 (33.3)	31.4 (24.8)	31.2 (23.4)	28.2 (24.8)	0.008
Spirits, mean (SD)	39.3 (145)	21.2 (69.9)	18.0 (74.7)	5.6 (20.0)	<0.001
Beer, mean (SD)	363 (629)	286 (491)	221 (369)	173 (314)	<0.001
High fat dairy, mean (SD)	183 (222)	129 (193)	92.2 (154)	74.4 (147)	<0.001
Soft drinks, mean (SD)	412 (513)	246 (316)	201 (258)	164 (237)	<0.001
White bread, mean (SD)	49.8 (56.0)	23.8 (41.3)	15.2 (31.5)	9.7 (24.5)	<0.001

†*p* values were from ANOVA analysis unadjusted.

Supplemental table 1. Food intakes (in food groups) across qualities of factor 1 and factor 2 according to factor analysis (cont.)

b) Factor 2 (food groups were ordered by factor scores in factor 2 from high to low)

Food groups (g)	Factor 2				p-value[†]
	Q1	Q2	Q3	Q4	
Processed meat, mean (SD)	14.9 (13.2)	25.0 (16.6)	34.6 (20.8)	50.8 (36.4)	<0.001
Snacks, mean (SD)	46.0 (34.4)	66.0 (39.2)	86.1 (49.3)	129 (84.8)	<0.001
Tomato sauce, mean (SD)	3.0 (4.8)	4.4 (5.6)	7.2 (7.8)	15.1 (16.5)	<0.001
Red meat, mean (SD)	55.5 (39.9)	80.7 (47.6)	90.8 (47.6)	124 (99.3)	<0.001
Take away foods, mean (SD)	12.6 (11.0)	16.9 (12.4)	20.7 (15.1)	29.1 (32.4)	<0.001
Spread, mean (SD)	10.8 (11.2)	16.0 (13.4)	20.7 (16.6)	27.7 (21.3)	<0.001
Poultry, mean (SD)	27.5 (21.9)	36.7 (24.0)	41.8 (25.3)	52.6 (52.1)	<0.001
Jam vegemite, mean (SD)	4.8 (6.3)	7.1 (7.4)	9.8 (9.7)	13.9 (13.4)	<0.001
Fruity vegetables, mean (SD)	101 (78.2)	136 (97.2)	147 (101)	203 (187)	<0.001
White bread, mean (SD)	9.8 (24.4)	15.7 (30.6)	27.7 (42.2)	45.5 (57.8)	<0.001
Potatoes with fat, mean (SD)	4.9 (7.7)	7.9 (13.3)	10.3 (14.4)	13.9 (17.5)	<0.001
Soft drinks, mean (SD)	152 (198)	215 (315)	251 (331)	405 (489)	<0.001
Beer, mean (SD)	158 (311)	200 (356)	242 (400)	443 (679)	<0.001
Juices, mean (SD)	56.6 (83.9)	88.9 (121)	110 (157)	145 (178)	<0.001
Eggs, mean (SD)	20.2 (15.6)	21.6 (16.2)	23.2 (17.1)	30.6 (21.5)	<0.001
Pasta/noodle and rice, mean (SD)	37.0 (40.7)	49.5 (48.0)	52.3 (42.3)	61.5 (60.0)	<0.001
Other fruit, mean (SD)	205 (142)	234 (168)	241 (173)	278 (209)	<0.001
Peanut butter, mean (SD)	5.2 (10.9)	6.9 (10.4)	8.6 (15.8)	11.0 (15.7)	<0.001
High fat dairy, mean (SD)	84.3 (150)	100 (172)	131 (183)	164 (222)	<0.001
Cabbages, mean (SD)	24.3 (25.2)	29.9 (26.9)	32.9 (29.9)	36.1 (32.5)	<0.001
Cooking oil, mean (SD)	6.7 (8.2)	7.7 (7.8)	8.5 (8.9)	10.3 (11.1)	<0.001
Coffee, mean (SD)	312 (293)	388 (300)	439 (339)	459 (367)	<0.001
Root vegetables, mean (SD)	14.4 (12.9)	17.7 (14.4)	20.1 (17.8)	21.3 (18.4)	<0.001
Fish, mean (SD)	22.2 (23.8)	26.0 (27.9)	26.2 (29.5)	30.4 (40.1)	0.001
Dressing, mean (SD)	11.2 (10.0)	11.6 (9.5)	12.5 (11.1)	14.5 (13.2)	<0.001
Leafy vegetables, mean (SD)	19.3 (21.5)	26.2 (28.2)	27.4 (29.1)	29.6 (31.8)	<0.001
Legumes, mean (SD)	41.6 (41.7)	44.4 (44.2)	50.0 (47.2)	52.7 (53.0)	0.001
Spirits, mean (SD)	10.3 (35.5)	13.1 (47.9)	24.1 (84.7)	36.7 (146)	<0.001
High fibre bread, mean (SD)	49.3 (44.5)	55.8 (45.1)	56.3 (48.7)	59.7 (58.3)	0.016
Stalk vegetables, mean (SD)	8.1 (8.3)	9.4 (8.6)	9.5 (8.3)	10.5 (9.0)	<0.001
Potatoes without fat, mean (SD)	17.6 (23.0)	20.1 (24.4)	21.0 (23.5)	21.6 (24.6)	0.06
Flavoured milk, mean (SD)	7.6 (48.1)	12.0 (65.6)	14.4 (65.6)	8.1 (47.4)	0.22
Other bread, mean (SD)	3.0 (11.8)	2.2 (9.3)	4.7 (17.7)	2.9 (12.4)	0.035
Wine, mean (SD)	80.2 (139)	86.1 (166)	93.0 (197)	73.6 (131)	0.31
High fibre cereal, mean (SD)	3.3 (10.0)	3.9 (10.5)	3.3 (9.5)	2.9 (8.9)	0.45
Skim milk, mean (SD)	97.4 (181)	98.7 (186)	76.6 (163)	78.8 (175)	0.11
Citrus fruit, mean (SD)	20.6 (33.6)	19.9 (28.1)	15.4 (23.5)	18.2 (25.8)	0.027
Medium fat dairy, mean (SD)	137 (210)	144 (197)	136 (211)	107 (175)	0.026
Nuts, mean (SD)	7.1 (12.7)	6.9 (10.9)	6.7 (9.5)	5.5 (7.8)	0.10
Tea, mean (SD)	400 (420)	309 (335)	294 (357)	289 (352)	<0.001
Other cereal, mean (SD)	78.8 (79.3)	64.9 (64.6)	61.2 (61.2)	47.8 (55.5)	<0.001

Supplemental table 2. Food intakes (in food groups) across the three patterns (western, mixed and prudent) that based on the distribution of two factors

Food groups	Western pattern	Mixed pattern	Prudent pattern	*p*-value†
High fat dairy, mean (SD)	202 (228)	114 (180)	50.3 (104)	<0.001
Medium fat dairy, mean (SD)	63.1 (124)	140 (207)	174 (219)	<0.001
Skimmilk, mean (SD)	45.4 (125)	87.9 (176)	135 (211)	<0.001
Flavouredmilk, mean (SD)	15.8 (68.3)	10.4 (58.3)	5.2 (36.5)	0.060
Juices, mean (SD)	92.4 (117)	106 (156)	85.7 (115)	0.044
Softdrinks, mean (SD)	476 (557)	229 (287)	109 (174)	<0.001
Tea, mean (SD)	213 (326)	307 (347)	503 (430)	<0.001
Coffee, mean (SD)	468 (374)	409 (326)	287 (261)	<0.001
Redmeat, mean (SD)	111 (82.9)	85.7 (66.1)	69.0 (43.9)	<0.001
Processed meat, mean (SD)	48.5 (37.2)	30.2 (22.7)	16.3 (14.9)	<0.001
Poultry, mean (SD)	50.0 (46.7)	38.3 (31.5)	33.1 (24.4)	<0.001
Fish, mean (SD)	18.6 (22.6)	27.1 (33.0)	31.4 (30.1)	<0.001
Takeawayfoods, mean (SD)	26.2 (20.7)	19.9 (21.8)	12.3 (11.6)	<0.001
Pasta rice, mean (SD)	55.7 (60.6)	50.4 (46.8)	42.6 (41.6)	0.003
High fibre cereal, mean (SD)	2.0 (7.8)	3.5 (9.8)	4.3 (11.0)	0.006
Othercereal, mean (SD)	37.5 (47.7)	59.8 (61.8)	104 (82.0)	<0.001
Potatoeswithfat, mean (SD)	10.8 (14.3)	9.9 (15.1)	5.1 (7.3)	<0.001
Potatoes without fat, mean (SD)	12.8 (14.1)	19.5 (23.4)	30.3 (30.3)	<0.001
Citrusfruit, mean (SD)	9.5 (15.9)	17.8 (25.1)	31.3 (41.4)	<0.001
Otherfruit, mean (SD)	174 (135)	243 (182)	300 (172)	<0.001
Fruity vegetables, mean (SD)	112 (102)	151 (141)	169 (98.2)	<0.001
Stalk vegetables, mean (SD)	5.7 (5.3)	9.3 (8.3)	13.9 (10.3)	<0.001
Rootvegetables, mean (SD)	11.2 (9.6)	18.4 (16.9)	26.3 (15.9)	<0.001
Cabbages, mean (SD)	18.8 (16.4)	31.2 (29.4)	42.7 (33.3)	<0.001
Leafy vegetables, mean (SD)	14.1 (14.4)	26.6 (29.1)	35.0 (31.9)	<0.001
Legumes, mean (SD)	34.3 (34.5)	47.3 (47.4)	61.0 (52.7)	<0.001
High fibre bread, mean (SD)	36.8 (48.2)	58.6 (49.2)	63.3 (47.8)	<0.001
Whitebread, mean (SD)	62.9 (60.7)	18.7 (33.9)	4.2 (13.9)	<0.001
Otherbread, mean (SD)	1.2 (6.9)	3.5 (14.1)	4.4 (14.8)	0.004
Eggs, mean (SD)	26.1 (19.9)	23.8 (17.9)	21.8 (17.0)	0.009
Spread, mean (SD)	26.0 (20.8)	18.5 (16.3)	11.9 (12.5)	<0.001
Beer, mean (SD)	460 (740)	243 (394)	102 (202)	<0.001
Wine, mean (SD)	59.6 (120)	89.6 (178)	85.9 (122)	0.009
Spirits, mean (SD)	50.0 (169)	16.8 (61.4)	4.7 (17.9)	<0.001
Snacks, mean (SD)	116 (84.8)	79.3 (55.9)	52.3 (40.0)	<0.001
Nuts, mean (SD)	3.4 (5.1)	6.2 (9.0)	11.6 (16.1)	<0.001
Peanut butter, mean (SD)	8.7 (13.5)	7.8 (13.7)	7.8 (13.5)	0.54
Jam vegemite, mean (SD)	9.7 (10.6)	9.2 (10.5)	6.9 (8.0)	<0.001
Tomatosauce, mean (SD)	11.8 (14.0)	7.2 (10.5)	3.6 (5.6)	<0.001
Dressing, mean (SD)	11.1 (10.5)	13.0 (11.6)	12.0 (9.7)	0.017
Cookingoil, mean (SD)	9.7 (9.8)	8.4 (9.3)	6.4 (7.6)	<0.001

†*p* values were from ANOVA analysis unadjusted.

Supplemental table 3. Associations between quartiles of separate factors from factor analysis and PSG sleep parameters[†]

	Factor 1				p for	Factor 2				p for
	β (95% CI)					β (95% CI)				trend[‡]
	Q1(ref)	Q2	Q3	Q4		Q1(ref)	Q2	Q3	Q4	
Sleep onset latency (min)										
Model 1	0	-4.67 (-8.50, -0.84)*	-4.22 (-8.03, -0.40)*	-6.27 (-10.1, -2.44)**	0.003	0	0.86 (-2.97, 4.69)	2.08 (-1.76, 5.92)	0.20 (-3.67, 4.08)	0.93
Model 2	0	-5.17 (-9.43, -0.91)*	-5.72 (-10.0, -1.43)**	-6.41 (-10.8, -2.01)**	0.008	0	1.71 (-2.45, 5.88)	2.71 (-1.50, 6.92)	-0.10 (-4.34, 4.13)	0.78
Model 3	0	-5.20 (-9.46, -0.93)*	-5.76 (-10.1, -1.46)**	-6.48 (-10.9, -2.07)**	0.008	0	1.80 (-2.38, 5.98)	2.75 (-1.47, 6.96)	-0.03 (-4.24, 4.30)	0.81
Model 4	0	-3.63 (-7.92, 0.65)	-4.94 (-9.22, -0.67)*	-5.44 (-9.87, -1.00)*	0.018	0	2.34 (-1.86, 6.54)	3.00 (-1.19, 7.20)	0.60 (-3.70, 4.90)	0.97
Apnoea-hypopnea index (/hour)										
Model 1	0	-1.75 (-4.50, 1.00)	-1.76 (-4.50, 0.98)	0.77 (-1.99, 3.52)	0.45	0	-1.02 (-3.77, 1.74)	1.01 (-1.76, 3.77)	3.26 (0.47, 6.04)*	0.002
Model 2	0	-3.75 (-6.81, -0.69)*	-3.18 (-6.26, -0.10)*	-0.58 (-3.73, 2.58)	0.77	0	-0.99 (-3.98, 2.00)	-0.13 (-3.15, 2.90)	2.62 (-0.42, 5.66)	0.023
Model 3	0	-3.52 (-6.47, -0.56)*	-2.90 (-5.88, -0.07)*	-0.01 (-3.04, 3.07)	0.53	0	-1.78 (-4.67, 1.12)	-0.44 (-3.35, 2.48)	1.47 (-1.49, 4.42)	0.08
Model 4	0	-3.18 (-6.20, -0.16)*	-2.96 (-5.98, 0.06)	0.05 (-3.08, 3.18)	0.62	0	-2.34 (-5.30, 0.62)	-1.01 (-3.97, 1.95)	1.13 (-1.90, 4.16)	0.11
Total sleep duration (min)										
Model 1	0	-4.39 (-16.0, 7.19)	-3.48 (-15.0, 8.05)	1.25 (-10.4, 12.9)	0.80	0	2.20 (-9.39, 13.8)	-0.61 (-12.2, 11.0)	-7.51 (-19.2, 4.21)	0.17
Model 2	0	-6.59 (-19.7, 6.48)	-6.93 (-20.1, 6.24)	-1.53 (-15.0, 12.0)	0.87	0	4.59 (-8.19, 17.4)	2.45 (-10.5, 15.4)	-3.92 (-16.9, 9.08)	0.45
Model 3	0	-6.68 (-19.8, 6.40)	-7.04 (-20.2, 6.14)	-1.77 (-15.3, 11.8)	0.85	0	4.90 (-7.92, 17.7)	2.57 (-10.4, 15.5)	-3.46 (-16.5, 9.63)	0.49
Model 4	0	-9.12 (-22.5, 4.25)	-8.13 (-21.5, 5.22)	-3.59 (-17.4, 10.3)	0.70	0	5.06 (-8.05, 18.2)	1.60 (-11.5, 14.7)	-3.88 (-17.3, 9.54)	0.46

[†]Results presented were from multivariable linear regression models.
[‡]p for trend was calculated using the median value of the factor score by the quartiles of scores of the factor.
Model 1 adjusted for age.
Model 2 extra adjusted for education, smoking, alcohol, physical activity and shift work.
Model 3 extra adjusted for waist circumference.
Model 4 extra adjusted for depression, diabetes and medication.
**$p<0.01$, *$p<0.05$.