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by Asti Dewi Rahayu Fitrianingsih

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Predictive model for dysmenorrhea level in female Taekwondo athletes: Investigating the influence of BMI and micronutrient intake

Asti Dewi Rahayu Fitrianingsih[abcde*], **Ayu Mutiara Santanu**, **& Putri Novitasari**

Universitas Pendidikan Indonesia, Indonesia

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ABSTRACT

Disturbances during menstruation such as dysmenorrhea affect the performance of female athletes. However, research on the physiologic conditions of female Taekwondo athletes was still very limited. This study aimed to obtain a predictive model for the level of dysmenorrhea and to test which variable had the most influence on the rate of dysmenorrhea. The research design adopted cross-sectional methods. Multiple linear regression analysis was performed to analyze the effect of BMI and micronutrient intake of nine elite regional and national female Taekwondo. The results showed that the average female athlete had a normal BMI, while for micronutrient intake per day, the average intake of vitamin E was low, the vitamin B6 intake was low, Magnesium intake was low and Calcium intake was fulfilled. The most influence on the occurrence of primary dysmenorrhea in female Taekwondo athletes was calcium intake. This study was limited to measurements of BMI and dietary micronutrient intake, which might help provide data that coaches, athlete nutritionists, and athletes could be used to predict and assess the incidence of primary dysmenorrhea. More research could use the Food Frequency Questionnaire (FFQ), which could better explain how often athletes consumed certain food ingredients over a specific time period.

Keywords: Female athletes; micronutrients; dysmenorrhea; reproductive health

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Corresponding Author: Asti Dewi Rahayu Fitrianingsih, Department of Nutrition, Faculty of Sport and Health Education, Universitas Pendidikan Indonesia, Bandung, Indonesia
Email: rahayufitria@upi.edu

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INTRODUCTION

Taekwondo, a well-liked sport that appeals to people of all ages, has a significant place in the world of competitive athletics, with regular championships taking place at both the national and international levels (Akhmad et al., 2021). As a sport that emphasises body weight, Taekwondo's connection to body mass index (BMI) becomes apparent (Sasmarianto et al., 2021). Notably, a study by Giustino et al. (2020) revealed that successful Olympic Taekwondo athletes between 2000 and 2010 displayed a higher body size and a lower BMI compared to non-champion athletes. In line with this, Baek et al. (2021) discovered a notable

correlation between an increase in BMI and a decline in athletes' performance. However, BMI alone is not the sole factor influencing performance; nutritional intake also plays a vital role (Abdullah et al., 2022).

To perform at their best in practice and competition, Taekwondo athletes require an adequate supply of micronutrients. Farapti et al. (2019) conducted a study involving 40 athletes from various martial arts disciplines and found that their intake of essential micronutrients, including vitamins C, E, A, B6, zinc, copper, calcium, and magnesium, was insufficient. This deficiency may be attributed to the athletes' limited diversity in food consumption. Furthermore, inadequate intake of micronutrients has been linked to the prevalence of dysmenorrhea (Saei et al., 2020), a condition characterized by severe menstrual pain that can force individuals to rest and disrupt their work for hours or even days. Asian countries, such as Taiwan and Malaysia, have particularly high incidence rates, with 75.2% and 50.9% of their populations affected, respectively. In Indonesia, 54.89% of women suffer from primary dysmenorrhea, while the remaining population experiences secondary dysmenorrhea (Joshi et al., 2015). Dysmenorrhea is accompanied by common symptoms such as back pain, fatigue, irritability, and anxiety, which undoubtedly hinder the training process and impede performance during competitions (Fitrianingsih & Santanu, 2021). In fact, a study by Reiko et al. (2021) revealed that 85.6% of female athletes from various sports experienced dysmenorrhea, with 27.8% reporting mild pain, 19.3% experiencing moderate pain, and a significant 52.9% enduring severe pain.

Although women have different menstrual cycles and hormonal complications than men, it does not prevent them from participating and practicing Taekwondo seriously to become elite athletes (Holtzman & Ackerman, 2021). The difficulty of studying the menstrual cycle and hormonal complexities of women compared to men means that research on female athletes is few and limited. Only 4% of studies focusing only on women are from the World's Top Sports Medicine Journals such as Medicine and Science in Sport and Exercise, British Journal of Sports Medicine, and American Journal of Sports Medicine (Holtzman & Ackerman, 2021). Seeing the limited research on the hormonal complexity of female athletes and the high incidence of dysmenorrhea, it makes this study pivotal as it assists to increase research in the field of nutrition for female athletes.

Over time, the sport of Taekwondo became popular not only with men but also with many women who were interested in the sport (Abdullah et al., 2022). However, in order for women to be able to do this exercise well without being bothered by primary dysmenorrhea, adequate intake of micronutrients is required (Saei et al., 2020). The previous research had tried to analyze the nutritional needs of karate, pencak silat, judo and wrestling athletes (Farapti et al., 2019). However, not for the Taekwondo sport and only in the form of an overview of the intake of micronutrients that the average athlete has every day, there has been no research linking nutritional needs, especially micronutrients with the incidence of primary dysmenorrhea in Taekwondo athletes. This effort is expected to able to provide direction for further research on nutritional management of athletes and provides useful data for designing food menus as a preventive measure for primary dysmenorrhea. Based on the description that has been explained, the researcher was interested in conducting research that aimed to obtain a predictive model for the occurrence of dysmenorrhea in female Taekwondo athletes based on micronutrient intake and BMI and to test which variables had the most influence.

METHOD

A quantitative research used a correlational analytic method with a cross sectional approach. This research was conducted at the Faculty of Sports and Health Education, Universitas Pendidikan Indonesia (FPOK UPI), in 2020. The samples of the study were 9 female Taekwondo athletes who are over or equal to 17 years of age and who had participated at least in national championships who met the inclusion criteria, including unmarried, did not have a history of secondary dysmenorrhea, and was willing to participate in the study after signing a research consent form. The selection of respondents who were not married and did not have a history of secondary dysmenorrhea was carried out to homogenize the research sample so that good research results would be obtained. There are differences in the causes of dysmenorrhea between married and unmarried women (Priyakumari, 2020). Dysmenorrhea in married women can be caused by the presence

of husband's sperm in the reproductive organs, which has the effect of producing prostaglandins that cause the uterine muscles to contract and stimulate pain during menstruation. Not only that, but also during sexual intercourse, the muscles of the uterus contract, causing the cervix to widen. In addition to the difference in marital status (Priyakumari, 2020). In this study, respondents were also selected who did not have a history of secondary dysmenorrhea, namely dysmenorrhea caused by abnormalities in the female reproductive organs such as pelvic inflammatory disease and endometriosis because this study focused on the causes of primary dysmenorrhea, namely dysmenorrhea caused more by her lifestyle such as diet and physical activity (Rejo et al., 2021).

The sampling technique used was the total sampling technique. The instruments used in the study to analyze nutrients were a 24-hour food recall form and a food model. The analysis was then carried out by using the *NutriSurvey* application, the *WHO Anthro* application used to analyze BMI (Wald et al., 2019). Meanwhile, to measure the level of dysmenorrhea pain, the Numeric Rating Scale (NRS) was used. The scale is as follows: 0= no pain; 1-3= Mild pain; 4-6= Moderate Pain; 7-10= Severe Pain (Paluwih et al., 2019). All obtained measurement data were then analyzed by using STATA Statistical software: Release 17 (Stata Corp LP, College Station, Texas, USA) to administer the univariate, bivariate, and multivariate test methods (Saei et al., 2020; Verket et al., 2019).

RESULTS AND DISCUSSION

Relevant data has been collected to answer the research questions, and the research results are presented in detail in Tables 1, 2, and 3. These tables provide a comprehensive overview of the findings and reveal relevant findings.

Table 1. The Overview of BMI, Vit E, Vit B6, Mg, Ca, and Dysmenorrhea Levels

Variables	Min-Max	Mean	SD
BMI	17-24	20.3	2.1
Vit E	3.6 – 15.6	10.2	4.1
Vit B6	0.6 – 1.3	0.95	0.3
Mg	78 – 378.4	211	107.1
Ca	400 –1200	770	258.3
Dysmenorrhea Levels	1 – 8	4.8	2.8

Table 1 shows the average BMI of female Taekwondo athletes at FPOK UPI was 20.3. The average amount of Vit E consumed per day was 10.2 mg, while the average amount of Vit B6 consumed per day was 0.95 mg. The average amount of Mg consumed per day was 211 mg. The average amount of Ca consumed per day was 770 mg, while the average dysmenorrhea pain level was 4.8.

Table 2. Bivariate Selection

Variables	R	ANOVA (p value)	B	Coef (p value)
BMI	0,66	0,014	-0,009	0,001
Vit E	0,77	0,005	-0,539	0,005
Vit B6	0,89	0,002	-8,307	0,001
Magnesium	0,93	0,001	-0,862	0,001
Calcium	0,79	0,001	-0,024	0,001

Table 2 shows the p value < 0.05 for each variable. Therefore, all variables that met the requirements were included into the full model for multivariate analysis. The next stage was carrying out the Full Model which was followed by conducting a confounding test on the variable gaining a p value > 0.05, starting from the one with the highest p value, namely Magnesium. After Magnesium variable was released, the change in B coefficient value on each variable was seen. It showed that there was more than 10% of change, thus the Magnesium variable was put back into the Full Model. Furthermore, in the model, there was still a variable with p value > 0.05, namely the BMI variable. From the calculation of changes in the B coefficient value on each variable, it showed that there had been a change of more than 10%, thus the BMI variable was put back into the Full Model.

After deciding which variables were included into the Full model, the Assumption Test of Multiple Linear Regression was carried out. The mean of the Existence Assumption Test was close to zero (0.001) and there was a distribution of variants, thus the existence assumption was fulfilled. The test results showed that the Durbin Watson coefficient was 2.505, which indicated that the independence assumption was fulfilled. The ANOVA test resulted in p value 0.004 < α = 0.05, which indicated that the assumption of linearity was fulfilled. The VIF value was not more than 10, thus there was no Multicollinearity.

The results of the analysis described that the data met the requirements for multivariate linear regression test. After the assumption test was carried out, the analysis was followed by the interaction test. The result was that there was no interaction among variables. Then, the analysis was continued with the confounding test. The test was started from the variable gaining the highest p value, namely BMI and Magnesium. The result showed that BMI and Magnesium were still included in the model because there was a change in Odds Ratio > 10%. The next stage was proceeding the exclusion of the Mg variable. The result showed that Mg was still involved in the Fit Model.

Table 3. Fit Model

Variables	B	Std.Error	Beta	P Value
(Constant)	18.858	3.790		0.016
BMI	-0.153	0.132	-0.118	0.330
Vit E	-0.313	0.086	-0.451	0.036
Vit B6	-2.635	0.676	0.261	0.030
Magnesium	-0.004	0.004	-0.168	0.373
Calcium	-0.006	0.002	-0.513	0.034

In the model summary table, the coefficient of determination (R square) value was 0.995, which means that the regression model obtained was 99.5% of the variation in the dependent variable of dysmenorrhea level, or in other words, the five independent variables can explain 99.5% of the variation of the dependent variable of dysmenorrhea level. Moreover, the result of ANOVA test showed that the p value of the F test was 0.004, which indicated that, at 5% alpha, the regression model was suitable (fitted) with existing data. In the other hands, the five variables could predict dysmenorrhea variables. The variable with the greatest influence was Calcium intake. In the Coefficient box, the line equation is presented. In column B, the regression coefficient for each variable is presented.

Dysmenorrhea = 18.858 – 0.15BMI – 0.31Vit E – 2,6Vit B6 – 0,004 Mg- 0,006 Ca

From this equation model, the dysmenorrhea pain level could be estimated by using BMI, Vit E, Vit B6, and Calcium variables. The interpretation of Coefficient of each variable is as follows: (i) Every 1 kg / m2 decrease in BMI, the level of dysmenorrhea in Taekwondo athletes will decrease by 0.15 after being controlled by other variables. (ii) Female Taekwondo athletes who consumed 1 mg of Vit E in the food they consumed, experienced a decrease of dysmenorrhea pain level by 0.313 after being controlled by other variables. (iii) Female Taekwondo athletes who consumed 1 mg Vit B6 in the food they consumed, experienced a decrease of dysmenorrhea pain level by 2.635 after being controlled by other variables. (iv) Female Taekwondo athletes, who consumed 1 mg of magnesium in the food they consumed, experienced a decrease of dysmenorrhea pain level by 0.004 after being controlled by other variables. (v) Female Taekwondo athletes who consumed 1 mcg of calcium in the food, experienced a decrease of dysmenorrhea pain level by 0.006 after being controlled by other variables.

The number of women participating in sports and physical activity continues to increase (Holtzman & Ackerman, 2021). Although exercise has a lot of advantages, it can cause menstrual cycle disorders. One of sports that is popular among women, especially female students are Taekwondo (Abdullah et al., 2022; Holtzman & Ackerman, 2021). Taekwondo is a modern self-defense sport from Korean traditional martial arts. It has been known since 1954 as a modification and refinement of various Korean traditional martial arts (Baek et al., 2021). Taekwondo is a fully body contact sport that involves high uses of feet to attack the opponent and get points. 50% of Taekwondo athletes experience irregular menstrual cycles, this percentage

is largest compared to athletes of other sports. Menstrual cycle and dysmenorrhea are different things. There are no studies that link or test the effect of Taekwondo exercise on the level of dysmenorrhea (Dehnavi et al., 2018).

The Effect of Body Mass Index (BMI) on Primary Dysmenorrhea

Based on the research, it was found that every 1 kg/m2 decrease in BMI of female Taekwondo athletes can reduce the level of dysmenorrhea pain by 0.153 points after being controlled by Vitamin B6, Vitamin E, Magnesium, and Calcium variables. The average BMI of respondents was 20.3 kg/m2, which was categorized as a normal nutritional status. Under nutritional status and over nutritional status were risk factors for menstrual cramps. Directly, under nutritional status will cause a weak physical condition so that the body's resistance to pain will be reduced, while in over nutritional status, the excess fat tissue will inhibit menstrual blood flow in the uterus that will cause pain during menstruation (Bajalan et al., 2019).

Several previous studies have shown different results regarding the relationship between nutritional status/Body Mass Index (BMI) and dysmenorrhea (Mohapatra et al., 2016). One of the results of the study states that nutritional status is the dominant factor affecting dysmenorrhea, respondents with overweight nutritional status have higher chance of experiencing dysmenorrhea compared to those with normal nutritional status (Kaur et al., 2017). Other statements also argue that there is no relationship between BMI and dysmenorrhea (Wahyuni et al., 2018). Meanwhile, in theory, the excess of fat tissue in the body can lead to hyperplasia of blood vessels in the female reproductive organs, resulting in impaired blood flow in the menstrual process and causing dysmenorrhea pain. The increase in BMI is along with the increase in the estrogen hormone, while high levels of estrogen hormone have a positive correlation with the incidence of dysmenorrhea (Bavil et al., 2018).

The Effect of Vitamin E on Primary Dysmenorrhea

Vitamin E is a fat-soluble vitamin and is known to have antioxidant substances. The antioxidant mechanism of vitamin E works by preventing cell damage. Another role of vitamin E, besides as an antioxidant, is to prevent menstrual problems. It is known that dietary supplementation such as vitamins (E, B1, B3, and B6) is an alternative treatment for dysmenorrhea, but it has not been widely studied. Vitamin E can reduce menstrual pain through inhibiting prostaglandin biosynthesis. Vitamin E will suppress the activity of the phospholipase A and cyclooxygenase enzymes through inhibiting post-translational activation of cyclooxygenase that will inhibit prostaglandin production. Conversely, Vitamin E also increases the production of prostacyclin and PGE2, which have a function as a vasodilator that can relax uterine smooth muscle (Pakniat et al., 2019).

The recommended Vitamin E adequacy rate by Ministry of Health for women aged 17 years or over per day is 15 mg Based on the research, the average daily Vitamin E intake of female taekwondo athletes was 10.2 mg, which was categorized as a lacking nutritional status (< 15mg). It was found that each 1 mg of Vitamin E additional intake in the food consumed by female Taekwondo athletes could reduce the level of dysmenorrhea by 0.313 points after being controlled by BMI, Vitamin B6, Magnesium, and Calcium variables. The average intake of vitamin for female Taekwondo athletes is 10.5 mcg, which does not meet the nutritional adequacy rate of 15 mcg for women more than equal to 17 years. The results of this study are in line with the results of previous studies, including the research of Vilvapriya and Vinodhini (2018), which shows that Vitamin E is effective in significantly reducing dysmenorrhea. Research by Liao et al. (2022) shows that there is an effect of vitamin E supplementation on prostaglandin levels (PGF2α) and primary menstrual pain intensity (dysmenorrhea) in female adolescents by reducing PGF2α and pain intensity.

The Effect of Vitamin B6 on Primary Dysmenorrhea

Vitamin B6 stimulates the magnesium transfer in cell membranes and increases intracellular magnesium which plays a role in muscle relaxation. It is known that a decrease in Vit B6 levels in the blood affects the liver inability in conjugating estrogen, thus estrogen levels increase which is associated with menstrual pain

complaints (Randabunga et al., 2018). Vitamin B6 is known as an antidepressant vitamin because it controls the production of serotonin which is important in controlling one's feelings (Jenkins et al., 2016).

The recommended Vitamin B6 adequacy rate by Ministry of Health for women aged 17 years or over per day is 1.3 mg. Based on the research, the average Vitamin B6 of female Taekwondo athletes was 0.95 mg, which was categorized as a lacking nutritional status, after data processing and multivariate analysis were carried out, the results showed that each 1 mg increase in the Vitamin B6 intake in the food consumed by female Taekwondo athletes could reduce the level of dysmenorrhea by 2.6 points after being controlled by the BMI, Vitamin E, Magnesium, and Calcium variables. The average intake of Vitamin B6 in respondents was 0.95 mg, which is equal to 73% of the Recommended Dietary Allowance. An adequate consumption of vitamin B6 can help reducing the premenstrual syndrome. Vitamin B6 is known to have a role in reducing anxiety in humans. Vitamin B6 alleviates the level of pain in primary dysmenorrhea and decreases the level of plasma prostaglandins (which are known to be involved in the pathogenesis of primary dysmenorrhea pain), thus Vitamin B6 can be considered as a treatment for primary dysmenorrhea (Randabunga et al., 2018).

The Effect of Magnesium (Mg) on Primary Dysmenorrhea

Based on the research, the average daily Magnesium intake of female Taekwondo athletes was 211 mg, which was categorized as a lacking nutritional status (< 340 mg). The results of the research showed that every 1 mg increase of Magnesium (Mg) mineral intake in the food consumed by female Taekwondo athletes can reduce the level of dysmenorrhea by 0.004 points after being controlled by the BMI, Vitamin E, Vitamin B6, and Calcium variables. The average Magnesium intake of the respondents was 211 mg, which is equal to 91.7% of the Recommended Dietary Allowance for women aged 16-18 years and 63.9% of the Recommended Dietary Allowance for women aged 19-29 years. This is in line with the research of which argues that there is a relationship between Magnesium intake and dysmenorrhea in adolescents. The recommended Magnesium Adequacy is 700 mg by Ministry of Health for women aged 17 years or over per day is 340 mg. The consumption of calcium or magnesium supplements reduces dysmenorrhea complaints and premenstrual syndrome symptoms in women aged 19–23 years. However, not all research results prove a relationship between the level of magnesium consumption and dysmenorrhea, some research results say that there is no relationship between them (Carolina & Devita, 2022).

Research by Kia et al. (2016) states that there was a significant relationship between Magnesium intake and mild premenstrual syndrome. Yaralizadeh et al. (2021) showed that there was a significant relationship between nutritional status and dysmenorrhea. This study also shows that there is an interaction between Magnesium intake and Vitamin B6 and dysmenorrhea. Vitamin B6 enhances magnesium utilization, they work together to promote anti-inflammatory effects.

The main role of magnesium (Mg) is to stabilize cell membranes. In addition, Mg plays a role in regulating Na-K pumps and affects the calcium mechanism. Mg deficiency increases nerve transmission and causes muscle over-stimulation. Mg levels in cells are regulated by various factors, including estradiol and progesterone. The increase of estradiol levels in the preovulatory phase is caused by the lack of Mg levels in cells. Similar with progesterone, the increase in progesterone levels occurred before menstruation is caused by an increase in Mg levels in cells. In the case of dysmenorrhea, the decrease of progesterone levels is caused by the decrease of Mg, which leads to the increase of uterine muscle contractions. A study states that Mg can reduce prostaglandin (PGF2) in menstrual fluid up to 45%. Another research also states that magnesium is more effective in reducing menstrual pain (Yaralizadeh et al., 2021).

The Effect of Calcium (Ca) on Primary Dysmenorrhea

Besides for bones, Calcium is also a substance needed for muscle contraction (Kuo & Ehrlich 2015). The lack of calcium causes the muscles to be unable to relax after contractions, which can lead to muscle cramp (Abdi et al., 2019). Calcium consumption is highly important in preventing dysmenorrhea. When the calcium in blood is lower than normal, the muscles cannot relax after contraction and will cause cramps, thus dysmenorrhea can occur (Abdi et al., 2019).

By considering the results of statistical analysis, it is known that calcium has the highest effect on reducing the level of dysmenorrhea in female Taekwondo athletes (B = 0.513). This result is quite unique considering that every 1 mg increase of Ca consumption has a lower rate in alleviating dysmenorrhea pain compared to other nutrients, including Vitamin B6 and Vitamin E (B = 0.006). It may be due to the Calcium has the highest number in Recommended Dietary Allowance (RDA) compared to all other analyzed nutrients. The recommended Calcium Adequacy by Ministry of Health for women per day is more than 700 mg and the average Calcium intake of respondents was 770 mg, which was categorized as a normal nutritional status. It becomes a multiplying factor causing calcium detected having the highest effect on reducing the level of dysmenorrhea (Shobeiri et al., 2017).

The results of the analysis of Bajalan et al. (2019) showed a relationship between the level of Calcium consumption and the incidence of primary dysmenorrhea. The higher the Calcium intake, the lower the incidence of dysmenorrhea. The results are also in line with the researches of Abdi et al. (2019) that argue that there is a relationship between calcium intake and dysmenorrhea in adolescents. The lower the Calcium intake, the higher the level of primary dysmenorrhea. Research by Shobeiri et al. (2017) showed that female high school students having less Calcium intake have a higher risk chance of experiencing premenstrual syndrome than those who have sufficient Calcium intake. Women aged 19-23 years consuming 1,000 mg/day calcium or 250 mg/day magnesium supplements decrease the pain scale during the next menstrual cycle. Calcium can reduce neuromuscular excitability so that it relaxes muscles. Meanwhile, magnesium suppresses the release of prostaglandins so that it has a relaxing effect on neuromuscular stimulation. A recent study of Saei et al. (2020) related to pain management in dysmenorrhea, reviews the positive effects of the combination of calcium and magnesium intervention on primary dysmenorrhea pain reduction.

CONCLUSION

There is an effect of BMI, Vitamin E, Vitamin B6, Magnesium and Calcium on the incidence of dysmenorrhea in Taekwondo athletes. The variable that has the greatest influence is Calcium intake. The mathematical model obtained in this study was: the incidence of dysmenorrhea in female athletes = 18.858 - 0.15 BMI - 0.31Vit E - 2.6, Vit B6 - 0.004 Mg - 0.006 Ca. This mathematical model can be used as a reference for trainers and athletes' nutritionists to predict and evaluate the incidence of primary dysmenorrhea in female Taekwondo athletes based on BMI and food intake and provides useful data for designing food menus, especially the micronutrient needs required by Taekwondo athletes. More research can use Food Frequency Questionnaire (FFQ), because in this study only used the 24-hour food recall form. Therefore, it is less able to describe the frequency of athletes consuming certain food ingredients in a certain period of time such as days, weeks, and months.

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CONFLICT OF INTEREST

No conflict of interest

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