HOW DOES WEIGHT INFLUENCE THE TIMING

OF PUBERTY ONSET IN

FEMALE ADOLESCENTS?

A Scholarly Project Submitted in Partial Fulfillment of

The Requirements for the Degree of

Master of Science in Nursing In

The Onanian School of Nursing

Rhode Island College

April 24, 2023

by

Jennifer Blake

MSN Scholarly Project Team

____

MSN Scholarly Project Advisor

____

MSN Scholarly Project Content Expert

____

MSN Scholarly Project Organizational Mentor

____MSN

Program Director

HOW DOES WEIGHT INFLUENCE THE TIMING OF PUBERTY ONSET IN FEMALE ADOLESCENTS?

A Scholarly Project Submitted in Partial Fulfillment of

The Requirements for the Degree of

Master of Science in Nursing in

The Onanian School of Nursing

Rhode Island College

April 24, 2023

by

Jennifer Blake

Acknowledgements

I would like to acknowledge and thank my adoring husband, Justin. Without his encouragement, love, and support, I would not be capable of achieving my goals. I recognize all the sacrifices he has made to support my dreams and he is appreciated more than he knows. Also, my children, Jaxson and Mackenzie for being so resilient and understanding when mommy was unable to give them all the attention they deserved. You are both amazing and I am so proud of the people you are becoming. Special thank you to my readers who have read this paper nearly as many times as I have, your guidance and knowledge through this process has been a blessing.

Abstract

Background: The early onset of puberty poses threats to a child's social, emotional, and physical well-being including an increase in the risk of developing chronic conditions. Studies have shown an increased incidence of type 2 diabetes, cardiovascular disease, and breast and endometrial cancers for adults who experienced menarche earlier than their peers (Villamor & Jansen, 2016). Data has shown most females of higher weight have experienced menarche at younger ages than those of lesser weight.

Purpose/Specific Aims: The purpose of this systematic review was to investigate the influence of weight, on the timing of puberty onset in adolescent females.

Methods: A systematic review was conducted for articles comparing the onset of menarche and weight in females using EBSCOHost, Google Scholar, and CINAHL Plus. Inclusion criteria included female participants, menarche as the determining factor for onset of puberty, written in English in the last ten years, early onset puberty, and obesity, overweight, or elevated BMI as an influencing factor. Only articles using the onset of menarche as the determining factor for the onset of puberty were included.

Results: The initial search yielded 35 studies; four met the inclusion criteria for this review. No randomized control studies met inclusion criteria. Commonalities between studies included a higher incidence of earlier menses in females with higher amounts of adipose tissue, higher BMIs, increased dietary fat, and/or higher prepubescent weights. Limitations of this study include, but are not limited to, recall bias for age of menses, age of menses often reported in whole years rather than exact age, and limited sample size.

Conclusion: Results of this study show an association between increased prepubescent weight in females and earlier onset of menarche. Considering these findings, efforts should be made to decrease the prevalence of childhood obesity and the risk of early menarche.

Key Words: early menstruation, menses, early puberty, central precocious puberty, obesity, overweight, obese, high BMI, risk factors, contributing factors, environmental factors, and long-term effects.

Table of Contents

HOW DOES NUTRITION INFLUENCE THE TIMING OF THE ONSET OF PUBERTY IN FEMALE ADOLESCENTS?

Background and Significance

The early onset of puberty can pose threats to a child's social, emotional, and physical well-being. Implications of early onset puberty can include, but are not limited to, adolescent alcohol abuse, tobacco use, earlier sexual activity, sexually transmitted infections, teen pregnancy, poor academic performance, type 2 diabetes, cardiovascular disease, and breast and endometrial cancers (Villamor & Jansen, 2016). Consideration of these potentially life threatening, adverse consequences, are highly relevant from an endocrinological and public heath standpoint (Cheng et al., 2012).

Precocious puberty, in females, is defined as breast development occurring prior to the age of 8 years. Early puberty is defined as the onset of pubertal changes between the ages 8 and 9 years of age (Kim et al., 2016). This study investigated the influence of weight, on the timing of puberty onset, defined by menarche, in adolescent females.

Multiple studies have been conducted from the 1960s to present, comparing the increasing rate of obesity among prepubescent females with the decreasing age at which females are experiencing the onset of puberty. Studies have reported that puberty has begun between the ages of 7 and 10 for girls, dependent on the research article being referenced (Burkhart, 2012; Cheng et al., 2012; Jansen et al., 2018; Kim et al., 2018; Villamor & Jansen, 2016). Burkhart (2012) found that young females are beginning to experience puberty between 7 or 8 years of age. The Center for Disease Control and Prevention (CDC) reported a decrease in the median age for menarche between 1995 and 2017. Data showed a median age of 12.1 years in 1995 compared to a decreased median age of 11.9 years consistently from 2013 to 2017. From 2013 to

2017 half of the participants had reached menarche by the age of 11 years and 10 months (Martinez, 2020). The possible environmental causes linked to the earlier onset of puberty have been studied. One environmental factor that has been identified and studied is the influence of a diet high in fat on the timing of puberty (Cheng et al., 2012).

External factors that may be attributed to the timing of sexual development were initially studied with animal experimentation in the 1960s. In the 1970s, Frisch et al., noted a correlation between an individual's attained weight and the onset of menarche (Villamor & Jansen, 2016). Further studies have shown that girls with higher adiposity during childhood have had a consistent link with earlier menarche. A study which followed 856 infants found that higher weight gains from age 0 to 2 years of age coincided with a higher incidence of earlier menarche compared to children with lower weight gains (Villamor & Jansen, 2016).

In 1971, Frisch hypothesized that a higher body mass index (BMI) was associated with the earlier onset of puberty in girls. Frisch's study showed adolescent females with lower body fat percentages and BMI experienced a delayed onset of puberty. For example, elite gymnasts and ballet dancers often experience a later menarche than their less physically fit peers (Villamor & Jansen, 2016).

With the incidence of childhood obesity nearly doubling between 1985 and 2015, the rate at which young females are experiencing precocious puberty has also increased. In 1980, only 7% of children aged 6 to 11 years were obese compared to 18% of children in this age group in 2012 (Maron, 2015). The CDC reports that childhood obesity for children ages 6 to 11 years was 20.3% in 2017-2018 (Centers for Disease Control and Prevention [CDC], 2022). With obesity rates among children and the incidence of precocious puberty steadily rising, children are at an increased risk of developing future chronic diseases in adulthood (Maron, 2015).

Literature Review

Etiology/Epidemiology

Puberty, a naturally occurring event during the human aging process, represents the hormonal, physical and psychological transition adolescent children experience while crossing into adulthood (Villamor & Jansen, 2016). The exact catalyst which activates the pubertal process remains idiopathic, although multiple studies have speculated on environmental, genetic, metabolic, cultural and/or ethnic causes for altering the onset time for puberty (Villamor & Jansen, 2016).

Hormonally, the excretion of gonadotropin releasing hormone (GnRH) by the pituitary serves as a trigger for the induction of puberty and a cascade of events follows, including the activation of the hypothalamic-pituitary-gonadal (HPG) axis which increases the secretion of GnRH and initiates the secretion of luteinizing hormone (LH) and follicle stimulating hormone (FSH). Finally, gonadal steroids are released which promotes gametogenesis (Villamor & Jansen, 2016). Norris (2019) defines gametogenesis as the process cells undergo to form gametes or reproductive cells (i.e., sperm and ovum).

Central precocious puberty (CPP) is the term used when the onset of puberty occurs earlier than normally observed within the population. Cheuiche et al. (2021) defines "normal" as the age when 95% of the population of children present with Tanner stage II. Tanner stage II is defined as the breast maturity level in girls where a small rise of breast tissue and widening of the areola occurs (Jarvis & Eckhardt, 2020). Throughout their study, the researchers found the most often used timeframe for CPP was before 8 years of age for females.

The following are studies showing CPP predominantly occurs in females. An incidence study conducted in Spain, revealed that females were ten times more likely to experience CPP than males (Chen & Eugster, 2015). Jansen et al. (2018) reported an even higher incidence of precocious sexual maturation with a ratio of 15-20 girls for every boy. The primary cause of CPP is often considered idiopathic. Up to 75-90% of girls have no known reason for the early onset of puberty (Jansen et al., 2018).

Clinical Manifestations

Biologically born females transition through three stages of puberty. The initial stage, thelarche, is when breast development occurs. Thelarche is classified using the Tanner Staging tool, which identifies five stages of breast development. Tanner stages have shown to be influenced by race, ethnicity, and body mass index (BMI). Average breast development onset varies depending on ethnicity occurring at 8.8 years for African Americans girls, 9.2 years for Hispanic girls, 9.6 years for Caucasian girls, and 9.9 years for Asian girls. (Jarvis & Eckhardt, 2020).

The second stage of female adolescent puberty, pubarche, is when the development of pubic hair occurs. This stage typically coincides with Tanner stage II-III (Chen & Eugster, 2015). In stage II, hair growth is sparse, long, thin, and only slightly curly. Hair is located primarily on labia. Consistent with breast maturation, pubarche rating is also influenced by race (Jarvis & Eckhardt, 2020).

The third and final stage of adolescent puberty for females is menarche which typically coincides with Tanner stage IV. Menarche generally follows about 2 years after the onset of thelarche (Jarvis & Eckhardt, 2020). This stage is the beginning of oocyte maturation and release from the ovary during ovulation. Menstruation is the act of shedding the endometrial lining.

Effects of Central Precocious Puberty

Studies of the effects of the earlier onset of puberty have shown these female adolescents are at increased risk for many physical, psychosocial, and mental health conditions. These risks include, but are not limited to, obesity, diabetes, cardiovascular disease, cancer, sexually transmitted infections, pregnancy, smoking, alcohol use, drug use, sexual promiscuity, depression, poor academic performance, and eating disorders (Jae-Ho Yoo, 2016; Martinez, 2020; Villamor & Jansen, 2016).

Early Onset Physical, Psychosocial and Mental Health Risks

The National Health Statistics report from the Department of Health and Human Services (DHHS) reports that an earlier age of menarche may result in female's experiencing their first sexual intercourse earlier (Martinez, 2020). This is attributed to the females appearing older therefore having older friends, leading them to engage in negative behaviors (Martinez, 2020).

A meta-analysis conducted in Korea showed that young females with early onset puberty were more likely to engage in sexual intercourse, noncoital sexual behavior (petting, kissing, caressing, and oral sex), and risky sexual behavior including unplanned pregnancy, STI's, human immunodeficiency virus, unsafe sex, and use of drugs/alcohol during sex (Jae-Ho Yoo, 2016). Additional findings from the study conducted in Korea found that girls who experienced menarche prior to or during the 4th grade had an increased prevalence of intimate sexual relationships at 1.54 times higher {95% confidence interval [CI] 1.28-1.87}, sexual intercourse at 2.35 times higher {95% CI, 1.65-3.36}, unprotected intercourse at 1.92 times higher {95% CI, 1.06-3.46}, and pregnancy at 5.72 times higher {95% CI, 2.31-14.15} as compared to those who experienced menarche after the 5th grade. (Jae-Ho Yoo, 2016).

Frank M. Biro, a board-certified medical doctor in internal medicine, pediatrics, and adolescent medicine, of Cincinnati Children's Hospital Medical Center made a compelling statement concerning early puberty and its impact on a young girl's social well-being. He stated, "We interact with girls as they appear …people relate to an early-maturing girl as if she is older than she is, but there is really no correlation between age of onset of puberty and one's emotional maturation." This can create a confusing social life faced with sexual innuendo's or teasing before they are mentally mature enough to understand the intent and meaning or defend themselves (Maron, 2015).

Chronic Long-Term Physical Health Risks

Results from a meta-analysis review by Jae-Ho Yoo (2016) utilizing data from the fourth Korean National Health and Nutrition Examination Survey showed women between the ages of 20 and 50 years who had type 2 diabetes were 3.61 times higher {95% CI, 1.90-6.88} to have experienced menarche before the age of 12. The author also found that middle aged women whose menarche was before the age of 12 were 1.83 {95% CI, 1.38-2.44} times more likely to experience central obesity, defined as waist circumference >85 cm, 2.02 {95% CI, 1.55-2.64} times more likely to experience obesity, defined as BMI >35 kg/m2, and 1.80 {95% CI, 1.33-2.45} times more likely to experience insulin resistance.

As reported by Jae-Ho Yoo (2016), the Kangwha cohort study conducted between 1985 and 2005 compared cardiovascular disease risk between women who experienced menarche after the age of 17 and those who had menarche between 10 and 16 years of age. The study revealed that women who had menarche after the age of 17 were 51% less likely to experience coronary heart disease mortality. A cohort study conducted from 1976-1998 concerning ischemic heart disease and stroke and its' correlation with menarche at the age of 11, demonstrated a reduction in total mortality by 4.5%, ischemic heart disease mortality by 6.0% and stroke mortality by 8.6% when menarche was delayed by 1 year (Jae-Ho Yoo, 2016).

The risk of breast and endometrial cancer was studied among females who experienced menarche at a younger age. A meta-analysis of 117 epidemiological studies, including over 110,000 women revealed that the incidence of breast cancer was increased by 5% when menarche was 1 year earlier than the average menarcheal age of 12-14 years. The risk for endometrial cancer was studied through a meta-analysis of eight prospective studies which included 4,553 individuals diagnosed with endometrial cancer. The results revealed that the endometrial cancer risk in the group with the highest menarcheal age of greater than 15 years, was 32% lower. Compared with the group who had lower menarcheal age of less than 11 years, the study confirmed the decrease in cancer risk was 4% when menarche age was increased by 2 years over the average (Jae-Ho Yoo, 2016).

Causes of Precocious Puberty

Multiple theories exist to explain the decrease in age for the beginning of puberty for young female adolescents. Numerous risk factors for CPP have been associated with various environmental exposures. The risk of these exposures, a public health concern, could be minimized through community interventions. (Martinez, 2020; Villamor & Jansen, 2016). Environmental exposures include the increased use of pesticides and endocrine-disrupting chemicals such as bisphenol A (BPA) found in plastic materials. The National Toxicology Program of the US Department of Health and Human Services (DHHS) found concern that BPA may alter the timeline for puberty in females, causing earlier onset. Although the 2008 report found “minimal” concern, there remains a need to further investigate. (Burkhart, 2012). BPA has been stated to mimic the effects of estrogen in a prepubescent female's body which can potentially stimulate early breast development (Maron, 2015).

The consumption of animal proteins has been investigated as a causal agent for precocious puberty. A descriptive, cross-sectional study conducted in Saudi Arabia found that diets absent of chicken and beef were associated with a delayed onset of puberty and menarche (Shahatah et al., 2021). Another study further investigated this theory and found consumption of animal protein by young girls between the ages of 3 and 7 years old had a strong influence on the onset of menarche. Researchers concluded the correlation was due to steroid hormone residues in nonorganic poultry (Shahatah et al., 2021).

In contrast, studies have shown that diets high in vegetables versus diets high in meat protein delay the onset of puberty. A systematic review revealed in a study conducted with 112 German children with a diet high in vegetable protein at 3-4 and 5-6 years of age, correlated with a later pubertal growth spurt, increased height peak, and age at menarche (Jansen et al., 2018). The same systematic review discussed a study with 67 females from the US that found a correlation between high consumptions of vegetable proteins between the ages of 3 to 5 years old and later menarche age (Jansen et al., 2018). Theories by Peng et al. (2017) explain this correlation being due to the increased intake of cadmium through vegetables. Cadmium has been shown to delay sexual maturation in some studies (Jansen et al., 2018). The presence of fiber, phytoestrogens isoflavones, and enterolactone found in vegetables have shown a delay on the age of menarche or breast development among female adolescents also (Jansen et al., 2018). These studies do not include the factors that concern higher weight with a lower age of menarche but they do trend towards a connection between a higher weight influencing CPP.

Research has been conducted to investigate a correlation between breast fed girls and the onset of puberty. As reported in a 2016 systematic review by Villamor and Jansen, in 2016, a study by Maron in 2015 with 1,200 girls found that breast feeding correlated with a delayed onset of breast development in some populations. Evidence, however, remains inconclusive, as the results of the other studies are scattered and do not prove or disprove the theory of breast feeding altering pubertal onset. Longitudinal studies have yielded inconsistent results. An investigation of children in Hong Kong, Germany, Great Britain, and the midwestern United States found no independent relationship between breast feeding practices and the age of menarche (Villamor & Jansen, 2016). Studies supporting the hypothesis include an investigation of 219 Korean children who were breastfed for 6 months or more with findings that showed these girls were less likely to reach Tanner stage II or more by the age of 9. Additionally, a prospective study of 994 Filipino girls showed that for every month of exclusive breast feeding, a 6% lower probability of menarche was achieved (Villamor & Jansen, 2016).

Obesity

Most recent studies reported by the CDC report obesity rates for children in the United States between the ages 6 years to 11-year-olds for 2017-2020 was 20.7%. Prevalence of obesity varied among Hispanic at 26.2%, non-Hispanic black children at 24.8%, non-Hispanic white children at 16.6%, and non-Hispanic Asian children at 9.0% (CDC, 2022). With the number of possible adverse health outcomes associated with precocious puberty, the timing of puberty has important public health ramifications. Multiple studies have revealed modifiable risk factors that may be amenable to interventions with obesity at the forefront.

One of the earliest landmark studies conducted on the relationship between weight and puberty onset was published in 1971 by Frisch and Revelle and is often referred to in recent studies. Frisch and Revelle hypothesized that the onset of menarche was related to the height and weight of females and nondiscriminatory to age. Researchers conducted a study documenting females height and weight at the time of menarche. The study revealed that the early maturing females had more weight for height in the year of starting menarche than those maturing within the average age range. The study also revealed the girls who experienced late menarche were significantly taller than girls with early menarche (Frisch & Revelle, 1971). The authors concluded that the age of menarche was highly variable among human populations but weight at the time of menarche appeared relatively homogenous. Further research by Frisch and Revelle, led to the hypothesis that puberty onset was triggered only when total body fat reached approximately 17%.

Hormonal Influences and Weight

Obesity and being overweight are thought to influence the onset of puberty through the development of insulin resistance. This resistance, subsequently, leads to an increase in circulating serum insulin and diminished levels of sex hormone binding globulin. This reaction then increases the bioavailability of estrogen and promotes thelarche (Shahatah et al., 2021). Similar to ovaries, fat cells are capable of producing the hormone estrogen, therefore increased fat cells promote increased estrogen excretion (Maron, 2015). Adiposity directly influences the level of peripheral estrogen production, resulting in higher concentrations in overweight and obese individuals. Adipose tissue serves as a site for extra-gonadal estrogen biosynthesis. Overweight and obese children show a higher circulating level of leptin which is the catalyst for the GnRH axis, responsible for controlling the development, reproduction, and aging. This occurs through the signaling of energy abundance through its interaction with kisspeptin and facilitates the initiation of puberty (Shahatah et al., 2021).

Purpose Statement and Specific Aims

The purpose of this systematic review was to investigate the influence of weight, on the timing of puberty onset in adolescent females.

Conceptual/Theoretical Framework

Pender's Health Promotion Model (HPM), a middle-range theory developed in 1982, was used. Pender's HPM incorporates surrounding influences that may impact a person's commitment to health improvement interventions (Polit & Beck, 2021, pp. 117-118). The components of the HPM are classified by three specific groupings: (a) individual characteristics and experiences, (b) behavior specific cognitions and affects, and (c) situational/interpersonal influences. Examples of individual characteristics could include gender, age, or genetics with experiences that could predict future behavior. These factors are typically not modifiable (Srof & Velsor-Friedrich, 2006). The behavior specific cognitions and affects grouping includes a person's perceived benefits or barriers to a behavior and self-efficacy. These factors are the focus of most HPM research. The situational/interpersonal influences are social and environmental contributors that mold healthy behavior (Srof & Velsor-Friedrich, 2006).

Khodaveisi et al. (2017) tested and explored the effect of Pender's HPM on improving nutritional behavior of obese woman. To satisfy the components of the HPM, the following criteria were met:

1. The study included women ranging from age 18-60 with a BMI of 25 or greater. The study took place in a town of western Iran called Hamadan. Hamadan had a high prevalence of overweight (33.7%) and obese women (15.8%).

2. Perceived barriers among the women in the Iranian community included the increased rate of woman being employed which forced an increased absence from home. This caused lifestyle and dietary changes, often leading the employed women to consume high calorie foods with low nutritional value.
3. The situational/interpersonal influences which contributed to the increased number of overweight women were unhealthy nutritional behaviors and increased frequency of eating at fast-food chains. These factors contributed to an increased risk of hypercholesterolemia, cardiovascular disease, type II diabetes, and certain cancers.

The study confirmed that Pender's HPM-based training can provide a positive impact on obese women's nutritional behaviors. Khodaveisi et al. recommended nutritional behavior modifications through promotion of education about nutrition to improve personal choices made concerning nutrition and health promoting behaviors. Additionally, the authors recommended that nutritional programs focused on nutritional behaviors, obesity, and prevalence of chronic disease should be conducted on television and mass media.

Standiford Brown (2009) conducted a systematic review utilizing Pender's HPM and the Physical Activity Lifestyle Model (PALM). The PALM is similar to the HPM but differs in that it is adapted specifically to the needs of adolescent females. The systematic review focused on the increasing incidence of overweight and obese children and adolescents. Data was collected from 14 articles which investigated the increasing number of obese and overweight children which lead to a higher prevalence of obesity in adulthood resulting in premature morbidity and mortality. Modeling the structure of the HPM, Standiford Brown included adolescent females aged 9-19 years in the study to investigate reported barriers from participants for adherence to behavior modifications to improve their health. Participants in the study reported that obstacles which altered their level of success in lifestyle modifications included a perception on how society believes a female adolescent body should appear and how participants may perceive their own body. How a participant perceived their level of physical conditioning, and their level of endurance were also identified as barrier in the study. The individual's level of dislike for the physical activity being conducted also contributed to creating a barrier. The situational/ interpersonal influence which contributed to a member's failure or success were sedentary behaviors. With increasing popularity of television, video games, and computers, the likelihood of adolescent obesity has increased.

Standiford Brown's results brought increased attention to the need for screening of students for sedentary lifestyles. This could be completed by pediatric and school nurses. Physicians can provide education and assist with setting goals or motivating and monitoring physical activity using a pedometer, to improve adolescents level of physical activity.

With research supporting the use of HPM, endorsements have been made toward promoting change "from the inside" rather than increasing encouragement for physical activity (Standiford Brown, 2009). The HBM has shown that compliance is more likely if self-acceptance improves. Discouraging daily weighing and using negative references to one's weight may lead to decreased body satisfaction and activities to encourage self-acceptance should be encouraged (Standiford Brown, 2009).

Methods

Purpose

The purpose of this systematic review was to investigate the influence of weight, on the timing of puberty onset in adolescent females.

Inclusion/Exclusion Criteria

The inclusion criteria included female participants subjects, menarche as the determining factor for onset of puberty, written in English in the last ten years, early onset puberty, and obesity, overweight, or elevated BMI as an influencing factor. To maintain consistency, only articles using the onset of menarche as the determining factor for the onset of puberty were included.

Exclusions included studies with male subjects, studies with underlying diseases that influenced normal pubertal development, and obesity not being referenced as an influencing factor. Studies using the Tanner Stages of breast development, pelvic ultrasound to assess uterine development, assessment of hormone levels, and bone age assessment via imaging, as methods to determine the onset of puberty, were excluded.

Search Strategy

A literature review was conducted using the following search engines: EBSCOhost, Google Scholar and CINAHL Plus.

Keywords included early menstruation, menses, early puberty, central precocious puberty, obesity, overweight, obese, high BMI, risk factors, contributing factors, environmental factors, and long-term effects.

Filters were applied to further narrow each search to include only full text peer reviewed journal articles published between October 1, 2012 and October 1, 2022, written in the English language

The Preferred Reporting Items for Systematic Reviews and Meta-Analysis [PRISMA] (Page et al., 2021) was utilized to ensure adherence of meeting search criteria for the systematic review. The PRISMA flow diagram (see Appendix A) provided an organized visual tool to display the articles included in this systematic review and the articles excluded with the reason for the exclusion. The PRISMA Checklist (see Appendix B) consisting of 27 items including title, abstract, methods, results, and discussion was used to ensure the literature selected followed the standards to provide adequate, accurate and sufficient information for the topic.

Data Collection Tables

The data extracted from each article meeting criteria was organized into a data collection table (see Appendices C1-C4). Data collected included author and year of study, purpose, design, site/sample, methods, outcomes measured, results, and limitations.

Critical Appraisal and Cross Analysis

The Critical Appraisal Skills Programme (CASP) checklist was used as a framework to review the outcomes of each individual study and compare the results and methods across the studies (see Appendices D1-D4). The checklist includes 10 questions with an area for comments to elaborate on the researchers answer. The use of the checklist assisted with organizing each study's level of applicability to the research topic and assured each study was reviewed in the same way.

Data from each study meeting criteria was then organized into a cross analysis table (see Appendix E) to identify how prepubescent females' weight influences the onset of puberty. Data analyzed included author and year of study, location/sample size, age of participants, overweight participants, average menarche age, overweight versus not overweight, and menarche reporting method.

Results

Search Results

Using the CINAHL Plus, Google Scholar and EBSCOhost databases, an initial search yielded 35 studies. The titles, abstracts and availability for full text were then reviewed for each article. This process eliminated 20 studies. The remaining 15 studies were carefully reviewed by this author to establish if the study was pertinent to the subject matter. Using the PRISMA flowchart and checklist (see Appendices A and B) and exclusion/inclusion criteria, four articles met the criteria for this systematic review. Information from each of the four studies was extracted and organized into data collection tables (see Appendices C1-C4). The studies outcomes were reviewed using the CASP checklist (see Appendices D1-D4) and after meeting criteria, the four remaining studies were compared using a cross analysis table (see Appendix E).

Study Characteristics

Matsuo et al., (2015) compared Brazilian school-aged female weight with their age of menarche onset using data from three cross-sectional studies (see Appendix C1). They reported 21.49% of the females were overweight in 2007 with a mean menarche onset age of 12.3 years. These numbers increased to 28.5% of the females being overweight in 2018 with a mean menarche onset age of 11.9 years. The authors concluded the mean age of menarche was lower in all time periods assessed with girls who were overweight when compared to girls without overweight. The results also noted no difference in the age of menarche between public versus private school girls. The limitations of this study included the less accurate recall of age at menarche due to a high proportion of girls reporting age of menarche in whole years rather than the date of onset. Other factors that may have influenced a female's onset of menarche were not taken into consideration for this study. A decline in the sample size over time increased the risk of sample bias and methods of higher accuracy could have been utilized to assess fat adiposity such as skin folds and body fat percentage.

A 2021 descriptive cross-sectional study was conducted by Shahatah et al. of females visiting the general and endocrinology pediatric clinic in King Abdul Aziz University Hospital comparing the onset of menarche with weight and the daily intake of fast-food reported a mean menarche onset age of 11.9 years (see Appendix C2). No relationship was found between higher weight and age of menarche; however, findings showed a correlation between female adolescents' fast-food intake and a younger age of onset for menarche. A correlation between higher weight and an earlier onset of thelarche and adrenarche was found in the study. Researchers established that weight standard deviation (SD) and daily fast-food intake were not confounding factors by confirming that those who consumed fast-food daily did not have a high weight SD of statistical significance. The authors concluded that in daily fast-food and overweight decrease the age of onset for puberty but these factors individually, affect different stages of puberty. Overweight decreases the age of thelarche and adrenarche, while daily fast-food decreases the age of menarche. Limitations of this study include the size of the sample used and the cross-sectional/observational nature of the study.

A cross-sectional study using previous data from the Italian Health Behaviour in School-Aged Children Study (HSBC) was conducted by Lazzeri et al. (2018). The authors compared weight and age of menarche in 21 regions of Italy (see Appendix C3). This study had a much larger sample size compared to the other studies included in this review. The regions had a median age of menarche for 15-year-olds in 2013/2014, ranging from 12 years and 3 months to 13 years and 4 months and a prevalence of overweight from 4% to 19%. In 11-year-olds in the

2009/2010 survey, overweight prevalence ranged from 10% to 35% (Lazzieri et al., 2018). The authors concluded that regions in southern Italy had a higher percentage of overweight females and had a lower median age of menarche for 15-year-old females. Further investigation of region-specific lifestyles, the environment and genetics would be useful to better understand the associations found in this study. The surveys utilized for the collection of data were not originally intended for this specific study, the self-reported information may be inaccurate and the cross-sectional nature of the study are all limitations of this study (Lazzieri et al., 2018).

Finally, a longitudinal study by Gavela-Pérez (2015) using data from the Four Provinces Study included Spanish females beginning at the age of 6-8 years old and following-up with the participants at the age of 13-16 years old. The researchers found the average age of menarche onset was 12.08 years of age and females with higher BMI, waist circumference, hip circumference, and body fat had an average menarche age less than 12 years compared to the opposition with a menarche average age greater than 13 years. The authors concluded higher weight in girls is associated with an earlier age of menarche, specifically, girls who had weight gain between pre-pubertal school age and adolescence. Limitations of the study included recall bias due to the method of data collection using questionnaires and the means of determining body composition has not yet been validated for use in children with the age group studied (Gavela-Pérez, 2015).

Cross-Analysis and Discussion

The four included studies took place in different countries including Brazil (Matsuo et al., 2015), Saudi Arabia (Shahatah et al., 2021), Italy (Lazzieri et al., 2018), and Spain (Gavela-Pérez, 2015). No studies took place in the United States. Three of the studies used previous data from the Four Provinces Study (Gavela-Pérez, (2015), Italian Health Behavior in School-Aged Children Study (Lazzieri et al., 2018), and the Study on the Prevalence of Obesity in Children and Adolescents (Matsuo et al., 2022). Shahatah et al. (2021) used original data collected from interviews with female clinic patients visiting the general and endocrinology pediatric clinic in King AbdulAziz University Hospital.

A common finding across three of the four studies, Matsuo et al. (2022), Lazzieri et al. (2018), and Gavela-Pérez (2015) studies found overweight or obese female adolescents experienced a younger age of onset for menarche in comparison to female adolescents who were of normal weight or underweight. In contrast, Shahatah et al. (2021) found no association with a lower age of menarche with overweight females but did find a correlation with a younger age of menarche with the daily consumption of fast-food with Saudi females. Shahatah et al., (2021) also concluded that in comparing females attending private school versus public school no difference was seen and had shown similar results. Additionally, one study showed earlier menarche was associated with increased BMI, increased waist circumference, and increased body fat percentage (Gavela-Pérez et al., 2015). This study also assessed associations with anthropometric variables at birth, childhood and adolescence and if the age of menarche were affected by the data. The results yielded no correlation between menarcheal age and the anthropometric variables (Gavela-Pérez et al., 2015).

Demographic location, socio-economic standing, and access to healthcare are only some of the varying influences from each study that potentially effected findings; further research on this topic could address these influences to improve patient outcomes and influence positive change within cultures. These findings raise the question of demographic factors from differing countries altering the prevalence of increased weight and decreased age of menarche.

Finally, three of the four studies had concerns for recall bias in relation to the age of menarche onset. The Gavela-Pérez (2015) study decreased the risk for recall bias discrepancies by having a short duration of time elapsed between questionnaire recall. The Shahatah et al. (2021), Lazzieri et al. (2018), and Matsuo et al. (2022) studies had a longer duration of time from menarche onset to participant recall, increasing the possibility of recall bias. By decreasing the duration of time between the event of menarche and reporting the event, higher accuracy of information is possible and recall bias is less likely.

Limitations

Limitations identified with the systematic review included the use of menarche as a clearly identified marker for the onset of puberty. Many studies exist that utilized breast development and pubic hair as objective traits for the onset of puberty. Other studies utilized findings such as bone density, uterine development, and hormone levels. This limitation decreased the number of applicable studies for this systematic review. Obtaining studies that had taken place in the United States were a limitation and makes the study less generalizable. Using weight as the determining factor for the influence on menarche limited the number of studies. Multiple measurements were found while conducting research, for example, waist circumference, body fat percentage, skin fold measurements and dietary intake. No randomized control trials were found for this study. Having limited resources with only one researcher created time constraints and inability to coordinate sharing of responsibility for locating appropriate resources.

Conclusion

This systematic review focused on the association between weight and onset of menarche in adolescent females. Although there were a limited number of studies meeting the study criteria of utilizing weight as the influencing variable for the early onset of menarche, three out of four showed an association between weight and menarche onset. Some studies in the literature investigate other factors potentially contributing to the early onset of menarche including the consumption of animal proteins versus plant protein, being breast fed, and the increased use of pesticides and exposure to BPA found in plastics (Burkhart, 2012; Shahatah et al., 2021; Jansen et al., 2018).

These findings raise the question of the need for additional studies to compare factors from differing countries to appraise how a female's demographical location may increase the likelihood of being overweight and its impact on the age of menarche. Factors such as access to healthy food choices and methods for physical activity may be investigated to review how these variables alter a female's maturation progression.

Obesity is a serious epidemic in the United States, potentially exacerbating many medical conditions. Childhood obesity has nearly doubled between 1985 and 2015 and nearly tripled between 1980 and 2018. In 1980 only 7% of children aged 6 to 11 years of age were obese. According to CDC reports, this number increased to 20.3% of children aged 6 to 11 years of age in 2017-2018 (CDC, 2022). The results of this study show an association between the rise in the number of obese children and the decreasing age of menarche onset in females in some populations. This is concerning, as female adolescents who experience an earlier onset of puberty are at an increased risk for obesity, diabetes, cardiovascular disease, cancer, sexually transmitted infections, pregnancy, smoking, alcohol use, drug use, sexual promiscuity, depression, poor academic performance, and eating disorders (Jae-Ho Yoo, 2016; Martinez, 2020; Villamor & Jansen, 2016). These conditions may follow through to adulthood and if left untreated or undermanaged, could result in death. Further research is needed to study the impact earlier menarche has on adult conditions and lifestyle modifications that can be made to decrease the risk of these conditions.

Implications for APRN Practice

The evolving role of an APRN in the healthcare system has increased the APRN's impact in nearly all areas of healthcare. The APRN has proven to be an integral part in the management of patients' acute and chronic diseases. With the knowledge of possible childhood conditions potentially contributing to adult illnesses, plans for prevention can be implemented earlier in life. This systematic review brings awareness to a focus that APRNs may find valuable when treating female adult patients. Questions pertaining to childhood obesity and age of onset of menarche may assist with determining an individual's risk for chronic conditions. A thorough health history assists the APRN in individualizing patient education on lifestyle modifications which can lower risk related to childhood obesity or early menarche. APRNs should include mental health and substance abuse screenings to identify those who may be at higher risk related to having experienced menarche at a younger age. These mental health conditions could follow into adulthood especially when left untreated.

This information could be applied by the APRN in the outpatient and inpatient setting to decrease patient hospitalizations and improve prevention. An APRN's increased knowledge of all possible risk factors contributing to the development of chronic conditions can ensure the provision of best care to patients. This systematic review presents a strong case for an association between early menarche among young females who are overweight. This knowledge can aid the APRN in assisting patients to minimize the risks related to early onset menarche. Due to the evidence on this topic, further research needs to be done to study the correlation of obesity with early menarche and the increased risk of chronic conditions imposed by early menarche.

References

Burkhart, L. (2012). The rise in precocious puberty. *Journal of the American Chiropractic Association*. https://link.gale.com/apps/doc/A353753424/AONE?u=anon~4e94b8da&sid=googleScholar&xid=a1ca9eab

Critical appraisal skills program. (2022) CASP checklists. Retrieved from https://casp-uk.net/casp-tools-checklists/SP Checklists - CASP - Critical Appraisal Skills Programme (casp-uk.net)

Centers for Disease Control and Prevention. (2021, December 3). *Defining childhood weight status*. https://www.cdc.gov/obesity/childhood/defining.html

Centers for Disease Control and Prevention. (2022, May 17). *Prevalence of childhood obesity in the United States*. https://www.cdc.gov/obesity/data/childhood.html

Chen, M., & Eugster, E. (2015). Central precocious puberty: Update on diagnosis and treatment. *Pediatric Drugs, 17*(4), 273-281. doi:10.1007/s40272-015-0130-8

Cheng, G., Buyken, A. E., Shi, L., Karaolis-Danckert, N., Kroke, A., Wudy, S. A., Remer, T. (2012). Beyond overweight: Nutrition as an important lifestyle factor influencing timing of puberty. *Nutrition Reviews, 70*(3), 133-152.

Cheuiche, A. V., da Silveira, L. G., de Paula, Leila Cristina Pedroso, Lucena, I. R. S., & Silveiro, S. P. (2021). Diagnosis and management of precocious sexual maturation: An updated review. *European Journal of Pediatrics,* 1-15.

Frisch, R. E., & Revelle, R. (1971). Height and weight at menarche and a hypothesis of menarche. *Archives of Disease in Childhood, 46*, 695.

Gavela-Pérez, T., Garcés, C., Navarro-Sánchez, P., López Villanueva, L., & Soriano-Guillén, L. (2015). Earlier menarcheal age in Spanish girls is related with an increase in body mass index between pre-pubertal school age and adolescence. Pediatric Obesity, 10(6), 410–5. https://doi.org/10.1111/ijpo.277

Jae-Ho Yoo. (2016). Effects of early menarche on physical and psychosocial health problems in adolescent girls and adult women. *Korean Journal of Pediatrics, 59*(9), 355-361. doi:10.3345/kjp.2016.59.9.355

Jansen, E. C., Zhou, L., Perng, W., Song, P. X., Rojo, M. M. T., Mercado, A., Cantoral, A. (2018). Vegetables and lean proteins–based and processed meats and refined grains–based dietary patterns in early childhood are associated with pubertal timing in a sex-specific manner: A prospective study of children from Mexico City. *Nutrition Research, 56*, 41-50.

Jarvis, C. P., & Eckhardt, A. P. (2020). *Physical examination & health assessment* (8th edition ed.). St Louis: Elsevier.

Khodaveisi, M. P., Omidi, A. M., Farokhi, S. M., & Soltanian AR, P. (2017). The effect of Pender's health promotion model in improving the nutritional behavior of overweight and obese women. *International Journal of Community Based Nursing and Midwifery, 5*(2), 165-174.

Kim, S. W., Kim, Y. B., Lee, J. E., Kim, N. R., Lee, W. K., Kim, E. J., Ku, J. K., Jung, S. H., & Chung, W. Y. (2016). The influence of gonadotropin releasing hormone agonist treatment on the body weight and body mass index in girls with idiopathic precocious puberty and early puberty. *Annals of Pediatric Endocrinology & Metabolism, 22*(2), 95-101. doi:10.6065/apem.2017.22.2.95

Kim, D. W., Suh, J., Kwon, A. R., Chae, H. W., Yoon, C. S., Kim, H. S., & Kim, D. H. (2018). Visceral fat thickness and its associations with pubertal and metabolic parameters among girls with precocious puberty. *Annals of Pediatric Endocrinology & Metabolism, 23*(2), 81-87. doi:10.6065/apem.2018.23.2.81

Lazzeri, G., Tosti, C., Pammolli, A., Troiano, G., Vieno, A., Canale, N., Dalmasso, P., Lemma, P., Borraccino, A., Petraglia, F., & Luisi, S. (2018). Overweight and lower age at menarche: evidence from the Italian HBSC cross-sectional survey. BMC Women's Health, 18(1), 168–168. https://doi.org/10.1186/s12905-018-0659-0

Maron, D. F. (2015). Why girls are starting puberty early. *Scientific American, 312*(5), 28.

Martinez, G. P. (2020). Trends and patterns in menarche in the United States: 1995 through 2013-2017. Retrieved from https://www.cdc.gov/nchs/data/nhsr/nhsr146-508.pdf

Matsuo LH, Adami F, Pereira LJ, Silva DAS, de Vasconcelos FAG, Longo GZ, Vieira FGK, Hinnig PF. Age at menarche and its association with overweight including obesity and socio-economic conditions of Brazilian schoolgirls: A time-trend analysis. *Nutrition Bulletin*. 2022 Mar;47(1):70-81. doi: 10.1111/nbu.12544. PMID: 36045078.McEwen, M., & Wills, E. (2014). *Theoretical basis for nursing* (4th ed.) Wolters Kluwer.

Norris T. L. (2019). *Porth's pathophysiology: Concepts of altered health states* (Tenth). Wolters Kluwer.

Perns, W., Fernandez, C., Peterson, K. E., Zhang, Z. Z., Cantoral, A., Sanchez, B. N., Solano-Gonzalez, M., Tellez-Rojo, M. M., & Baylin, A. (2017). Dietary patterns exhibit sex-specific associations with adiposity and metabolic risk in a cross-sectional study in urban Mexican adolescents. *Journal of Nutrition*, 147 (10), 1977-1985.

Page, M. J., McKenzie, J., Bossuyt, P., Boutron, I., Hoffmann, T., Mulrow, C. D., Shamseer, L., Tetzlaff, J., Akl, E., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. doi:10.1136/bmj.n71

Polit, D. & Beck, C. (2021) *Nursing research: Generating and assessing evidence for nursing practice (11th ed.)* Wolters Kluwer.

Shahatah, M. A., Jadkarim, A. M., Banjar, R. Z., Kabli, Y. O., Milyani, A. A., & Al-Agha, A. E. (2021). The relationship between body weight and dietary habits with respect to the timing of puberty among Saudi children and adolescents. *Annals of African Medicine, 20*(3), 193-197. doi:10.4103/aam.aam_41_20

Srof, B. J., & Velsor-Friedrich, B. (2006). Health promotion in adolescents: A review of Pender's health promotion model. *Nursing Science Quarterly, 19*(4), 366-373.

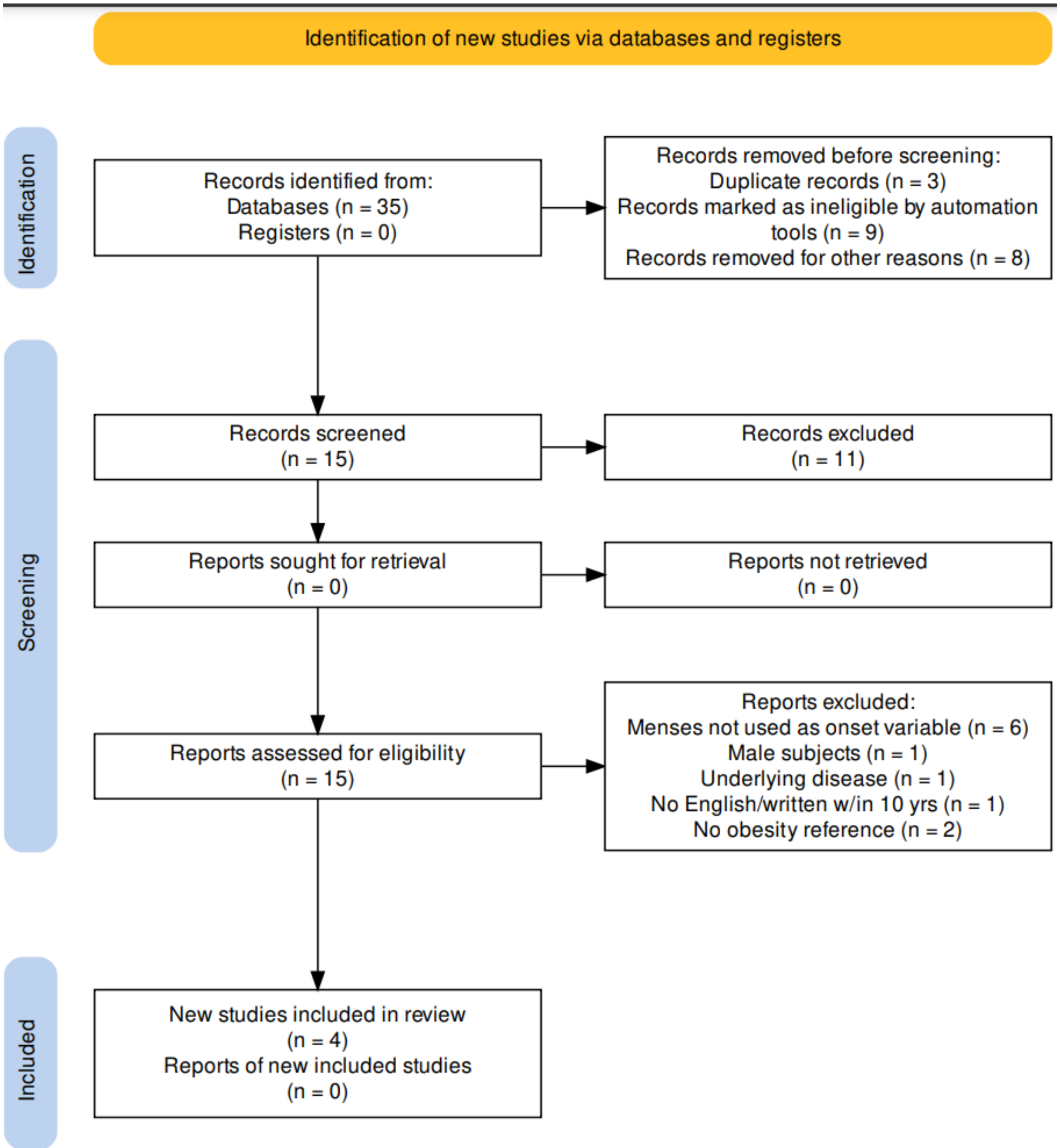
Standiford Brown, A. (2009). Promoting physical activity amongst adolescent girls. *Issues in Comprehensive Pediatric Nursing, 32*(2), 49-64.

Villamor, E., & Jansen, E. C. (2016). Nutritional determinants of the timing of puberty. *Annual Review of Public Health, 37*, 33-46.

Appendices

Appendix A

Prisma Flow Diagram (Page et al., 2021)



Appendix B

PRISMA Checklist (Page et al,. 2021)

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	
Study characteristics	17	Cite each included study and present its characteristics.	
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	
	23b	Discuss any limitations of the evidence included in the review.	
	23c	Discuss any limitations of the review processes used.	
	23d	Discuss implications of the results for practice, policy, and future research.	
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	
Competing interests	26	Declare any competing interests of review authors.	
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

For more information, visit: http://www.prisma-statement.org/

Appendix C

Data Tables

C1

Matsuo LH, Adami F, Pereira LJ, Silva DAS, de Vasconcelos FAG, Longo GZ, Vieira FGK, Hinnig PF. Age at menarche and its association with overweight including obesity and socio-economic conditions of Brazilian schoolgirls: A time-trend analysis. Nutr Bull. 2022 Mar;47(1):70-81. doi: 10.1111/nbu.12544. PMID: 36045078.

Purpose	Design	Site/Sample	Methods	Outcomes Measured	Results	Limitations
Correlate age of menarche with Brazilian school-aged females with the association or disassociation with being overweight	Quantitative study comparing overweight versus without overweight female adolescents who have and have not experienced menarche Utilized 3 Cross-sectional studies	• 2nd-9th grade students; age 7-14 years within private and public-school systems. • 2007: 838; 2012/2013: 688; 2018/2019: 326 • 2 categories: w/out overweight and& overweight (calculated BMI Z scores)	• Data collected from EPOCA survey (Study on the Prevalence of Obesity in Children and Adolescents) • Participants answered questionnaire ○ Have you had your first period (yes/no)? ○ If yes, age or date of menarche	• Weight status per BMI Z scores • Age of menarche • Type of school; private v. public	• Prevalence of overweight females increased each year of testing: ○ 2007: 21.4%; ○ 2012: 27.2%; ○ 2018: 28.5% • Mean age of menarche onset decreased; ○ 2007: 12.3 years; ○ 2018/2019: 11.9 years • Mean age of menarche was lower in overweight girls versus w/out overweight • Higher frequency of menarche occurrence between 7 and 11 years of age with overweight girls versus menarche between 12 and 14 years without overweight.	• Majority of girls reported menarche in whole years instead of date; less accurate • Study only used BMI as measurement, other measures like adiposity, body fat percentage or skin folds, were not used • Decline in sample size over time • Data does not report if overweight status was prior to menarche or occurred after incidence

C2

Shahatah, M. A., Jadkarim, A. M., Banjar, R. Z., Kabli, Y. O., Milyani, A. A., & Al-Agha, A. E. (2021). The relationship between body weight and dietary habits with respect to the timing of puberty among Saudi children and adolescents. *Annals of African Medicine, 20*(3), 193-197. doi:10.4103/aam.aam_41_20						
Purpose	**Design**	**Site/Sample**	**Methods**	**Outcomes Measured**	**Results**	**Limitations**
Investigate the environmental factors (diet, pesticide exposure, childhood obesity) that effect the timing of the onset of puberty in females	Descriptive, cross-sectional study	• Children/adolescents visiting general and endocrinology pediatric clinics in King Abdul Aziz University Hospital. • Females between the ages of 5 and 20 years old • Female and Tanner stage of more than or equal to 2. • Total of 164 females participated. • Recruitment was random selection	• Ethical approval obtained • Verbal informed consent from legal parents/guardians • Data collected through clinical interviews with parents/legal guardians, examination of participants, review of medical records, and questionnaires filled out by patients or parents wherever appropriate.	• Questionnaires gathered info on past medical and surgical history, medications, family history, and age of thelarche, adrenarche, and menarche • Participants categorized according to weight standard deviation (SD); ○ underweight if SD below -1, ○ overweight if higher than +1, ○ obese if higher than +2 and normal weight if SD between -1 and +1	• Weight range between 17 kg and 78kg, mean weight of 40.6 kg • Range of menarche between 10 and 16 years with mean age of 11.9 years • No relationship was found between higher weight and age of menarche. • Correlation with fast food intake and earlier age of menarche. • Correlation with higher weight and an earlier onset of thelarche and adrenarche	• Limited sample size • Cross-sectional/ observational nature of the study • Possible self-report and/or recall bias

C3

Lazzeri, G., Tosti, C., Pammolli, A., Troiano, G., Vieno, A., Canale, N., Dalmasso, P., Lemma, P., Borraccino, A., Petraglia, F., & Luisi, S. (2018). Overweight and lower age at menarche: Evidence from the Italian HBSC cross-sectional survey. *BMC Women's Health*, 18(1), 168–168. https://doi.org/10.1186/s12905-018-0659-0						
Purpose	**Design**	**Site/Sample**	**Methods**	**Outcomes Measured**	**Results**	**Limitations**

Investigate whether a correlation exists between body mass index and the age of menarche	Cross-sectional study	• 15-year-old girls
		  ○ 906 schools in the 21 regions of Italy for the study conducted in 2013/2014
		  ○ Sample sizes from each school ranged from 150-774 participants
		• 11-year-old girls
		  ○ 1160 schools in 20 regions of Italy from study conducted in 2009/2010
		  ○ Sample sizes from each school ranged from 281-763 participants
		• Same population cohort in 11-year-olds 2009/2010 study sampled again at 15 years old in 2013/2014
			• Information sheet about study and opt out form sent home to legal guardians
			• Self-report questionnaire administered by trained teachers
			• Data collected remained anonymous
			• Two independent nationally representative survey datasets
			  • 15-year-olds
			  • 11-year-olds
			  ○ Health behavior in school-aged children (HBSC) study conducted in Italy. Collaborative cross-national study that conducts health behavior every 4 years on nationally representative studies of adolescents
			• Hierarchal models used to assess BMI and age at menarche relationships
				• Self-reported results if participant had begun to menstruate
				• Divided into 2 categories: pre-menarcheal and post-menarcheal
				• Self-reported height and weight used to calculate BMI.
				• Categorized as overweight
				• Prevalence of overweight calculated for both age groups
					• Median age at menarche ranged from 12 years 3 months and 13 years 4 months.
					• Overweight prevalence among 15-year-old girls ranged 4 to 19%
					• BMI accounted for 60% of region-level variance in age at menarche
					• Menarche age was inversely associated with BMI
						• Study does not determine if overweight is the cause or consequence of early menarche
						• Possible self-report and/or recall bias

C4

Gavela-Pérez, T., Garcés, C., Navarro-Sánchez, P., López Villanueva, L., & Soriano-Guillén, L. (2015). Earlier menarcheal age in Spanish girls is related with an increase in body mass index between pre-pubertal school age and adolescence. *Pediatric Obesity*, 10(6), 410–5. https://doi.org/10.1111/ijpo.277						
Purpose	**Design**	**Site/Sample**	**Methods**	**Outcomes Measured**	**Results**	**Limitations**

Determine menarcheal age and assess associations with anthropometric variables at birth, childhood, and adolescence. Also analyze if tracking weight between different ages could affect menarche timing	Longitudinal Study	• 195 randomly selected girls
		• Age 6-8-years-old girls who took part in the Four Provinces baseline study and the follow-up with the same girls at 13–16-year-old
		• 13-16-year survey included questions regarding menarche
			• Using the data from the Four Provinces study; sampling was carried out in 2 stages
			  • Schools were selected from lists provided by Regional Education Authorities
			  • Students were selected randomly from classrooms
			• Informative meeting held for parents of selected students and written consent was obtained.
			• Separated into 2 groups; normal weight and overweight or obese
				• Height, weight, waist circumference, hip circumference, and body fat percent were collected
				• BMI calculated
				• Questionnaires collected birth weight, gestational age and age at menarche
					• Average age at menarche was 12.08 years
					• No correlation between menarcheal age and birth weight adjusted by gestational age.
					• Girls between ages 13 and 16 with a negative correlation between age at menarche and waist circumference.
					• Girls classified into 3 groups;
					  ○ Group 1 menarche was <12,
					  ○ Group 2 menarche was between 12 and <13
					  ○ Group 3 menarche was >13.
					• Girls in group 1 had higher BMI, waist circumference, hip circumference and body fat compared to Group 3.
						• Use of questionnaires for collection of onsets for menstruation may present recollection bias.
						• The study also used the Tanita TBF-300MA impedance composition analyzer for body composition determination. This method has not been validated for use in children within this age group yet

Appendix D

Completed Critical Appraisal Skills Program Checklists (CASP, 2022)

D1

Matsuo LH, Adami F, Pereira LJ, Silva DAS, de Vasconcelos FAG, Longo GZ, Vieira FGK, Hinnig PF. Age at menarche and its association with overweight including obesity and socio-economic conditions of Brazilian schoolgirls: A time-trend analysis. Nutr Bull. 2022 Mar;47(1):70-81. doi: 10.1111/nbu.12544. PMID: 36045078.			
A. Are the results of the trial valid?	**Yes**	**Can't tell**	**No**
1. Did the trial address a clearly focused issue?	X		
2. Was the assignment of patients randomized?	X		
3. Were all of the patients who entered the trial properly accounted for at its conclusion?	X		
4. Were patients, health workers, and study personnel "blind" to treatment?			X
5. Were the groups similar at the start of the trial?	X Similar demographics		
6. Aside from the experimental intervention, were the groups treated equally?	X		
B. What are the results?	**Yes**	**Can't tell**	**No**
7. How large was the treatment effect?			N/A
8. How precise was the estimate of the treatment effect?			N/A
C. Will the results help locally?	**Yes**	**Can't tell**	**No**
9. Can the results be applied in your context?	**X**		
10. Were all clinically important outcomes considered?			**X** (Only obesity considered)
11. Are the benefits worth the harms and costs?			**X**

D2

Shahatah, M. A., Jadkarim, A. M., Banjar, R. Z., Kabli, Y. O., Milyani, A. A., & Al-Agha, A. E. (2021). The relationship between body weight and dietary habits with respect to the timing of puberty among Saudi children and adolescents. *Annals of African Medicine, 20*(3), 193-197. doi:10.4103/aam.aam_41_20			
A. Are the results of the trial valid?	**Yes**	**Can't tell**	**No**
1. Did the trial address a clearly focused issue?	X		
2. Was the assignment of patients randomized?	X		
3. Were all of the patients who entered the trial properly accounted for at its conclusion?	X		
4. Were patients, health workers, and study personnel "blind" to treatment?			X (legal consent given)
5. Were the groups similar at the start of the trial?	X (Endocrinology patients)		
6. Aside from the experimental intervention, were the groups treated equally?	X		
B. What are the results?	**Yes**	**Can't tell**	**No**
7. How large was the treatment effect?			N/A
8. How precise was the estimate of the treatment effect?			N/A
C. Will the results help locally?	**Yes**	**Can't tell**	**No**
9. Can the results be applied in your context?	**X**		
10. Were all clinically important outcomes considered?	**X**		
11. Are the benefits worth the harms and costs?			**X**

D3

Lazzeri, G., Tosti, C., Pammolli, A., Troiano, G., Vieno, A., Canale, N., Dalmasso, P., Lemma, P., Borraccino, A., Petraglia, F., & Luisi, S. (2018). Overweight and lower age at menarche: Evidence from the Italian HBSC cross-sectional survey. BMC Women's Health, 18(1), 168–168. https://doi.org/10.1186/s12905-018-0659-0			
A. Are the results of the trial valid?	**Yes**	**Can't tell**	**No**
1. Did the trial address a clearly focused issue?	X		
2. Was the assignment of patients to treatments randomized?	X		
3. Were all of the patients who entered the trial properly accounted for at its conclusion?	X		
4. Were patients, health workers, and study personnel "blind" to treatment?			X (legal consent)
5. Were the groups similar at the start of the trial?	X (15 and 11-year-old girls)		
6. Aside from the experimental intervention, were the groups treated equally?	X		
B. What are the results?	**Yes**	**Can't tell**	**No**
7. How large was the treatment effect?			N/A
8. How precise was the estimate of the treatment effect?			N/A
C. Will the results help locally?	**Yes**	**Can't tell**	**No**
9. Can the results be applied in your context?	**X**		
10. Were all clinically important outcomes considered?	**X**		
11. Are the benefits worth the harms and costs?			**X**

D4

Gavela-Pérez, T., Garcés, C., Navarro-Sánchez, P., López Villanueva, L., & Soriano-Guillén, L. (2015). Earlier menarcheal age in Spanish girls is related with an increase in body mass index between pre-pubertal school age and adolescence. Pediatric Obesity, 10(6), 410–5. https://doi.org/10.1111/ijpo.277			
A. Are the results of the trial valid?	**Yes**	**Can't tell**	**No**
1. Did the trial address a clearly focused issue?	X		
2. Was the assignment of patients to treatments randomized?	X		
3. Were all of the patients who entered the trial properly accounted for at its conclusion?	X		
4. Were patients, health workers, and study personnel "blind" to treatment?			X (legal consent)
5. Were the groups similar at the start of the trial?	X (surveyed at 6-8 and again at 13-16 yrs old)		
6. Aside from the experimental intervention, were the groups treated equally?	X		
B. What are the results?	**Yes**	**Can't tell**	**No**
7. How large was the treatment effect?			N/A
8. How precise was the estimate of the treatment effect?			N/A
C. Will the results help locally?	**Yes**	**Can't tell**	**No**
9. Can the results be applied in your context?	**X**		
10. Were all clinically important outcomes considered?			X (only assessed weight)
11. Are the benefits worth the harms and costs?			**X**

Appendix E

Cross Analysis Table

	Author	Year of Study	Location/ Sample Size	Age	Overweight Participants	Avg Menarche Age	Overweight (OW) vs. Normal Weight (NW)	Menarche Reporting Method
1	Matsuo et al.	2007; 2012/2013; 2018/2019	Brazilian School • 2007: 838 • 2012/2013: 688 • 2018/2019: 326	7-14 years	Overweight increased w/age 2007: 21.4% 2012: 27.2% 2018: 28.5%	2007: 12.3 yrs 2018/2019: 11.9 yrs	2007: OW 11.9; NW 12.4 2012/2013: OW 11.8; NW 12.4 2018/2019:OW 11.5; NW 12.1	Self- reported Whole years or exact date
2	Shahatah et al.	May-Oct 2019	Saudi Arabian Hospital 164	5-20 years	No relationship found between weight and menarche	11.9 yrs	Under wt: 13.25 yrs Normal wt: 11.75 yrs Over wt: 10.75 yrs	Clinical interviews parents/legal guardians, medical records, patients/ parents' questionnaires
3	Lazzeri et al.	2009/2010 (11 yr olds) 2013/2014 (15 yr olds)	Italian Health Behavior in School-Aged Children Study 15 y.o survey: 906 schools, sample sizes ranging from 150-774 11 y.o. survey: 1160 schools, sample sizes ranged from 281-763	Two data sets 11 years & 15 years	All regions of Italy 15 yr old: 4-19% 11 yr old: 10-35% For each unit increase in BMI=menarche occurred ~1month earlier	12yrs 3mos to 13 yrs 4 mos	Obesity values differed between Northern and Southern Italy Region w/lowest age (North): 12 yrs 3 mos Overwt/obese: 15 y.o.: 11.8 % 11 y.o: 19.8% Region w/highest rate of obesity for 15 y.o (South).: 15 y.o: 19.1% 11 y.o.: 29.4% Menarche: 12 yrs 6mos Region w/highest rate obesity 11 yrs: 11 y.o.: 34.7% 15 y.o: 18.8% Menarche: 12 yrs mos	Self-report questionnaire administered by trained teachers
4	Gavela-Pérez et al.	Four Provinces Study date was not stated. Compilation of data from the Four Provinces Study was not stated.	Spanish Cohort; Madrid, Spain 195	Two data sets 6-8 yrs & 13-16 yrs	Mean BMI 6-8 yr old: 17.06 (16.7-17.41) 13-16 yr old: 21.8 (21.29-22.31)	12.08 years	Assessed 4 variations w/6-8 & 13-16 yrs NW-NW: 12.32 yrs NW-OW: 10.93 yrs OW-NW: 12.25 yrs OW-OW: 11.43 yrs	Self-report questionnaire