Effects of chamomile and L-theanine beverage on menstrual pain, menstrual symptoms, mood, and sleep quality in young women experiencing primary dysmenorrhea: A randomized, double-blind, placebo-controlled study

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Abstract

Primary dysmenorrhea is one of the most common complaints among young women. This study aimed to evaluate the effects of chamomile and L-theanine beverage intake on menstrual symptoms, pain intensity, mood, and sleep quality in young adult females with primary dysmenorrhea, using a two-phase continuous study design. In the first phase, a cross-sectional study was conducted to assess the prevalence of primary dysmenorrhea. In the second phase, participants were randomly assigned to either the intervention group ($n = 15$), which consumed chamomile and L-theanine beverage (CTT), or the control group ($n = 15$), which consumed chamomile-flavored beverage (non-CTT). Beverages were consumed daily for five consecutive days, starting two days before the expected onset of menstruation and continuing through the first three days of menstruation. Compared to baseline values, consumption of CTT significantly reduced ($p < 0.001$) visual analog scale and numerical rating scale values by 57.17% and 55.46%, respectively. Additionally, CTT intake led to significant reductions ($p < 0.05$) in the severity of lower abdominal pain, loss of appetite, backpain, complexation, stomachache, body pain, depression, and irritability by 52.86%, 47.24%, 56.29%, 31.03%, 43.14%, 42.52%, 49.46%, 45.11%, respectively. CTT consumption also significantly decreased ($p < 0.05$) daytime dysfunction by 31.97% compared to baseline. Meanwhile, non-CTT consumption significantly reduced ($p < 0.05$) the severity of complexation, neuroticism, and confusion in the control group. The CTT beverage could be a potential alternative for managing primary dysmenorrhea. Further studies with longer durations are warranted to assess its potential long-term physiological effects.

Keywords: Chamomile, L-theanine, Mood, Primary dysmenorrhea, Sleep

1. Introduction

Dysmenorrhea is characterized by pain during menstruation and is a common menstrual disorder affecting more than 50% of women of reproductive age worldwide [1,2]. It is one of the main contributing factors that disrupt the social activities and quality of life of women [3]. Depending on the presence or absence of pelvic pathology, dysmenorrhea can be classified as either primary or secondary. Primary dysmenorrhea involves painful cramps without any underlying pelvic pathology. In contrast, the painful cramps associated with secondary dysmenorrhea are due to underlying pelvic conditions such as endometriosis, adenomyosis, fibroids, pelvic inflammatory disease, or endometrial polyps.

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For women suffering from primary dysmenorrhea, the pain usually begin 1–2 days before the onset of menstruation or just after the menstrual flow starts, and may persist for up to 3 days [4]. It is one of the most common complaints among adolescent and young adult females [1,5,6]. The onset of primary dysmenorrhea typically occurs 6–24 months after menarche. The pain associated with primary dysmenorrhea follows a clear and cyclic pattern [7]. Globally, about 45–95% of women of reproductive age experience primary dysmenorrhea [4]. This condition can lead to school and work absenteeism, increased use of sedative medications, reduced socialization, and interference with daily living activities [8]. Primary dysmenorrhea can also result in increased pain sensitivity and enhanced inflammatory response associated with tissue damage, which are closely linked to the development of other physical and psychological symptoms such as back pain, headache, irritable, and more [9]. Additionally, women may be more susceptible to pain later in life owning to this heightened pain sensitivity [9].

Primary dysmenorrhea can disturb sleep, especially since pain intensity tends be greatest during the first two days of menstruation, resulting in daytime fatigue [10]. This can lead to reduced sleep efficiency. It has been reported that female adolescents with more severe dysmenorrhea have lower sleep quality scores [11]. Positive correlations have been observed between pain intensity associated with primary dysmenorrhea and several sleep parameters, including subjective sleep quality, daytime dysfunction, sleep latency, and overall sleep quality, among young female adults [10]. In addition, primary dysmenorrhea is often accompanied by mood or behavioral changes. Fluctuations in hormones, particularly estrogen and progesterone, during the menstrual cycle can affect mood regulation through their effects on the brain [12].

The Western medicinal approach to managing and treating dysmenorrhea mainly involves the use of non-steroidal anti-inflammatory drugs (NSAIDs) such as ibuprofen and naproxen. However, prolonged use of NSAIDs can lead to side effects affecting the gastrointestinal tract, liver, kidneys, and may increase cardiovascular risks [13]. Due to concerns about these side effects, many women prefer to use complementary and alternative medicine (CAM) to address reproductive health issues, including dysmenorrhea, infertility, and pregnancy-related problems [2,14].

The use of CAM approaches aimed at improving sleep quality, enhancing mood, and managing the pain and discomfort associated with primary dysmenorrhea are becoming increasingly popular among women. Among these, chamomile (*Matricaria recutita*) is one of the most widely used medicinal plants and has been shown to possess anti-inflammatory and analgesic properties [2]. It has traditionally been used as a calming remedy [15]. A meta-analysis by Kazemi et al. [16] suggested that chamomile may be an effective alternative treatment for sleep quality improvements in various populations.

Meanwhile, L-theanine is a non-protein amino acid found in large quantities in the leaves of tea plants (*Camellia sinensis*). It is a popular ingredient in health supplements aimed at enhancing mood and promoting relaxation [17]. A meta-analysis by Bulman et al. [18] indicated that L-theanine supplementation can improve overall sleep quality and suggested it as a potential alternative treatment for managing sleep disturbances.

Studies on the effects of chamomile and L-theanine on menstrual pain intensity and symptoms, mood index, and sleep quality have been conducted separately [19–21]. However, no research has examined the simultaneous intake of these two substances or their potential synergistic effects. The combination of natural products and ingredients is typically intended to enhance efficacy, but not every combination results in synergism [3]. Therefore, this study aimed to investigate the effects of consuming a beverage containing both chamomile and L-theanine on menstrual symptoms, pain intensity, mood, and sleep quality in young female adults with primary dysmenorrhea.

2. Methodology

2.1. Study design and data collection procedures

This two-phase continuous study consisted of a cross-sectional study in the first phase and a randomized controlled trial in the second phase. Ethical approval for the study was obtained from the UTAR Scientific and Ethical Review Committee (reference number: U/SERC/78-373/2024) and the trial protocol was registered at ClinicalTrial.gov (registration number: NCT07092878). Phase one was a cross-sectional study aimed at determining the prevalence of primary dysmenorrhea among young adult females. The sample size was calculated using a single proportion formula [22], with the prevalence of primary dysmenorrhea set at 73.2% [6], a 95% confidence interval, and a 5% margin of error. The minimum required sample size was 302. However, a total of 467 responses were collected during the data collection period. To recruit

respondents, a QR code linking to an online questionnaire was shared through the social media accounts of both researchers (Ziqing Soh and Soo Cing Tan). The questionnaire included a consent form, sociodemographic questions, a visual analogue scale (VAS), and eligibility screening questions for participation in the second phase of the study. All Malaysian female citizens aged 18–30 years were invited to participate. Individuals who were currently pregnant or breastfeeding were excluded.

Phase two was a double-blind, randomized, placebo-controlled study aimed to evaluate the effects of chamomile and L-theanine (CTT) beverage consumption on menstrual pain intensity and syndromes, hemoglobin levels, sleep quality, and mood index in females with primary dysmenorrhea. Participants in the intervention group consumed the CTT beverage, which contained 480 mg of chamomile extract and 200 mg of L-theanine. In contrast, those in the control group consumed a chamomile-flavored beverage (non-CTT), which was flavored with natural chamomile flavoring. Both beverages were identical in volume (240 mL) and had a similar nutrient composition [energy: 46 kcal; carbohydrates (total sugars): 11.5 g; fat: 0 g; protein: 0 g]. The beverages were manufactured and supplied by Fraser and Neave limited, Singapore.

The sample size for phase two was determined using G*Power software version 3.1.9.7, with an a priori matched paired t-test analysis. The effect size, power, and alpha error were set at 0.80, 0.80, and 0.05, respectively [23]. A sample size of 15 participants per group was required. Fig. 1 shows the overall study protocol. Since the effects of consuming a beverage containing both chamomile and L-theanine on menstrual pain, menstrual symptoms, mood, and sleep quality had not been investigated previously, no data were available to guide the sample size estimation. The data generated from this preliminary study can serve as a reference to determine the effect size and variability of chamomile and L-theanine beverage compared to placebo for use in future sample size calculations.

Data collected during phase one were analyzed, and respondents who met the following criteria were invited to participate in phase two of the study: a VAS score of ≥4 cm for past three consecutive menstrual cycles, regular monthly menstruation, no history of allergies or psychological/gynecological illnesses, absence of secondary

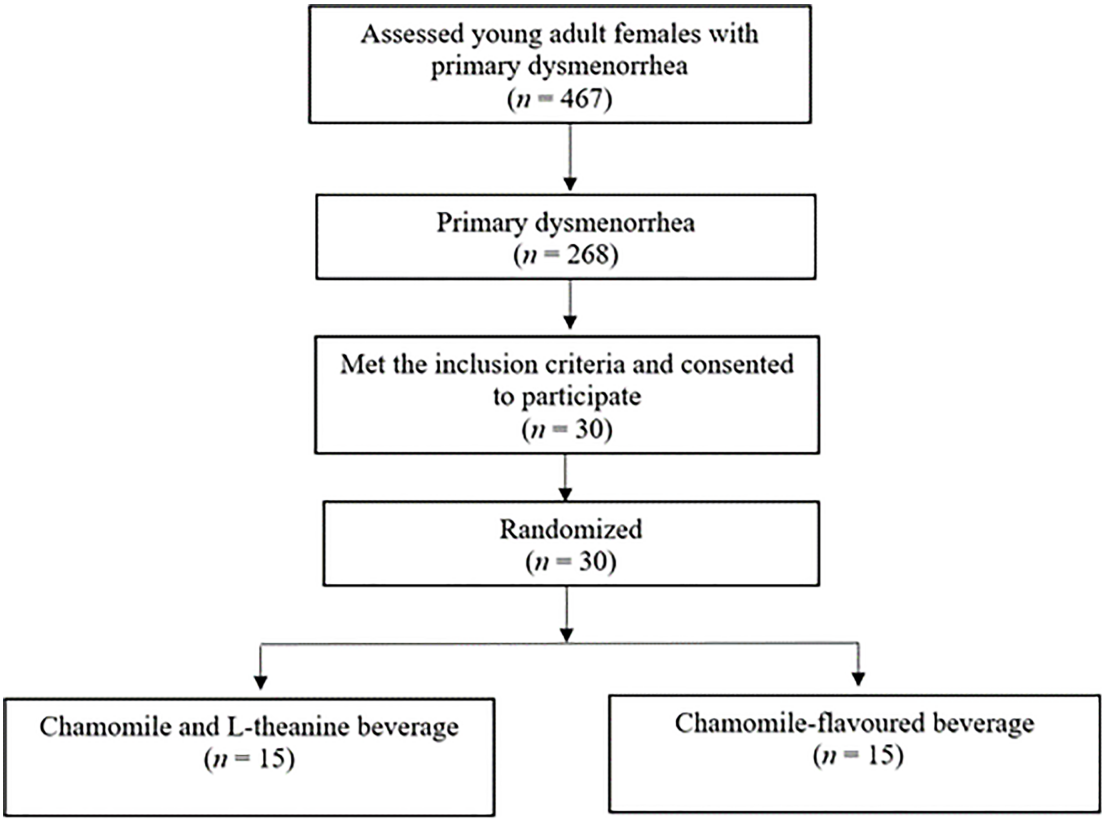

Fig. 1. Flow diagram of the study.

dysmenorrhea, no current use of any medications (including pain relievers), no ongoing non-pharmacological management for dysmenorrhea, and willingness to drink either the CTT or non-CTT beverage. A total of 30 participants who met the aforementioned criteria were recruited and randomly assigned to either the CTT or non-CTT group using computer-generated random numbers from an online research randomizer tool (https://www.randomizer.org/). A postgraduate student who was not involved in the study performed the randomization, pre-packaged the beverages for each participant, and distributed them to both researchers, Ziqing Soh and Soo Cing Tan.

Participants were instructed to consume the assigned beverages for five consecutive days, beginning two days before the expected onset of menstruation and continuing through the first three days of menstruation [3]. Each participant consumed two packs of the beverage per day. One pack was taken in the morning within an hour of waking up, and the other was consumed an hour before bedtime [24]. The timing of beverage intake was based on the rationale that L-theanine can cross the blood–brain barrier within 30 min of ingestion, thereby exerting its effects on mental health regulation and sleep quality enhancement [24,25]. Additionally, the severity of menstrual pain was reported to decrease when 250 mg of chamomile was consumed every 8 h [14,26].

The beverages provided to the CTT and non-CTT groups were identical in appearance, volume, and packaging. All participants and both researchers were blinded to the group allocations throughout phase two of the study. To monitor compliance, all participants were required to record videos of themselves consuming the assigned beverages and submit them daily to the researchers during the intervention period. There were no participant dropouts in either the CTT or the non-CTT groups. Participants received a monetary honorarium after completing the study.

2.2. Instrument

2.2.1. Visual analogue scale

The VAS consisted of a 10-cm horizontal line anchored by descriptors at each end [23]. One end was labeled “no pain” (0 cm), and the other was labeled “worst possible pain” (10 cm). Participants were required to mark the point on the line that best represented the average intensity of their menstrual pain. Higher VAS scores indicate more severe menstrual pain.

2.2.2. Numeric rating scale (NRS)

The NRS consisted of an 11-point scale ranging from 0 to 10, where 0 represented no pain, 1–3 indicated mild pain, 4–6 indicated moderate pain, and 7–10 indicated severe pain [13]. Participants were required to mark the point on the scale that best represented the average intensity of their menstrual pain. Higher NRS scores indicated more severe menstrual pain.

2.2.3. Hemoglobin

Hemoglobin levels were measured using the finger prick method with a hemoglobin device (Mission® ultra, ACON Lab, USA). The fingertip of the participant was cleaned with an alcohol swab and punctured using a single-use lancet (On Call, ACON Lab, USA). The hemoglobin test strip (Mission ultra®, ACON Lab, USA) was inserted into the device. After wiping away the first drop of blood, the tip of the test strip was placed in contact with the second drop of the blood. The hemoglobin value (mmol/L) displayed on the screen of the hemoglobin device was recorded.

2.2.4. Cox menstrual symptom scale (CMSS)

The 18-item CMSS, as described by Xue et al. [13], were used to assess the severity of menstrual-related symptoms experienced by participants during their most recent menstrual cycle. Each item in the CMSS was rated on a scale from 0 (not noticeable) to 4 (very severely bothersome).

2.2.5. Pittsburgh sleep quality index (PSQI)

The PSQI, as described by Beck et al. [27], was used to assess the sleep quality of participants during the past week. This scale consists of 19 items distributed in seven components. The total PSQI score ranges from 0 to 21, with higher scores indicating poorer sleep quality. A total score of 0–4 reflects good sleep quality, while a score of 5 or above indicates poor sleep quality [28].

2.2.6. Profile of mood states (POMS)

The 37-item POMS was used to assess six mood subscales (vigor, tension, depression, anger, fatigue, and confusion) of participants during the past week [29]. Each item was rated on a 5-point Likert scale, ranging from 0 for not at all, 1 for a little, 2 for moderately, 3 for quite a lot, and 4 for extremely. Higher scores on the vigor subscale indicate a better mood, while lower scores on the other subscales also reflect a more positive mood state [30,31].

2.3. Statistical analysis

Statistical Package for the Social Sciences (SPSS) version 26 was used to analyze the data. Sociodemographic differences between the CTT and non-CTT groups were examined using an independent t-test for continuous variables and Fisher's exact test for categorical variables. A paired-samples t-test was conducted to assess differences before and after CTT or non-CTT consumption. Percentage change was calculated using the formula: [(reading after beverage consumption - reading before beverage consumption) / reading before beverage consumption] × 100. The baseline differences between CTT and non-CTT groups, as shown in Supplementary Tables S1–S4 (https://doi.org/10.38212/2224-6614.3565), were examined using an independent t-test. A p-value of less than 0.05 was considered statistically significant.

3. Results

3.1. Prevalence of primary dysmenorrhea

Fig. 2 illustrates the prevalence of primary dysmenorrhea among young adult females in phase one of the cross-sectional study. Of the 467 respondents, 268 (57.39%) reported experiencing primary dysmenorrhea, while 199 (42.61%) did not.

3.2. Sociodemographic profile

Table 1 shows the sociodemographic profile of the participants in phase two of the double-blind, randomized, placebo-controlled study. The current age, age at menarche, age of first menstrual cramp, ethnicity, relationship status, and duration of menstrual cramps were similar ($p > 0.05$) between the CTT and non-CTT groups.

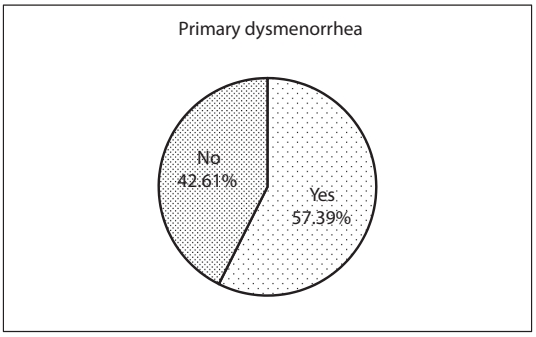

Fig. 2. Prevalence of primary dysmenorrhea among young adult females.

3.3. Menstrual pain intensity and hemoglobin levels

Table 2 shows the changes in menstrual pain intensity and hemoglobin levels before and after the consumption of CTT and non-CTT. Compared to the baseline values, the intake of CTT significantly reduced ($p < 0.001$) VAS and NRS values by 57.17% and 55.46%, respectively.

3.4. Menstrual pain symptoms

The changes in the severity of menstrual pain symptoms before and after the consumption of CTT and non-CTT are shown in Table 3. Compared to baseline values, the intake of CTT significantly reduced ($p < 0.05$) the severity of lower abdominal pain, loss of appetite, backpain, complexation, stomachache, body pain, depression, and irritability by 52.86%, 47.24%, 56.29%, 31.03%, 43.14%, 42.52%, 49.46%, 45.11%, respectively. In addition, the intake of non-CTT significantly reduced ($p < 0.05$) the severity of complexation and neuroticism by 64.52% and 72.50%, respectively, compared to baseline values.

3.5. Mood index

The changes in the mood index before and after the consumption of CTT and non-CTT are presented in Table 4. Compared to baseline values, the intake of CTT significantly reduced ($p < 0.05$) the depression by 12.19% and significantly increased ($p < 0.05$) vigor by 62.35%. Besides, the intake of

Table 1. Sociodemographic properties of the participants.

Variable	Group		p-value[a]
	CTT ($n = 15$)	Non-CTT ($n = 15$)	
Current age	20.33 ± 1.88	19.47 ± 1.19	0.144
Age at menarche	12.40 ± 1.35	12.07 ± 0.80	0.420
Age of first menstrual cramp	14.93 ± 2.78	14.47 ± 2.45	0.630
Ethnicity			1.000
Chinese	14 (93.3%)	14 (93.3%)	
Non-Chinese	1 (6.7%)	1 (6.7%)	
Relationship status			1.000
Single	7 (46.7%)	8 (53.3%)	
In a relationship	8 (53.3%)	7 (46.7%)	
Duration of menstrual cramp			1.000
1–2 days	10 (66.7%)	10 (66.7%)	
≥ 3 days	5 (33.3%)	5 (33.3%)	

[a] The p-value for continuous data was generated using the student's unpaired t-test, whereas the p-value for categorical data was generated using Fisher's exact test. A p-value <0.05 indicates a significant difference.

Table 2. Changes in menstrual pain intensity and hemoglobin before and after the consumption of CTT and non-CTT.

Variable	CTT		*t* (*p*-value)	Non-CTT		*t* (*p*-value)
	Before	After		Before	After	
Visual analogue scale (cm)	6.07 ± 1.79	2.60 ± 0.91	6.985 (<0.001)	5.47 ± 1.69	4.60 ± 2.29	2.162 (0.050)
Numeric rating scale	6.13 ± 1.81	2.73 ± 1.10	7.462 (<0.001)	5.27 ± 1.98	4.93 ± 2.37	0.863 (0.403)
Hemoglobin (mmol/L)	8.25 ± 0.91	8.08 ± 0.62	0.966 (0.350)	7.81 ± 0.54	8.14 ± 0.68	−1.413 (0.179)

A *p*-value <0.05 indicates a significant difference.

Table 3. Changes in the severity of menstrual pain symptoms before and after the consumption of CTT and non-CTT.

Symptom	CTT		*t* (*p*-value)	Non-CTT		*t* (*p*-value)
	Before	After		Before	After	
Lower abdominal pain	2.27 ± 0.80	1.07 ± 0.59	6.000 (<0.001)	2.00 ± 0.93	1.93 ± 1.10	0.250 (0.806)
Nausea	0.93 ± 1.22	0.40 ± 0.74	1.586 (0.135)	0.27 ± 0.59	0.40 ± 0.63	−0.807 (0.433)
Vomit	0.27 ± 0.80	0.07 ± 0.26	1.000 (0.334)	0.00 ± 0.00	0.07 ± 0.26	−1.000 (0.344)
Loss of appetite	1.27 ± 0.70	0.67 ± 0.62	4.583 (<0.001)	0.80 ± 0.86	0.27 ± 0.46	1.948 (0.072)
Headache	1.00 ± 1.20	0.53 ± 0.64	1.825 (0.089)	0.87 ± 1.13	0.67 ± 0.82	1.146 (0.271)
Backpain	1.67 ± 1.23	0.73 ± 0.80	3.761 (0.002)	1.67 ± 0.90	1.20 ± 0.68	1.522 (0.150)
Leg pain	0.80 ± 1.15	0.40 ± 0.74	1.382 (0.189)	0.33 ± 0.62	0.20 ± 0.56	0.695 (0.499)
Fatigue	1.93 ± 0.80	1.53 ± 0.64	2.103 (0.054)	1.47 ± 0.74	1.47 ± 0.83	0.000 (1.000)
Dizziness	0.67 ± 1.11	0.33 ± 0.62	1.324 (0.238)	0.53 ± 0.92	0.33 ± 0.90	0.823 (0.424)
Diarrhea	0.73 ± 0.70	0.47 ± 0.74	1.293 (0.217)	0.87 ± 0.83	0.47 ± 0.83	1.193 (0.253)
Complexation	0.87 ± 0.83	0.60 ± 0.74	2.256 (0.041)	0.93 ± 0.80	0.33 ± 0.62	3.154 (0.007)
Stomachache	1.53 ± 0.99	0.87 ± 0.64	2.646 (0.019)	1.67 ± 1.35	0.93 ± 1.10	1.911 (0.077)
Blushing	0.20 ± 0.41	0.13 ± 0.35	1.000 (0.334)	0.00 ± 0.00	0.07 ± 0.26	−1.000 (0.334)
Insomnia	0.60 ± 0.91	0.60 ± 0.91	0.000 (1.000)	0.73 ± 1.10	0.33 ± 1.05	0.945 (0.361)
Body pain	1.27 ± 0.88	0.73 ± 0.96	2.477 (0.027)	0.60 ± 0.83	0.40 ± 0.51	1.146 (0.271)
Depression	0.93 ± 0.59	0.47 ± 0.64	2.432 (0.029)	0.80 ± 0.86	0.47 ± 0.74	1.784 (0.096)
Irritable	1.33 ± 0.90	0.73 ± 0.80	2.553 (0.023)	1.07 ± 0.80	0.53 ± 0.74	1.948 (0.072)
Neuroticism	1.27 ± 0.80	0.73 ± 0.70	1.948 (0.072)	1.20 ± 1.21	0.33 ± 0.62	2.578 (0.022)

A *p*-value <0.05 indicates a significant difference.

Table 4. Changes in the mood index before and after the consumption of CTT and non-CTT.

Mood	CTT		*t* (*p*-value)	Non-CTT		*t* (*p*-value)
	Before	After		Before	After	
Tension	6.20 ± 3.67	6.00 ± 4.69	0.203 (0.842)	7.40 ± 3.88	5.40 ± 4.27	1.833 (0.088)
Depression	6.07 ± 5.52	5.33 ± 5.07	3.229 (0.006)	2.93 ± 2.92	2.67 ± 3.56	1.852 (0.085)
Anger	5.73 ± 4.33	4.33 ± 4.11	1.755 (0.101)	4.67 ± 4.19	2.60 ± 2.77	1.627 (0.126)
Fatigue	6.06 ± 3.17	6.20 ± 4.59	−0.147 (0.886)	5.00 ± 3.38	3.87 ± 2.17	1.205 (0.248)
Confusion	4.73 ± 2.32	4.07 ± 3.41	0.721 (0.483)	5.20 ± 3.93	2.47 ± 2.72	2.653 (0.019)
Vigor	5.87 ± 3.25	9.53 ± 5.22	−2.275 (0.039)	9.20 ± 4.51	11.47 ± 3.73	−1.489 (0.159)

A *p*-value <0.05 indicates a significant difference.

non-CTT significantly reduced ($p < 0.05$) confusion by 52.50% compared to baseline value.

3.6. Sleep quality

Table 5 presents sleep quality before and after the intake of CTT and non-CTT. The intake of CTT significantly reduced ($p < 0.05$) daytime dysfunction by 31.97% compared to the baseline value.

4. Discussion

Phase one of the study aimed to determine the prevalence of primary dysmenorrhea among young adult females aged 18–30 years old. The VAS is a validated and widely adopted instrument for assessing menstrual pain intensity [32]. Primary dysmenorrhea refers to painful menstruation that is not caused by any underlying gynecological condition or macroscopic pelvic pathology and is characterized by a VAS score of ≥4 over the last three consecutive menstruations [1,5,28]. Using a self-reported VAS, our study found that the prevalence of primary dysmenorrhea among young adult females in Malaysia was 57.39%. This value is comparable to that reported by Yahaya et al. [33], who found a prevalence of 60.5% among Malaysian females aged 18–35 years attending health clinics. However, Bakro et al. [6] reported a higher prevalence of 73.2% among females aged 18–25 years living in urban areas of Malaysia. In contrast to Bakro et al. [6], our study included the respondents

Table 5. Changes in the sleep quality before and after the consumption of CTT and non-CTT.

Variable	CTT		*t* (*p*-value)	Non-CTT		*t* (*p*-value)
	Before	After		Before	After	
Total PSQI score	6.60 ± 2.92	6.00 ± 1.65	1.126 (0.279)	5.40 ± 2.06	5.27 ± 1.91	0.254 (0.803)
Total sleeping hours	7.20 ± 1.70	6.70 ± 1.10	1.153 (0.268)	6.50 ± 1.66	6.40 ± 1.11	0.236 (0.817)
Sleep quality	1.13 ± 0.64	0.93 ± 0.59	1.000 (0.334)	0.87 ± 0.63	0.67 ± 0.62	1.382 (0.189)
Sleep latency	1.33 ± 1.05	0.73 ± 0.70	2.073 (0.057)	1.13 ± 1.19	1.00 ± 1.00	0.807 (0.433)
Sleep duration	1.00 ± 0.76	1.20 ± 0.86	−0.899 (0.384)	1.07 ± 0.88	1.33 ± 0.89	−1.169 (0.262)
Habitual sleep efficiency	0.67 ± 1.05	0.87 ± 0.99	−0.899 (0.384)	0.22 ± 0.56	0.40 ± 0.83	−1.871 (0.082)
Sleep disturbances	1.00 ± 0.65	1.07 ± 0.46	−0.564 (0.582)	0.87 ± 0.64	1.00 ± 0.00	−0.807 (0.433)
Daytime dysfunction	1.47 ± 0.52	1.00 ± 0.65	2.824 (0.014)	1.13 ± 0.74	0.87 ± 0.52	1.293 (0.217)

A p-value <0.05 indicates a significant difference.

up to the age of 30 years. Pain intensity associated with primary dysmenorrhea decreased as age increased [8].

In the phase two of this study, 30 subjects with self-reported primary dysmenorrhea were invited to participate in an intervention study aimed to assess the effects of CTT consumption on the menstrual pain intensity, menstrual pain symptoms, sleep quality, and mood index. Chamomile flavored beverage served as the control of the study. A dose-response relationship between the frequency of soft drink intake and the severity of primary dysmenorrhea has been reported [34]. This suggests a potential link between sugary beverage consumption and menstrual pain. The sugar content in both CTT and non-CTT beverages was 4.8 g per 100 mL, which is lower than that of soft drinks, which typically contain 10 g or more per 100 mL [34]. Females with excessive sugar intake had a 1.77-fold higher risk of dysmenorrhea compared to those with minimal sugar intake [35]. Since the sugar content of the beverages used in this study is lower than that of soft drinks, their consumption may be a better alternative for females experiencing primary dysmenorrhea.

An earlier study indicated that VAS and NRS demonstrated high degree of correlation and were reliable scales to assess menstrual pain [36]. Hence, both scales were utilized in our study to enhance the accuracy of menstrual pain intensity assessment. Previous studies found that consuming chamomile capsules at dosages of 250–400 mg every 6–8 h during the first 3 days of menstruation reduced pain intensity as measured by the VAS [14,19]. Our study showed that consuming two packs of 240 mL CTT beverage per day, with one pack in the morning and another pack before bedtime, for five consecutive days (starting two days before the expected onset of menstruation and continuing through the first three days of menstruation), reduced the pain intensity as measured by both the VAS and NRS. The consumption of non-CTT demonstrated no changes in the VAS and NRS values. A systematic review by Niazi and Moradi [2] indicated that oral consumption of chamomile was more effective for pain relief than NSAIDs. Meanwhile, Shabani and Zareian [3] reported that a combination of chamomile and ginger was less effective than chamomile alone in managing pain associated with dysmenorrhea. Chamomile has been used for centuries as an analgesic remedy to relieve various types of pain. Apigenin, which accounts for more than 50% of the total flavonoid content in chamomile [37], can bind to gamma-aminobutyric acid (GABA) receptors [38], thereby contributing to reduced pain perception. Further study is recommended to quantify the bioactive compounds present in the CTT beverage.

Females with lower hemoglobin levels experienced a higher intensity of primary dysmenorrhea pain [39]. This is because hypoxia in the uterine tissue increases prostaglandin production, thereby causing stronger and more painful contraction of the uterine muscles. Anemia is a health condition characterized by deficiency in hemoglobin, defined as levels below 7.4 mmol/L (12 g/dl) in non-pregnant females [40]. Chamomile infusion has traditionally been used to treat anemia [41], however, the effect of chamomile consumption on hemoglobin levels remains inconclusive. Our study showed that consumption of the CTT beverage did not affect the hemoglobin levels of young female adults.

Primary dysmenorrhea is associated with physical and psychological symptoms. The physical symptoms could be gastrointestinal, systemic, and elimination-related [7]. Meanwhile, regarding the psychological symptoms, females with primary dysmenorrhea may experience mood disturbances [7]. An earlier study indicated that the consumption of a combination of medicinal herbs consisted of chamomile, ginger, and fennel relieved symptoms of primary dysmenorrhea among female students [42]. In the present study, the consumption of CTT

was found to reduce the severity of physical symptoms (lower abdominal pain, loss of appetite, backpain, complexation, stomachache, and body pain) and emotional symptoms (depression, and irritable). Using the POMS scale, intake of the CTT beverage was found to reduce depression and increase vigor among the female participants.

Chamomile is widely recognized for its anti-prostaglandin properties due to its ability to inhibit cyclooxygenase and reduce or eventually stop prostaglandin synthesis [43]. Prostaglandins play a central role in uterine contractions and systemic inflammation during menstruation. These compounds are key mediators of pain, and their overproduction is associated with primary dysmenorrhea. Reducing prostaglandin production can alleviate physical symptoms such as lower abdominal pain, back pain, and general body aches. Although the exact mechanism is still unknown, it has been hypothesized that the flavonoid constituents of chamomile may modulate serotonin, dopamine, central noradrenalin, GABA neurotransmission, thereby exerting antidepressant and mood-stabilizing effects [15,44]. Additionally, L-theanine can enhance the production of serotonin and dopamine in the brain [45], which are associated with increased energy and motivation. Taken together, the presence of chamomile and L-theanine in the CTT beverage may provide a dual-action benefit by targeting both the physical sources of pain through anti-prostaglandin pathways and the emotional symptoms through neuromodulation. This synergy might explain the broad range of symptom relief observed among participants after consuming the CTT beverage.

Interestingly, our study demonstrated that the consumption of the non-CTT reduced the severity of complexation, neuroticism, and confusion among participants in the control group. Although the CTT and non-CTT beverages were identical in appearance, volume, and packaging, their aroma and taste may have differed due to the presence or absence of chamomile extract and L-theanine. To minimize variations in aroma and taste, the beverage consumed by participants in the control group was a chamomile-flavored beverage. It has been reported that human mood and emotion can be modulated either overtly or subliminally by odors [46]. The flavor of chamomile has been described as mild and sweet, with fruity undertones [47]. Sweet odors and flavors can activate the insular cortex and trigger the release of dopamine [48], which may help reduce perceived confusion, complexity, and neuroticism. Further studies could be conducted to better understand the influence of sensory perception on psychological responses in young adult females following the intake of CTT and non-CTT beverages.

Dysmenorrhea has been reported to negatively affect nighttime sleep quality and daytime functioning in young female adults [28]. Chamomile tea consumption is believed to have a calming effect on the body and relax the muscles, helping individuals fall asleep more quickly [49]. An early study demonstrated that consuming 270 mg of chamomile extract twice daily led to a modest improvement in daytime functioning among subjects with chronic primary insomnia, although no significant changes were observed in total sleep time, sleep quality, sleep latency, and sleep duration [20]. Another study by Hidese et al. [21] found that consuming a 200 mg L-theanine tablet before sleep each night for four consecutive weeks improved daytime dysfunction and sleep latency, but did not affect sleep quality, sleep duration, sleep efficiency, and sleep disturbance in healthy adults. Our study found that consuming a CTT beverage containing 480 mg chamomile extract and 200 mg L-theanine twice daily for five consecutive days improved daytime dysfunction in young adult females with primary dysmenorrhea. Daytime dysfunction refers to a cluster of symptoms resulting from poor sleep quality, including poor concentration, daytime sleepiness, fatigue, memory issues, increased errors and accidents, mood changes, and low energy, all of which can impact daily functioning [50]. L-theanine is believed to improve daytime dysfunction by increasing alpha wave activity in the brain, promoting a relaxed yet alert mental state without causing drowsiness [24]. Additionally, the flavonoids in chamomile, particularly apigenin, can readily cross the blood–brain barrier, regulating the brain microenvironment and providing essential nutrients for neuronal function [51], which may indirectly improve the daytime dysfunction. Despite using a similar dosage of L-theanine as in Hidese et al. [21], our study did not observe an improvement in sleep latency. It is possible that a longer period of CTT consumption is required to produce this effect.

This study has several limitations that should be addressed. Firstly, the short intervention duration limits the ability to observe long-term physiological changes, particularly in hemoglobin levels. Iron metabolism and red blood cell regeneration are relatively slow processes, and improvements in hemoglobin concentration typically require several weeks to months of consistent intervention to become detectable. This is because the lifespan of hemoglobin is approximately 120 days. Secondly,

the results do not confirm whether L-theanine exerts a synergistic effect with chamomile or whether the observed benefits are attributable to chamomile alone. Thirdly, the effectiveness of participant blinding was not assessed through a post-trial blinding questionnaire. The psychological effects of belief and expectancy, especially on treatment efficiency, may impact the outcomes of interventions [31]. Fourthly, the caffeine intake and stress levels, which may influence the mood and sleep quality of the participants, were not measured in the present study.

Future studies are recommended to extend the intervention duration to cover at least two or more menstrual cycles, allowing sufficient time for physiological responses to manifest. Additionally, a larger and more diverse sample could be used to increase statistical reliability. The use of a more inert placebo formulation is recommended in future studies, given the possible psychological or olfactory effects of the chamomile flavor used as the beverage in the control group. Lastly, a crossover design, rather than a single-point trial, could be implemented to reduce inter-individual variability.

5. Conclusion

Primary dysmenorrhea is a common menstrual disorder affecting more than 50% of young adult females. Consumption of a beverage containing chamomile and L-theanine was found to reduce menstrual pain and alleviate various symptoms, including lower abdominal pain, loss of appetite, back pain, complexation, stomachache, body pain, depression, and irritability. Additionally, daytime dysfunction was also reduced following CTT intake. Further studies with longer intervention durations that include two or more menstrual cycles are recommended to evaluate the long-term effects of CTT on menstrual symptoms, pain intensity, mood, and sleep quality in young female adults with primary dysmenorrhea.

Data availability

Supporting data will be made available upon request.

Author contributions

Ziqing Soh: Methodology; data curation; formal analysis; visualization; writing – original draft. **Soo Cing Tan:** Methodology; data curation; formal analysis; visualization; writing – original draft. **Tak Hiong Wong:** Resources; funding acquisition. **Seok Tyug Tan:** Writing – review and editing; investigation; validation. **Seok Shin Tan:** Writing – review and editing; investigation; validation. **Chin Xuan Tan:** Supervision, project administration; methodology; writing – review and editing; software; investigation; conceptualization; funding acquisition.

Conflicts of interest

All authors declare no conflict of interest. The funding sponsor had no role in the collection, analysis, or interpretation of data.

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