

[Paper]

Effects of Sub-Threshold Neurodevelopmental Traits on the Adjustment of Female Students to High School: A Study Focused on Premenstrual Dysphoric Mood

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Abstract

The purpose of this study was to determine the impact of the adjustment to high school on female students with sub-threshold neurodevelopmental disabilities traits by monitoring premenstrual discomfort. A questionnaire survey was conducted on a group of 500 high school seniors and on first- and second-year college students, using the sub-threshold neurodevelopmental disabilities traits scale, the PMDD rating scale, and the school adjustment questionnaire. To test the accuracy of each of the scales used, we analyzed them using item response theory. To determine whether sub-threshold ASD and ADHD traits influenced school adjustment, the analysis was conducted by monitoring PMDD. The results of this analysis determined that female high school students with sub-threshold ASD traits have difficulties with school life and study performance. In the case of female high school students with sub-threshold ADHD traits, PMDD was found to interfere with school relationships. In particular, female high school students with sub-threshold ASD traits were more likely than female high school students with sub-threshold ADHD traits to experience depressed or hopeless moods and to have higher levels of anxiety and tension. These results suggest that there is an urgent need to develop classroom-based support techniques that allow for good communication between female high school students with sub-threshold neurodevelopmental disabilities traits and their peers.

Keywords: Female High School Students, Sub-Threshold Neurodevelopmental Disabilities Traits, PMDD, School Adjustment

1. Introduction

In clinical practice, it is often observed that in women symptoms of psychiatric disorders such as depression, panic disorder, mood dysphoria, and personality disorders, as well as physical disorders such as asthma, allergic diseases, and epilepsy tend to worsen over time and are poorly controlled before menstruation (Egawa, 2020). The most severe form of these disorders, in which psychiatric symptoms are so severe that daily life and interpersonal relationships are severely impaired, is called premenstrual dysphoric disorder (PMDD). In the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) (American Psychiatric Association, 2013), PMDD is classified as a depressive disorder.

In Japan, the prevalence of moderate to severe PMDD and premenstrual syndrome (PMS) among female high school students was found to be higher than among adult females (Takeda et al., 2010). A survey of a total of 1,431 female high school students was used to determine the relationship between PMDD and PMS dysmenorrhea, and found that 3.2% of the cases qualified as PMDD. In addition, the prevalence of PMDD and moderate to severe PMS increased with the severity of dysmenorrhea, indicating a correlation between PMS and PMDD severity and dysmenorrhea in adolescents (Kitamura et al., 2012). PMDD can interfere with the daily lives of female high school students and can have serious consequences.

Furthermore, women with intellectual or developmental disabilities are more likely to have menstrual abnormalities (Yada (Hashimoto) et al. 2017). To determine the prevalence of PMS in women with autism, we compared a group of women with autism and learning disabilities ($n = 26$) with a group of women without autism and learning disabilities ($n = 36$). Results showed that a 30% or greater increase in premenstrual DSM-IV symptoms was an evidence of fulfillment of the diagnostic criteria. The prevalence of PMS was 92% in the autistic group compared to 11% in the control group. This difference was highly significant. Susceptibility to premenstrual syndrome has been shown to be significantly increased in women with autism (Obaydi and Puri, 2008).

Based on the above previous studies, support for women with developmental disabilities should take into account the impact of women's unique hormonal fluctuations on their everyday lives (Noda et al., 2021). In addition, it is assumed that providing appropriate support, especially during the adolescent period of female high school students, will lead to an improvement in mental health during adolescence. However, there have been no studies demonstrating an association between sub-threshold neurodevelopmental disabilities traits and mood disturbance in PMDD and its impact on school adjustment among female high school students.

In this study, we clarify the effects of sub-threshold neurodevelopmental disabilities traits on school adjustment mediated by discomfort in PMDD among female high school students. The objective of this study is to gain, through the analysis of the results, a perspective on how to better support female students with sub-threshold neurodevelopmental disabilities traits.

2. Method

2.1 Survey subjects

A total of 500 people were surveyed: 257 high school senior students (120 males and 137 females) and 243 first- and second-year college students (138 males and 105 females).

2.2 Survey timing and means of implementation

The survey was conducted in March 2021. The survey was conducted online through the research contractor Rakuten Insight. The parents or guardians of the subjects and the subjects themselves were asked to consent to the online study in advance, and only the subjects were asked to complete the questionnaire. The study was approved by the Ethical Review Committee of Tokyo University of Agriculture and Technology (Approval No. 210203-0270).

2.3 Survey Items

2.3.1 Sub-threshold neurodevelopmental disabilities traits scale

From the questionnaires developed by Takahashi et al. (2015) and Shinoda et al. (2017), seven items were selected from the sub-threshold Attention-Deficit/Hyperactivity Disorder (ADHD) traits

questionnaire short version and the sub-threshold autism spectrum disorder (ASD) traits questionnaire, respectively. The representative of the questionnaire creator had confirmed that the questionnaire could be used by high school students. A five-point scale was used, ranging from “very troubled (5 points)” to “not troubled at all (1 point)”.

2.3.2 PMDD rating scale

The 12 items of the PMDD Rating Scale developed by Miyoka et al. (2009) were used to evaluate PMDD, which is defined as symptoms mainly consisting of recurrent mood changes before menstruation. A five-point scale ranging from “very strongly (5 points)” to “no change (1 point)” was used.

2.3.3 School adjustment questionnaire

Two items related to poor adjustment to school, “It interfered with my efficiency in school life and studies” and “It interfered with my relationships with people at school” (Miyoka et al., 2009), were selected for female high school students who had one or more symptoms of the PMDD Rating Scale (all applicable). A five-point scale was used, ranging from “very strongly (5 points)” to no change maybe “no change? Instead of just NOT (1 point).”

2.4 Method of analysis

2.4.1 Validation of scale accuracy

To verify the accuracy of the scale used in this study, we decided to analyze the results using Item Response Theory (IRT). The IRT is a method of inferring measurable abilities from the results of a questionnaire using responses to items (response status) when the characteristics of the items (difficulty and discrimination) are known. In other words, it is an analytical method that allows detailed confirmation of measurement accuracy. In addition, since the nature of the population of survey participants does not affect the analysis process, the scale can be used in a variety of school settings. As shown in (1) to (3) below, the analytical procedure for this study was adapted from Eguchi (2011) and Uragami and Wakita (2016). Easy Estimation Ver. 2.1.5 by Kumagaya (2009) was used for the analysis.

(1) Confirmation of unidimensionality of the scale

For each item of the scale used in this study, a factor analysis of the inter-item correlation matrix using tetrachoric correlation coefficients was performed. The eigenvalues are then plotted on a graph (scree plot) to confirm the unidimensionality of the scale.

(2) Estimation of item parameters

Since the five-item method was used in this study, the Graded Response Model (GRM) was employed to estimate the item parameters. Then, the discrimination parameter (a) and the difficulty parameter (b) for each item were calculated by the marginal maximum likelihood estimation method. In this study, the five-case method was used to obtain responses, so four difficulty parameters (b) were estimated for each item (Iwabuchi and Kato, 2018). This analysis yielded an Item Response Category Characteristic curve (IRCCC) for each item. The IRCCC represents the probability that respondents with a particular latent characteristic scale value (θ) will select each choice branch. The position and slope of this curve provide a visual indication of the characteristics of the item in question.

The parameter (a), which represents the item’s discriminative power, is an indicator of the extent to which it can identify the respondent’s latent characteristics. A high value implies a high degree of contribution to the estimation of latent characteristic values (θ). The item difficulty parameter (b) is an index of item difficulty. It represents the position of the item on the latent

characteristics scale. The larger this value is, the more the position of the curve is to the right, and the smaller it is, the more it is to the left. Therefore, a large value of b expresses that the item cannot be answered correctly unless the ability value (θ) is high, indicating that it determines the difficulty of the item. In this study, the level of the discrimination ability parameter (a) was set to $a > 0.75$ (Ironson et al., 1989). The level of the difficulty parameter (b) was set to $4.00 > b > -4.00$ (Kijima, 1999).

(3) Estimation of reliability

To examine measurement accuracy, Cronbach's alpha coefficient was obtained as an estimate of the reliability coefficient. Generally, when α is 0.7 to 0.8 or higher, it is considered an indication that a certain level of reliability is ensured. The free statistical software HAD by Shimizu (2016) was used for the analysis.

2.4.2 Characteristics of female high-school students with sub-threshold neurodevelopmental disabilities traits

The sub-threshold ASD and ADHD traits scores of female high school students were compared with those of male high school students and female college students using an unpaired t-test.

2.4.3 Characteristics of PMDD among female high school students

We compared scores for premenstrual unpleasant mood in the group with high scores of sub-threshold ASD and ADHD traits using an unpaired t-test with female college students. In addition, scores are compared between the group with high scores of sub-threshold ASD and ADHD traits and the group with overlapping sense of distress in female high school students and the group with stereotyped developmental students using a one-way ANOVA.

2.4.4 Effects of characteristics related to sub-threshold neurodevelopmental disabilities traits on school adjustment among female high school students

A mediation analysis was conducted to see if characteristics of sub-threshold ASD and ADHD traits influenced school adjustment by mediating PMDD.

3. Results

3.1 Confirmation of the accuracy of each scale

The accuracy of each scale was confirmed by IRT. First, the inter-item correlation matrix with tetrachoric correlation coefficients was factor analyzed to check its eigenvalues. The first three eigenvalues were 4.87, 0.60, 0.41, ... for the sub-threshold ASD traits questionnaire; the ratio of the first eigenvalue to the second eigenvalue was 4.27, which is large, indicating that the unidimensionality aspect of the scale was satisfied. Next, for the sub-threshold ADHD traits questionnaire, the scores were 3.99, 0.86, 0.58, ..., and the ratio of the first eigenvalue to the second eigenvalue is 3.13, which indicated that the unidimensionality of the scale was satisfied. Finally, the PMDD rating scale was 7.81, 0.94, 0.64, ..., and the ratio of the first eigenvalue to the second eigenvalue was 6.87, which is large, and the unidimensionality of the scale was judged to be satisfying. Next, the GRM was employed in this study to estimate the item parameters by calculating the discrimination parameter (a) and the difficulty parameter (b) for each item using the marginal maximum likelihood estimation method. The value of the discrimination parameter (a) was determined to satisfy the range $a > 0.75$. The sub-threshold ASD traits questionnaire was $1.97 > a$, the sub-threshold ADHD traits questionnaire was $1.42 > a$, and the PMDD rating scale was $1.50 > a$, meeting the $a > 0.75$ level of Ironson et al. (1989). The value of the difficulty parameter (b) was determined to satisfy the range $4.00 > b > -4.00$ for all items. The sub-threshold ASD traits

questionnaire was $2.75 > b > -1.56$, the sub-threshold ADHD trait questionnaire was $3.26 > b > -1.86$, and the PMDD rating scale was $2.92 > b > -1.15$, meeting the Kijima (1999) level of $4.00 > b > -4.00$. Finally, Cronbach's alpha coefficient was determined for each scale as an estimate of the reliability coefficient. As a result, a value of $\alpha = 0.91$ was calculated for the sub-threshold ASD traits questionnaire, $\alpha = 0.84$ for the sub-threshold ADHD traits questionnaire, and $\alpha = 0.93$ for the PMDD rating scale. The values were determined to be sufficiently internally consistent (Tables 1, 2, and 3). The English translations of all items of each scale were prepared independently by the authors after examining their content validity.

3.2 Extraction of female high school students with high scores on each scale

Twenty-three female high school students (16.8% of the female students) had high scores (mean

Table 1 Parameter estimates for each model (sub-threshold ASD traits questionnaire)

Item	Slope		Location Parameters ^{*2 *3}							
	Parameters ^{*1}		1		2		3		4	
	<i>a</i>	Standard Error	<i>b</i>	Standard Error	<i>b</i>	Standard Error	<i>b</i>	Standard Error	<i>b</i>	Standard Error
1. Past experiences come back to life as if they are happening in the present, and feelings become unstable	1.97	0.13	-1.25	0.08	0.19	0.06	1.52	0.09	2.75	0.19
2. Cannot talk as well as other people	3.26	0.19	-1.03	0.07	0.06	0.04	1.06	0.07	2.25	0.15
3. Have trouble feeling that they are different from the usual person	3.00	0.18	-0.94	0.06	0.23	0.04	1.43	0.09	2.64	0.20
4. Have trouble feeling comfortable in group activities	3.00	0.18	-1.06	0.07	0.12	0.04	1.24	0.08	2.46	0.17
5. Feelings are easily hurt	2.62	0.16	-1.39	0.09	-0.09	0.05	1.18	0.07	2.25	0.14
6. I am not good at making new friends when I go to school or change classes	2.20	0.13	-1.56	0.10	-0.34	0.05	0.80	0.06	2.05	0.12
7. I think other people see me as being out of place all the time	2.76	0.17	-1.14	0.08	0.21	0.05	1.91	0.12	2.72	0.21
<i>M</i>	2.69		-1.19		0.05		1.31		2.45	
<i>SD</i>	0.47		0.22		0.20		0.36		0.27	

^{*1} Parameter (*a*): an indicator of the extent to which the respondent's latent characteristics can be identified (characteristic value proportional to the slope of the item characteristic curve at ability value (θ) = *b*)

^{*2} Parameter (*b*): Indicator of item difficulty (characteristic value representing the position of the item characteristic curve)

^{*3} In this study, the GRM was employed and responses were requested using the five-case method, so four difficulty parameters (*b*) were estimated for each item (Iwabuchi and Kato, 2018).

+1 SD or higher) on the sub-threshold ASD traits questionnaire. There were 16 female high school students (11.7% of the female students) with high scores (mean +1 SD or higher) on the sub-threshold ADHD traits questionnaire. In addition, 13 female high school students (9.49% of the female students) had high scores on both the sub-threshold ASD traits questionnaire and the sub-threshold ADHD traits questionnaire. Twelve female high school students (8.8% of the female students) had high scores only on the sub-threshold ASD traits questionnaire, and four female high school students (2.9% of the female students) had high scores only on the sub-threshold ADHD traits questionnaire. Twenty-five female high school students (18.3% of the female students) had high scores (mean +1 SD or higher) on the PMDD rating scale.

3.3 Gender Comparison on sub-threshold ASD and ADHD traits questionnaire

To begin, an unpaired t-test was conducted on the sub-threshold ASD traits questionnaire scores of female and male high school students. The results showed no significant difference between

Table 2 Parameter estimates for each model (sub-threshold ADHD traits questionnaire)

Item	Slope		Location Parameters ^{*2 *3}							
	Parameters ^{*1}		1		2		3		4	
	<i>a</i>	Standard Error	<i>b</i>	Standard Error	<i>b</i>	Standard Error	<i>b</i>	Standard Error	<i>b</i>	Standard Error
1. I have trouble remembering things	1.64	0.12	-0.87	0.08	0.70	0.07	1.73	0.11	3.26	0.25
2. I have trouble with irregularity in my life	1.67	0.12	-1.27	0.09	0.11	0.06	1.25	0.08	2.64	0.17
3. I have trouble with my room being so messy that I can't invite people over	1.42	0.11	-1.14	0.09	0.11	0.07	1.37	0.10	2.78	0.18
4. I cannot do well when there are multiple things that need to be done	3.60	0.21	-1.34	0.09	-0.13	0.04	0.94	0.06	1.97	0.13
5. I am always busy with things that need to be done and have no time to spare	2.67	0.16	-1.44	0.09	-0.08	0.05	1.12	0.07	2.27	0.15
6. I get irritated easily	1.94	0.13	-1.19	0.08	0.25	0.06	1.57	0.10	2.76	0.19
7. I work hard, but the results are not as expected	2.02	0.13	-1.86	0.12	-0.41	0.06	1.00	0.07	2.47	0.16
<i>M</i>	2.14		-1.30		0.08		1.28		2.59	
<i>SD</i>	0.76		0.31		0.35		0.29		0.41	

^{*1} Parameter (*a*): an indicator of the extent to which the respondent's latent characteristics can be identified (characteristic value proportional to the slope of the item characteristic curve at ability value (θ) = *b*)

^{*2} Parameter (*b*): Indicator of item difficulty (characteristic value representing the position of the item characteristic curve)

^{*3} In this study, the GRM was employed and responses were requested using the five-case method, so four difficulty parameters (*b*) were estimated for each item (Iwabuchi and Kato, 2018).

conditions ($t(244.12) = 0.09, p = 0.93$). Similarly, sub-threshold ADHD traits questionnaire scores ($t(251.75) = 0.15, p = 0.88$) did not differ significantly by gender.

3.4 Comparison of scores on the sub-threshold ASD and ADHD traits questionnaire by age

To begin, an unpaired t-test was conducted on the sub-threshold ASD traits questionnaire

Table 3 Parameter estimates for each model (PMDD Rating Scale)

Item	Slope		Location Parameters ^{*2 *3}							
	Parameters ^{*1}		1		2		3		4	
	<i>a</i>	Standard Error	<i>b</i>	Standard Error	<i>b</i>	Standard Error	<i>b</i>	Standard Error	<i>b</i>	Standard Error
1. feeling depressed or hopeless	4.09	0.38	0.08	0.05	0.54	0.07	1.40	0.13	2.35	0.24
2. feeling anxious or nervous	3.89	0.34	-0.23	0.06	0.53	0.07	1.26	0.11	2.16	0.20
3. tearfulness or sudden sadness	2.72	0.27	0.21	0.07	0.57	0.08	1.52	0.14	2.20	0.21
4. Becoming angry or irritable or hitting others	2.52	0.22	-0.42	0.08	0.55	0.08	1.21	0.11	2.20	0.20
5. Loss of interest (in school, hobbies, etc.)	3.37	0.31	0.04	0.06	0.54	0.07	1.51	0.13	1.97	0.18
6. difficulty concentrating	2.81	0.25	-0.69	0.08	0.66	0.08	1.24	0.11	2.34	0.22
7. Tiredness or loss of energy	2.43	0.22	-0.77	0.09	0.55	0.08	1.12	0.10	2.13	0.19
8. Increased appetite or cravings for certain foods (e.g., sweets, etc.)	1.75	0.17	-0.65	0.10	0.21	0.09	1.02	0.11	2.24	0.19
9. Sleeps more than usual	1.50	0.15	-1.15	0.13	0.00	0.10	0.90	0.11	2.19	0.19
10. Sleeps less than usual	1.94	0.21	0.21	0.09	0.53	0.09	1.87	0.17	2.92	0.31
11. Feeling out of control	3.44	0.32	0.05	0.06	0.37	0.06	1.54	0.14	2.18	0.21
12. Any of the following physical symptoms (breast pain or tightness, abdominal tightness, abdominal pain, headache, joint pain, muscle pain, feeling swollen, weight gain, constipation)	1.84	0.18	-0.64	0.10	0.36	0.09	1.23	0.12	2.03	0.17
<i>M</i>	2.69		-0.33		0.45		1.32		2.24	
<i>SD</i>	0.86		0.45		0.19		0.26		0.24	

^{*1} Parameter (*a*): an indicator of the extent to which the respondent's latent characteristics can be identified (characteristic value proportional to the slope of the item characteristic curve at ability value (θ) = *b*)

^{*2} Parameter (*b*): Indicator of item difficulty (characteristic value representing the position of the item characteristic curve)

^{*3} In this study, the GRM was employed and responses were requested using the five-case method, so four difficulty parameters (*b*) were estimated for each item (Iwabuchi and Kato, 2018).

scores of female high school and college students. The results showed no significant differences between conditions ($t(232.36) = 0.20, p = 0.84$). Similarly, there was no significant difference in scores on the sub-threshold ADHD traits questionnaire ($t(222.87) = 0.42, p = 0.67$) due to age.

3.5 Comparison by age on PMDD rating scale scores (group with higher scores on sub-threshold ASD and ADHD traits questionnaire)

Unpaired t-tests were conducted on PMDD rating scale scores for the groups with higher scores on the sub-threshold ASD traits questionnaire for female high school students and female college students. The results showed a trend toward significant differences between conditions ($t(28.51) = 1.95, p = 0.06$). That is, female high school students with higher scores on the sub-threshold ASD traits questionnaire ($M = 35.13, SD = 9.56$) were more likely to feel uncomfortable before menstruation than female college students ($M = 28.67, SD = 10.27$). Similarly, an unpaired t-test was conducted on PMDD rating scale scores for the group with higher scores on the sub-threshold ADHD traits questionnaire. The results showed a significant difference between conditions ($t(27.87) = 2.10, p = 0.05$). That is, female high school students ($M = 36.250, SD = 11.02$) with higher scores on the sub-threshold ADHD traits questionnaire were more uncomfortable before menstruation than female college students ($M = 29.00, SD = 8.30$).

3.6 Comparison of PMDD assessment scores among high-scoring groups of female high school students on the sub-threshold ASD and ADHD traits questionnaire

A one-way ANOVA was conducted on the PMDD scores of female high school students in the groups on the sub-threshold ASD-only (12 students) and on the sub-threshold ADHD-only (4 students) and on students who fell within the overlap of both the sub-threshold of ASD and ADHD (13 students), as well as on randomly selected typically developing students (29 students). The results showed a significant main effect for female high school students with sub-threshold neurodevelopmental disabilities traits with respect to the overall PMDD scores ($F(3,54) = 40.72, p = 0.00$). The results of multiple comparisons (Holm method) showed that the with overlapping on the sub-threshold ASD and ADHD groups (sub-threshold ASD: $M = 31.92, SD = 7.93$, sub-threshold ADHD: $M = 27.25, SD = 9.95$, overlapping: $M = 39.08, SD = 9.57$) scored significantly higher on PMDD than did typically developing students ($M = 17.24, SD = 1.55$) (sub-threshold ASD: $t(54) = 6.77, Padj = 0.00$, sub-threshold ADHD: $t(54) = 2.97, Padj = 0.01$, duplicate: $t(54) = 10.34, Padj = 0.00$). Note that there was no significant difference between the on the sub-threshold ASD-only group and the on the sub-threshold ADHD-only group for overall PMDD scores ($t(54) = 1.28, n.s.$). Therefore, a one-factor analysis of variance was conducted for each item of the PMDD scale, and the main effect of scores on the sub-threshold neurodevelopmental disabilities traits was found to be significant for the item "feeling depressed or hopeless" ($F(3,54) = 23.68, p = 0.00$). In addition, a significant main effect of sub-threshold neurodevelopmental disabilities traits scores was found for the item "feeling anxious or nervous" ($F(3,54) = 22.64, p = 0.00$). Multiple comparisons (Holm method) showed that the on-the-subthreshold ASD-only group ($M = 3.17, SD = 1.27$) scored significantly higher on PMDD than the on-the-subthreshold ADHD-only group ($M = 1.50, SD = 1.00$) ($t(54) = 3.36, Padj = 0.04$).

3.7 Sub-threshold neurodevelopmental disabilities traits scores predict premenstrual unpleasant mood and problems with school adjustment

A mediation analysis was conducted to prove whether PMDD is mediated by the assumption that sub-threshold neurodevelopmental disabilities traits affect school adjustment in female high

school students. First, multiple regression analysis were conducted using scores on the school adjustment item “It interfered with my efficiency in school life and studies” as the objective variable, and with scores on sub-threshold ASD as the explanatory variable. The results showed that sub-threshold ASD scores significantly predicted “It interfered with my efficiency in school life and studies” ($b = 0.10$, $SE = 0.02$, $t(135) = 5.37$, $p = 0.00$). Furthermore, when PMDD scores were added as explanatory variables, PMDD significantly predicted “It interfered with my efficiency in school life and studies” ($b = 0.07$, $SE = 0.01$, $t(134) = 9.59$, $p = 0.00$), while sub-threshold ASD effect became non-significant ($b = 0.02$, $SE = 0.02$, $t(134) = 1.50$, $p = 0.14$). The results of the indirect effect test (Bootstrap method, 2000 runs) showed that the 95% confidence interval ($[0.05, 0.10]$) did not include 0, indicating significant mediation of PMDD.

Next, multiple regression analysis was conducted using sub-threshold ADHD scores as the explanatory variable. The results showed that sub-threshold ADHD scores significantly predicted “It interfered with my efficiency in school life and studies” ($b = 0.12$, $SE = 0.02$, $t(135) = 6.78$, $p = 0.00$). Furthermore, when PMDD was added as an explanatory variable, PMDD significantly predicted “It interfered with my efficiency in school life and studies” ($b = 0.07$, $SE = 0.01$, $t(134) = 8.67$, $p = 0.00$). The effect of sub-threshold ADHD scores was also significant but smaller ($b = 0.04$, $SE = 0.02$, $t(134) = 2.29$, $p = 0.02$).

Similarly, multiple regression analysis was conducted using the school adjustment item “It interfered with my relationships with people at school” as the objective variable and sub-threshold ASD scores as the explanatory variable. The results showed that sub-threshold ASD scores significantly predicted “It interfered with my relationships with people at school” ($b = 0.10$, $SE = 0.01$, $t(135) = 7.17$, $p = 0.00$). Furthermore, when PMDD scores were added as an explanatory variable, PMDD significantly predicted “It interfered with my relationships with people at school” ($b = 0.05$, $SE = 0.01$, $t(134) = 6.88$, $p = 0.00$). The effect of sub-threshold ASD scores was also significant, but the effect was smaller ($b = 0.06$, $SE = 0.01$, $t(134) = 4.00$, $p = 0.00$).

Next, multiple regression analysis were conducted using sub-threshold ADHD scores as the explanatory variable. The results showed that sub-threshold ADHD scores significantly predicted “It interfered with my relationships with people at school” ($b = 0.08$, $SE = 0.02$, $t(135) = 4.93$, $p = 0.00$). Furthermore, when PMDD scores were added as explanatory variables, PMDD significantly predicted “It interfered with my relationships with people at school” ($b = 0.06$, $SE = 0.01$, $t(134) = 7.51$, $p = 0.00$), while sub-threshold ADHD scores effect became non-significant ($b = 0.01$, $SE = 0.02$, $t(134) = 0.77$, $p = 0.45$). The results of the indirect effect test (Bootstrap method, 2000 times) showed that the 95% confidence interval ($[0.04, 0.10]$) did not include 0, indicating significant mediation of PMDD.

4. Discussion

The analysis in this study showed, first, that female high school students with sub-threshold ASD and ADHD were not significantly different from both male high school students and female college students. Second, that female high school students with sub-threshold neurodevelopmental disabilities traits were more uncomfortable before menstruation than female college students or female high school students with typical development. In particular, female high school students with sub-threshold ASD traits were more likely than female high school students with sub-threshold ADHD traits to experience depressed or hopeless moods and to have higher levels of anxiety and tension. Since the results of this study indicate that four female high school students had sub-

threshold ADHD traits, it is desirable to survey a larger number of subjects in the future.

The results showed that sub-threshold ASD scores among female high school students were associated with PMDD, summarized as “it interfered with my efficiency in school life and studies”. Women with ASD experienced heightened sensory sensitivity and severe premenstrual symptoms before menstruation, which have been proven to be related to the difficulty of living in ASD women (Noda et al., 2021). In addition, more than 75% of women with ASD who are aware of PMS symptoms, tend to become hypersensitive due to changes in themselves, becoming aware of mental symptoms like lethargy, difficulty concentrating, and crying before menstruation. In addition, there is evidence of premenstrual changes in lifestyle behaviors such as poor performance, forgetfulness, and increased compulsive behaviors (Kyrkou, 2005).

In addition, in the case of female high school students with sub-threshold ADHD traits, it was demonstrated that PMDD caused them to respond “It interfered with my relationships with people at school”. The prevalence of PMDD has been shown to be higher in women with ADHD compared to the general female population (Dorani et al., 2021). In addition, prevalence differences for ADHD-related mental disorders have also been demonstrated to be significantly greater in women than in men for anxiety, depression, bipolar disorder, and personality disorders (Solberg et al., 2017).

Adolescence is a unique period in human development, both psychologically and physiologically. In addition, it is a critical and vulnerable period between childhood and adulthood (Takeda et al., 2010). Many female high school students experience stress in their daily lives, and with little accurate information on reproductive health, they may experience significant stress related to menstruation. It has also been noted that when PMS and other symptoms occur, these females may have negative thoughts that further reinforce premenstrual symptoms (Kitamura et al., 2012).

A woman with sub-threshold neurodevelopmental disabilities traits experience a state of help-seeking, which is noted when she expresses her difficulty in talking to others about her menstruation, while seeking understanding from those around her (Noda et al., 2021). In order to promote adjustment of female high school students with sub-threshold neurodevelopmental disabilities traits to the school environment, reproductive health education should be actively provided in a standard classroom accounting for sub-threshold neurodevelopmental disabilities traits. Furthermore, it is expected that female students with sub-threshold neurodevelopmental disabilities traits will gain understanding of their own difficulties from the female high school students around them, and will develop supportive techniques that facilitate good communication experiences with them.

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