Menarche and Sleep among Japanese Schoolgirls: An Epidemiological Approach to Onset of Menarche

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MURATA, K. and ARAKI, S. Menarche and Sleep among Japanese Schoolgirls: An Epidemiological Approach to Onset of Menarche. Tohoku J. Exp. Med., 1993, 171 (1), 21-27 — Menarche occurs in the pubertal period of normal girls without endocrine disorders; nevertheless, the mechanism of its onset remains unclear. A cross-sectional study was conducted in 254 schoolgirls aged 9 to 15 years to clarify the effects of age, body weight, height, hours of sleep, and sleep conditions on the onset of menarche. Among six schoolyear groups comprising about 42 girls for each, the menarcheal percent, body weight, and height significantly increased according to the school year; by contrast, hours of sleep shortened significantly. The maximal increase in the menarcheal percent followed the abrupt decrease in hours of sleep. The result of multiple logistic regression analysis indicated that body weight, height, and hours of sleep were significantly related to the presence/absence of menarche while controlling for the effects of age and sleep conditions. These data suggest that the onset of menarche is affected by hours of sleep, as well as body weight and height reported in the previous studies.

The mechanism of the onset of menarche, a consequence of a complex sequence of maturational changes in the pubertal period, remains ambiguous. Age at menarche has been demonstrated to be influenced by nutrition (Goldfarb 1977), body composition (Johnston et al. 1971; Frisch 1972; Nagai et al. 1980a) and socioeconomic factors (Zacharias and Wurtman 1969; Low et al. 1982; Grumbach et al. 1990; Moisan et al. 1990) including socioeconomic status, family size, public and individual health; such socioeconomic and physical factors, however, do not always seem to be directly connected with endocrinological changes regarding the onset of menarche, e.g., the increased secretion of sex steroids in the pubertal period (Penny et al. 1978).

Several hormones combined with the menarche/menstruation have close relations to sleep (Takahashi et al. 1968; Silman et al. 1979; Lang et al. 1981; Ehrenkranz et al. 1982; Waldhauser et al. 1984; Grumbach et al. 1990). Especially, the serum levels of melatonin, which is secreted by the pineal body mainly during the night and appears to have inhibitory actions to reproductive functions.
in mammals, decrease progressively with advancing age (Silman et al. 1979; Iguchi et al. 1982; Grumbach et al. 1990). Apart from endocrinological observations, the amount of sleep decreases with increasing age among school children (Terman and Hocking 1913; Roffwarg et al. 1966; Ohno et al. 1973); whereas, it has been stated that adolescents require more sleep than those in other age groups (Goldfarb 1977). Also, regularity of sleep time has been reported to affect menstrual cycles in high school students (Murata et al. 1980). Based upon these findings, it would be suggested that sleep is associated with the onset of menarche. In this article, a cross-sectional study was conducted in schoolgirls to clarify the effects of sleep, together with body weight and height, on the onset of menarche.

**SUBJECTS AND METHODS**

The study population was 254 Japanese healthy schoolgirls, aged 9 to 15 years, namely the fourth to sixth grade of the elementary school and the first to third grade of the junior high school. According to the school year, the sample numbers (average ages in parentheses) were 44 (9.4 years), 41 (10.3), 44 (11.3), 41 (12.4), 41 (13.4) and 43 (14.3), respectively; as a rule, there is not “skip” or “drop out” in the grade of the elementary or junior high schools of Japan. None of them had ever suffered from endocrinologic or confounding disorders such as pituitary insufficiency, pinealoma, myxedema, Addison’s disease, or hypoglycemia. One school with both the elementary and high schools, affiliated to a national university, in the center of Tokyo was selected to preserve the uniformity in socioeconomic status of children’s parents which is, supposedly, related to the age at menarche (Moisan et al. 1990). This school has 2 classrooms for each grade in the elementary school and 4 in the junior high school (about 45 boys and girls per classroom); approximately 90 pupils from external public elementary schools enter into this junior high school after entrance examination every year, who were excluded in this study to avoid selection bias. Proportions of the specialized and technological workers and the administrative workers in children’s parents were 27% and 46%, respectively (none of the parents engaged in either farm, fishing and forestry or skilled and manufacturing work); all their families belonged to the high middle-socioeconomic class. It is generally accepted in Japan that the rate of entrance into famous universities is much higher in students who graduate from such attached schools than from other public schools.

Age, body weight, height, hours of sleep, sleep conditions and the presence or absence of menarche were examined in cooperation with two nurse-teachers of the school in June (i.e., between the midterm and term examinations), by means of the self rating questionnaire. Hours of sleep were calculated as the difference between the usual times to go to bed and to wake up on weekdays. The items on sleep conditions comprised regularity of sleep time (“On weekdays, do you go to bed and get up punctually?”) and easiness of sleep (“Do you usually fall asleep within 30 minutes?”). The response to the former question was scored as “Yes, regular” = 0 and either “No, irregular” or “Sometimes, irregular” = 1; also, the response to the latter was scored as “Yes” = 0 and “No” = 1. In the elementary school, one nurse-teacher wrote only one item about the menarcheal age, because she had obtained personal information on school health including diseases, injuries and menses.

Scheffe’s multiple comparison method was used to determine the significance level of the differences in body weight, height and hours of sleep among six grade groups; also, the difference in the menarcheal percent was tested by the Fisher’s exact test. The multiple logistic regression analysis was done to examine the relations of age, body weight, height, hours of sleep, regularity of sleep time and easiness of sleep to the presence/absence of menarche (Walker and Duncan 1967). All analyses were performed using the Statistical
As shown in Fig 1, body weight and height increased significantly according to the school year (or age); similarly, the menarcheal percent increased, especially between the first and second grades of the junior high school. By contrast, hours of sleep shortened significantly, mainly between the fifth and sixth grades of the elementary school. There was no significant difference in either regularity of sleep time (the rate of those who answered “Yes, regular” to the 254 schoolgirls was 26%) or easiness of sleep (the rate of those who answered “Yes” was 77%) between 120 girls with menses and 134 girls without menses (chi-square test, \( p > 0.05 \)).

The result of multiple logistic regression analysis indicated that body weight,
height and hours of sleep were significantly related to the presence/absence of menarche (Table 1); the goodness-of-fit hypothesis of this logistic model was accepted \( \chi^2 = 7.92, \text{df} = 10, p > 0.05 \), testing the differences between the estimated and observed values after the schoolgirls were divided into 10 equal parts according to the ranked probability, calculated from the model, on the presence of menarche.

**DISCUSSION**

The principal results of this study were that the maximal increase in the menarcheal percent followed the abrupt decrease in hours of sleep, and that hours of sleep were significantly related to the presence/absence of menarche while controlling for the effects of age, body weight, height and sleep conditions. In previous studies, a similar decrease in hours of sleep has been observed both in Japan (Ohno et al. 1973; Japan Prime Minister's Office 1978) and in other countries (Terman and Hocking 1913; Roffwarg et al. 1966). Also, sleep appears to be closely associated with some hormone secretions, e.g., melatonin, growth and luteinizing hormones (Takahashi et al. 1968; Boyar et al. 1974; Silman et al. 1979; Lang et al. 1981; Ehrenkranz et al. 1982; Iguchi et al. 1982; Waldhauser et al. 1984; Grumbach et al. 1990). Thus these data suggest that the onset of menarche may be affected by hours of sleep.

There is some indirect evidence for our results. First, the trend toward earlier menarche was shown in Western Europe over the period 1830-1960 (Zacharias and Wurtman 1969), and in Japan during the period of 1946-1966 (Moriyama et al. 1977; Nagai et al. 1980a), which might have been attributable to not only improvement of nutritional status (Zacharias and Wurtman 1969; Goldfarb 1977) but also shortening of hours of sleep in children year by year on account of expansive diffusion of the television (Nippon Houso Kyokai 1972). Secondly, the average age at menarche among students who graduated from one private junior high school has been reported to be significantly lower than that from several public junior high schools, suggesting that the onset of menarche was influenced by entrance examination to the private junior high school (Nagai et al. 1980b). In this case, such an entrance examination would imply shortening of sleep due to hard work, as well as psychological stress (Grumbach et al. 1990). Thirdly, it is very likely that early menstrual cycles in high school students were influenced by changeability in hours of sleep, independent of the interval after menarche (Murata et al. 1980).

There was a time lag of about 2 years between the abrupt decrease in hours of sleep and the maximal increase in the menarcheal percent in the present study. Two explanations are possible for its interval: (1) as the amount of sleep is changeable within the individuals due to life events such as examination and excursion, it may be difficult for children to maintain constantly a certain amount of sleep, and (2) human reproductive organs including the hypothalamic-
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The pituitary gonadotropin-gonadal system might take such a long time to prepare the endocrinological milieu of menarche.

In the current study using the multiple logistic model, body weight and height also were significantly associated with the onset of menarche. The effects of these factors agree with many epidemiological studies (Johnston et al. 1971; Frisch 1972; Nagai et al. 1980a; Dewhurst 1985). Body weight and height might reflect physical maturation including nutritional status prior to menarche, since the high percentage of body fat in mature women is necessary for regular ovulatory cycles (Frisch 1990). On the other hand, no significant relationship was seen between the onset of menarche and age, suggesting that the onset of menarche is more susceptible to environmental factors than to age itself.

There was no significant association between the onset of menarche and sleep conditions (Table 1), although the regularity of sleep time and easiness of sleep, as well as low body temperature, bad awakening, and “breakfast-skipper” behavior, which were not examined in this study, appear to disturb both the circadian rhythm and menstrual cycle (Murata et al. 1980). From this finding, it is inferred that factors affecting the onset of menarche and the menstrual cycle may differ mutually. Additional study with multifactorial analyses is needed to clarify the difference of biobehavioral effects on the menarche/menstruation.

The comprehensive mechanism of menarche is not well understood (Dewhurst 1985; Plant 1988). Many endocrinologists showed that melatonin, one of the pineal hormones, suppressed the reproductive functions in mammals (Martin and Klein 1976; Silman et al. 1979; Lewy et al. 1980; Grumbach et al. 1990); melatonin in humans is secreted more during the night than during the day (Silman et al. 1979; Lang et al. 1981; Ehrenkranz et al. 1982; Iguchi et al. 1982; Waldhauser et al. 1984; Grumbach et al. 1990), speculating that the melatonin concentration is regulated by hours of sleep. There has been reported to be an abrupt fall in the melatonin concentration with advancing development in the pubertal period (Lang et al. 1981; Waldhauser et al. 1984). Moreover, nocturnal serum luteinizing hormone is low in prepubertal children, and increases progressively with sexual maturation, with a pattern inverse to that of melatonin (Waldhauser et al. 1984). The recent literature describes that the onset of puberty is heralded by disinhibition of the suppressed hypothalamic luteinizing hormone-releasing factor pulse generator (Grumbach et al. 1990). On the basis of the previous and present observations, accordingly, it is hypothesized that menarche may occur through depression of the melatonin concentration during the night resulting from the decrease in mean hours of sleep; whereas, an assumption that light influences human sexual maturation has not received much attention (Zacharias and Wurtman 1969). The explication of long-term effects of melatonin on the reproductive organs related to menstruation awaits further research.

Hours of sleep are easily affected by society, culture, and lifestyle. For that
reason, our results should be re-tested in children with a variety of different societies and cultures in the near future. Nevertheless, our notion itself may be extensive in respect to the aging process other than menarche, since hours of sleep gradually shorten at least from baby to young adult (Roffwarg et al. 1966; Japan Prime Minister’s Office 1978).

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