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Measurement in Physical Education and Exercise Science

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/hmpe20

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To cite this article: S. R. Siegel , L. True , K. A. Pfeiffer , J. D. Wilson , E. M. Martin , C. F. Branta , C. Pacewicz & R. A. Battista (2020): Recalled Age at Menarche: A Follow-up to the Michigan State University Motor Performance Study, Measurement in Physical Education and Exercise Science, DOI: 10.1080/1091367X.2020.1769633

To link to this article: https://doi.org/10.1080/1091367X.2020.1769633

Published online: 31 May 2020.

MEASUREMENT IN PHYSICAL EDUCATION AND EXERCISE SCIENCE
https://doi.org/10.1080/1091367X.2020.1769633

Recalled Age at Menarche: A Follow-up to the Michigan State University Motor Performance Study

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ABSTRACT

Sexual maturation is one method by which researchers account for developmental timing during growth. In a longitudinal motor performance study (MPS), mothers reported their own recalled age at menarche and their daughters.' Approximately twenty years later, a sample of those daughters provided their recalled age at menarche. Study purposes were to determine whether: 1) average age at menarche for this sample was similar to the extant literature; 2) daughters' and mothers' ages at menarche collected during the MPS differed; and 3) a retrospective assessment of age at menarche (daughters' reports as adults) was correlated to recall data (mothers' reports of daughters' age). Descriptive and inferential statistics were calculated for the sample; via probit analysis, MPS females were average in maturational timing. Mothers and daughters did not differ in menarcheal age; daughters' initial reported mean age at menarche correlated with their recalled mean age at follow up, $r = 0.82$ ($p < .0001$).

KEYWORDS

Age at menarche; Michigan State University Motor Performance Study; longitudinal research

Introduction

Assessing biological maturation in youth is necessary to determine developmental timing during physical growth. Biological maturation can be evaluated by a variety of methods. One of these measures, age at menarche, or the beginning of sexual reproductive maturity, is the most commonly used indicator of sexual maturation status in females (Malina & Bouchard, 1991). Age at menarche has a number of advantages over other assessment methods. Specifically, the method is less intrusive than other methods of assessing sexual maturity status, does not require radiation (as does assessment of skeletal maturation), and does not require a longitudinal research design (as does assessment of somatic maturity via peak height velocity). Menarche occurs later than other components of sexual maturation (Cameron, 2002; Karapanou & Papadimitriou, 2010; Malina & Bouchard, 1991; Marshall & Tanner, 1969; Malina et al., 2004; Tanner, 1962), and average age at menarche (whether mean or median) varies by socioeconomic status (SES), living conditions, physical activity levels, geographic location, and ethnicity (See Table 1 for further details). In the United States, the median age at menarche is 12.34 years (95% Confidence Interval {CI} = 12.24–12.45) (Anderson & Must, 2005). Overall, age at menarche is a critical measure of assessing female maturation due to its being a less intrusive and less expensive option, but some concerns exist in how the measure is typically assessed and further investigation is warranted.

Age at menarche can be assessed in a number of ways, with the most common estimation methods being status quo, prospective, and retrospective or recall. In the status quo method, which remains the most common procedure to estimate age at menarche in a large sample (Hediger & Stine, 1987; Malina, 1994), the investigator simply asks whether the girl has yet begun menstruating, and the researcher elicits a yes or no response. These answers are recorded and statistically analyzed by means of a probit method to arrive at the median menarcheal age and the standard deviation of age at first menstruation in the group studied. Unfortunately, as soon as the question of "when" arises, as opposed to the simple yes/no response, the problem of accurate recall reappears (e.g., Claessens et al., 1992; Chompootaweep et al., 1997; Eveleth & Tanner, 1990; Tanner, 1962).

To a certain extent, using the status quo and probit method of analysis removes the bias due to errors in

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Table 1. Select studies, average age at menarche.

Study, year	Country	n	Mean ± SD (yrs)	Median (yrs)
Al-Sahab et al., 2010	Canada	1403	12.72 ± 1.05	-
Anderson & Must, 2005	US	1720	12.34 (CI 12.24–12.45)	-
Chumlea et al., 2003	US	2510 Total	-	12.43 (CI 12.33–12.53)**
		Non-Hispanic Whites		12.55 (CI 12.31–12.79)
		Non-Hispanic Blacks		12.06 (CI 11.84–12.08)
		Mexican American		12.25 (CI 12.04–12.46)
Chompootaweep et al., 1997	Thailand	15,998	12.51 ± 1.17	-
Claessens et al., 2003	European Rowers	212	12.75 ± 1.20	-
Damon & Bajema, 1974	US	143	12.81 ± 1.30	-
Freedman et al., 2002***	US	Black	12.30	12.10
	Louisiana	White	12.60	12.50
Geithner et al., 1998	Poland	23 A*	13.20 ± 0.72	-
		26 NA	12.90 ± 0.83	
Hediger & Stine, 1987	US Pennsylvania	272	12.44 (SE = 0.08)	-
Lindgren, 1976	Sweden	360	13.05 ± 1.03	-
Lundblad & Jacobsen, 2017	Norway	6731	13.20 ± 1.30	-
Nicholson & Hanley, 1953	US California	91	12.80 ± 1.10	-
Mao et al., 2017	China	2458	12.50 ± 1.44	-
Talma et al., 2013	Netherlands	6270 Dutch	-	13.05 (CI 12.9–13.18)
		1267 Turkish		12.50 (CI 12.1–12.8)
		1328 Moroccan		12.60 (CI 12.3–12.0)
Ulijaszek et al., 1991	London	1265 European	13.59 ± 0.37	-
		530 Afro-Caribbean	13.18 ± 0.11	
		282 Indo-Pakistani	13.06 ± 0.20	
Wellens et al., 1990	Belgium (Flemish)	4894	-	13.20 ± 1.25

*A = Actively training in sport; NA = Not actively training in sport.
**CI = 95% confidence interval.
***Sample sizes varied by study design, they ranged from 2058 to 11,218.

recall over time. However, it is still open to issues common to self-report. Several studies have addressed participants' perceptions regarding the cultural components of reporting this information and whether it is socially desirable to have an earlier versus later age at menarche. In other words, some girls may be stating they have achieved menarche, when, in fact, they have not (Artaria & Henneberg, 2000; Lindgren et al., 1991). In the Artaria and Henneberg sample (Artaria & Henneberg, 2000), girls of higher SES reported a mean age at menarche of 9.49 years, when this was not apparent in the actual data collection. The invasiveness of questions on the topic of menarche, the cultural sensitivity needs of the population (Lindgren, 1976), and possible social stigma attached to timing of maturation may also cause modesty among participants and, ultimately, an unwillingness to discuss menarche (Ulijaszek et al., 1991), leading to a reliability issue in this method.

A second method of obtaining age at menarche is through prospective assessment, this is the most accurate as it is occurring in conjunction with the event; participants are asked every six months or so if they have yet reached menses. Despite its accuracy, the prospective method is also the most difficult to collect as it requires a longitudinal study that pre-dates puberty and lasts past the event (Cameron, 2002; Damon & Bajema, 1974; Damon et al., 1969; Malina & Bouchard, 1991).

Finally, a third way of obtaining age at menarche is through recall, or asking post-menarcheal females if they remember their age at first menses. In some cases, requesting the menarcheal information from the mother of the child of interest may be a better option than asking the girl herself. In addition, obtaining the mother's menarcheal information may also allow researchers to more completely assess environmental vs genetic influences on age at menarche (Baxter-Jones et al., 2002). For example, menarcheal age is known to be highly correlated with maternal menarcheal age due to genetic influences (Baxter-Jones et al., 2002; Damon et al., 1969). However, genetic factors are not solely responsible for variability in age at menarche, as environmental components also play a role. For example, SES, physical activity, and nutritional status all have the potential to impact menarcheal timing (Brooks-Gunn et al., 1987; Ersoy et al., 2005; Malina & Bouchard, 1991; Malina et al., 2004; Tanner, 1962). Depending on a variety of conditions, recall may be less valid, and reliability of the measurement is often lost (Bergsten-Brucefors, 1976; Cameron, 2002; Livson &

McNeill, 1962), oftentimes due to faulty memory. In other cases, reliability may decrease due to a sort of regression toward the mean age at menarche (Livson & McNeill, 1962). In addition, there appears to be a negative association between the age of the woman being asked and her age at reported menarche (Cameron, 2002). However in much of the literature, the studies began after puberty, so having retrospective data was the only option.

Recent research has shown that methods of assessing age at menarche can be problematic, and participant answers for age at menarche are possibly dependent on assessment method. In 253 girls assessed in a cross-sectional study (Dorn et al., 2013), age at menarche was annually assessed using in-person clinician interviews followed by phone interviews conducted by research assistants. Reliability of recalled age at menarche across time was moderate and depended on how the data were collected. In-person interviews were more reliable (ICC = 0.77) compared to phone interviews (ICC = 0.64) (Dorn et al., 2013). Significant correlations between prospective data and the follow up recall data range from r = 0.66–0.84, and the time period over which recall data have been collected varies from 4 to 39 years (Bergsten-Brucefors, 1976; Cooper et al., 2006; Koprowski et al., 2001; Livson & MacNeill, 1962; Must et al., 2002). While the accuracy of the recall method may decrease over time, it is a reasonable estimate according to many researchers (e.g., Cameron, 2002; Livson & McNeill, 1962; Lundblad & Jacobsen, 2017). However, recalled age at menarche still deserves more investigation, especially in groups that can track female participants longitudinally and can obtain measures of both mother and daughter ages at menarche.

In addition to the measurement concerns cited previously, there is also interest in secular trends, or change in age at menarche over time. Past studies have shown secular changes in age of menarche were multifactorial and impacted by a variety of factors including (but not limited to) wartime vs times of peace, nutritional status (abundant vs sparse), economic downturns vs times of prosperity, urbanization, and growth hormones in food (Danker-Hopfe, 1986; Freedman et al., 2002; Tanner, 1962; Wellens et al., 1990). Assessing secular trends in age of menarche can be difficult and ideally would be conducted with a more controlled sample over time where measurement methods could be assessed for accuracy.

One study in which researchers assessed age at menarche at both prospective and retrospective times as well as collected mother and daughter age at menses was the Michigan State University Motor Performance Study (MPS). The MPS tested youth on a battery of physical growth, maturation, and motor performance tasks twice yearly from 1967–1999 (Branta et al., 1984). In 1978–1979, in order to include the maturational age of females in the study, mothers of MPS participants were asked to report the age at menarche for their daughters. At the same time (1978–1979), the mothers also reported their own recalled ages at menarche. In the follow-up study to investigate participants' adult health outcomes (mid to late 1990s), a small sample of females (daughters) reported their recalled age at menarche.

Thus, this paper assessed menarcheal age in a sample of participants and their mothers. The purposes of this study included determining whether: 1) the average age at menarche for this sample of females from the 1960s and 1970s was similar to reported data from the literature, 2) daughters' and mothers' ages at menarche differed during the MPS, and 3) a retrospective assessment of daughters' age at menarche (~20 years after the fact) was related to their menarcheal data reported during the study.

Methods

Over 1200 (n = 1216) children and youth participated in the overall MPS over 32 years. Participants attended schools in 20 districts near the university and were healthy, free of overt disease, and had no physical, mental, or emotional disabilities. Participants were assessed biannually on myriad growth, maturation, and motor performance variables. For the purposes of this paper, *MPS* is designated as the longitudinal time period when the data were being collected every 6 months. The *follow-up* occurred in the mid to late 1990s.

For the maturational component of the females in the MPS, letters were sent to the mothers of all female participants who were between 9 and 18 years of age (n = 202), asking for age at menarche for themselves and their participating daughters in October 1978. The estimated average age of the daughters during this time of the MPS was approximately 11 years of age. Between November 1978-February 1979, 118 mothers (58.4%) reported their own ages at menarche, and 99 provided the information for their daughters (49.0%). As per recommended protocol (Cameron, 2002; Malina et al., 2004; Tanner, 1962), via telephone calls or in person, the researchers provided cues to help remind the mothers if their daughters' menarcheal age was close to a birthday, near a holiday, in the summer or fall, etc. (C. F. Branta, personal communication, February 6, 2020).

Although 118 of the mothers reported their own ages at menarche, only 83.8% were able to report their daughters' age at menarche. In part, this is because a few of the MPS daughters had not yet reached menses, and 3–4 individuals had been adopted, had already achieved menarche, and their mothers responded "not applicable" when queried (C. F. Branta, personal communication, February 6, 2020).

To acquire the estimated median age at menarche for the sample, a probit analysis of responses was calculated for the original sample of data (n = 99) from 1978/1979. With this method, the percentage of girls at each age who had reached menarche was determined, and the median age at menarche was calculated.

Correlations were calculated between mothers' data recalled for themselves and their daughters, collected in 1978–79. An independent samples t-test was performed to determine if mothers and daughters differed in age at menarche.

In the mid to late 90 s, researchers mailed a follow-up survey to assess sport, physical activity participation, and various health parameters in the sample; recalled age at menarche was one of the questions asked at follow-up. The surveys were mailed to 421 eligible participants, and 256 were fully completed and returned. The female portion of this sample (n = 129) was 32.63 ± 3.86 years of age at follow-up. Of the females who were asked to provide information concerning their age at menarche, 127 agreed (98.4% response rate). Similar to the original data collection on menarcheal age, respondents (daughters) in the follow-up sample were asked to provide recalled age at menarche.

A total of 39/127 (31%) of the MPS daughters who had their data reported during the MPS also provided their age at menarche at the follow-up. Using R software (R Core Team, 2017), descriptive statistics for age at menarche were calculated for mothers during the MPS, daughters during the MPS, and follow-up on daughters, respectively. In addition, correlations were calculated among the 39 daughters who had age at menarche reported during the MPS and age at menarche recalled during the follow-up. For all statistical analyses, a significance level of α = 0.05 was required.

Results

The percentages for recalled median age at menarche of the MPS daughters as reported by their mothers are presented in Figure 1. The estimated median age at menarche based on probit analysis of the status quo data was 13.00 ± 1.1 years.

Age at menarche reported by mothers for their daughters during the MPS was (mean ± sd) 13.13 ± 1.2 years (minimum-maximum = 11.2–16.7 years). In addition, a positive relationship was found between mothers' self-report and their report of their daughters' ages at menarche, r = 0.44, p = .0045. Mothers of the MPS participants reported a slightly younger mean age at menarche than their daughters (12.98 ± 1.5 years). However, mothers and daughters did not significantly differ in age at menarche (p > .05). Further, at follow-up, daughters recalled their mean age at menarche as 13.07 ± 1.3 years (minimum-maximum = 10.8–16.4 years). For the 39 MPS participants (daughters) who had both their mothers' reports of their age at menses and their own recall almost 20 years later, the correlation was positive and strong: r = 0.82, p < .0001.

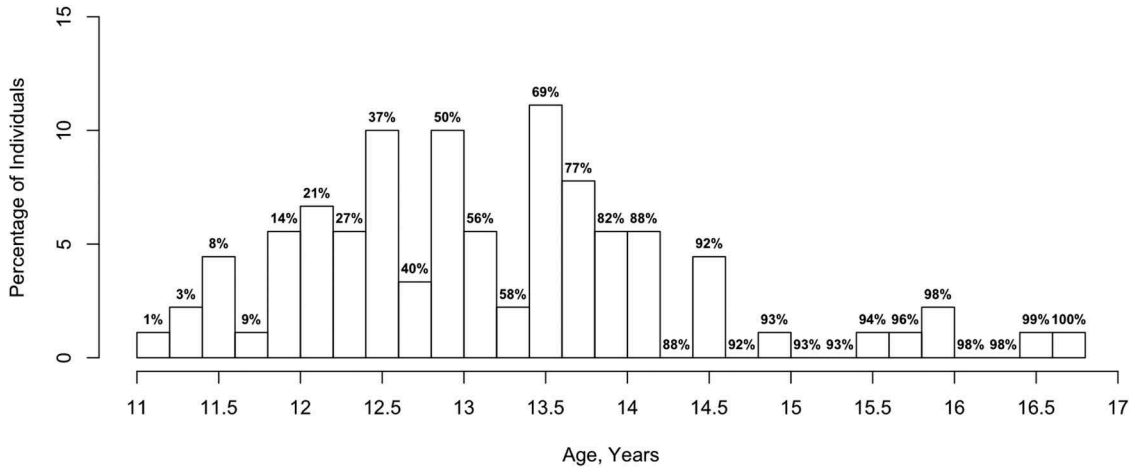

Figure 1. Cumulative percentage of daughter participants (n = 99) and their median age at menarche during the Michigan State Motor Performance Study.

Discussion

Age at menarche can be assessed via status quo, prospectively, and retrospectively. The ages at menarche in the MPS are similar to the average for a healthy U.S. population (Anderson & Must, 2005; Chumlea et al., 2003; Malina, 1994), as average age at menarche ranges from 12 to 14 years in most populations (Malina et al., 2004). Results from the current study are also consistent with data collected during the 60 s and 70 s (e.g., Damon & Bajema, 1974), and are similar to results across the globe (See Table 1). For example, a larger sample from China (n = 3748) showed that average age at menarche was 12.50 ± 1.20 years (Mao et al., 2017), and minimal differences in outcome were found whether age at menarche was obtained via a computer administered questionnaire or in-person interview. Mean age at menarche in a Norwegian sample was 13.20 ± 1.30 years (Lundblad & Jacobsen, 2017). This range of ages for menarche is reasonably consistent across around the world (with some fluctuation depending on maturational timing, ethnicity and/or region of residence; see Malina et al., 2004, for example), and the MPS participants are no exception.

Reliability of maternal report is also relevant in the MPS study, and the method of assessment is not common in the literature. In the only other study found with a methodology including parental report of menarcheal age versus daughters' reporting of same, the correlation between reports was $r = 0.799$ using a Spearman rank order correlation, $p < .001$ (Biro et al., 2018). The Biro et al. study (Biro et al., 2018) was prospective in nature, so the parents and daughters were asked annually whether menarche had yet been reached, and agreements calculated. Although the methodology of the Biro et al. study differed from that of the MPS, the correlations between parental report and daughter report were similar.

The relationship between mothers' and daughters' ages at menarche in the MPS sample ($r = 0.44$, $p = .0045$) showed a slightly stronger correlation than prior research in which significant correlations ranged from $r = 0.24$–0.32 between mothers' and daughters' ages at menarche (i.e., Brooks-Gunn & Warren, 1988; Damon et al., 1969; Ersoy et al., 2005; Malina et al., 1994; Tehrani et al., 2010) (See Table 2). Even though the correlation in this study was stronger than past studies, the correlation was still moderate with several other factors likely impacting age at menarche. In general, if girls are healthy and well nourished, menarche is largely a genetically driven marker (Ersoy et al., 2005; Malina & Bouchard, 1991; Malina et al., 2004), and so a moderate-strong correlation between mothers and daughters might be expected. That said, activity levels, such as whether the individual is an athlete or not, familial size, SES, nutritional status, education level, urban vs rural location, and other environmental factors can also have a strong influence on menarcheal timing (Baxter-Jones et al., 2002; Brooks-Gunn & Warren, 1988; Danker-Hopfe, 1986; Ersoy et al., 2005; Malina et al., 1994, 2004; Ulijaszek et al., 1991). The extent to which environmental factors modified or confounded the age at menarche relationship between mothers and daughters in the MPS sample is unknown and was not the focus of this paper.

In addition, mothers and daughters in the MPS were similar in average age at menarche; that is, they did not significantly differ ($p > .05$). This result contrasts with much of the literature, which indicates mothers' ages at menarche as being significantly later than those of their daughters. Many researchers have reported that age at menarche is declining, meaning that, on average, girls are maturing earlier than in the past. These secular trends have occurred over time and throughout the world (see, for example, Damon et al., 1969; Ersoy et al., 2005; Eveleth & Tanner, 1990; Freedman et al., 2002; Tanner, 1981). Lindgren et al. (1991) found the secular trend stopped by 1978 in a sample of Swedish girls, with age at menarche no longer decreasing at the

Table 2. Select studies, average ages at menarche of daughters (D) and their mothers (M) and correlations between the two.

			Daughters	Mothers	
Study, year	Country	n	Mean ± SD	Mean ± SD	r**
Brooks-Gunn & Warren, 1988	US	47-DN*	13.26 ± 1.29	12.70 ± 1.49	0.32
		260-CO	12.79 ± 1.13	12.69 ± 1.41	0.26
Damon et al., 1969	US	78-D	12.88 ± 1.08	14.38 ± 1.39	0.24
	Massachusetts	66-M			
Al-Agha et al., 2015	Saudi Arabia	165	11.50 ± 1.48	12.97 ± 1.71	0.26
Ersoy et al., 2005	Turkey	1017	12.82 ± 1.07	13.60 ± 1.39	0.26
Malina et al., 1994	US	109	13.80 ± 1.50	13.40 ± 1.70	0.25
	Athletes				
Tehrani et al., 2010	Iran	770	13.17 ± 1.36	13.61 ± 1.50	0.27
Current study	US	99-D	13.13 ± 1.20	12.98 ± 1.50	0.44
	Michigan	118-M			

*DN = Dancers; CO = Non-dancer comparison group.
** all correlations were significant ($p < 0.05$).

time of their study. In a population-based study of US women born between 1910–1949, Nichols et al. (2006) found a slight but significant decrease in age at menarche; however, for women born in the 1960's, there was a slight increase in average menarcheal age. Lastly, Lee et al. (2001) could not confirm any significant changes (decrease or increase) in pubertal timing, including age at menarche. Thus, the lack of significant difference between ages at menarche in the daughters and their mothers in the MPS were consistent with Lee et al. (2001) but were not consistent with other previous research that showed mothers had later ages at menarche than their daughters.

Despite the inherent flaws associated with self-report, such as accuracy and social desirability (e.g., Artaria & Henneberg, 2000; Lindgren, 1976; Lindgren et al., 1991), recalled age at menarche is often the only option for menarcheal data. Many studies have examined the accuracy of recalled age at menarche, with the sample sizes varying considerably from the current sample of 39, to as many as 8800 (Talma et al., 2013). The correlations between actual (often prospectively collected data) and recalled age at menarche ranged from r = 0.60–0.84. Time periods used for recall ranged from 3 to 39 years after participants were originally assessed (Bergsten-Brucefors, 1976; Bosetti et al., 2001; Cooper et al., 2006; Dorn et al., 2013; Koprowski et al., 2001; Livson & MacNeill, 1969; Lundblad & Jacobsen, 2017; Must et al., 2002). Results from the small MPS sample showed that participants had their reported ages at menarche from 1978/1979 correlate relatively reliably with recall data from the mid to late 90 s (r = 0.82, p < .0001). This agreement between the two points in time is particularly noteworthy given that the original data were reported from the mothers of the study participants.

As previous studies have reported a range of correlation coefficients, researchers have understandably shown various levels of support for the intrinsic usefulness of recall data. The relationship between prospectively collected and recalled ages at menarche for 339 Swedish girls 4–6 years after they reached menarche was r = 0.81 ± 0.5 (Bergsten-Brucefors, 1976). Because of the short time span between the two time periods, Bergsten-Brucefors believed that recalled menarcheal age was too inaccurate for most uses. Nonetheless, Livson and McNeill (1962) previously found the correlation of physician-measured prospective data and recalled ages to be r = 0.75 after 17 years. Additionally, Damon et al. (1969) reported a correlation of r = 0.78 between baseline and follow up after 19 years, and Damon and Bajema (1974) noted a correlation of r = 0.60 ± 0.5 after 39 years; in both studies, age at menarche was assessed prospectively for the baseline measure. Lundblad and Jacobsen (2017) assessed the reproducibility of age at menarche in 6731 Norwegian women prospectively self-reported between 1986–1987 and 1994–1995 and found agreement to be r = 0.84. Cooper et al. (2006) found the validity of the recall improved when the groups were categorized as early, average, or late maturers. Although the current sample was not, by definition, assessed prospectively, the correlation between maternally reported age at menarche of daughters during the MPS and the daughters' later recalled age at menarche was similar to results from earlier studies.

Limitations

This subset of the MPS had a small sample size for the recall data, and the sample was demographically homogenous (see Pfeiffer et al. methods paper, this issue). Related studies ranged in participant number from 23 to over 8,000. Due to the small sample size in the current study, the relationship between recall at the time of the current study and at the follow-up may be inflated. In the study with the most similar sample size, Livson and McNeill (1962) found a systematic error of 0.5 years after 17 years had passed from prospective data collection. Mean actual age of menarche was 12.8 ± 1.1 years, but for the 43 who reported their recalled age at menarche, the mean was 12.3 ± 1.1 years (Livson & McNeill, 1962). Nonetheless, in this same sample (Livson & McNeill, 1962), the correlation between recalled and prospective data was r = 0.75.

Another limitation of the current study is that researchers never directly asked the daughters their age at menarche during the original longitudinal study, although their mothers may have asked them. The daughters only provided their own information at the follow-up in the mid-late 1990s. Determining the accuracy of the mother's reports can only be addressed in hindsight, but the follow-up data were reasonably consistent (r = 0.82) with the information provided during the study.

The final two limitations to the study are related to data collection. First, the chronological ages of the mothers were not reported when they were asked for their age at menarche during the MPS. Although they were estimated to be in their 30 s during the time of data collection, we have no record of confirmation of this information (C. F. Branta, personal communication, February 6, 2020). Secondly, due to the variable ages of entry into the study, and that the data on menarcheal age were collected over a period of 3–4 months, we do not have information on exactly

how many years post menses the daughters were during the MPS or at the follow-up.

Strengths

Although the sample size was small for matched recall data, the correlation between age at menarche recorded during the MPS and age recalled at follow-up is positive, strong, and statistically significant. This is particularly interesting given that the original menarcheal ages were reported by the mothers of the MPS participants.

In addition, the reliability of the recall data was likely improved due to the nature of the longitudinal study itself. It is a logical assumption that the daughters would be likely to remember a detail such as age at menarche when they were adults since they were involved in a study whereby they were assessed every 6 months from childhood through adolescence, and they received consultations from the researchers after every visit (C. F. Branta, personal communication, October 9, 2019).

Conclusion

Overall, the average age of menarche for the MPS sample was similar to that of the extant literature. Contrary to much of the literature, mothers and daughters did not significantly differ in their average age at menarche. Further, the correlation between menarcheal ages of mothers and daughters showed a stronger association than that found in the literature (r = 0.44, p = .0045). Lastly, daughters' age at menarche, reported by their mothers and collected in the late 1970s during the MPS was positively and strongly correlated with the daughters' recall data collected at the follow-up (r = 0.82, p < .0001).

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