Food & Function

PAPER

View Article Online
View Journal | View Issue

Cite this: *Food Funct.*, 2024, **15**, 4170

Association between dietary patterns and premenstrual disorders: a cross-sectional analysis of 1382 college students in China†

Xinyi Shi,[a,b] Min Chen,[a] Qing Pan,[a] Jing Zhou,[c] Yuqing Liu,[a,b] Tingting Jiang,[d] Yifei Lin,[a] Jin Huang,[a] Xi Shen,[e] Donghao Lu*‡[a,c] and Yuchen Li*‡[b]

Received 3rd January 2024,
Accepted 25th February 2024

DOI: 10.1039/d3fo05782h

rsc.li/food-function

Premenstrual disorders (PMDs) are common among young women and have been linked to metabolic dysfunction. Limited evidence exists regarding the associations between dietary patterns and PMDs. This cross-sectional study involved young female adults recruited from the Care of Premenstrual Emotion (COPE) cohort study in China to examine the relationship between dietary patterns and PMDs in young adulthood. PMDs were assessed using the Calendar of Premenstrual Experiences, and the consumption frequency of 12 common food groups was evaluated using a Food Frequency Questionnaire. We used principal component analysis to identify the dietary patterns and employed logistic regression to investigate the association between dietary pattern adherence and PMDs. The study included 1382 participants, of whom 337 (24.4%) reported having PMDs. Three dietary patterns were identified and named based on regional food preferences: the Traditional North China Diet (TNCD), the Traditional South China Diet (TSCD), and the Lacto-ovo Vegetarian Diet (LVD). The TSCD, characterized by high consumption of rice, red meat, and poultry, showed a significant inverse association with PMDs. This pattern held good for both premenstrual syndrome and premenstrual dysphoric disorder. These findings suggest that targeted dietary modifications could serve as a localized strategy for PMDs prevention.

1 Introduction

Premenstrual disorders (PMDs) are characterized by a group of physical/behavioral and affective symptoms that develop during the luteal phase of the menstrual cycle and resolve within days since menstruation. Evidence has suggested that PMDs result in decreased productivity, lower quality of life, and higher medical expenses.[1,2] PMDs can be further categorized into premenstrual syndrome (PMS) and premenstrual dysphoric disorder (PMDD) based on the severity and impact of the symptoms, with an estimated prevalence of 20%–35.7% and 1.3%–5.3%, respectively.[3,4] PMS usually involves relatively milder affective symptoms and/or predominant physical or behavioral symptoms, while PMDD is a more severe condition characterized by more intense affective symptoms which significantly impair psychosocial functioning.[5]

The etiology of PMDs, though largely unknown, appears to be closely linked to metabolic biomarkers and dysfunction. First, patients with PMDs may exhibit unique insulin/glucose interaction patterns, potentially intensifying the menstrual cycle's impact on insulin sensitivity.[6] Notably, during both the follicular and luteal phases, women with PMDs showed lower blood glucose levels and less insulin resistance compared to controls.[7] Second, PMDs might partially originate from childhood adiposity and continue to be associated with increased body mass into adulthood, a connection especially evident in PMDD cases.[8,9] Given these insights, it is crucial to explore the role of dietary factors, significant contributors to metabolic health, in the context of PMDs.

Cross-sectional data have suggested that certain foods, such as fruits, vegetables, whole grains, fish,[1,10–12] and specific

[a]*Health Management Center, General Practice Medical Center, Innovation Institute for Integration of Medicine and Engineering, West China Hospital, Sichuan University, Chengdu, China. E-mail: donghao.lu@ki.se*
[b]*Mental Health Center, West China Hospital, Sichuan University, Chengdu, China. E-mail: liyuchen@wchscu.cn*
[c]*Institute of Environmental Medicine, Karolinska Institutet, Stockholm, Sweden*
[d]*Youth League Committee (Youth Work Department, Medical and Social Work Office), West China Hospital, Sichuan University, Chengdu, China*
[e]*Department of Nutrition and Food Hygiene, West China School of Public Health and West China Fourth Hospital, Sichuan University, Chengdu, China*

† Electronic supplementary information (ESI) available. See DOI: **https://doi.org/10.1039/d3fo05782h**

‡ Equal contribution.

nutrients (*e.g.*, vitamins), are inversely associated with PMS, while foods containing egg yolk are positively associated with PMS.[13,14] Moreover, prospective studies have shown that a higher intake of potassium and lower consumption of vitamin B were associated with an elevated risk of PMDs.[15,16] Few studies investigated the association with dietary patterns, which better reflect the overview of diet profiles. The Mediterranean dietary pattern (featuring high consumption of vegetables, fruits, whole grains, legumes, nuts, and olive oil) is inversely associated with PMDs, while the bread/snack pattern (featuring high consumption of bread/rice cakes and snacks) and western dietary pattern (featuring high consumption of red and visceral meats, high-fat dairy products, sweets, and salty snacks) have been positively associated with PMS.[17,18] However, these studies were relatively small (about 200–300 individuals) and only one study used the standard questionnaire for PMD assessment.[17–19] Moreover, the relationship between dietary patterns and specific PMD subtypes (especially PMDD) remains poorly established. Additionally, little is known about the association with Asian dietary patterns.

In China, a typical East Asian country with vast geographic diversity, food preferences vary significantly due to differences in cultural practices and local agricultural products, which, in turn, influence regional dietary patterns. The Traditional North China Diet (TNCD) is characterized by a higher intake of wheat-based foods such as noodles and steamed buns, while the Traditional South China Diet (TSCD) predominantly includes rice and rice-based dishes.[20,21] Moreover, the Lacto-ovo Vegetarian Diet (LVD), emerging among younger generations influenced by health and environmental consciousness, primarily consists of plant-based foods, dairy products, and eggs, with minimal consumption of meat and fish. This variance in dietary preferences across China provides a unique opportunity to study the impact of different dietary patterns on PMDs.[22] By leveraging the cross-sectional data from a cohort of female medical students in China, we aimed to evaluate the associations between dietary patterns and PMDs in young adulthood.

2 Materials and methods

2.1 Study population

The study population was selected from the Care of Premenstrual Emotion (COPE) study, a prospective cohort of medical students at Sichuan University in Chengdu, China. From 2021 to 2023, undergraduate students were invited from West China Schools of Medicine, Stomatology, Basic Medical Sciences & Forensic Medicine, Public Health, and Pharmacy to participate in the study. The recruitment was done by trained investigators *via* visits to student dormitories. An electronic survey was conducted during the recruitment to collect information on demographics, PMD symptoms, mental health conditions, and potential risk factors. In total, 1382 students were recruited with a participation rate of 64% in the School of Medicine and 21% in other schools. All participants completed the questionnaire, leading to the inclusion of 1382 participants aged 17–30 years (1135 from the School of Medicine). No individuals were excluded from the cross-sectional analysis. This study was approved by the Institutional Review Board of West China Hospital, Sichuan University (No. 2018-535). All individuals provided electronic informed consent.

2.2 Assessment of food consumption frequency

The consumption frequency of various food groups was assessed using a food frequency questionnaire adapted from the China Kadoorie Biobank,[23] which has demonstrated a fairly good validity (Spearman coefficients ranging from 0.23 to 0.59) and reproducibility (Spearman coefficients ranging from 0.17 to 0.56).[24] Briefly, participants were asked to report the frequency of consumption of 12 common food groups during the last year including rice, wheat, other staple foods (such as corn, millet, *etc.*), red meat, poultry, fish/seafood, eggs, soy products, fresh vegetables, preserved vegetables, fresh fruits, and dairy products. The response options were converted to a number of days per week as follows: "never or rarely" (0 day per week), "monthly" (0.5 day per week), "1–3 days per week" (2 days per week), "4–6 days per week" (5 days per week), and "daily"(7 days per week).[25]

2.3 Assessment of PMDs

PMDs were assessed with a modified version of the Calendar of Premenstrual Experiences,[26] which was translated to Chinese after back-translation verification. This questionnaire was successfully implemented in our previous studies in the US and validated with a positive predictive value (PPV) of 80%.[27,28] Participants were asked to rate the severity of 27 premenstrual symptoms during the past year (8 affective symptoms and 19 physical/behavioral symptoms) on a 4-point Likert scale, ranging from none/minimal (0) to severe (3). If the participants had no menstruation at the time of the survey, they were asked to recall their premenstrual symptoms from their most recent menstruations ($N = 9$). Aggregated scores for overall symptoms, affective symptoms, and physical symptoms were computed respectively. The overall severity and impact of the PMD symptoms on the study performance and relationships with family, classmates, and social life activities were similarly evaluated. The criteria for PMDs include (1) the presence of at least one physical/behavioral symptom or one affective symptom; (2) the overall symptom severity categorized as moderate/severe, significant impact on daily activities/relationships categorized as moderate/severe, or the presence of at least two severe affective symptoms; and (3) symptoms occurring within 14 days of the start of menstruation and subsiding within seven days, with absence of symptoms in the week following menstruation.

To shed light on subtypes, PMDs were grouped as PMS or probable PMDD based on the criteria adapted from the Diagnostic and Statistical Manual of Mental Disorders.[29] Individuals were categorized as having a PMDD if they met the following criteria: (1) manifestation of at least one of four severe affective symptoms; (2) the presence of a minimum of six symptom groups out of eleven, including hypersensitivity, desire for aloneness, insomnia, difficulty concentrating, fatigue, food cravings, and other physical symptoms; and (3) experiencing a moderate-to-severe impact on their daily activities and relationships. In addition to symptom severity, PMDs were also categorized by the timing of symptom onset,[27] distinguishing between those that began since menarche and those that started in middle/late adolescence.

2.4 Covariates

Participants provided information on their age and schools at recruitment and lifestyle factors associated with both PMDs and diet, *e.g.*, body mass index (BMI, calculated from self-reported weight and height)[8,30,31] and alcohol consumption (assessed as whether they had consumed alcohol at any point in the past 30 days).[32] Adverse childhood experiences (ACEs) that influence diet and PMDs[33,34] were evaluated using the Adverse Childhood Experiences International Questionnaire (ACE-IQ).[35,36] As the dietary patterns vary across China, information on the place of origin was obtained (classified as North China and South China according to the national policy and geographical location)[37,38] from the Student Affairs Department, School of Medicine. Such information was unavailable for other schools. Depression or anxiety status is highly comorbid with PMDs and was assessed with the Patient Health Questionnaire-9 and General Anxiety Disorder-7, both using a cut-off value of 10 to identify probable cases.[39–43] In addition, participants were surveyed on the regularity and length of menstrual cycles and the use of hormonal contraceptives within the past three months. Covariates were categorized as shown in Table 1.

2.5 Statistical analysis

Descriptive characteristics were compared between groups using ANOVA for continuous covariates and Chi-square tests (or Fisher's exact test if the expected cell count was less than 5) for categorical ones.

Considering the potential synergistic effects of foods and nutrients, principal component analysis (PCA), a data-driven approach for dimensionality reduction, was conducted to identify the underlying patterns among the 12 food groups.[44,45] To determine the number of dimensions to retain, a screen plot was used to identify the elbow point based on the eigenvalues, which represented the variance explained by each principal component.[46] To enhance the interpretability of each dimension, factor loadings were calculated using the correlations between food groups and the derived dimensions in a standardized covariance/correlation matrix, and varimax rotation was applied to emphasize high loadings for specific food groups within each dimension. Differences in food consumption groups across the identified dimensions were visualized by presenting the factor loading of each food group in a radar chart and labeling each pattern with its featured food groups (with factor loadings of at least 0.5) as a proposed dietary pattern.[47] Additionally, considering individual consumption of the corresponding food groups, pattern scores were calculated and presented in two ways (*i.e.*, transformed into z scores to ensure normality and categorized into quintiles [Q1–Q5] to observe potential trends) for each participant to quantify their adherence to each dietary pattern.

Table 1 Characteristics of participants with and without premenstrual disorders (PMDs)

	Participants without PMDs N (%)	Participants with PMDs N (%)	p-Value
Total participants	1045	337	
Mean age in years (SD)	20.0 (1.37)	20.0 (1.53)	0.947
School			0.235
Medicine	866 (82.9)	269 (79.8)	
Other[a]	179 (17.1)	68 (20.2)	
BMI, kg m^{-2}			0.121
<18.5	234 (22.4)	71 (21.1)	
18.5 to <25	745 (71.3)	254 (75.4)	
≥25	66 (6.32)	12 (3.56)	
ACEs			0.006
No	428 (41.0)	109 (32.3)	
Yes	617 (59.0)	228 (67.7)	
Alcohol consumption[b]			0.578
Never	423 (40.5)	130 (38.6)	
Ever	622 (59.5)	207 (61.4)	
Place of origin[c]			0.075
South China	261 (25.0)	91 (27.0)	
North China	477 (45.6)	124 (36.8)	
Depression or anxiety[d]			<0.001
No	944 (90.3)	274 (81.3)	
Yes	101 (9.67)	63 (18.7)	
Regularity of menstrual cycle[e]			0.614
No	214 (20.5)	74 (22.0)	
Yes	831 (79.5)	263 (78.0)	
Length of menstrual cycle			0.238
No menstruation in the past year	6 (0.57)	3 (0.89)	
<26 days	128 (12.2)	38 (11.3)	
26 to <32 days	590 (56.5)	186 (55.2)	
32 to <40 days	195 (18.7)	57 (16.9)	
≥40 days	24 (2.30)	16 (4.75)	
Too irregular to estimate	102 (9.76)	37 (11.0)	
Use of hormonal contraceptives[f]			0.661
No	1009 (96.6)	323 (95.8)	
Yes	36 (3.44)	14 (4.15)	

Abbreviations: adverse childhood experiences (ACEs), body mass index (BMI), and standard deviation (SD). [a] Other biomedical schools include the School of Stomatology, the School of Basic Medical Sciences & Forensic Medicine, the School of Public Health, and the School of Pharmacy. [b] Defined as whether they had consumed alcohol at any point in the past 30 days. [c] Unknown data were excluded at a rate of 31%. [d] Assessed with Patient Health Questionnaire-9 and General Anxiety Disorder-7, both with a cut-off value of 10. [e] A regular menstrual cycle was defined as having a variability within 7 days of the individual's self-estimated cycle length. [f] Defined as any use of hormonal contraceptives within the last three months.

Logistic regression analyses were conducted to examine the associations between the consumption frequency of food groups and PMDs as well as dietary pattern adherence (in quintiles) and PMDs (lowest quintile as the reference group). Three models were established, including a crude model, a partially adjusted model (adjusted for age and school), and a fully adjusted model (additionally adjusted for BMI, ACEs, and alcohol consumption). An additional fully adjusted model, which did not account for BMI groups, was also introduced to mitigate potential inaccuracies arising from self-reported BMI measurements.

Multiple secondary analyses, using the fully adjusted model, focused on the dietary pattern that was significantly associated with PMDs in the primary analysis. To shed light on PMD subtypes, the association with PMD subtypes by severity and timing of onset was also examined using multinomial logistic regression. Furthermore, to examine potential risk modification, there were analyses stratified by depression or anxiety status, school, place of origin (limiting to participants from the School of Medicine whose information on the place of origin was available), BMI, ACEs, and alcohol consumption. To alleviate the concern of potential factors influencing premenstrual symptoms and assessment, we performed a sensitivity analysis by restricting participants to those with regular menstrual cycles of 26–31 days and no use of hormonal contraceptives within the past three months. Moreover, the association between the dietary pattern (in z score) and PMD symptoms was further investigated, including the overall symptoms, affective symptoms, physical/behavioral symptoms, and individual symptoms using linear regression.

We used R (version 4.1.1) for statistical analysis with a two-sided p-value <0.05 set for statistical significance.

3 Results

3.1 Characteristics of the participants

On an average age of 20.0 (SD 1.41) years, 337 (24.4%) participants met the criteria for PMDs, with 307 (22.2%) classified as PMS and 30 (2.17%) as probable PMDD. Compared to participants without PMDs, those with PMDs were more likely to have experienced ACEs and have depression or anxiety. The distribution of schools, BMI groups, alcohol consumption, place of origin, menstrual cycle characteristics, and hormonal contraceptive use were comparable between groups (Table 1).

3.2 Identification of dietary patterns

Three exposure patterns were identified through PCA, which collectively accounted for 46.7% of the data variance (Fig. 1; Table S1 in the ESI†). According to the regional food preference, subgroups were named (1)"Traditional North China Diet (TNCD)" (which accounted for 24.8% of the data variance and was characterized by high consumption of wheat, other staple food, fish/seafood, and preserved vegetables); (2)"Traditional South China Diet (TSCD)" (which accounted for 12.0% of the data variance and was characterized by high consumption of rice, red meat, poultry, and fresh vegetables); and (3)"Lacto-ovo Vegetarian Diet (LVD)" (which accounted for 9.9% of the data variance and was characterized by high consumption of fresh vegetables, fruits, and dairy products).

3.3 Associations between dietary patterns and PMDs

In the analysis of individual food groups, no significant differences were found in the consumption frequency between participants with and without PMDs (Table S2 in the ESI†), except for an inverse association with rice consumption (fully-adjusted OR = 0.93 [0.87–1.00], p-value = 0.048).

When analyzing dietary pattern adherence, an inverse association between TSCD adherence and PMDs was observed (fully-adjusted OR = 0.88 [95% CI 0.78–1.00] per SD, p-value = 0.043, Fig. 2). Such an association appeared to be of the dose–response type when analyzing the adherence in quintiles (P-for-trend = 0.035). No clear associations were found for other dietary patterns (Fig. 2).

3.4 PMD subtypes and symptoms

We focused on TSCD adherence for the following analyses with the above-given findings. It revealed largely comparable associations for PMS and PMDD (OR = 0.87 [0.77–0.99] *vs.* 0.95 [0.66–1.37] per SD, P-for-difference = 0.678) as well as between

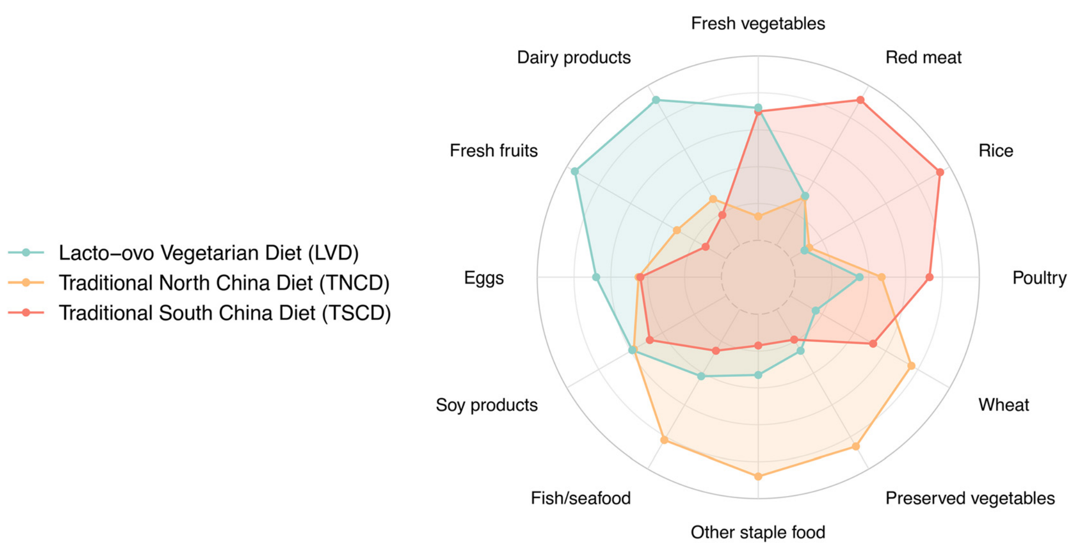

Fig. 1 Factor loading plot of major dietary patterns by principal component analysis with varimax rotation.

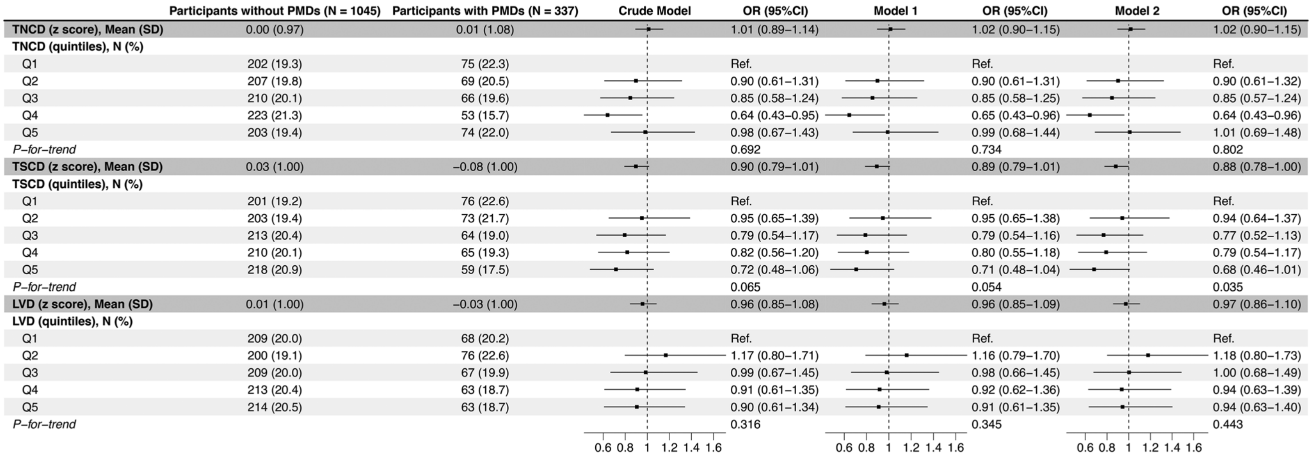

Fig. 2 Associations between dietary pattern adherence and premenstrual disorders (PMDs). Abbreviations: adverse childhood experiences (ACEs), body mass index (BMI), confidence interval (CI), Lacto-ovo Vegetarian Diet (LVD), odds ratio (OR), standard deviation (SD), Traditional North China Diet (TNCD), and Traditional South China Diet (TSCD).(a) Model 1 was adjusted for age and school. (b) Model 2 was additionally adjusted for the BMI group, ACEs, and alcohol consumption. (c) Q1–Q5 represent five quintiles of dietary pattern adherence, with Q5 indicating the highest level of adherence.

PMDs that began since menarche and those that started in middle/late adolescence (OR = 0.93 [0.63–1.36] *vs.* 0.88 [0.77–1.00] per SD, *P*-for-difference = 0.780) (Table 2).

An inverse association was noted for overall premenstrual symptoms (β = −0.11[−0.16 to −0.05] per SD) as well as when dividing into affective (β = −0.08 [−0.13 to −0.02] per SD) and physical/behavioral symptoms (β = −0.12 [−0.17 to −0.06] per SD). When analyzing individual premenstrual symptoms, empirical significance was shown for 5 (62.5%) out of 8 affective symptoms and 16 (84.2%) out of 19 physical/behavioral symptoms (Table S3 in the ESI†).

3.5 Stratified analysis

As shown in Table 3, a comparable association of TSCD adherence with PMDs was found between participants from North and South China (*P*-for-interaction = 0.731). Moreover, an inverse association was noted among individuals without comorbid depression/anxiety, although it was statistically comparable to the association observed in participants with depression/anxiety (*P*-for-interaction = 0.371). In addition, the association was not modified by the school, BMI, and ACEs, except for a more pronounced association observed in participants without alcohol consumption (*P*-for-interaction = 0.036).

3.6 Sensitivity analysis

Out of the initial samples, 762 participants (55.1%) remained after we restricted the group to those with a menstrual cycle duration of 26 to 31 days, a variability of no more than 7 days from the individual's self-estimated cycle length, and no hormonal contraceptive use. The remaining inverse associations between TSCD adherence and PMDs proved robust (fully-adjusted OR = 0.83 [95% CI 0.70–0.98] per SD, *P*-for-trend = 0.028, Table S4 in the ESI†).

Table 2 Associations between Traditional South China Diet (TSCD) adherence and premenstrual disorder (PMD) subtypes

	No. of participants	TSCD *z* score, mean (SD)	Fully adjusted OR[a] (95%CI)
Participants without PMDs	1045	0.03 (1.00)	Ref.
PMDs severity classification			
PMS	307	−0.09 (0.98)	0.87 (0.77–0.99)
PMDD	30	−0.02 (1.15)	0.95 (0.66–1.37)
P-for-difference			0.678
PMD symptoms onset timing			
Since menarche	27	−0.07 (1.07)	0.93 (0.63–1.36)
In middle/late adolescence	310	−0.08 (0.99)	0.88 (0.77–1.00)
P-for-difference			0.780

Abbreviations: confidence interval (CI), odds ratio (OR), and standard deviation (SD). [a] Adjusted for age, school, body mass index group, adverse childhood experiences, and alcohol consumption.

4 Discussion

In a large sample of young women in China, we found that higher adherence to the TSCD, which features high consumption of rice, red meat, poultry, and fresh vegetables, was inversely associated with PMDs in a dose–response manner. Importantly, this relationship remained consistent across PMD subtypes by severity (PMS and PMDD) and onset timing (those that began since menarche and those that commenced in middle/late adolescence). Moreover, this association was not explained by comorbid depression/anxiety symptoms.

To the best of our knowledge, this is the first study reporting a robust inverse association between the TSCD and PMDs. Compared to the TNCD and LVD, the TSCD was characterized by high consumption of rice and animal proteins. The TSCD shared some similarities with the Mediterranean diet in pro-

Table 3 Associations between the Traditional South China Diet (TSCD) adherence and premenstrual disorders (PMDs) with stratification

	No. of participants (%)	TSCD *z* score in participants without PMDs, mean (SD)	TSCD *z* score in participants with PMDs, mean (SD)	Fully adjusted OR[a] (95%CI)
Place of origin[b]				
North China	352 (25.5)	−0.29 (1.10)	−0.42 (1.01)	0.88 (0.70–1.10)
South China	601 (43.5)	0.15 (0.92)	0.10 (1.02)	0.94 (0.76–1.15)
P-for-interaction				0.731
Depression or anxiety				
No	1218 (88.1)	0.04 (1.01)	−0.09 (1.00)	0.86 (0.75–0.99)
Yes	164 (11.9)	−0.07 (0.95)	−0.03 (0.98)	1.05 (0.74–1.49)
P-for-interaction				0.371
School				
Medicine	1135 (82.1)	0.00 (1.01)	−0.11 (1.02)	0.84 (0.64–1.08)
Other[c]	247 (17.9)	0.15 (0.95)	0.01 (0.88)	0.91 (0.79–1.06)
P-for-interaction				0.697
BMI, kg m^{-2}				
<18.5	305 (22.1)	0.05 (0.98)	−0.13 (1.15)	0.84 (0.64–1.08)
18.5 to <25	999 (72.3)	0.03 (1.02)	−0.04 (0.94)	0.91 (0.79–1.06)
≥25	78 (5.64)	0.05 (0.98)	−0.13 (1.15)	0.57 (0.27–1.15)
P-for-interaction				0.342
ACEs				
No	537 (38.9)	0.05 (0.98)	−0.13 (1.15)	0.89 (0.72–1.09)
Yes	845 (61.1)	0.03 (1.02)	−0.04 (0.94)	0.88 (0.75–1.03)
P-for-interaction				0.992
Alcohol consumption				
Never	553 (40.0)	0.12 (0.97)	−0.14 (0.99)	0.75 (0.61–0.92)
Ever	829 (60.0)	−0.03 (1.02)	−0.05 (1.00)	0.98 (0.83–1.14)
P-for-interaction				0.036

Abbreviations: adverse childhood experiences (ACEs), body mass index (BMI), confidence interval (CI), odds ratio (OR), and standard deviation (SD). [a] Adjusted for age, school, BMI group, ACEs, and alcohol consumption. [b] Limiting to participants from the School of Medicine whose information on the place of origin was available. [c] Other biomedical schools include the School of Stomatology, the School of Basic Medical Sciences & Forensic Medicine, the School of Public Health, and the School of Pharmacy.

moting fresh vegetables and moderate intake of animal proteins, which has been shown to be inversely associated with PMS.[17] However, the Mediterranean diet emphasizes minimally processed whole grains and legumes as the staple food, while the TSCD emphasizes rice as a significant source of carbohydrates.[38] Indeed, our data showed that among all individual food items, only rice was inversely associated with PMDs, suggesting that rice consumption may play a role in the observed association between TSCD and PMDs. Due to its contribution to the high glycemic index, rice might enhance brain serotonin neurotransmission, which potentially modulates mood and alleviates emotional and cognitive issues associated with premenstrual symptoms.[48,49] In the context of mood disorders during pregnancy, which may share hormone-related mechanisms with PMDs,[50] studies have suggested a negative association with dietary patterns characterized by a high intake of rice.[51,52] However, conflicting data arise when examining the relationship between rice consumption and mood disorders. For example, some studies indicate that a diet rich in refined rice is positively associated with depression.[53–55] It is worth exploring in the future whether rice might be linked to a decreased risk of mood disorders related to female reproductive hormones.

In addition to rice consumption, the high intake of meat, particularly from livestock and poultry in the TSCD, may contribute to its association with PMDs. A prospective study has shown an inverse relationship between protein intake and PMD risk, which diminished after adjusting for vitamins, iron, zinc, and other covariates. This suggests that the protective effect of a diet rich in protein against PMDs might be attributed to these micronutrients rather than the protein itself.[56] Red meat and poultry are good sources of vitamin D, vitamin B, iron, and zinc,[57,58] which have been associated with lower PMD risks.[15,16,59,60] Furthermore, it is plausible that the consumption of red meat and poultry, which may contain elevated levels of exogenous hormones due to predominant artificial breeding, could lead to increased levels of total and free estradiol while reducing sex hormone-binding globulin levels.[61] These changes could potentially impact menstrual hormonal regulation and subsequently affect PMDs.[62] However, it is important to note that diets featuring high consumption of red meat have shown both inverse and positive associations with PMDs.[19] This inconsistency underscores the need for further research to understand the specific impacts and biological mechanisms of red meat and poultry consumption on premenstrual symptoms, especially considering the influence of key nutrients.

The TSCD showed a comparable inverse association with PMDs across various subtypes, both in terms of severity and the timing of symptom onset. However, the strength of the association was marginally greater in participants diagnosed with PMS as compared to those with PMDD and among those whose symptoms initiated during middle/late adolescence as compared to those with the onset since menarche. PMS is more responsive to dietary influences potentially due to the stronger impact on physical symptoms. Indeed, our findings indicated a stronger inverse association with physical symptoms than with affective symptoms (16 out of 19 *vs.* 5 out of 8). Regarding PMD groups with different onset timings, it is possible that longer exposure to dietary habits could contribute to the stronger association with PMDs that feature late symptom onset.

Our findings raise several possible explanations. First, it is not implausible that individuals who originated from the south, who primarily practice the TSCD, have a lower risk of PMDs due to environment and genetic makeup. However, previous research indicated that the genetic structure of the Han Chinese population does not exhibit significant geographic variations.[63] Moreover, our findings remained consistent after stratifying on the place of origin, suggesting that geographically diverse backgrounds cannot explain the association. Second, the observed association may be explained by depression/anxiety which is highly comorbid with PMDs.[64] However, our study showed a significant association among individuals without depression/anxiety. Third, individuals practicing the TSCD are leaner,[30,65,66] and subsequently their risk of PMDs is lower.[8] Nevertheless, BMI has been thoroughly adjusted in our analysis and cannot explain our findings.

4.1 Strengths and limitations

The major strength of our study is the relatively large sample with a validated tool in the assessment of PMDs. However, our study has several limitations. First, using food groups instead of specific foods provided a comprehensive picture of the data but may have compromised analysis precision, particularly in quantifying specific food consumption or differentiating between similar foods (*e.g.*, whole and refined grains).[67] Second, while the assessment tool for PMDs was validated with a PPV of 80%,[28] we did not confirm PMDs in a prospective manner, which is less feasible in a large cohort. However, the prevalence of PMDs in our cohort aligns with findings from other population-based studies.[3,4] Third, although our study has adjusted for several known confounders, there remains the potential for residual confounding due to uncollected factors (*e.g.*, physical activities)[68,69] and possible misclassification of confounders, such as the use of self-reported weight and height for BMI calculation.[70] Fourth, the participation rate was fairly good in the School of Medicine, while the lower rate in other schools is due to the ongoing data collection. However, we have observed comparable associations between schools. Finally, due to the cross-sectional design, our findings cannot shed light on the temporal relationship between diet and PMDs.

5 Conclusions

The TSCD characterized by a high intake of rice and animal proteins is inversely associated with PMDs. Future studies using quantitative methods assessing dietary patterns and with prospectively collected data are warranted to confirm our findings. If confirmed, our findings may inform health promotion and prevention strategies for PMDs through localized dietary interventions.

Conflicts of interest

All the authors declare no conflict of interest.

Author contributions

Xinyi Shi: conceptualization, methodology, formal analysis, visualization, writing – original draft, and writing – review and editing. Min Chen: data curation and writing – review and editing. Jing Zhou: writing – review and editing. Yuqing Liu: data curation. Tingting Jiang: resources and writing – review and editing. Yifei Lin: writing – review and editing. Jin Huang: writing – review and editing. Xi Shen: writing – review and editing. Donghao Lu: conceptualization, resources, supervision, writing – review and editing, and funding acquisition. Yuchen Li: conceptualization, resources, supervision, writing – review and editing, and funding acquisition.

Acknowledgements

This work was supported by the Natural Science Foundation for the Youth of Sichuan Province (No. 2023NSFSC1487 to Yuchen Li), National Natural Science Foundation of China (No. 81801359 and 82271581 to Donghao Lu), the Swedish Research Council for Health, Working Life and Welfare (FORTE) (No. 2020-00971 to Donghao Lu), Karolinska Institutet Faculty Board Fund (to Donghao Lu), Post-Doctor Research Project, West China Hospital, Sichuan University (No. 2023HXBH058 to Yuchen Li), the Fundamental Research Funds for the Central Universities (No. 2023SCU12059 to Yuchen Li), Swedish Research Council (2020-01003 to Donghao Lu), and the Swedish Research Council for Health, Working Life and Welfare (2023-00399 to Donghao Lu).

References

1 M. S. Hashim, A. A. Obaideen, H. A. Jahrami, H. Radwan, H. J. Hamad, A. A. Owais, L. G. Alardah, S. Qiblawi, N. Al-Yateem and M. A.-I. E. Faris, Premenstrual Syndrome Is Associated with Dietary and Lifestyle Behaviors among University Students: A Cross-Sectional Study from Sharjah, UAE, *Nutrients*, 2019, **11**, E1939.
2 S. H. Hamaideh, S. A. Al-Ashram and H. Al-Modallal, Premenstrual syndrome and premenstrual dysphoric disorder among Jordanian women, *J. Psychiatr. Ment. Health Nurs.*, 2014, **21**, 60–68.
3 K. A. Yonkers and M. K. Simoni, Premenstrual disorders, *Am. J. Obstet. Gynecol.*, 2018, **218**, 68–74.

4 S. Hofmeister and S. Bodden, Premenstrual Syndrome and Premenstrual Dysphoric Disorder, *Am. Fam. Physician*, 2016, **94**, 236–240.
5 A. Ryu and T.-H. Kim, Premenstrual syndrome: A mini review, *Maturitas*, 2015, **82**, 436–440.
6 K. K. Trout and K. L. Teff, Insulin sensitivity and premenstrual syndrome, *Curr. Diabetes Rep.*, 2004, **4**, 273–280.
7 S. Zarei, L. Mosalanejad, M. A. Ghobadifar, S. Zarei, L. Mosalanejad and M. A. Ghobadifar, Blood glucose levels, insulin concentrations, and insulin resistance in healthy women and women with premenstrual syndrome: a comparative study, *Clin. Exp. Reprod. Med.*, 2013, **40**, 76.
8 D. Lu, J. Aleknaviciute, A. M. Kamperman, R. M. Tamimi, J. F. Ludvigsson, U. A. Valdimarsdóttir and E. R. Bertone-Johnson, Association Between Childhood Body Size and Premenstrual Disorders in Young Adulthood, *JAMA Netw. Open*, 2022, **5**, e221256.
9 E. R. Bertone-Johnson, S. E. Hankinson, W. C. Willett, S. R. Johnson and J. E. Manson, Adiposity and the Development of Premenstrual Syndrome, *J. Women's Health*, 2010, **19**, 1955–1962.
10 K. Babakhani, G. Sotoudeh, F. Siassi and M. Qorbani, Comparison of Vegetable Intake in Nurses with and without Premenstrual Syndrome: A Case-Control Study, *Shiraz E Med. J.*, 2019, **21**, e91319.
11 M. Esmaeilpour, S. Ghasemian and M. Alizadeh, Diets enriched with whole grains reduce premenstrual syndrome scores in nurses: an open-label parallel randomised controlled trial, *Br. J. Nutr.*, 2019, **121**, 992–1001.
12 T. Takeda, Y. Imoto, H. Nagasawa, A. Takeshita and M. Shiina, Fish Consumption and Premenstrual Syndrome and Dysphoric Disorder in Japanese Collegiate Athletes, *J. Pediatr. Adolesc. Gynecol.*, 2016, **29**, 386–389.
13 E. R. Bertone-Johnson, P. O. Chocano-Bedoya, S. E. Zagarins, A. E. Micka and A. G. Ronnenberg, Dietary vitamin D intake, 25-hydroxyvitamin D3 levels and premenstrual syndrome in a college-aged population, *J. Steroid Biochem. Mol. Biol.*, 2010, **121**, 434–437.
14 S.-H. Cheng, C.-C. Shih, Y.-K. Yang, K.-T. Chen, Y.-H. Chang and Y.-C. Yang, Factors associated with premenstrual syndrome—A survey of new female university students, *Kaohsiung J. Med. Sci.*, 2013, **29**, 100–105.
15 P. O. Chocano-Bedoya, J. E. Manson, S. E. Hankinson, S. R. Johnson, L. Chasan-Taber, A. G. Ronnenberg, C. Bigelow and E. R. Bertone-Johnson, Intake of selected minerals and risk of premenstrual syndrome, *Am. J. Epidemiol.*, 2013, **177**, 1118–1127.
16 P. O. Chocano-Bedoya, J. E. Manson, S. E. Hankinson, W. C. Willett, S. R. Johnson, L. Chasan-Taber, A. G. Ronnenberg, C. Bigelow and E. R. Bertone-Johnson, Dietary B vitamin intake and incident premenstrual syndrome, *Am. J. Clin. Nutr.*, 2011, **93**, 1080–1086.
17 Y.-J. Kwon, Da.-In Sung and J.-H. Lee, Association among Premenstrual Syndrome, Dietary Patterns, and Adherence to Mediterranean Diet, *Nutrients*, 2022, **14**, E2460.
18 N. Farasati, F. Siassi, F. Koohdani, M. Qorbani, K. Abashzadeh and G. Sotoudeh, Western dietary pattern is related to premenstrual syndrome: a case-control study, *Br. J. Nutr.*, 2015, **114**, 2016–2021.
19 B. MoradiFili, R. Ghiasvand, M. Pourmasoumi, A. Feizi, F. Shahdadian and Z. Shahshahan, Dietary patterns are associated with premenstrual syndrome: evidence from a case-control study, *Public Health Nutr.*, 2020, **23**, 833–842.
20 F. Song and M. Cho, Geography of Food Consumption Patterns between South and North China, *Foods*, 2017, **6**, 34.
21 C. Batis, D. Sotres-Alvarez, P. Gordon-Larsen, M. A. Mendez, L. Adair and B. Popkin, Longitudinal analysis of dietary patterns in Chinese adults from 1991 to 2009, *Br. J. Nutr.*, 2014, **111**, 1441–1451.
22 G. Chen, W. Tan, N. Ran, J. Zhang and B. Yan, Do urban tourists prefer vegetarianism? An urban-rural comparison of vegetarian consumption in China, *Front. Nutr.*, 2022, **9**, 996158.
23 Z. Chen, L. Lee, J. Chen, R. Collins, F. Wu, Y. Guo, P. Linksted and R. Peto, Cohort Profile: The Kadoorie Study of Chronic Disease in China (KSCDC), *Int. J. Epidemiol.*, 2005, **34**, 1243–1249.
24 C. Qin, Y. Guo, P. Pei, H. Du, L. Yang, Y. Chen, X. Shen, Z. Shi, L. Qi, J. Chen, Z. Chen, C. Yu, J. Lv and L. Li, The Relative Validity and Reproducibility of Food Frequency Questionnaires in the China Kadoorie Biobank Study, *Nutrients*, 2022, **14**, 794.
25 W. Yu, L. Pan, W. Cao, J. Lv, Y. Guo, P. Pei, Q. Xia, H. Du, Y. Chen, L. Yang, J. Chen, C. Yu, Z. Chen, L. Li and on behalf of C. K. B. C. Group, Dietary Patterns and Risk of Chronic Obstructive Pulmonary Disease among Chinese Adults: An 11-Year Prospective Study, *Nutrients*, 2022, **14**, E996.
26 J. F. Mortola, L. Girton, L. Beck and S. S. Yen, Diagnosis of premenstrual syndrome by a simple, prospective, and reliable instrument: the calendar of premenstrual experiences, *Obstet. Gynecol.*, 1990, **76**, 302–307.
27 D. Lu, J. Aleknaviciute, R. Bjarnason, R. M. Tamimi, U. A. Valdimarsdóttir and E. R. Bertone-Johnson, Pubertal development and risk of premenstrual disorders in young adulthood, *Hum. Reprod.*, 2021, **36**, 455–464.
28 E. R. Bertone-Johnson, S. E. Hankinson, S. R. Johnson and J. E. Manson, A simple method of assessing premenstrual syndrome in large prospective studies, *J. Reprod. Med.*, 2007, **52**, 779–786.
29 *Diagnostic and statistical manual of mental disorders: DSM-5*, ed. American Psychiatric Association and American Psychiatric Association, American Psychiatric Association, Washington, D.C, 5th edn, 2013.
30 R. Zhao, L. Zhao, X. Gao, F. Yang, Y. Yang, H. Fang, L. Ju, X. Xu, Q. Guo, S. Li, X. Cheng, S. Cai, D. Yu and G. Ding, Geographic Variations in Dietary Patterns and Their Associations with Overweight/Obesity and Hypertension in China: Findings from China Nutrition and Health Surveillance (2015–2017), *Nutrients*, 2022, **14**, 3949.

31 L. Ibáñez and F. de Zegher, Adolescent PCOS: a postpubertal central obesity syndrome, *Trends Mol. Med.*, 2023, **29**, 354–363.
32 M. D. M. Fernández, J. Saulyte, H. M. Inskip and B. Takkouche, Premenstrual syndrome and alcohol consumption: a systematic review and meta-analysis, *BMJ Open*, 2018, **8**, e019490.
33 A. Tan, K. R. Morton, J. W. Lee, R. Hartman and G. Lee, Adverse childhood experiences and depressive symptoms: Protective effects of dietary flavonoids, *J. Psychosom. Res.*, 2020, **131**, 109957.
34 Q. Yang, E. B. Þórðardóttir, A. Hauksdóttir, T. Aspelund, J. Jakobsdóttir, T. Halldorsdottir, G. Tomasson, H. Rúnarsdóttir, H. B. Danielsdottir, E. R. Bertone-Johnson, A. Sjölander, F. Fang, D. Lu and U. A. Valdimarsdóttir, Association between adverse childhood experiences and premenstrual disorders: a cross-sectional analysis of 11,973 women, *BMC Med.*, 2022, **20**, 60.
35 Adverse Childhood Experiences International Questionnaire (ACE-IQ), https://www.who.int/publications/m/item/adverse-childhood-experiences-international-questionnaire-(ace-iq), (accessed 12 November 2022).
36 G. W. K. Ho, A. C. Y. Chan, W.-T. Chien, D. T. Bressington and T. Karatzias, Examining patterns of adversity in Chinese young adults using the Adverse Childhood Experiences—International Questionnaire (ACE-IQ), *Child Abuse Negl.*, 2019, **88**, 179–188.
37 S. Han, D. Sun, B. Jiang, H. Sun, X. Ru, A. Jin, Y. Wang and W. Wang, Prevalence and distribution of lacunar stroke in China: a cross-sectional study using self-reported survey data, *BMJ Open*, 2022, **12**, e063520.
38 J. Wang, X. Lin, Z. T. Bloomgarden and G. Ning, The Jiangnan diet, a healthy diet pattern for Chinese, *J. Diabetes*, 2020, **12**, 365–371.
39 P. Jaholkowski, A. A. Shadrin, A. Jangmo, E. Frei, M. Tesfaye, G. F. L. Hindley, M. Haram, Z. Rahman, L. Athanasiu, N. R. Bakken, B. Holen, V. Fominykh, G. Kutrolli, P. Parekh, N. Parker, L. Rødevand, V. Birkenæs, S. Djurovic, O. Frei, K. S. O'Connell, O. B. Smeland, M. Tesli and O. A. Andreassen, Associations Between Symptoms of Premenstrual Disorders and Polygenic Liability for Major Psychiatric Disorders, *JAMA Psychiatry*, 2023, **80**, 738–742.
40 K. Kroenke, R. L. Spitzer and J. B. Williams, The PHQ-9: validity of a brief depression severity measure, *J. Gen. Intern. Med.*, 2001, **16**, 606–613.
41 W. Wang, Q. Bian, Y. Zhao, X. Li, W. Wang, J. Du, G. Zhang, Q. Zhou and M. Zhao, Reliability and validity of the Chinese version of the Patient Health Questionnaire (PHQ-9) in the general population, *Gen. Hosp. Psychiatry*, 2014, **36**, 539–544.
42 R. L. Spitzer, K. Kroenke, J. B. W. Williams and B. Löwe, A brief measure for assessing generalized anxiety disorder: the GAD-7, *Arch. Intern. Med.*, 2006, **166**, 1092–1097.
43 J. Sun, K. Liang, X. Chi and S. Chen, Psychometric Properties of the Generalized Anxiety Disorder Scale-7 Item (GAD-7) in a Large Sample of Chinese Adolescents, *Healthcare*, 2021, **9**, 1709.
44 K. Murakami, N. Shinozaki, A. Fujiwara, X. Yuan, A. Hashimoto, H. Fujihashi, H.-C. Wang, M. B. E. Livingstone and S. Sasaki, A Systematic Review of Principal Component Analysis–Derived Dietary Patterns in Japanese Adults: Are Major Dietary Patterns Reproducible Within a Country?, *Adv. Nutr.*, 2019, **10**, 237–249.
45 M. G. Thorpe, C. M. Milte, D. Crawford and S. A. McNaughton, A comparison of the dietary patterns derived by principal component analysis and cluster analysis in older Australians, *Int. J. Behav. Nutr. Phys. Act.*, 2016, **13**, 30.
46 H. P. Fransen, A. M. May, M. D. Stricker, J. M. A. Boer, C. Hennig, Y. Rosseel, M. C. Ocké, P. H. M. Peeters and J. W. J. Beulens, A Posteriori Dietary Patterns: How Many Patterns to Retain?, *J. Nutr.*, 2014, **144**, 1274–1282.
47 A. G. Yong and S. Pearce, A Beginner's Guide to Factor Analysis: Focusing on Exploratory Factor Analysis, *Tutor. Quant. Methods Psychol.*, 2013, **9**, 79–94.
48 K. Murakami, S. Sasaki, Y. Takahashi, K. Uenishi, T. Watanabe, T. Kohri, M. Yamasaki, R. Watanabe, K. Baba, K. Shibata, T. Takahashi, H. Hayabuchi, K. Ohki and J. Suzuki, Dietary glycemic index is associated with decreased premenstrual symptoms in young Japanese women, *Nutrition*, 2008, **24**, 554–561.
49 A. J. Rapkin and A. L. Akopians, Pathophysiology of premenstrual syndrome and premenstrual dysphoric disorder, *Menopause Int.*, 2012, **18**, 52–59.
50 S. Cao, M. Jones, L. Tooth and G. Mishra, Does premenstrual syndrome before pregnancy increase the risk of postpartum depression? Findings from the Australian Longitudinal Study on Women's Health, *J. Affect. Disord.*, 2021, **279**, 143–148.
51 A. A. F. Vilela, T. de J. P. Pinto, F. Rebelo, C. Benaim, J. Lepsch, C. H. Dias-Silva, M. B. T. Castro and G. Kac, Association of Prepregnancy Dietary Patterns and Anxiety Symptoms from Midpregnancy to Early Postpartum in a Prospective Cohort of Brazilian Women, *J. Acad. Nutr. Diet.*, 2015, **115**, 1626–1635.
52 Y. Miyake, K. Tanaka, H. Okubo, S. Sasaki, S. Furukawa and M. Arakawa, Dietary patterns and depressive symptoms during pregnancy in Japan: Baseline data from the Kyushu Okinawa Maternal and Child Health Study, *J. Affect. Disord.*, 2018, **225**, 552–558.
53 T. Miki, M. Eguchi, S. Akter, T. Kochi, K. Kuwahara, I. Kashino, H. Hu, I. Kabe, N. Kawakami, A. Nanri and T. Mizoue, Longitudinal adherence to a dietary pattern and risk of depressive symptoms: the Furukawa Nutrition and Health Study, *Nutrition*, 2018, **48**, 48–54.
54 T. Miki, T. Kochi, K. Kuwahara, M. Eguchi, K. Kurotani, H. Tsuruoka, R. Ito, I. Kabe, N. Kawakami, T. Mizoue and A. Nanri, Dietary patterns derived by reduced rank regression (RRR) and depressive symptoms in Japanese employees: The Furukawa nutrition and health study, *Psychiatry Res.*, 2015, **229**, 214–219.

55 S.-J. Park, M.-S. Kim and H.-J. Lee, The association between dietary pattern and depression in middle-aged Korean adults, *Nutr. Res. Pract.*, 2019, **13**, 316.

56 S. C. Houghton, J. E. Manson, B. W. Whitcomb, S. E. Hankinson, L. M. Troy, C. Bigelow and E. R. Bertone-Johnson, Protein intake and the risk of premenstrual syndrome, *Public Health Nutr.*, 2019, **22**, 1762–1769.

57 P. Williams, Nutritional composition of red meat, *Nutr. Diet.*, 2007, **64**, S113–S119.

58 S. Agarwal, K. McCullough and V. Fulgoni, Nutritional Effects of Removing a Serving of Meat or Poultry from Healthy Dietary Patterns—A Dietary Modeling Study, *Nutrients*, 2023, **15**, 1717.

59 A. Arab, S. Golpour-Hamedani and N. Rafie, The Association Between Vitamin D and Premenstrual Syndrome: A Systematic Review and Meta-Analysis of Current Literature, *J. Am. Coll. Nutr.*, 2019, **38**, 648–656.

60 F. Jafari, R. Amani and M. J. Tarrahi, Effect of Zinc Supplementation on Physical and Psychological Symptoms, Biomarkers of Inflammation, Oxidative Stress, and Brain-Derived Neurotrophic Factor in Young Women with Premenstrual Syndrome: a Randomized, Double-Blind, Placebo-Controlled Trial, *Biol. Trace Elem. Res.*, 2020, **194**, 89–95.

61 A. Andersson and N. Skakkebaek, Exposure to exogenous estrogens in food: possible impact on human development and health, *Eur. J. Endocrinol.*, 1999, **140**, 477–485.

62 A. Yamamoto, H. R. Harris, A. F. Vitonis, J. E. Chavarro, S. A. Missmer, A. Yamamoto, H. R. Harris, A. F. Vitonis, J. E. Chavarro and S. A. Missmer, A prospective cohort study of meat and fish consumption and endometriosis risk, *Am. J. Obstet. Gynecol.*, 2018, **219**, 178.e1–178.e10.

63 J. Chen, H. Zheng, J.-X. Bei, L. Sun, W. Jia, T. Li, F. Zhang, M. Seielstad, Y.-X. Zeng, X. Zhang and J. Liu, Genetic Structure of the Han Chinese Population Revealed by Genome-wide SNP Variation, *Am. J. Hum. Genet.*, 2009, **85**, 775–785.

64 D. R. Kim, L. Gyulai, E. W. Freeman, M. F. Morrison, C. Baldassano and B. Dub, Premenstrual dysphoric disorder and psychiatric co-morbidity, *Arch. Womens Ment. Health*, 2004, **7**, 37–47.

65 S. Zhen, Y. Ma, Z. Zhao, X. Yang and D. Wen, Dietary pattern is associated with obesity in Chinese children and adolescents: data from China Health and Nutrition Survey (CHNS), *Nutr. J.*, 2018, **17**, 68.

66 K. Jiang, Z. Zhang, L. A. Fullington, T. T. Huang, C. Kaliszewski, J. Wei, L. Zhao, S. Huang, A. Ellithorpe, S. Wu, X. Jiang and L. Wang, Dietary Patterns and Obesity in Chinese Adults: A Systematic Review and Meta-Analysis, *Nutrients*, 2022, **14**, 4911.

67 Y. Li, D. D. Wang, S. H. Ley, M. Vasanti, A. G. Howard, Y. He and F. B. Hu, Time Trends of Dietary and Lifestyle Factors and Their Potential Impact on Diabetes Burden in China, *Diabetes Care*, 2017, **40**, 1685–1694.

68 Y. Shi, M. Shi, C. Liu, L. Sui, Y. Zhao and X. Fan, Associations with physical activity, sedentary behavior, and premenstrual syndrome among Chinese female college students, *BMC Womens Health*, 2023, **23**, 173.

69 A. R. Kroll-Desrosiers, A. G. Ronnenberg, S. E. Zagarins, S. C. Houghton, B. B. Takashima-Uebelhoer and E. R. Bertone-Johnson, Recreational Physical Activity and Premenstrual Syndrome in Young Adult Women: A Cross-Sectional Study, *PLoS One*, 2017, **12**, e0169728.

70 M. Olfert, M. Barr, C. Charlier, O. Famodu, W. Zhou, A. Mathews, C. Byrd-Bredbenner, S. Colby, M. Olfert, M. Barr, C. Charlier, O. Famodu, W. Zhou, A. Mathews, C. Byrd-Bredbenner and S. Colby, Self-Reported vs. Measured Height, Weight, and BMI in Young Adults, *Int. J. Environ. Res. Public. Health*, 2018, **15**, 2216.