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SYSTEMATIC REVIEW

The relation between body mass index and primary dysmenorrhea: A systematic review and meta-analysis

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Abstract

Introduction: The relation between body mass index (BMI) categories and the occurrence of primary dysmenorrhea has been investigated, but the results of these studies are inconsistent and controversial. The aim of our study was to systematically review the literature and investigate the association between each category of BMI and the occurrence of primary dysmenorrhea.

Material and methods: We conducted a systematic review and meta-analysis of observational studies related to BMI and primary dysmenorrhea. Eleven databases—PubMed, Medline, Embase, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Scopus, Cochrane Library, Web of Science, China National Knowledge Infrastructure (CNKI), Chinese Science and Technology Periodical Database (VIP), Chinese Biomedical Literature Database (CBM), and Wanfang database—were systematically searched from inception to March 2022. We used the 11 items recommended by the Agency for Healthcare Research and Quality to assess the quality of included studies. The Q test and the I^2 test were used to evaluate the heterogeneity among studies. Odds ratios (OR) and their 95% confidence intervals (CI) were pooled by fixed-effects models or random-effects models. Stata software version 16.0 was used to complete the statistical analyses.

Results: A total of 4181 articles were collected from the database, and 12 studies were included based on inclusion and exclusion criteria. A total of 29 647 participants were included in the study, with a mean baseline age of 17–45 years. All included literature was published between 2017 and 2021 and was conducted in six countries. Eleven included studies were of medium quality and one included study was of high quality. Being underweight may be related to the occurrence of primary dysmenorrhea (12 studies, $n = 6545$, OR 1.43, 95% CI 1.18–1.73). Being overweight (12 studies, $n = 3098$) and obesity (four studies, $n = 94$) may not be associated with the development of primary dysmenorrhea.

Conclusions: Being underweight may increase the risk of the occurrence of primary dysmenorrhea, whereas overweight and obesity might not be associated with

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio.

primary dysmenorrhea. Due to the limitations of the meta-analysis, more studies are needed to investigate the relation between each category of BMI and the occurrence of primary dysmenorrhea. To maintain a balanced diet and an appropriate lifestyle is beneficial for people to have the normal category of BMI and live a healthy life, which may play a role in preventing the occurrence of primary dysmenorrhea.

KEYWORDS
body mass index, meta-analysis, primary dysmenorrhea, relationship

1 | INTRODUCTION

Primary dysmenorrhea is defined as periodic abdominal cramps occurring before or during menstruation, in the absence of other organic diseases.[1] The incidence of primary dysmenorrhea is high and shows an increasing trend year by year.[2] Primary dysmenorrhea seriously affects women's daily activities and quality of life. Not only does it cause physical discomfort, such as headache, vomiting, fatigue, and back pain, but also it can negatively affect mental health, thus further aggravating the relevant symptoms, forming a vicious circle.[3–5] Related research has shown that family history of primary dysmenorrhea, menstrual cycle length, dietary habits, and body mass index (BMI) are the related factors in the occurrence of primary dysmenorrhea.[6,7] However, our knowledge of these connections is limited.

Body mass index, an anthropometric assessment measure defined as body weight measured in kilograms divided by the square of height in meters, is a valuable measure of the nutritional status of a person.[8,9] The World Health Organization classifies BMI into four categories: underweight, normal weight, overweight, and obesity.[10] Although the cut-off values of BMI are different in various parts of the world, they are all grouped into the four categories mentioned above. Some studies have revealed that BMI was associated with the occurrence of primary dysmenorrhea.[11–13] Some researchers further pointed out that a lower or higher BMI increases the risk of the occurrence of primary dysmenorrhea,[14] whereas other researchers believe that there was no significant connection between them.[15,16]

Although several studies have explored the relation between BMI and the occurrence of primary dysmenorrhea, these findings are inconsistent and the results are controversial. This meta-analysis aimed to synthesize the association between each category of BMI and the occurrence of primary dysmenorrhea.

Key message

This review suggests that being underweight may increase the risk of the occurrence of primary dysmenorrhea, whereas being overweight and obese may not be associated with the primary dysmenorrhea. More high-quality studies in these areas are needed in the future.

2 | MATERIAL AND METHODS

2.1 | Protocol and registration

This systematic review was conducted following PRISMA recommendations,[17] with registration no. CRD42022324984.

2.2 | Data sources: search strategy and selection criteria

We searched literature published in PubMed, Medline, Embase, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Scopus, Cochrane Library, Web of Science, China National Knowledge Infrastructure (CNKI), Chinese Science and Technology Periodical Database (VIP), Chinese Biomedical Literature Database (CBM), and the Wanfang database from their inception through March 2022, without language restrictions. Meanwhile, we manually retrieved the list of references for each included study to identify other potentially relevant articles. The medical subject words and keywords used in the search were: “BMI”, “body mass index”, “obesity”, “weight”, “dysmenorrhea”, “pain,menstrual”, “primary dysmenorrhea”, “functional dysmenorrhea”, “menorrhalgia”, “menstrual cramps”. Studies were included if (a) the participants were women with primary dysmenorrhea, (b) the studies examined the relation between BMI and primary dysmenorrhea, (c) the designs were population-based observational studies, including cross-sectional studies, case–control studies and cohort studies, and (d) the studies included three or more categories for BMI, because we wished to perform a detailed study of the relation between underweight, overweight, and obese BMI and the occurrence of primary dysmenorrhea. We excluded studies that were reviews, case reports, comments, conference papers, animal experiments, and unpublished studies; duplicate publications (keeping the study with the most information only); and literature with incomplete data. Screening of studies was performed independently by two authors (LW, JT), and disagreements were resolved through discussion (LW, JT, HF).

2.3 | Outcome measure

The primary outcome was the odds ratio (OR) and its 95% confidence interval (CI) indicating the relation between each category of BMI and the occurrence of primary dysmenorrhea.

2.4 | Data extraction and quality assessment

The data extraction was performed by two authors (LW, JZ) independently. Differences of opinion among the reviewers were resolved in extensive discussion (LW, JZ, HF). As a result, consensus was reached on the inclusion of the following information: the name of the first author, publication year, country, study design, study period, sample size, age of women with primary dysmenorrhea, continent, pain measure, BMI categories, and the corresponding OR and their 95% CI. Three authors (LW, JZ, JT) independently used the 11 items recommended by Agency for Healthcare Research and Quality[18] to evaluate the quality of cross-sectional studies. Differences were resolved by careful communication (LW, JZ, JT, HF). All 11 entries were evaluated with "yes", "no", and "unclear" and scored as 1 for "yes" and 0 for "no" or "unclear". The total score, which ranged from 0 to 11, was obtained by adding up the scores of the 11 items. The quality of the articles was assessed as follows: a total score of 0–3 was considered low quality, 4–7 was considered medium quality, and 8–11 was considered high quality.[19]

2.5 | Statistical analyses

The effect sizes of the relation between the categories of BMI and primary dysmenorrhea were expressed as OR with 95% CI. In detail, we used the normal category of BMI in each included study as a reference group (OR 1) and then compared it with underweight (<18.5 kg/m^2), overweight (25–29.9 kg/m^2) and obese (≥30 kg/m^2) BMI, respectively. The heterogeneity among studies was assessed using the Q test and the I^2 test.[20] According to the calculation results, we used a fixed-effects model when heterogeneity was not statistically different ($p > 0.05$ or $I^2 < 50\%$); on the contrast, a random-effects model was used. Then, we performed subgroup analyses of the results with high heterogeneity to detect its sources,[21] with the following prespecified subgroups: continents (Asia, Europe). Begg's tests and Egger's tests were performed to evaluate the risk of bias.[22] The results of all meta-analyses were presented as the relevant OR and 95% CI, I^2 and p values. In this study, all statistical analyses were performed using Stata software version 16.0 (StataCorp).

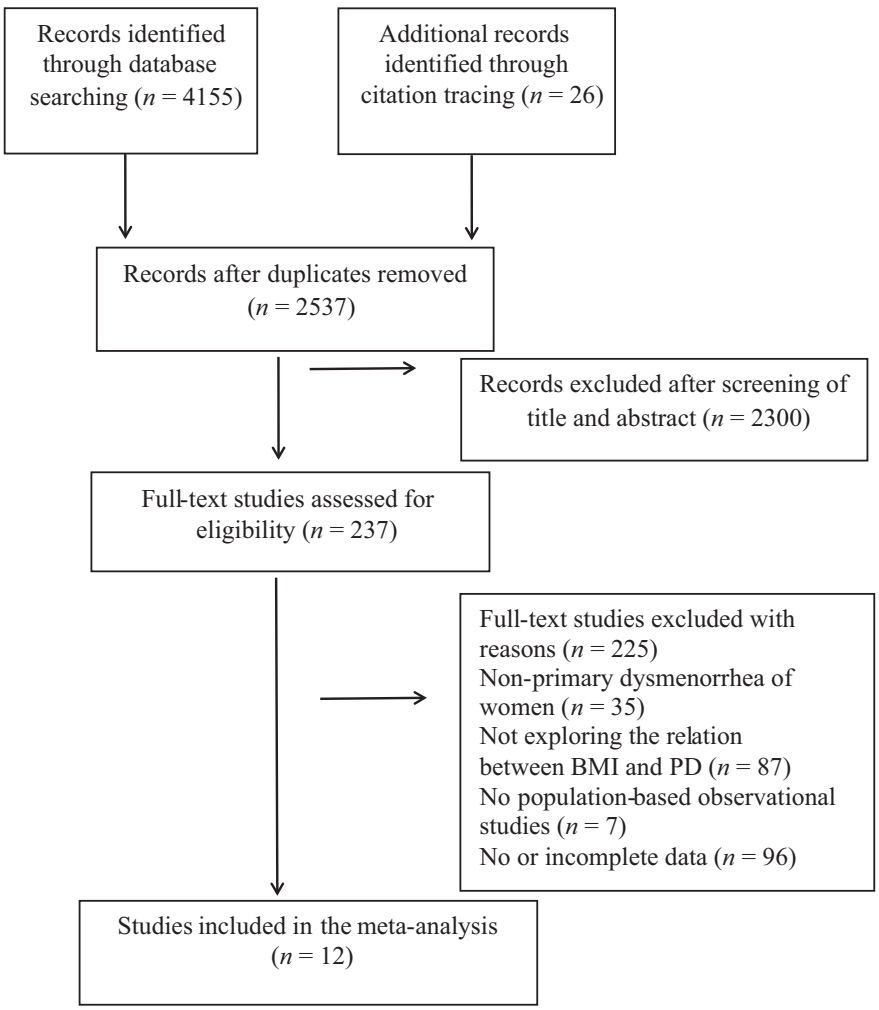

FIGURE 1 Selection process for literature inclusion in the meta-analysis

TABLE 1 Basic information of the included literature

Author/year/country[ref]	Study design	Study period	Sample size (n)/ age (years)/ continent	Pain measure	BMI categories	OR (95% CI)
Wang/2017/China[23]	Cross-sectional	Not reported	4630/17–22/Asia	*Guiding principles for clinical research of new Chinese medicine*	<18.5[a] 18.5–23.9[b] ≥24[c]	1.781 (1.568–2.023) 1 0.683 (0.574–0.813)
Jing/2018/China[24]	Cross-sectional	October–December, 2017	961/17–25/Asia	*Guiding principles for clinical research of new Chinese medicine*	<18.5[a] 18.5–24.9[b] ≥25[c]	1.235 (0.910–1.675) 1 0.777 (0.377–1.603)
Zurawiecka/2018/Poland[25]	Cross-sectional	2015–2016	771/19–25/Europe	The Andersch and Milsom scale	<18.5[a] 18.5–25[b] >25[c]	3.280 (1.760–6.110) 1 2.310 (1.230–4.330)
Rafique/2018/Arabia[26]	Cross-sectional	March, 2016–March, 2017	370/18–25/Asia	The numeric pain relating scale	<18.5[a] 18.5–24.99[b] 25–29.99[c] ≥30[d]	2.401 (1.076–5.358) 1 1.957 (0.961–3.985) 5.335 (1.215–23.416)
Fernández-Martínez/2018/Spain[27]	Cross-sectional	May–June, 2017	258/18–45/Europe	The visual analog scale	<18.5[a] 18.5–24.99[b] ≥25[c]	1.457 (0.565–3.757) 1 0.971 (0.425–2.221)
Wang/2019/China[28]	Cross-sectional	March–July, 2018	1069/18–25/Asia	*Obstetrics and gynecology*	≤18.4[a] 18.5–23.9[b] 24–27.9[c] ≥28[d]	0.786 (0.577–1.072) 1 0.659 (0.357–1.217) 0.844 (0.216–3.293)
Zheng/2020/China[29]	Cross-sectional	Not reported	1200/15.80±2.80/Asia	The visual analog scale	<18.5[a] 18.5–23[b] >23[c]	2.032 (1.496–2.761) 1 1.080 (0.816–1.428)
Jiang/2020/China[30]	Cross-sectional	Not reported	14828/18–45/Asia	*Gynecology of Traditional Chinese Medicine*	<18.5[a] 18.5–23.9[b] ≥24[c]	1.216 (1.073–1.379) 1 1.046 (0.901–1.215)
Hu/2020/China[31]	Cross-sectional	September, 2017–June, 2018	4428/19.00±1.20/Asia	The visual analog scale	<18.5[a] 18.5–24[b] ≥24[c]	1.249 (1.090–1.431) 1 0.965 (0.733–1.272)
Hashim/2020/Arabia[7]	Cross-sectional	September, 2017–May, 2018	336/19–26/Asia	Not reported	<18.5[a] 18.5–24.9[b] 25–29.9[c] ≥30[d]	1.060 (0.450–2.450) 1 1.140 (0.550–2.380) 0.970 (0.340–2.750)
Shellasih/2020/Indonesia[32]	Cross-sectional	July 17–24, 2018	246/not reported/Asia	Not reported	<18.5[a] 18.5–24.9[b] ≥25[c]	0.940 (0.454–1.949) 1 1.011 (0.444–2.304)
Karout/2021/Lebanon[33]	Cross-sectional	April–July, 2019	550/18–30/Asia	The visual analog scale	<18.5[a] 18.5–24.9[b] 25–29.9[c] ≥30[d]	2.013 (0.882–4.594) 1 1.650 (0.835–3.263) 1.445 (0.411–5.077)

Note: [a]underweight; [b]normal weight; [c]overweight; [d]obesity.

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio.

3 | RESULTS

3.1 | General study characteristics

A total of 4181 articles were collected from databases (4155 articles from searched databases and 26 additional articles obtained through citation tracing); 2300 studies were excluded after reading titles and abstracts, followed by reading the full text of 237 studies. Twelve studies were included[7,23–33] in this meta-analysis (Figure 1). Table 1 shows the basic information of the included literature. The 12 included studies were all cross-sectional studies, with a total sample size of 29 647 participants, with a mean baseline age of 17–45 years. All studies were published between 2017 and 2021. The study period ranged from 1 week to 1 year for the included studies, except for three studies[23,29,30] that did not report the study period. All included studies were conducted

TABLE 2 Quality assessment of the included literature

Author/year	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Score	Quality
Wang/2017	√	√	×	×	•	√	√	√	√	√	•	7	Medium
Jing/2018	√	√	√	×	•	√	√	√	√	×	•	7	Medium
Zurawiecka/2018	√	√	√	×	•	√	√	√	√	×	•	7	Medium
Rafique/2018	√	√	√	×	•	√	•	√	√	√	•	7	Medium
Fernández-Martínez /2018	√	√	√	×	•	√	√	√	√	×	•	7	Medium
Wang/2019	√	√	√	×	•	√	•	√	√	√	•	7	Medium
Zheng/2020	√	√	×	×	•	√	•	√	√	√	•	6	Medium
Jiang/2020	√	√	×	×	•	√	•	√	•	√	•	5	Medium
Hu/2020	√	√	√	×	•	√	√	√	√	×	•	7	Medium
Hashim/2020	√	√	√	×	•	√	√	√	√	√	•	8	High
Shellasih/2020	√	√	√	×	•	√	•	√	×	√	•	6	Medium
Karout/2021	√	√	√	×	•	√	•	√	√	√	•	7	Medium

Note: √: yes; ×: no; •: unclear; Item1: Define the source of information (survey, record review); Item 2: List inclusion and exclusion criteria for exposed and unexposed participants (cases and controls) or refer to previous publications; Item 3: Indicate time period used for identifying patients; Item 4: Indicate whether or not participants were consecutive if not population-based; Item 5: Indicate if evaluators of subjective components of study were masked to other aspects of the status of the participants; Item 6: Describe any assessments undertaken for quality assurance purposes (eg, test/retest of primary outcome measurements); Item 7: Explain any patient exclusions from analysis; Item 8: Describe how confounding was assessed and/or controlled; Item 9: If applicable, explain how missing data were handled in the analysis; Item 10: Summarize patient response rates and completeness of data collection; Item 11: Clarify what follow-up, if any, was expected and the percentage of patients for which incomplete data or follow-up was obtained; Medium: 4–7 (score); High: 8–11 (score).

TABLE 3 Results of meta-analysis of the relationship between BMI and primary dysmenorrhea

Category	Number of studies	Effect size		Heterogeneity test		Publication bias	
		OR (95% CI)	*p*	I^2 (%)	*p*	Egger's test	Begg's test
Underweight	12[7,23–33]	1.43 (1.18–1.73)	<0.001	78.9	<0.001	0.771	0.732
Overweight	12[7,23–33]	1.04 (0.85–1.27)	0.709	65.9	0.001	0.230	0.837
Obesity	4[7,26,28,33]	1.41 (0.76–2.64)	0.280	27.7	0.246	0.346	0.308

Abbreviations: BMI, body mass index; CI, confidence interval OR, odds ratio.

in six countries (China, Poland, Arabia, Spain, Indonesia, and Lebanon), and most of the studies[23,24,28–31] were conducted in China. Corresponding countries to their continents, 10 studies[7,23,24,26,28–33] were conducted in Asia, and only two studies[25,27] were conducted in Europe.

Ten included studies[23–31,33]explicitly mentioned the assessment of pain in primary dysmenorrhea, but two studies[7,32] did not specifically report it. A visual analog scale was used in four studies[27,29,31,33] to assess pain, which was simple and easy to use. In addition, two studies[23,24] assessed pain through the appropriate guidelines, two studies[28,30] assessed pain through content in the textbook, and two studies[25,26] used other scales separately. All included studies covered the following three categories of BMI: underweight, normal weight, and overweight; only four studies[7,26,28,33] explicitly included the category of obesity. Although the cut-off values of each category of BMI varied among the included studies, in most studies, the criteria for being underweight was BMI less than 18.5 kg/m^2, normal weight from 18.5 kg/m^2 to 24.9 kg/m^2, overweight from 25 kg/m^2 to 29.9 kg/m^2, and obesity was BMI of 30 kg/m^2 or more. The quality assessment results of the included studies are shown in Table 2. The quality assessment scores of the included studies ranged from 5 to 8; 11 of the studies[23–33] were of medium quality, and one study[7] was of high quality. The results of Begg's test and Egger's test revealed that there was no significant publication bias ($p > 0.05$) in the association between each abnormal category of BMI (underweight, overweight, obesity) and the occurrence of primary dysmenorrhea in the included studies (Table 3).

3.2 | Synthesis: relationships

Table 3 showed the results of the relation between each category of BMI and the occurrence of primary dysmenorrhea. Twelve studies[7,23–33] reported the relation between being underweight and the occurrence of primary dysmenorrhea, involving a total of 6545

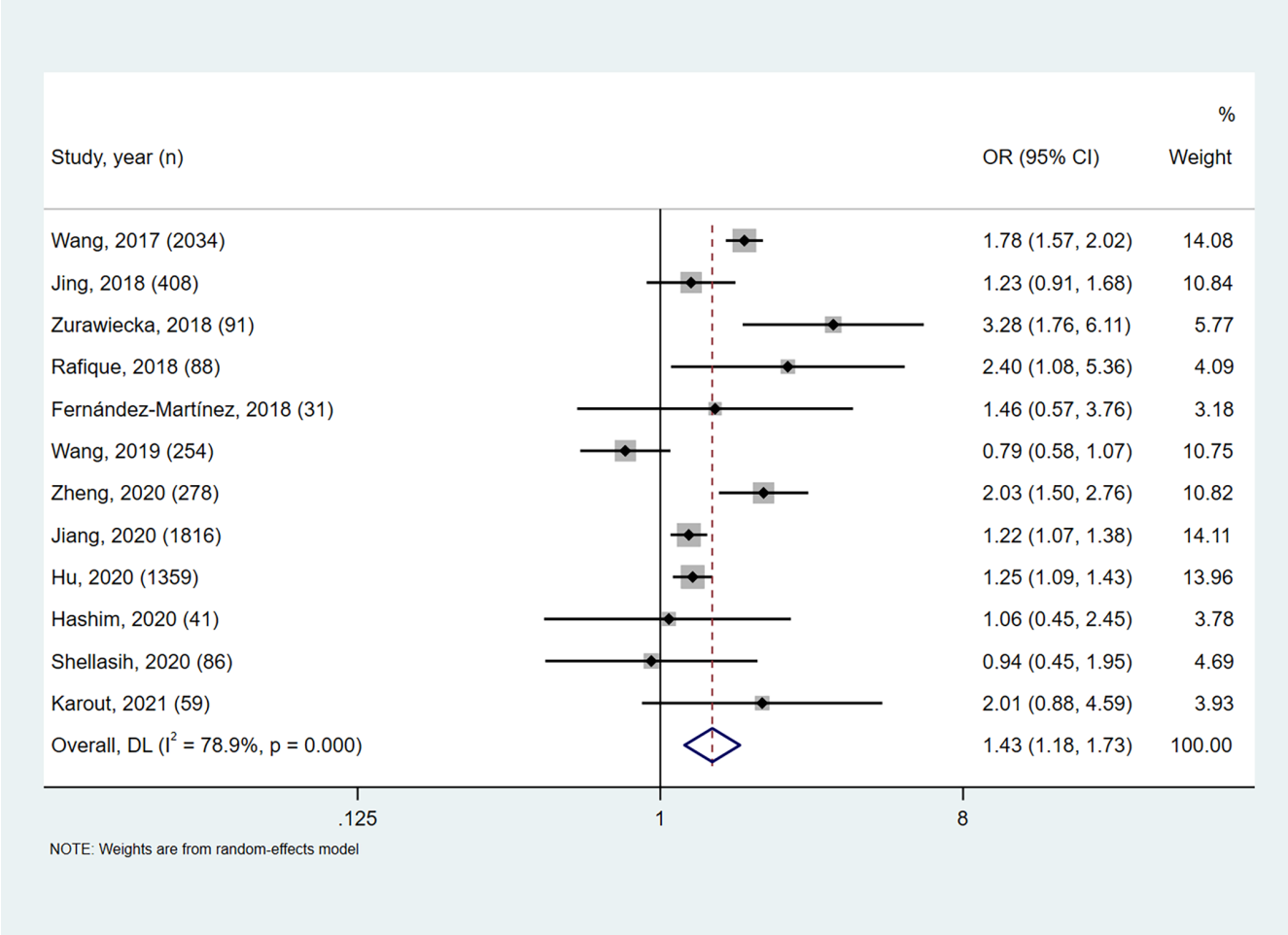

FIGURE 2 Forest plot of the relation between underweight and primary dysmenorrhea

TABLE 4 Results of subgroup analysis of the relation between underweight, and overweight, and primary dysmenorrhea

Subgroups	Number of studies	Effect size		Heterogeneity test	
		OR (95% CI)	*p*	I^2 (%)	*p*
Underweight			<0.001		
Asia	10[7,23,24,26,28–33]	1.35 (1.12–1.64)	0.002	79.9	<0.001
Europe	2[25,27]	2.37 (1.09–5.17)	0.030	49.2	0.161
Overweight			0.709		
Asia	10[7,23,24,26,28–33]	0.89 (0.80–1.19)	0.820	63.0	0.004
Europe	2[25,27]	1.56 (0.67–3.64)	0.300	62.6	0.102

Abbreviations: CI, confidence interval; OR, odds ratio.

underweight women (Figure 2). We used a random-effects model to calculate the OR along with its 95% CI due to the heterogeneity test testified $p < 0.001$ and $I^2 = 78.9\%$. The results (Table 3) suggested that being underweight may be associated with the occurrence of primary dysmenorrhea (OR 1.43; 95% CI 1.18–1.73). In addition, the results of the subgroup analysis (Table 4) indicated that the underweight women in Europe[25,27] (OR 2.37; 95% CI 1.09–5.17) might be more likely to experience primary dysmenorrhea than Asian women[7,23,24,26,28–33] (OR 1.35; 95% CI 1.12–1.64).

There was a regional difference in cut-off value of the overweight category of BMI in the included literature in this study. Eight included studies[23–25,27,29–32] covered only three categories (underweight, normal weight, overweight) of BMI and did not further distinguish between overweight and obesity. In order to explore the association between overweight and the occurrence of primary dysmenorrhea, we ignored the regional difference mentioned above and roughly considered the category of BMI in the above-undifferentiated condition to be overweight. As a result, a total of 12 studies[7,23–33] were

involved and the corresponding participants included in these studies numbered 3098. (Figure 3). Since the heterogeneity test reported $p = 0.001$ and $I^2 = 65.9\%$, a random-effects model was used. The findings (Table 3) suggested that being overweight may not be associated with the occurrence of primary dysmenorrhea. In subgroup analyses (Table 4), we found that overweight European women may not differ from overweight Asian women in their association with the occurrence of primary dysmenorrhea compared with overweight women.

Only four studies[7,26,28,33] explicitly explored the relation between obesity and the occurrence of primary dysmenorrhea, corresponding to a sample size of 94 (Figure 4). The heterogeneity test showed $p = 0.246$ and $I^2 = 27.7\%$, so we used a fixed-effects model and did not perform the relevant subgroup analyses. The results of the meta-analysis (Table 3) indicated that obesity might not be related to the development of primary dysmenorrhea.

4 | DISCUSSION

In this study, we identified the relation between BMI and primary dysmenorrhea by analyzing the relevant included studies. We found that being underweight may increase the risk of developing primary dysmenorrhea. However, overweight and obesity might not be associated with the occurrence of primary dysmenorrhea. In addition, the subgroup analysis showed that underweight European women may be more likely to experience primary dysmenorrhea than underweight Asian women. But there appeared to be no difference between overweight European women compared with overweight Asian women in their relation with the occurrence of primary dysmenorrhea.

There are several previous[10,11,34] studies that support the findings of this study regarding the association between underweight and primary dysmenorrhea. Although the cause of primary dysmenorrhea is still not fully understood, the currently accepted pathogenesis for the occurrence of primary dysmenorrhea is the overproduction of prostaglandins. Once too much prostaglandin is released, the uterus will contract excessively, causing increased pressure and reduced blood flow in the uterus, leading to ischemia and hypoxia, which result in the occurrence of primary dysmenorrhea.[4] Being underweight means that women may have low body fat and suffer from malnutrition. A certain amount of body fat is important for the maintenance of a normal ovulation cycle,[35] but low body fat may interfere with normal ovulation and menstrual cycles, which might lead to excessive prostaglandin release,[11] and so cause

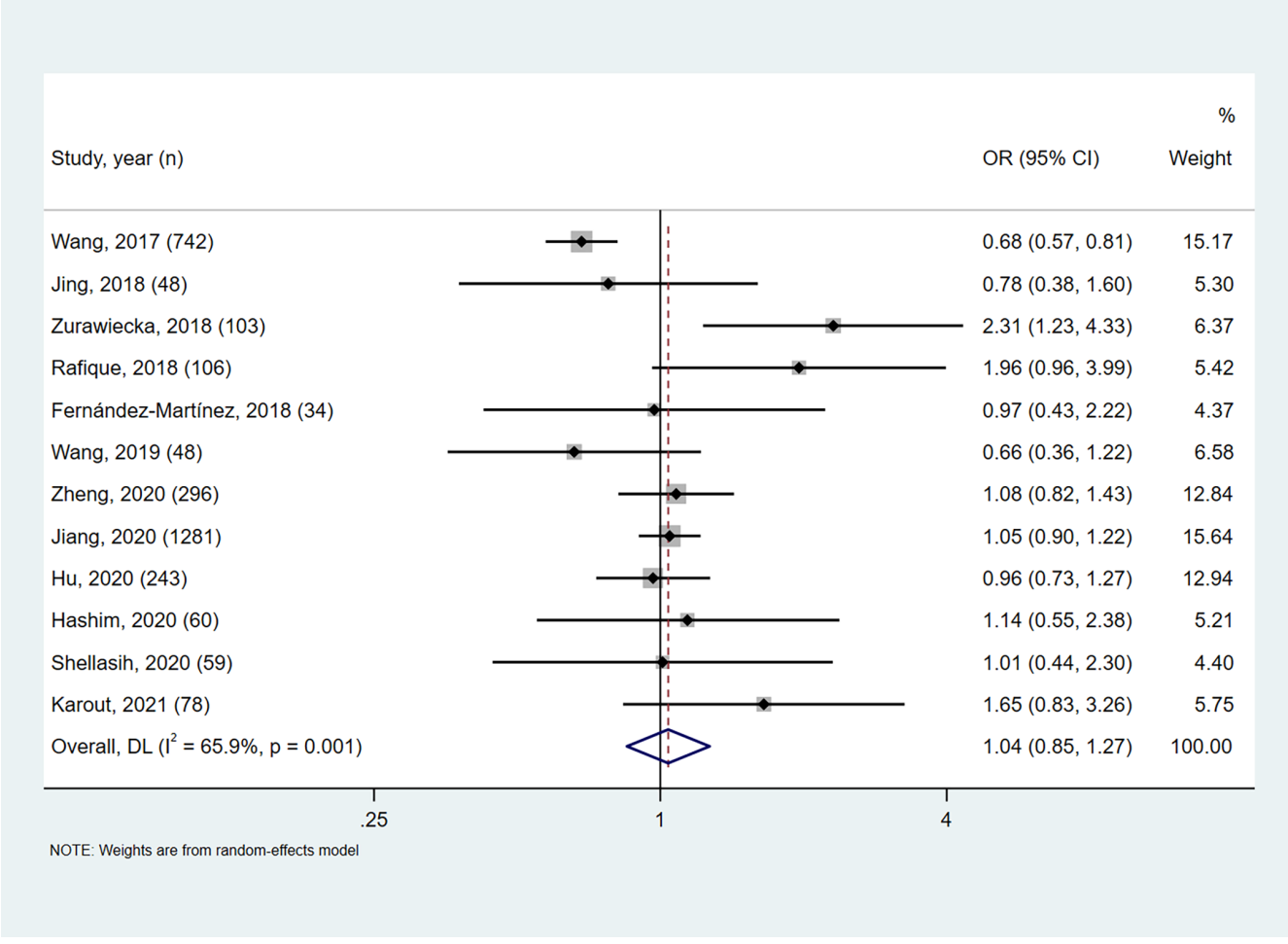

FIGURE 3 Forest plot of the relation between overweight and primary dysmenorrhea

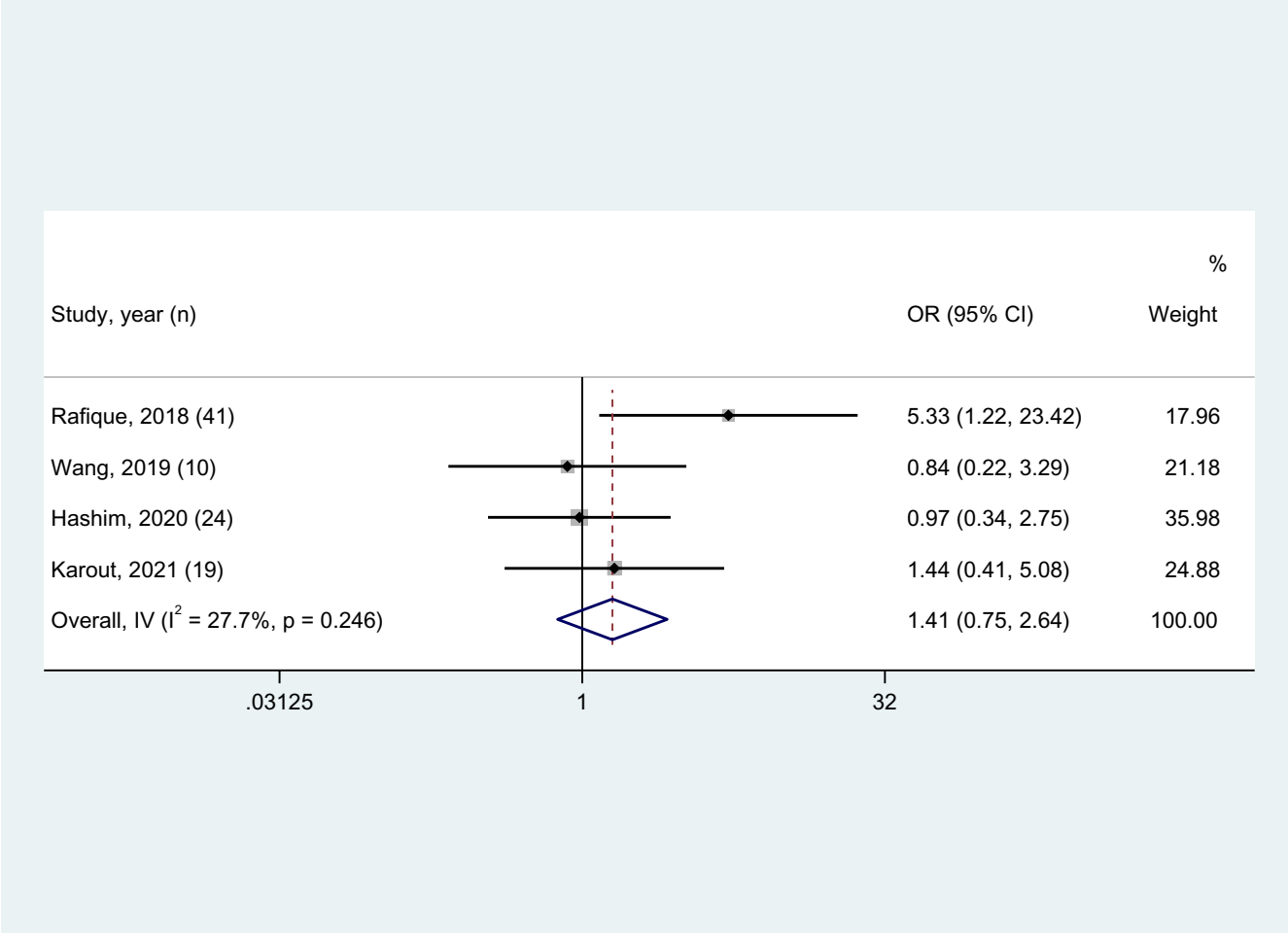

FIGURE 4 Forest plot of the relation between obesity and primary dysmenorrhea

excessive uterine contractions, leading to the occurrence of primary dysmenorrhea. In addition, underweight women produced less estrogen and this may also lead to irregularity in their ovulatory cycles and increase the risk of the occurrence of primary dysmenorrhea.[9,36] Related research showed that malnutrition was a possible factor for the occurrence of primary dysmenorrhea.[37] The above explanation may support the finding that being underweight may increase the risk of the occurrence of primary dysmenorrhea. It has been suggested that Europeans were likely to have a lower amount of body fat than Asians,[38] which might explain why the underweight European women were more likely than Asian women to experience primary dysmenorrhea. Moreover, sociocultural factors and environment in different continents may also be responsible for this result. More studies are needed to provide a more scientific interpretation of the subgroup results mentioned above.

Al-Matouq et al[39] and Nloh et al[40] found that there appeared to be no relation between overweight and the development of primary dysmenorrhea, which is consistent with the results of this meta-analysis. However, Rafique and Al-Sheikh[26] and Elizondo-Montemayor et al[41] found that there was a significant relation between overweight and primary dysmenorrhea in their studies. The contrary results of the studies may be related to factors such as the greatly varied sample size, regional differences, and cultural differences. In addition, the cut-off values for the overweight category of BMI were not consistent among the included studies exploring the relation between overweight and the occurrence of primary dysmenorrhea. And some included studies did not clearly distinguish between overweight and obesity. So it is possible that the overweight category of BMI may have also included obese women. It can be seen that the difference in the cut-off values of overweight may have had a significant effect on the results of this study. Therefore, the World Health Organization classification criteria for BMI should be used whenever possible in future relevant studies, and a distinction should be made between the overweight category and the obese category.

Tembhurne and Mitra[42] and Abadi Bavil et al[43] pointed out that obesity may increase the risk of developing primary dysmenorrhea. Temur et al[44] further believed that obesity may be one of the correctable influencing factors for primary dysmenorrhea. The results of the above studies are not consistent with this study. In our study, only four studies explored the relation between obesity and the occurrence of primary dysmenorrhea, and the sample sizes involved in these studies were small. Moreover, the cut-off values for the obesity of BMI in the included studies were not identical. These factors may have contributed to the inconsistency between the results of

this study and those of other available studies. As far as we know, obesity may increase the production of both prostaglandin and estrogen, which would lead to excessive uterine contraction and abnormal ovulatory cycles.[42,45] So obesity may be associated with the development of primary dysmenorrhea and it was worth noting that the prevalence of obesity among adolescents is increasing globally.[46] If obesity does increase the risk of primary dysmenorrhea to some extent, then the incidence of primary dysmenorrhea in young women will also increase year by year. Based on these findings, it is necessary to conduct more large-sample studies in the future to clarify the relation between obesity and the occurrence of primary dysmenorrhea and we should use cut-off values for the obesity category of the World Health Organization classification criteria.

Several limitations of the current meta-analysis should be described. First, the included studies were all cross-sectional studies and the sample sizes varied considerably between studies, which may produce some bias. We should therefore interpret the relevant results with caution. Second, we ignored the regional difference in the cut-off value of the overweight category of BMI in the included studies and roughly classified the category of BMI that did not further distinguish between overweight and obesity as overweight. This may lead to some deviation in the results. Third, because of the small amount of literature included in this study, only subgroup analyses of continents were ultimately performed, which could also affect the results of the relevant meta-analysis. Fourth, potential confounding factors, such as the family history of primary dysmenorrhea, length of menstrual cycle, and dietary habits, could not be completely excluded. These would probably affect the results. In addition to the above limitations, this study has the following strengths. First, we searched 11 medical databases, supplemented by manual searching to make sure the studies were retrieved completely. Second, we carried out quality control, which was performed by two or three researchers independently in terms of study selection, data extraction, and study quality assessment. Furthermore, we found no publication bias in the included studies by Begg's test and Egger's test and we used subgroup analyses to explore and control the sources of heterogeneity. In addition, we separated the categories of BMI, thus creating an opportunity to explore each category of BMI for its association with the occurrence of primary dysmenorrhea.

5 | CONCLUSION

The meta-analysis suggested that being underweight may increase the risk of the occurrence of primary dysmenorrhea, whereas being overweight and obese may not be associated with the development of primary dysmenorrhea. Furthermore, the underweight women in Europe may be more likely than Asian women to suffer from primary dysmenorrhea. The cut-off values for each category of BMI included in this study were not completely consistent, which may have influenced the results of this study to some extent. This should be avoided in future studies and more high-quality studies with large samples should be conducted to explore the relation between BMI categories and primary dysmenorrhea. Although the relation between each BMI category and the occurrence of primary dysmenorrhea was not fully clarified in this study, maintaining a balanced diet and an appropriate lifestyle is beneficial for people to have the normal category of BMI and live a healthy life, which may play a role in preventing the occurrence of primary dysmenorrhea.

AUTHOR CONTRIBUTIONS

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CONFLICT OF INTEREST

None.

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