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Trends in the Age of Menarche

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Trends in the Age of Menarche

Honors Thesis

Southern Illinois University Carbondale

Elizabeth Nielsen

Fall 2010

Advisor: Dr. James Ferraro

Thesis was completed in fulfillment

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Abstract:

Menarche is the onset of menses and this age this occurs differs with every girl. There are many factors that can influence this age or result from it. Menses is a crucial step in the process of pubertal maturation. This study conducted a survey to women of the Carbondale, IL area ranging from 12.5 to 74.42 years old. The survey inquired basic characteristics such as height, weight, and age of menarche. Factors such as body mass index (BMI), plastic use due to estrogen-like endocrine disrupting chemicals, the maternal age at childbirth and population size were also determined. The average age of menarche was 12.65 years old. Data analysis concluded few significant results. As BMI increased at menarche, the age of menarche decreased. Therefore, the girls who have a higher BMI are likely to start menses earlier. Also, the population size affected the age of menarche. As the population size increased, the age of menarche decreased. This is contrary to other studies in which girls living in a rural setting tend to start later than girls living in urban settings. There were many aspects in this study that did not have significance, such as a significant trend in age of menarche overtime. There was not a significant trend in age of menarche over time because the sample size was too small. Since there was a very weak correlation, it could be that this is the leveling off of age of menarche due to optimal nutritional level. Maternal age at childbirth did not seem to affect the daughter's age of menarche. The mother and father's health and family history would need to play a role also. Birth order was not seen to have an affect on age of menarche but possibly the number or types or gender of siblings could reach significance. Plastic use was not significantly affecting age of menarche due to survey clarification. Other studies have shown that the chemicals are affecting the reproductive system and this study did not show any change. Since chemicals in plastics are leaked into the environment more easily when heated, the question of microwave use and what type of cookware was inquired. There was no significance due to clarification on the survey. There are also many other ways to prepare food so asking just specifically one type is hard to see really what each participant does. It is difficult to compartmentalize household habits. Further research can find out more about these factors although there is significance of factors influencing the age of menarche.

Introduction:

The initial interest for this project rose from Dr. James Ferraro's course, Reproduction & Sexuality, PHSL320. This course taught the physiology involved in menstruation, fertilization, pregnancy and much more. The age of menarche at which females start their periods, had been reported to be decreasing over the years (6). The goal of this project was to discover whether this general trend might be continuing to occur in the age of menarche for girls and women. It was also aiming to find possible factors other than age that influences age of menarche. The following will be discussed in this study:

1) Perform a literature review to discover the physiological factors involved in females experiencing menarche.
2) Has there been a change in age of menarche over time? If so, in what way?
3) What elements could contribute to the change in age of menarche? (Such as genetics, BMI, or use of plastics)
4) What other studies have been conducted to show this change? What methods have they used?
5) With a physiological aspect, what could be done to further research this topic or educate others?

Menarche is the onset of menses or the first time females experience menstruation. This is a strong indicator of puberty in females and many factors can influence the age of menarche. Numerous studies have been done to identify these influences, as well as to identify possible consequences of an early age of menarche (13, 14, 15). The first sign of puberty in females is the breast bud formation, the onset of breast development. Next is the appearance of pubic hair and then finally, menarche.

The onset of puberty is based on many factors but one portion of the body that is crucial is the hypothalamic-pituitary-gonadal (HPG) axis. A hormone called gonadotropin-releasing hormone (GnRH) is released into the portal blood system in the median eminence, which then acts on the anterior pituitary gonadotrope cells. These cells will, in response to GnRH, release luteinizing hormone (LH) or follicle stimulating hormone (FSH), which in turn act on the gonads to secrete sex steroids progesterone and estrogens (4). GnRH is released in a pulsatile fashion, with low levels during childhood, which increase at puberty. There are many theories of how the pulsitil changes occur at puberty. The GnRH release has shown to be regulated by many different kinds of stimulatory and inhibitory neurotransmitters and peptides. In the pre-pubertal stage, GABA is acting to inhibit the release of GnRH, which explains why there are low levels of GnRH during childhood. In other words, there is a change in the feedback sensitivity of estrogen to allow the onset of puberty. Then during the onset of puberty, there is a disinhibition of GABA resulting in higher levels of GnRH. The gonadotrope cells will start to release LH and FSH. LH

and FSH act on the theca and granulosa cells of the ovaries to release sex steroids. This increase in testosterone and estradiol is responsible for pubertal changes. This heightened modulation of GnRH release results in puberty. The timing of puberty is due to many factors, but the HPG axis needs to be in working condition, resulting in higher testosterone and estrogen levels (23).

Age of menarche can be influenced by stress and living conditions. A study in Spain shows a decreasing and then leveling off of the age of menarche over time (5). This leveling off could be due to many different factors but one study suggests it could be a result of developing countries having reached an optimal nutritional level (22). This optimal nutritional level in this study from Italy refers to the relationship between childhood and adult body mass indexes (BMIs). BMI corresponds to the percentage of body fat for a person based on height and weight. In the study from Massachusetts Institute of Technology examining the relationship between body fat, menarche and fertility, the author discusses that there is an optimal body fat needed for reproductive maturation (8). There results suggest that a certain amount of body fat is needed and this will influence development during maturation or during puberty. Nutrition obviously influences BMI so this study was designed to examine these factors. One aspect of this research project was to find and predict the influence of BMI or body mass correlation to the age of menarche for the women that participated. This study also examined the percentage of body fat and its association with menarche. Pre-menarchal girls possessed smaller body fat percentage than girls that were post-menarchal (8). A study for the *Journal of Clinical Endocrinology & Metabolism* aimed to understand the effects of constitutional advancement of growth in girls in boys on the onset of puberty. One key conclusion they discovered was that children with more advanced growth or obesity, puberty tended to occur earlier (20).

Some studies have been working on different genes that may be involved in the process of maturation, puberty or even the synthesis of sex steroids. According to a few genetic studies, leptin may also be contributing to delayed puberty. Obesity occurs in those who have a mutation of the leptin genes (3, 14). There are studies that work with certain genes involved in the synthesis of estrogens. There are many steps in the synthesis of estrogens. Cytochrome enzymes are involved with the aromatization of androgens such as testosterone. This study looked at cytochromes *CYP17* and *CYP19* with a conclusion that *CYP19* might have an effect on the age of menarche in Caucasian females (10). There is further research going on to understand this mechanism connecting the two. Another gene study suggests that the *Kiss1* gene, which encodes for Kisspeptin, is associated with the reproductive system. The mechanism is not completely understood but researchers suggest that feedback of sex steroids acting on GnRH neurons may be involved. It has been proposed that testosterone and estradiol act on Kisspeptin which then is positively stimulating the release of GnRH (14, 18). As mentioned above, GnRH is the first step in the HPG axis to allow for steroid action and onset of puberty.

Several studies suggest that the average age that pubertal maturation occurs is in part, related to differences between races (25, 14). According to Herman-Giddens et al. in 1997, Caucasian girls start these changes later than African American Girls. This paper examines various factors, which may determine or influence the age of menarche and any relationships that might exist. Another study found that Blacks and Hispanics tend to have a significantly earlier age of menarche than Asians. This study summarized there being a strong relationship between early maturing girls and likelihood of being overweight (1). A cross-sectional study in school-aged girls followed for several years. The study found that African American girls started menses 3 months earlier than Caucasian girls (7). In a review by Olga Karapanou, from the department of

pediatrics in Athens, the racial differences were also supported between African American and Caucasian girls (14). Many ethnic studies with age of menarche report African American's starting earlier due to BMI. These studies have normalized their data to show that there even taking into account the BMI differences between groups, African American girls still start menses before girls of other races (14). Another aspect of puberty, breast and pubic hair development using the Tanner's Scale, was also researched in different racial groups. A sample of over 7,000 girls was examined using the Tanner's scale and it was concluded that there were differences between races/ethnicities. It was reported that African Americans, Mexican Americans and Non-Hispanic white girls were decreasing in stages of development respectively (25). It seems that race/ethnic group might have affect on the age of menarche but independently from BMI rates. In addition to trends in ethnic/racial groups, there have been studies on how genetics and family history can influence the age of menarche.

There have been studies on a possible trend in the age of menarche over time. A study done in Taiwan looked at three generations of females and saw a decreasing trend in the age of menarche overtime, approximately one year per generation (6). Further research is ongoing to look at the genetic influence in mothers and daughters in the age of menarche (6). In *Pediatrics*, a study shows that although there are many factors affecting the onset of menarche, although an interesting trend shown was the fact of the maternal age of menarche predicting that of her daughter's age of menarche (2). Like mother, like daughter, the age of menarche from mother to daughter can be closely related in almost every family.

The maternal age at time of childbirth can also have an effect on the daughter's age of menarche. A study shows that with every year increase in the mother's age at childbirth, the daughter's age of menarche will show a decreases by about 9 days compared to other girls. This

study also shows that the father's age when having a baby; the daughter's age of menarche also decreases but only about 5 days earlier (24). There have been few sibling studies to show any significant trend between the birth order and the age of menarche. Having siblings may affect the age of menarche but birth order does not. There are many other factors that affect on the family composition rather than birth order. The number of siblings could have an affect, such as having older sisters. This study suggests females with older sisters will tend to have a later menarche. This could be due to the increase of pheromones that can affect the reproductive system and perhaps the onset of menses (16).

Chemicals and hormones have been shown to influence the human body and timing of menarche. There have been many studies to show that the chemicals in plastic dinner ware are being emitted during microwaving meals. Endocrine disrupting chemicals (EDCs) are sometimes found in foods and can disturb the normal timing of menarche (17). These harmful EDCs can act on the same receptors as sex hormones (17). The protein, leptin, is shown to have a controlling effect on the secretion of gonadotropic hormones (13). Gonadotrophic hormones, such as LH and FSH, are the hormones that act on the ovaries, which is related to ovulation and menses. More specifically, there are Estrogen-like endocrine disrupting chemicals (EEDCs) that affect puberty. These chemicals are found in many different everyday products (23). In a review article, it was shown that during puberty, the neuroendocrine process and HPG axis is more sensitive to environmental stimuli. EEDC's also bind to estrogen receptors (ERs), but sometimes with a higher affinity and could cause more damage to the reproductive system (23). Dichlorodiphenyl-dichloroethylene (DDE) is one type that can be found in pesticides. It acts as an estrogen mimicker or an estrogen blocker. Mimicking estrogen can increase the estrogen's affects on ERs, which can allow for and earlier menarche due to increase estrogen exposure (23).

Bisphenol A, better known as BPA is found in dental sealants, lab flasks, baby formula bottles, reusable plastic containers such as water bottles and Tupperware that some use to microwave meals in (23). BPA is an estrogen blocker that can cause precocious puberty if exposed during prenatal periods (23). Heating plastics can increase the amount of chemicals leaking into the environment. This would suggest that it might not be the best for women who are pregnant to use these products. Polybrominated biphenyls (PBBs) are found mixed into plastics that make up computers, televisions and textiles. PBB is mixed with the plastic to make the product difficult to burn. When these products are disposed, the PBB is released into the environment. Water filtration systems are not able to filtrate these EEDC's from the water so they can easily get into our bodies from the water we use. EEDC exposure in prenatal girls can cause earlier menarche and earlier pubic hair growth patterns (23). The products that EEDCs are found in can be dangerous and many people might not even know they are being exposed.

Along with chemicals found in the environment, our social and economic surroundings have also been shown to affect the age of menarche. Seasonal changes, such as the availability of food, increase the number of girls experiencing menarche. In a study following girls in rural Bangladesh, it is seen that there is a peak of menarche occurring in the summer months May through August. The study suggests this is because there is an increase in food availability, which would allow for more food intake (21). Along with this, there is also a trend of more young females students going to school experiencing menarche in the summer months due to a reduced stress environment. The hormones that stress produces can affect and interact with the hypothalamus (21). Along with stress and living environment, different foods in an adolescent's diet at various ages can influence the age of menarche. One study suggests menarcheal trends associated with amount and type of protein intake during childhood (11). The influence of protein

intake on menarcheal age has been shown to relate to hormonal levels, but research in this area is continuing (11). The social status of an individual or family can affect the age of menarche because there is an association with food availability. A female with a higher socioeconomic status is described to in an earlier menarche (2). Having a higher economic status is closely related to population size. A higher population size will tend to have more food and resources available therefore; girls living in urban settings will tend to start menarche earlier. Girls who live in rural areas will tend to have a later menarche. This is not seen throughout all rural and urban settings, it is just a common trend in some studies (1).

There are many health conditions that have shown to have strong links to an early age of menarche, such as resulting in a higher risk of diabetes and hormone related cancers (11, 12). One study found that for every 1-year increase in menarcheal age, there was a 10% reduction in Type II diabetes (12). An early onset of menses is a risk factor for breast cancer and could be a result of longer exposure to estrogens associated with menses and pubertal changes (19). In agreement to this, Christopher Li and his co-researchers found in a *Cancer Epidemiol Biomakers* in 2007 say that early exposure to different sex steroids, at early menarche, can be a risk for breast cancer later on in life (15). Other than cancer, the exposure to hormones can also affect bone density. If a girl has menarche at an early age, she will be exposed to these sex steroids (i.e. estrogen and progesterone) for a longer duration, which can result in a higher bone mineral density. Having a high bone density will lessen the risk of osteoporosis. Those who experience menarche later will be associated with a lower bone density and could develop osteoporosis (14). Early menarche, occurring before the age of twelve, can correlate with having a shorter stature and being heavier (1). When girls start menses earlier, there are many body changes to understand. A study in France concluded that girls who start menses early would tend to initiate in sexual behavior

earlier, and perhaps other risky behavior due to early physical maturity (9). The girls in this study were seen to have a non-traditional family that could also contribute to the behaviors they exhibit. Learning about the changes one's body is going through can be tough psychologically. These young girls would need to grow up faster and might be exposed to experiences they are not ready for yet.

This literary review contributes many factors to the timing of puberty and also what could result from a certain age of menarche. The methods of this study aim to find out more about factors that may have an effect on the timing of menarche. In a physiology class called Sexuality and Reproduction, this topic was briefly researched with other classmates. As a group, surveys were conducted in a Biological Statistics class in the spring of 2010 to test the hypothesis that the age of menarche is decreasing over time. The sample size was 142 women and surveys found out ages of menarche, body types at time of menarche and organic diets. The average age of menarche was found to be 12.5 years old. There was no significant difference between organic food and onset of menarche ($p = 0.46$) but the relationship between body type and onset of menarche reached significance ($p = 0.06$). In addition, there was a change in the reducing age of menarche over time that was significant ($p < 0.001$). This spring 2010 study showed that the age of menarche, over the last century, has began to level off. One study has shown that the average age of menarche was 14 at the beginning of the twentieth century but has decreased about a month or more per decade during the century (1).

Materials and Methods:

During the fall semester, surveys were conducted throughout the Carbondale area, on and off campus. A retrospective experiment was conducted because data collected from women of all post-menarche ages. A prospective study by following a cohort of pre-adolescent girls for

several years was non-feasible due to time constraints. Data includes a variety of questions that may or may not be correlated to the age of menarche. Figure 1. Shows the survey conducted.

This survey is completely anonymous and your individual answers will not be disclosed to anyone. This survey is conducted to analyze the age of menarche. *Menarche* is defined as the first menstrual cycle, or first menstrual bleeding, in female human beings. This survey requires your complete honesty.

1. What is your current age? _____ years _____ months
2. What is your current weight (lbs)? _____ lbs
3. What is your current height? _____ feet _____ inches
4. What age were you at menarche (the start of your first period)? _____ years _____ months
5. How much weight (lbs) did you gain since menarche? _____ lbs
6. What was your height at time of menarche? _____ feet _____ inches
7. How many blood-related brothers and sisters do you have? _____ younger brothers _____ older brothers _____ younger sisters _____ older sisters
8. How old was your mother when she gave birth to you? _____ years-old
9. What is the size of the population within which you lived? _____less than 1,000 people _____1,000-5,000 people _____5,000-10,000 people _____10,000-50,000 people _____50,000-100,000 people _____more than 100,000 people
10. In a week, what is the number of drinks you use/consume out of plastic containers (plastic bottles, plastic glasses etc.)? _____times
11. Do you microwave any of your meals? Yes or No

a. If yes, what type of dishware do you use to microwave with? _____plastic _____styrofoam _____glass _____porcelain _____china _____other

b. If no, how do you cook your foods? _____

Figure 1. Survey conducted by Beth Nielsen to women of Carbondale (Fall 2010).

After data was collected, all values were entered into Microsoft® Excel® for Mac 2011. Unit conversion was done before values were entered. Height values were converted to inches, weight values were converted to pounds, and population size was recorded as A-F type. Another column for "Weight at Menarche (lbs)" was added and calculated by taking the current weight

minus the weight gained since menarche. A Pearson correlation test was done between Weight at Menarche and Age of Menarche. Body Mass Index at menarche and current time were both calculated by BMI= [Weight (pounds) * 703] / [Height (inches)^2].

Pearson correlation tests were performed on many different factors versus the Age of Menarche to see a possible positive or negative association. A Pearson test was performed with the following variables along with age of menarche: current age, weight at time of menarche, BMI at time of menarche, maternal age of childbirth, and number of plastic container drinks per week.

A T-test with two samples was performed for the response of yes or no to "do you use the microwave to prepare meals?" versus age of menarche. The answer yes was represented with the number 1 and the answer no was represented with the number 0. The correlation could explain microwaving meals in plastic containers affecting the age of menarche because of the EEDCs.

An ANOVA test was performed on variable that have categorical answers. Birth order was taken into account and compared to age of menarche using an ANOVA test. The participants were to say if they had older and/or younger brothers and sisters. The responses were collected and each participant was given a number of 1= "oldest/only child," 2= "middle child," or 3= "youngest child." ANOVA tests were done to see a presence or absence of difference between groups.

A Tukey's test is performed as further analysis if an ANOVA is proven to have significance. This will explain where the difference is between categorical responses.

Results:

In this data, the responses from 178 participants from the Carbondale area are included. The average age of participants was 28.07 years old. The average age at menarche was 12.65 years old. After statistical tests were done in Excel, the data was recorded as shown below.

Table 1. Pearson Test Values

	Birth Year vs. Age of Menarche	**Weight at time of Menarche vs. Age of Menarche**	**BMI at time of Menarche vs. Age of Menarche**	**Maternal Age at childbirth vs. Age of Menarche**	**Number of Plastic container drinks per week vs. Age of Menarche**
r value	0.02478	0.0602	-0.1149	-0.0146	0.09173

As one can see from Table 1 above, all correlation coefficients obtained from Pearson tests are shown. Pearson correlation tests are done to determine a possible linear relationship between two variables. An r-value near -1 or +1 would mean there is a strong correlation. Statisticians would say that an r-value of 0.7 or higher would be a strong relationship. As you can see from the values in Table 1, there are no strong correlations.

The first Pearson test dealt with the year in which the participant was born and the age of menarche. A correlation was done to find if there is a positive or negative or neutral relationship between the two. The r-value was 0.02478, which means there is a weak positive relationship. The older the woman was, the higher her age of menarche was. This shows that overtime there would be a decrease in the age of menarche, just not very strong. The next correlation was weight at time of menarche versus age of menarche. The r-value was 0.0602, which is also a very weak positive correlation. If the sample size was larger, there might have been a significant correlation. With the Pearson test comparing BMI and age of menarche, the r-value was

-0.1149, which was a stronger correlation compared to the rest which could show that as the BMI increased, the age of menarche decreased if the sample size was larger. This is supported by many studies on the effects of body mass index on puberty. Maternal age at childbirth was also compared to age of menarche but there was a very weak correlation, r-value was -0.0146. Even if some studies have shown that as the maternal age increases, the daughter's age of menarche will be earlier, this study does not show a strong enough correlation. The last Pearson test done was between the number of drinks per week from plastic container and the age of menarche. There was an r-value of 0.09173, which is still a very weak of a correlation, but this could be due to the confusion of the question. Since more and more plastics are being used now, this endocrine disrupting chemicals can affect the onset of menarche. If the sample size was larger and the questions were clarified, the correlation could be more significant.

Table 2. T-Test, ANOVA and Tukey Test Results

Test Type	Age of Menarche vs. Microwave Use	Age of Menarche vs. Birth Order	Age of Menarche vs. Population size
T-Test	p= 0.22	----	----
ANOVA	----	p= 0.90	p= 0.03
Tukey's Test	----	----	p= 0.04
Conclusions	----	----	Significance between population groups
	No significance	No significance	Significant difference between populations of <50,000 people & 100,000+ people

Table 2 shows the data analysis results from the T-test, ANOVA and Tukey's Test. The p-value is a value that shows significance between responses compared to the age of menarche. If the p-value is less than 0.05, there is significance. This means that 95% would not be error. Having a low p-value would represent a low error.

A T-test was used to test whether Microwave use affects menarche. Like mentioned before, Estrogen-like endocrine disrupting chemicals can leak from plastic ware when heated up in a microwave. This T-Test took the yes or no responses and compared them to the age of menarche. The p value was 0.22, which is too high of an error to be significantly affecting the age of menarche.

An ANOVA test was used to find a difference between "youngest," "middle child," and "oldest/only." There was not a significant difference between birth order groups when it comes to age of menarche in this study. This is because the p-value was very high, p=0.90, which shows a high percentage of error.

Another ANOVA was done with population size categories compared to the age of menarche. The responses for population size were as follows: A= "less than 1,000 people," B= "1,000-5,000 people," C= "5,000-10,000 people," D= "10,000-50,000 people," E= "50,000-100,000 people," and F= "more than 100,000 people." This test was used to find a difference between population groups the participants lived in. The p value for this test was 0.03, which shows a difference in population size when it comes to age of menarche. To find this difference, a Tukey's test was performed. Each group was compared to the others and a p-value was obtained for each. The significant difference was between the "10,000-50,000 people" group and the "more than 100,000 people" group. The p-value of this was 0.04 (shown in the Table 2). After seeing the difference, this study concludes the age of menarche tends to be earlier for those who lived in a population of 50,000 people or less and the age of menarche was later for those lived in a population of more than 100,000 people or more. This is contrary to research and could be due to not having a more diverse range of participants in each population group.

Table 3. Population Groups Average Age of Menarche

Population Groups	Average Age of Menarche
< 1,000 people	12.59
1,000-5,000 people	13.02
5,000-10,000 people	12.77
10,000-50,000 people	12.31
50,000-100,000 people	13.24
>100,000 people	12.35

The average age at menarche for women raised in population densities between 10,000 and 50,000 people was 12.31 years old and for women raised in population densities greater than 100,000 people it was 12.35 years old. Table 3, shows the average ages of menarche for the different population groups. As discussed above, Tukey's test shows the difference to lie between the "10,000-50,000 people" group and the ">100,000 people" group. The averages are very close but the higher population has a higher age of menarche. This data shows that the age of menarche tends to be earlier if the participant lived in a population of 50,000 people or less and the age of menarche would be later if they lived in a population equal to or greater than 100,000 people.

Discussion:

Data for this project was collected and analyzed from females in the Carbondale area during the fall 2010 semester at Southern Illinois University Carbondale. Information solicited in this honors thesis project include age of menarche in relation to current age, weight at menarche, BMI at menarche, maternal age at childbirth, plastics and microwave uses. Studies have shown a trend in the menarcheal age overtime to be decreasing. The review article called "Determinants of menarche," explains that during the 20th century, there was a continuous trend of the menarcheal age decreasing, even though the decrease has slowed [14, 24]. In 1900, the average age of menarche was 14 and during the 1980's to 1990's the average age was 12.43

years old (14). The results of this experiment did not show a significant trend in the age of menarche changing overtime, as seen by the values from the Pearson test performed. Although there was not a significant trend, the value found was positive. If the sample size was larger, this could bare a significant trend to have a lightly more positive value. This indicates that as the birth year increases, the age of menarche of menarche decreases. Therefore, overtime the age of menarche would be decreasing. The study in Spain supports this in that they show a trend in how the age of menarche has decreased and then leveled off over time (5). And again, this slowing of decreased age of menarche could be a result of the developed countries having reached an optimal nutritional level (22).

Research has also found that BMI, weight and height are strongly correlated with the age of menarche (3). From this study, there was a trend in the correlation between weight and age of menarche but did not reach significance. There was a trend that reached significance in the BMI when it comes to the age of menarche. Like many studies on reproductive onset have shown, it seems there is an optimal body fat content needed for reproductive maturation (8). The current data suggests that having a higher body mass index will most likely be associated with an earlier age of menarche. Not only have studies show body fat content and weight to be a factor that influences the onset of menses, but also the maternal age at childbirth of these womens' mother. From the article by Anushu Shrestha and others, there was a trend in that as maternal age at childbirth increases, the daugher's age of menarche was earlier (24). This research supports the data analysis because there was a significant correlation and value of -0.0146, which is lower than 0.05. This says that the higher the maternal age at childbirth, the lower the age of menarche of the daughter would be.

Along with body type, the environment and surroundings can also affect the age of menarche. Studies have stated that the socioeconomic status affect the onset of menarche in those girls having a higher status would be associated with an earlier menarcheal age. There is also a difference in the age of menarche when it comes to living in an urban versus rural setting. Studies have shown that girls raised in urban settings tend to experience menarche earlier than those raised in rural settings (14). This review article supports this project's data because there is a difference in population when it comes to age of menarche as shown by the ANOVA test on population types. There was a significant difference between group D (population between 10,000-50,000 people) and group F (population higher than 100,000 people). The data shows that girls who lived in a population of 50,000 people or less would start menses earlier than those who lived in a population equal to or greater than 100,000 people. The current data is not supported and actually the opposite of previous research saying that girls living in a rural area will start menses later (1).

The results of plastic use versus age of menarche did not show a high enough significance in this study although many studies have shown that environmental chemicals can affect the reproductive system. Endocrine-like endocrine disrupting chemicals found in reusable plastics, baby formula bottles, computers, televisions, pesticides and many more products. Although the variance of the data was not significant, many studies are showing an increase in plastic use, which can affect the menarcheal age. DDE, BPA and PBB are three more common chemicals that are in products that are being used more and more now due to the industrialized society around us. When females are exposed to these chemicals, it can decrease their age of menarche due to the increase estrogen effects (23).

The lack of significance in comparing microwaving plastics and age of menarche can be due to many factors. Not every family will use the same products or be consistent all the time. In future studies on this subject, a survey could be changed to obtain more qualitative data and clarifying questions. For the question asking the number of drinks from plastic containers, responses varied due to the confusion on timing. The question should clarify to time of menarche. If this were to change, many female participants would tend respond with correct numbers for the period of time being researched. With the increase in plastic use, the results might show a trend in the use of plastics and age of menarche. Another question that could also be changed is that of the preparation of food. Since many people choose food options different than preparing it themselves, such as food from a café, restaurants, deli, etc., this question is hard to prove causality. It is difficult to inquire the changes in cooking habits of many households because not every female was raised the same way or had the same family. Therefore, it is not fair to say that the food choices or preparation of foods are a cause of the age of menarche. This supports the data results for this study. There was not a significant difference between preparation types or use of microwave use when it comes to the age of menarche. Both values for ANOVA and T-tests were over 0.05, which shows that there is no difference between response types. If the questions were altered and the sample size was larger, a trend or difference may have been seen. With other studies, the EEDC's in products have shown to affect onset of puberty (23). Along with the high estrogen levels associated with puberty, studies show the genes involved in the synthesis of estrogen could also have an affect on the onset too (10).

In summary, there are many things that have been shown to affect the age of menarche through literature reviews. There can be many genes or gene mutations that affect the age of menarche, such as the genes for cytochrome p450 enzymes and even mutations in the leptin gene

(3, 10). The Maternal age of menarche is closely related to that of her daughter's age of menarche (1). It seems there has been a decrease in the age of menarche over time seen from generation to generation (6). The maternal age being older can influence the daughter's age of menarche to be earlier, about 9 days for every year increase in maternal age at childbirth (23). There have been many studies done with ethnicity and race. It is seen that when adjusted for BMI other factors, African American's still tend to have earlier menarche (14, 25). A higher BMI tends to be associated with an earlier menarche (8). Constitutional Advancement of Growth was termed by a study to show that girls who have advanced growth when they are younger tend to start menses earlier (20). The environment has also been shown to affect the age of menarche. Estrogen-like endocrine disrupting chemicals found in many products can affect the timing of menarche. If exposed to these chemicals longer or in early development, the onset of menarche could be earlier or a girl could go through precocious puberty (23). With many different studies, it has been shown that the settings in which girls were raised can influence the age of menarche (22). Urban settings tend to show an earlier menarche whereas rural areas show a later menarche. One reason for this could be the amount of food/resources available. Along with setting, the socioeconomic status has also shown a trend in the age of menarche. Those girls who have a higher status tend to have an early menarche compared to those with a lower socioeconomic status (1).

For future research, there are many aspects that could improve. Increasing the sample size is a big part of research and can result in more significant results and conclusions between variables. Having a larger age range would help to see a trend in the age of menarche over time. A more diverse group of participants would allow for more trends and significance. The survey conducted could be changed to obtain more information by clarifying questions so participants

know exactly what is asked of them. If certain questions, such as the microwave use, population size and number of plastic drinks a week was specified to be all at time of menarche and not present time, the results might have been significant to find effects on the age of menarche. There are many factors that influence or can result from the age of menarche. This study is a small part of all the research going on in this area, but the important part of future research is spreading awareness and education about what has been determined thus far.

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References:

1. Adair, Linda S., and Penny Gordon-Larsen, PhD. "Maturational Timing and Overweight Prevalence in US Adolescent Girls." *American Journal of Public Health.* 91.4 (2001): 642-644.
2. Adair, Linda S. "Size at birth predicts age at menarche." *Pediatrics.* 107.4 (April 2001): E59.
3. Bandini, L G, et al. "Change in leptin, body composition and other hormones around menarche--a visual representation." *Acta Paediatrica.* 97.10 (2008): 1454-1459.
4. Boron, Walter F. and Emile L. Boulpaep. Medical Physiology. 2e. Saunders 2 (2009): 1113-1210.
5. Cabanes, Anna et al. "Decline in age at menarche among Spanish women born from 1925 to 1962." *BMC Public Health.* 9.449 (2009).

6. Chang, Shiow-Ru, and Kuahng-Ho Chen. "Age at menarche of three-generation families in Taiwan." *Annals of Human Biology.* 35.4 (2008): 394-405.
7. Freedman, David S, et al. "Relation of age at menarche to race, time period, and anthropometric dimensions: the Bogalusa Heart Study." *Pediatrics* 110.4 (2002): e43.
8. Frisch, Rose E. "The right weight: body fat, menarche and fertility." *Proceedings of the Nutrition Society*. 53 (1994): 113-129.
9. Gaudineau, Adrien, et al. "Factors associated with early menarche: results from the French Health Behaviour in School-aged Children (HBSC) study." *BMC Public Health* 10.(2010): 175.
10. Guo, Yan, et al. "Polymorphisms of estrogen-biosynthesis genes CYP17 and CYP19 may influence age at menarche: a genetic association study in Caucasian females." *Human Molecular Genetics* 15.16 (2006): 2401-2408.
11. Gunther, Anke L. B. et al. "Dietary Protein Intake throughout Childhood Is Associated with the Timing of Puberty." *The Journal of Nutrition.* 140.3 (2010): 565-571.
12. He, Chunyan et al. "Age at Menarche and Risk of Type 2 Diabetes: Results From 2 Large Prospective Cohort Studies." *American Journal of Epidemiology.* 171.3 (2009): 334-344.
13. Kaplowitz, MD, PhD, Paul B. "Link Between Body Fat and the Timing of Puberty." *Pediatrics.* 121. Suppl. S (2008): S208-S217.
14. Karapanou, Olga, and Anastasios Papadimitriou. "Determinants of menarche." *Reproductive Biology And Endocrinology: RB&E* 8, (2010): 115.
15. Li, Christopher I, Alyson J Littman, and Emily White. "Relationship between age maximum height is attained, age at menarche, and age at first full-term birth and breast cancer risk." *Cancer Epidemiology, Biomarkers & Prevention: A Publication Of The American Association For Cancer Research, Cosponsored By The American Society Of Preventive Oncology* 16.10 (2007): 2144-2149.
16. Matchock, Robert L, and Elizabeth J Susman. "Family composition and menarcheal age: anti-inbreeding strategies." *American Journal Of Human Biology: The Official Journal Of The Human Biology Council* 18.4 (2006): 481-491
17. Mouritsen, A. et al. "Hypothesis: exposure to endocrine-disrupting chemicals may interfere with timing of puberty." *International Journal of Andrology.* 33.2 (2010): 346-359.
18. Murphy, Laura. (2010). Lecture Slides and Spoken Lecture. October 13- November 3.
19. Osuch, Janet et al. "Association of age at menarche with adult leg length and trunk height: Speculation in relation to breast cancer risk." *Annals of Human Biology.* 37.1 (2010): 76-85.
20. Papadimitriou, Anastasios. "Constitutional Advancement of Growth, a.k.a. Early Growth Acceleration, Predicts Early Puberty and Childhood Obestiy." *The Journal of Clinical Endocrinology & Metabolism.* 95.10 (2010):4535-4541.
21. Rah, Jee H. et al. "Age of Onset, Nutritional Determinants, and Seasonal Variations in Menarche in Rural Bangladesh." *Journal of Health Population and Nutrition.*27.6 (2009): 802-807.
22. Rigon MD, Franco et al. "Update on Age at Menarche in Italy: Toward the Leveling Off of the Secular Trend." *Journal of Adolescent Health.* 46 (2010): 238-244.

23. Roy, Jonathan R, Sanjoy Chakraborty, and Tandra R Chakraborty. "Estrogen-like endocrine disrupting chemicals affecting puberty in humans--a review." *Medical Science Monitor: International Medical Journal Of Experimental And Clinical Research* 15.6 (2009): RA137-RA145.
24. Shrestha, Anshu, et al. "Parental age at childbirth and age of menarche in the offspring." *Human Reproduction (Oxford, England)* 25.3 (2010): 799-804.
25. Wu, Tiejian, Pauline Mendola, and Germaine M Buck. "Ethnic differences in the presence of secondary sex characteristics and menarche among US girls: the Third National Health and Nutrition Examination Survey, 1988-1994." *Pediatrics* 110.4 (2002): 752-757.