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Plant-Based Diet during the Prepubertal Period and Age at Menarche: A Systematic Review

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ABSTRACT

This systematic review aimed to analyze the effect of a prepubertal plant-based diet, through dietary patterns and its nutritional components, on the age at menarche. Systematic searches through Medline (EBSCO), Embase, Health & Medical Collection (Proquest), Scopus, and Google Scholar for articles published between January 2000 and September 2022 in English using the keywords of plant-based diet, age at menarche, and their synonyms identified 673 articles. Articles were screened through titles and abstracts, as well as full-text reviews based on inclusion/exclusion criteria and assessment of research quality using the JBI Critical Appraisal Tools with a JBI cut-off final score of >50%, leaving 12 articles in this systematic review presented in the PRISMA 2020 flowchart. Data analysis was conducted descriptively by comparing findings between articles. Age at menarche/puberty was reported as an outcome of food intake through a vegetarian diet, Mediterranean diet, vegetable protein, phytoestrogens and isoflavones, and dietary fiber. Based on the analysis of each subgroup, the plant-based diet did not consistently influence the incidence of menarche. In conclusion, a plant-based diet does not significantly affect age at menarche when it is accompanied by a balanced intake of energy and macro-micronutrients. The principles of balanced nutrition and the assistance of nutritionists are needed in practicing a plant-based lifestyle, especially for children and adolescents who are still in the developmental stage.

Keywords: food fiber, menarche, phytoestrogens and isoflavones, plant-based diet, vegetable protein

INTRODUCTION

Menarche or first menstruation is a marker of puberty that is easy to remember. A menarche is an important event for a woman because it symbolizes physical and sexual maturity related to the ability to reproduce (Lacroix *et al.* 2022). In many countries, the average age at menarche is 11–13 years, for example, 11.71 years in Brazil (Barros *et al.* 2019), 12.3 years in Iran (Hozoori *et al.* 2017), 12.7 years in China (Duan *et al.* 2020), and 12.96 years in Indonesia (Sudikno & Sandjaja 2019).

Early menarche (menarche at the age of ≤10 years) or late menarche (menarche at the age of >15 years) is known to have health impact both physically and psychologically (Lacroix *et al.* 2022). Women who experience early menarche are at risk of developing impaired adult asthma (Minelli *et al.* 2018), obesity, diabetes, breast cancer, cardiovascular disease (Yoo 2016), hypercholesterolemia (Petersohn *et al.* 2019), and short adult stature (Kang *et al.* 2019). Psychologically, early menarche can cause mental health problems and risky sexual behavior for unwanted pregnancies, as well as cause anxiety and stress (Trépanier *et al.* 2013; Yoo 2016). Conversely, late menarche also increases the risk of cardiovascular disease, cervical cancer, musculoskeletal disorders, the possibility of experiencing early menopause (Day *et al.* 2015), miscarriage, and the risk of fertility problems (Canelón & Boland 2020). Adolescent girls with delayed menarche, compared to their peers, will experience anxiety, depression and decreased intelligence (Day *et al.* 2015).

The occurrence of menarche is influenced by several factors, including nutrition (Nasiri *et al.* 2022) as a modifiable factor. Several studies (Hozoori *et al.* 2017; Barros *et al.* 2019) have shown that there is a significant relationship between the age at menarche and nutritional

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status, which is strongly influenced by food intake during the prepubertal period. Higher total fat intake and animal-based foods are associated with earlier age at menarche. Meanwhile, intake of vegetable protein, higher fiber, and dietary isoflavones are associated with delayed puberty (Vilamor & Jansen 2016; Duan *et al.* 2020).

A plant-based diet is widely recommended as a dietary pattern that is beneficial for health. A plant-based diet means choosing food intake that mostly comes from plants, but can also include consuming small amounts of animal-based foods such as meat, fish, milk, and eggs (Figueroa *et al.* 2021). People who tend to choose plant-based diets are potentially lower in energy, protein, fat, and some micronutrients than omnivores (Nugroho *et al.* 2015; Calcaterra *et al.* 2021). This condition can affect the time of menarche and have an impact on subsequent health. Sunuwar *et al.* (2010) in Nepal found that vegetarian diet could delay the onset of menarche. The average age at menarche in the vegetarian group (12.82±0.81 years) was older than non-vegetarians (12.68±0.95 years) (Sunuwar *et al.* 2010). Meanwhile, a literature review by Šetinc (2022) on the effects of vegetarian's macro and micronutrients intake on health concluded that there was no difference in the age at menarche between vegetarian and omnivorous women (Šetinc 2022). This systematic literature review aimed to obtain further learning related to the age at menarche and plant-based diet through diet patterns and its nutritional components such as vegetable protein, phytoestrogens/isoflavones, and dietary fiber.

METHODS

Design, location, and time

This study was a systematic review from systematic article search results on Medline (EBSCO), Embase, Health & Medical Collection (ProQuest), Scopus, and Google Scholar. The inclusion criteria were articles regarding plant-based diets or vegetarianism and age at menarche/puberty from academic journals published in English between January 2000 and September 2022. Meanwhile, the exclusion criteria were publications that had no relevance to the research questions, such as articles on dysmenorrhea, breast cancer, menopause, etc. Article searches were limited to primary research articles and did not include review articles. Paid articles were also not included in this systematic review.

Data collection

The question of this research was how prepubertal plant-based diet influences the age at menarche. It was rendered into the concept of data search with the PICO framework consisting of P/Population, which was children or adolescents; I/Intervention/Exposure, which was the intake of plant-based diets; C/Comparison, which was animal-sourced/omnivorous food; and O/Outcome, which was the age at menarche/puberty. Articles identification was using the Boolean Operator OR/AND with the main keywords of plant-based diet or vegetarian and the age at menarche with their synonyms, which could be found with the help of the controlled vocabulary feature on EBSCO, Embase, and ProQuest.

Data analysis

Research data were presented in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 flowchart (PRISMA 2020). Article search results were imported into the reference manager application and duplication checks were carried out. Next, the articles with title and abstract that did not meet the PICO criteria through the team's assessment were excluded from the study. By reading the full texts, articles were filtered according to the inclusion and exclusion criteria. The remaining articles were assessed for the quality of their studies using the Joanna Briggs Institute (JBI) Critical Appraisal Tools (JBI 2020) according to the research methodology used in the article with a JBI cut-off final score of >50%. Then the selected articles were extracted into the table to facilitate data synthesis. The analysis was done descriptively and result synthesis was performed by comparing the findings between the articles. To facilitate analysis, articles containing similar intervention/exposure to plant-based diet components were grouped. The effects of a plant-based diet on menarcheal age were classified as accelerating/delaying menarcheal age or no relationship between a plant-based diet and menarcheal age.

RESULTS AND DISCUSSION

The process of collecting data that met the inclusion criteria in 5 electronic databases

resulted in 673 articles. After deleting duplicate articles, 615 titles and abstract were screened according to the PICO criteria, leaving 27 articles to be assessed for eligibility. Based on the full texts that had been reviewed, 15 articles were excluded because the articles did not include the age at menarche/puberty as an outcome (n=6), the articles were not primary research articles (n=6), and the full text of the articles could not be accessed (n=3). Of the remaining 12 articles, it was found that there were no articles that had a final JBI score of less than 50%, so the 12 articles were included in this systematic review (Figure 1).

This study included all types of primary research articles published in academic journals. Of the 12 articles that had been studied, there were 9 cohort studies, including nested case-controls studies, and 3 cross-sectional studies published between 2002–2022. Most of the studies were conducted in the United Kingdom (4 studies), Germany (2 studies), and the United States of America (2 studies), with the rest conducted in Canada, China, India, and Israel (1 study each). Based on the interventions/exposures presented in the article, the researchers highlighted the age at menarche as an outcome of plant-based

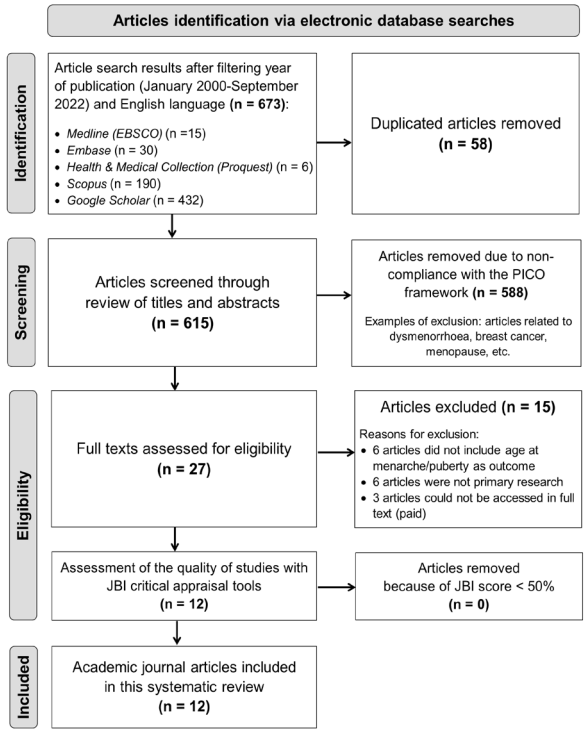

Figure 1. Flowchart of preferred reporting items for systematic reviews (PRISMA 2020)

diet through a prepubertal vegetarian diet and Mediterranean diet, intake of phytoestrogens and isoflavones, vegetable protein, and dietary fiber (Table 1).

The results of this systematic review showed variations in the data, as shown in Table 1. There were 4 out of 12 articles that provided more than one conclusion regarding the effect of a prepubertal plant-based diet on the age at menarche/puberty. Most of the articles (9 articles) stated that there was no effect of a plant-based diet on the age at menarche. However, 4 articles reported delayed puberty related to a plant-based diet and 3 articles stated otherwise. Variations in the results of these studies may be due to differences in research methods, sample size, and the presence of confounding factors that influenced the onset of menarche, such as nutritional status, energy intake, intake of other macronutrients and micronutrients, as well as other factors other than nutrition. In the next paragraphs, the findings will be discussed in groups of several articles that have similar interventions/exposures.

Vegetarian diet and age at menarche

Vegetarian diet is a type of plant-based diet that limits animal-based product intake. Vegetarian diet patterns may vary, but the most commonly used definitions include vegan diet, which is a pure, plant-based diet that completely avoids all types of animal products, and vegetarian diet, which still includes the consumption of eggs (ovo-vegetarian diet) or dairy products (lacto-vegetarian diet) or eggs and milk (lacto-ovo vegetarian diet) (Calcaterra *et al.* 2021).

This systematic search found two articles that studied the effect of a vegetarian diet on the age at menarche. Choudhary *et al.* (2015) conducted a cross-sectional study in India on 100 female students (45 vegetarians, 25 ovo-vegetarians, and 30 non-vegetarians) aged 19–25 years to discover the role of different dietary habits on age at menarche. This study found that there was no significant relationship between vegetarian and ovo-vegetarian dietary habits and the age at menarche, while the non-vegetarian group tended to have early menarche. However, this study had limitations because the subjects were only in a small group. Studies in larger populations are needed to confirm these findings (Choudhary *et al.* 2015).

Table 1. Research data extraction

Author and year of publication	Country	Methods	Sample size[a]	Intervention/ Exposure	Outcome	Results		
						Accelerate the age of menarche/ puberty	Delaying the age of menarche/ puberty	No relationship between exposure and outcome
(Choudhary *et al.* 2015)	India	Cross-sectional study	n=100 (female students aged 19–25 years)	Eating habits (vegetarian, eggetarian, and non-vegetarian)	Age of menarche	p≤0.05 in non-vegetarian diet (compared with vegetarian and eggetarian)	-	p>0.05 in vegetarian and ovo-vegetarian diet
(Rosell *et al.* 2005)	UK	Cross-sectional study	n=35,720 (women aged ≥20 years of the general population, including 12,705 vegetarians)	Vegetarian diet (time when starting a vegetarian diet)	Age of menarche	p≤0.01 in women who became vegetarian at age 10–14 years (compared with age ≥20 years)	-	p>0.01 (no difference between life-long vegetarian women and women who became vegetarian at age ≥20 years)
(Cheng *et al.* 2021)	UK	Longitudinal cohort study (followed from birth to age 17 years)	n=3,919 (girls from general population)	Food intake (type of vegetable/ animal protein)	Onset of female puberty	-	-	p>0.05 (no variation according to the type of protein intake)
(Günther *et al.* 2010)	Germanny	Longitudinal cohort study (followed from birth to age 13 years)	n=112 (children from general population, including 57 girls)	Vegetable protein intake	Onset of puberty	-	p<0.05 in high intake of vegetable protein at the age of 3–4 years (p=0.02) and 5–6 years (p=0.04)	-
(Rogers *et al.* 2010)	UK	Cohort study (followed from birth to age 12 years and 8 months)	n=3,298 (girls from general population)	Food intake	Age of menarche	p≤0.01 in high vegetable consumption at age 3 years	-	p>0.01 in vegetable protein intake
(Sinai *et al.* 2019)	Israel	Nested case-control study (followed from birth to age 3 years for exposure and monitored again at age 8–12 years for outcome)	n case=29 (children with soy-based formula), n control=60 (children from general population)	Soy intake (soy-based formula)	Onset of puberty	-	-	p=0.95 (no difference in the age of puberty in the case group and the control group)

Continue from Table 1

Author and year of publication	Country	Methods	Sample size[a]	Intervention/ Exposure	Outcome	Results		
						Accelerate the age of menarche/ puberty	Delaying the age of menarche/ puberty	No relationship between exposure and outcome
(Segovia-Siapco *et al.* 2014)	USA	Cross-sectional study	n=327 (female students aged 12–18 years)	Soy intake	Age of menarche	-	-	p=0.77 (no difference between the lowest and the highest quartile level of total soybean consumption)
(Adgent *et al.* 2012)	UK	Longitudinal cohort study (followed from birth to age 14.5 years)	n=2,920 (girls from general population)	Soy based baby feeding	Age of menarche	p<0.05 (compared to breast milk or non-soy formula)	-	-
(Xiong *et al.* 2022)	China	Prospective cohort study (followed up for 5 years)	n=2,152 (female students aged 6–8 years)	Soy and fiber intake	Onset of female puberty	-	p=0.03 (high intake of soy)	p=0.06 (total fiber intake)
(Cheng *et al.* 2010)	Germany	Subcohort (followed from birth to age 14 years)	n=119 (girls from general population)	Intake of isoflavones and dietary fiber	Onset of female puberty	-	p=0.04 (isoflavone intake on breast development)	p=0.2 (isoflavone intake on age of menarche) p=0.6 (fiber intake on puberty)
(Koo *et al.* 2002)	Canada	Prospective cohort study (followed up for 3 years)	n=589 (girls from general population aged 6–14 years)	Dietary fiber (and cellulose) intake	Age of menarche	-	p=0.0269 (the highest fiber intake group compared to the lowest fiber intake group)	-
(Szamreta *et al.* 2020)	USA	Longitudinal cohort study (followed up for 2.5 years)	n=202 (girls from general population aged 9–10 years old)	Mediterranean diet (high in fiber-rich plant foods and fish, but low in red meat)	Age of menarche	-	p<0.01 (high adherence compared to low adherence to a Mediterranean-like diet)	-

[a]n: The number of samples that produce research outcomes (age of menarche/female puberty)

Another study was conducted by Rosell *et al.* (2005) in the United Kingdom that compared the age at menarche in a group of vegetarians who started a vegetarian diet at different ages and a group of non-vegetarians. The study, using data from the EPIC-Oxford cohort involving 35,720 British women aged over 20 years, proved that there was no significant difference between the ages at menarche in the vegetarian group for life (since before the age of 1 year) and in the group of vegetarian after age 20 with assuming this group had experienced menarche before becoming

vegetarian. However, the age at menarche was found to be 0.2 years lower in women who became vegetarians around the onset of puberty (10–14 years) than in women who became vegetarian after age 20 ($p<0.01$), but the authors did not explain the cause of this difference (Rosell *et al.* 2005).

Both studies concluded that there was no relationship between vegetarian dietary habits and menarcheal age. The vegetarian diet is determined by the components and variety of food consumed. If there is a balance of energy and macro- and micronutrients, a vegetarian diet may not affect the age at menarche (Calcaterra *et al.* 2021).

Mediterranean diet and age at menarche

Similar to the vegetarian diet, the Mediterranean diet is high in plant-based foods such as fiber-rich whole grains, vegetables, fruit, nuts, and fish, but limits red meat and processed foods. Szamreta *et al.* (2020) studied the relationship between Mediterranean diet and age at menarche in the United States of America through the Jersey Girl Study, a longitudinal cohort study of 202 girls aged 9–10 years. Dietary intake was assessed using the 24-hour Food Recall method for at least 3 different days and grouped them into high, medium, and low Mediterranean Diet Scores. Data on the age at menarche were asked annually and monitored for an average of 2.5 years. Higher adherence to the Mediterranean diet was associated with older age at menarche after controlling for body mass index, body composition measures, and fat distribution. This association might be influenced by higher consumption of vegetables and non-fat or low-fat dairy products. Szamreta *et al.* also highlighted the role of higher sex hormone-bound globulin and lower levels of endogenous estrogen in Mediterranean diet that might result in delayed onset of puberty (Szamreta *et al.* 2020).

A literature review on the role of prepubertal nutrition on the timing of puberty provided reasons for possible causes of menarche delay in followers of a plant-based diet. There is a risk of malnutrition if micronutrient needs are not considered. It can cause developmental disorders in children, including disorders of puberty (Calcaterra *et al.* 2021)

Vegetable protein intake and age at menarche

A longitudinal cohort study in Germany (Günther *et al.* 2010) reported that a higher intake of vegetable protein in childhood was associated with delayed puberty. Günther *et al.* (2010) studied 112 children using data from the Dortmund Nutritional and Anthropometric Longitudinally Designed Study (DONALD Study) which assessed food intake with a 3-day weighted food diary at the age of 12 months, 18–24 months, 3–4 years, and 5–6 years. Puberty-related data were collected from 5 to 13 years of age in girls (n=57). Higher vegetable protein intake at the age of 3–4 years was associated with delayed puberty which was described as a pubertal growth spurt ($p=0.02$). Although the data were not presented in the article, age at menarche was also investigated as another marker of puberty and showed similar results (Günther *et al.* 2010).

A different opinion was conveyed in two studies in United Kingdom (Rogers *et al.* 2010; Cheng *et al.* 2021) that used population-based cohort data from The Avon Longitudinal Study of Parents and Children (ALSPAC). Rogers *et al.* collected FFQ data when the children were 3 and 7 years old, followed by a 3-day food diary when the children were 10–11 years old. Data related to the age at menarche (n=3,298) were collected once when the children were on average 12 years and 8 months old as a limit to whether the child had menarche or not (Rogers *et al.* 2010). Meanwhile, Cheng *et al.* used the FFQ on children aged 3, 4, 7 years, and a 3-day food diary when the children were 7.5 years old. Data on the pubertal development of children were collected using repeated questionnaires every year throughout the children's 8–17 years of age. Menarche in girls (n=3,919) was reported as exact date and/or age in years at which menarche has occured (Cheng *et al.* 2021). The results of both studies showed that there was no significant relationship between vegetable protein intake and menarcheal age (Rogers *et al.* 2010; Cheng *et al.* 2021). The type of protein intake, whether animal or vegetable protein intake, does not cause pubertal age variations if total energy intake and intake of other macronutrients are also considered (Cheng *et al*. 2021).

Phytoestrogen/isoflavone intake and age at menarche

Vegetarian groups often include soy foods as a source of high-quality protein in their daily diet to replace meat. Soybeans contain high concentrations of isoflavones, one of the

main groups of phytoestrogens. Phytoestrogens are plant compounds that are structurally and functionally similar to endogenous estrogens so that they can also influence the sexual maturity of children (Jefferson *et al.* 2012; Segovia-Siapco *et al.* 2014; Xiong *et al.* 2022).

Adgent *et al.* (2012) studied the effect of soy-based infant feeding on the age at menarche. Using ALSPAC data, 2,920 girls were studied longitudinally. About 2% of mothers reported that they introduced soy products into their baby's diet as early as at or before 4 months of age. Compared with girls who were given breast milk or non-soy-based milk, girls who were given soy milk early were 25% more likely to experience menarche during the follow-up period (HR 1.25; 95% CI; 0.92–1.71) (Adgent *et al.* 2012).

However, different results were found by Sinai *et al.* (2019) in Israel who also examined the consumption of soy-based formulas. A nested case-control study of a prospectively followed cohort studied 29 children fed a soy-based formula and 60 children randomly selected as controls. Eating habits were followed from birth until the children were 3 years old, then when the children were 7.8 and 10.5 years old. Nutritional intake was re-evaluated using a food diary for 3 days and a physical examination related to signs of puberty was conducted. The results of the study found that there was no relationship between the consumption of soy-based formulas and the onset of puberty (Sinai *et al.* 2019).

Segovia-Siapco *et al.* (2014), through a cross-sectional study of 339 girls aged 12–18 years in the United States of America, also found no relationship between soybean consumption and the age at menarche. Dietary intake was assessed using a web-based FFQ that grouped 36 types of soy foods from a total of 151 foods. The data analysis showed that there was no significant difference in median age at menarche between those in the lowest quartile and the highest quartile of total soy consumption levels (12.67 years and 12.58 years, respectively) after adjusting for energy levels (Segovia-Siapco *et al.* 2014).

Contrary to previous findings, cohort studies in China (Xiong *et al.* 2022) and Germany (Cheng *et al.* 2010) found that girls with high intakes of isoflavones in prepubertal age actually entered puberty at an older age. Research by Xiong *et al.* (2022) with 2,152 subjects resulted in data on an increase in the age of menarche in girls who consumed 57.2 g of soybeans per day compared to in girls who only consumed 1.6 g of soybeans per day (13.1 years vs. 12.5 years; p=0.03). Research by Cheng *et al.* (2010) on 119 girls also found that girls on a high total isoflavone diet experienced about 8 months slower breast development compared to girls on a low total isoflavone diet (p=0.04). However, data on the age at menarche did not show an association with total dietary isoflavones (p=0.2) although there was actually an increase in age at menarche to 13 years in the group with a high total isoflavone diet, while in the group with a low total isoflavone diet, age at menarche was 12.6 years (Cheng *et al.* 2010). The inconsistency of the findings of the two menarcheal age studies was probably due to differences in samples size and differences in isoflavone intake level, which was higher in the study in China. A higher concentration of isoflavones may be needed to influence the incidence of menarche (Cheng *et al.* 2010; Xiong *et al.* 2022). Meanwhile, the explanation given regarding the delay in puberty is not fully known. It was suspected that the isoflavone can bind directly to the estrogen receptor and cause an antiestrogenic effect that can inhibit the enzyme for the formation of the hormone estrogen (Cheng *et al.* 2010; Xiong *et al.* 2022).

A literature review on the relationship between phytoestrogen intake and the timing of puberty stated that the timing of exposure to phytoestrogens was related to different body developments. Exposure to phytoestrogens since early prepuberty when endogenous estradiol levels were low might influence the incidence of early puberty, whereas exposure to phytoestrogens in later periods might interfere with endogenous estrogen-mediated puberty because of weak estrogen receptor agonist activity (Jefferson *et al.* 2012).

In general, intake of phytoestrogens/ isoflavones did not show a relationship with menarcheal age. Its influence on the age at menarche depends on how much the concentration level and timing of exposure in the prepubertal period. Intake of high concentrations of phytoestrogens or isoflavones at the end of the prepubertal period can delay menarche.

Dietary fiber intake and age at menarche

Dietary fiber is naturally provided by various foods such as grain products, vegetables,

and fruit, which are the main foods for vegetarians. A prospective cohort study conducted in China (Xiong *et al.* 2022) on 2,152 girls aged 6–8 years found that fiber intake was not significantly associated with the timing of puberty. Similar findings were reported in a subcohort study of 119 girls in Germany (Cheng *et al.* 2010). However, a previous study in Canada which examined 637 girls aged 6–14 years prospectively found that intake of dietary fiber and cellulose in the prepubertal period was associated with later age at menarche (Koo *et al.* 2002). Food intake was assessed using a semi-annual FFQ questionnaire for 3 years and the age at menarche was also asked during that period. The results showed that the risk of experiencing menarche in the group with the highest fiber intake (>25.5 g per day) was only about half (HR=0.54; 95% CI:0.31–0.94) compared to the group with the lowest fiber intake (<18.2 g per day). An increase in dietary fiber intake was thought to reduce the availability of circulating estrogen in the body caused by increased estrogen removal through feces along with fiber. It would affect the development of puberty, including menarche (Koo *et al.* 2002).

An interesting point was reported by Rogers *et al.* (2010) in a cohort study in UK. They found weak evidence that higher consumption of vegetables at 3 years of age was positively related to the incidence of menarche. Girls who consumed 14 or more servings of vegetables per week at 3 years of age were 37% more likely (OR=1.37; 95% CI:0.96–1.94) to have experienced menarche before 12.8 years of age than girls who consume less than 3 servings of vegetables per week. Explanations for these findings were not clearly stated, but similar things were not found in association with food intake at an older age, so it could be assumed that dietary intake during early to mid-childhood might be more strongly associated with the incidence of menarche than dietary intake during late childhood before menarche (Rogers *et al.* 2010).

Dietary fiber intake also does not show a definite relationship with menarcheal age. Fiber intake in the early prepubertal period will accelerate menarche, but high dietary fiber intake can delay the onset of menarche.

This systematic review was limited to searching for articles in English, so it may not include similar research from other countries. In this study, there was a possibility of bias in concluding due to the many confounding factors in the relationship between a plant-based diet and menarcheal age. However, this paper has the strength of reviewing the effects of a plant-based diet through its various nutritional components. Currently, the plant-based diet is increasingly in demand, so further research is needed to provide evidence-based on the pattern of relationship between plant-based diets during the prepubertal period and the age at menarche.

CONCLUSION

The results of this systematic review of 12 articles collected from 5 electronic databases indicated variations in the data. The components and types of food consumed, how much the concentration level, and the timing of exposure to plant-based diets in the prepubertal period also affect the time of menarche/puberty. In general, it can be concluded that a plant-based diet did not show a significant relationship with the age at menarche when accompanied by a balanced intake of energy and macro- or micronutrients. The principle of balanced nutrition by consuming a variety of foods must still be considered and the assistance of a nutritionist is needed in practicing a plant-based lifestyle, especially for children and adolescents who are still in the developmental stage.

DECLARATION OF INTERESTS

The authors have no conflict of interest.

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