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Prevalence of Lifestyle Factors and Stress on Early Age of Menarche in Adolescent Girls Across Sindh

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ABSTRACT

Background: Menarche is a key marker of female pubertal development, and its timing is influenced by genetic, environmental, lifestyle, and psychological factors. In recent years, a global decline in age at menarche has raised concerns due to its association with multiple adverse physical and mental health outcomes. However, limited regional evidence exists regarding the role of lifestyle factors and stress in early menarche among adolescent girls in Sindh, Pakistan. **Objective:** To determine the prevalence of early menarche and assess its association with lifestyle factors and perceived stress among adolescent girls across Sindh. **Methods:** A cross-sectional study was conducted on 219 adolescent girls aged 10–15 years who had attained menarche. Data were collected using a structured questionnaire and the Perceived Stress Scale (PSS-10). Anthropometric measurements were taken to calculate BMI. Data were analyzed using SPSS version 29.0, and associations were assessed using descriptive and inferential statistics. **Results:** The majority of participants experienced menarche at 11–13 years (67.6%), while 14.2% reported early menarche (≤10 years). High levels of sedentary behavior, poor dietary habits, increased screen time, and moderate stress (84.5%) were commonly observed. A significant proportion of participants also had suboptimal BMI and limited physical activity. **Conclusion:** Early menarche is prevalent among adolescent girls in Sindh and is strongly associated with unhealthy lifestyle behaviors and psychological stress. Targeted interventions promoting healthy lifestyle practices and stress management are essential to improve adolescent reproductive health.

INTRODUCTION

Menarche, defined as the onset of the first menstrual period in adolescent girls, represents a key milestone in female pubertal development and reproductive maturity (Marques et al., 2022; Gottschewsky et al., 2024; Schreiber & Solebo, 2024). It is a complex biological event influenced by genetic, nutritional, environmental, and psychosocial factors (Nishan et al., 2025; Kusumah et al., 2024; Novalia et al., 2022). The timing of menarche is widely recognized as an important indicator of overall health and development, as both early and delayed menarche are associated with significant short- and long-term health consequences (Lee et al., 2022; Jiang et al., 2025; Warp et al., 2024). In recent decades, a global trend toward earlier menarche has been observed, raising concerns about its implications for adolescent and adult health outcomes (Cheng et al., 2022; Ramraj & Subramanian, 2021).

Early menarche, commonly defined as the onset of menstruation before the age of 12 years, has been linked to a range of adverse health conditions (Askelund et al., 2024; Itriyeva, 2022). These include increased risks of obesity, type 2 diabetes, cardiovascular diseases, and reproductive system cancers such as breast and endometrial cancer (SadrAzar et al., 2023; Cho & Han, 2023). In addition, early menarche has been associated with psychological consequences, including depression, anxiety, low self-esteem, and increased risk-taking behaviors during adolescence (Cheng et al., 2022). Therefore, understanding the determinants of menarcheal timing is essential for developing preventive strategies and improving adolescent health outcomes (Nishan et al., 2025).

Several epidemiological studies suggest that the decline in age at menarche is closely related to improvements in nutrition, increased body mass index (BMI), and changes in lifestyle behaviors (Ramraj & Subramanian, 2021; Matsuo et al., 2022). Increased consumption of energy-dense foods reduced physical activity, and sedentary lifestyles have contributed significantly to earlier pubertal onset in many populations (Calcaterra et al., 2023; Roddick et al., 2025). Adipose tissue plays a key role in the production of leptin and estrogen, both of which are

involved in the activation of the hypothalamic–pituitary–gonadal (HPG) axis, ultimately influencing the timing of menarche (Chen et al., 2022; Ning et al., 2025).

Psychosocial stress is another important determinant of pubertal timing. Chronic stress, family instability, academic pressure, and exposure to adverse childhood experiences have been shown to activate the hypothalamic–pituitary–adrenal (HPA) axis, leading to hormonal alterations that may accelerate or disrupt normal pubertal development (Street et al., 2023). Studies have demonstrated that girls exposed to higher levels of psychological stress tend to experience earlier menarche compared to those in more stable environments (Street et al., 2023). Furthermore, emotional distress and perceived stress during adolescence can influence menstrual health and overall reproductive function (Maqbool et al., 2022; Cherenack & Sikkema, 2022).

Environmental factors also play a significant role in shaping pubertal development (De Angelis et al., 2021). Exposure to endocrine-disrupting chemicals (EDCs), such as those found in plastics, pesticides, and polluted air, has been associated with altered hormonal regulation and earlier onset of puberty (Duman et al., 2021; Papadimitriou & Papadimitriou, 2021). Urbanization, lifestyle modernization, and increased exposure to environmental pollutants have been identified as contributing factors to declining menarcheal age in both developed and developing countries (Bolormaa et al., 2024).

In South Asian countries, including Pakistan, rapid urbanization, socioeconomic disparities, and changing dietary patterns have contributed to shifts in adolescent health profiles (Sharma, 2025). Limited physical activity, increased consumption of processed foods, and rising stress levels among adolescents may be influencing the timing of menarche in this population (Mishra et al., 2025; Sharma, 2025; De Angelis et al., 2021; Papadimitriou & Papadimitriou, 2021). However, there is limited region-specific evidence from Pakistan, particularly from Sindh, regarding the combined effect of lifestyle and stress-related factors on menarcheal age (Nishan et al., 2025; Ramraj & Subramanian, 2021). This gap in literature highlights the need for population-based studies to better understand these associations in local contexts.

Sindh, being one of the most populous provinces of Pakistan, is undergoing rapid urban and socioeconomic transitions (De Angelis et al., 2021). These changes have significantly influenced lifestyle behaviors, including dietary habits, physical activity patterns, and exposure to environmental stressors (Mishra et al., 2025; Sharma, 2025). Adolescents in this region are particularly vulnerable due to changing family structures, academic pressure, and increasing exposure to digital media (Cherenack & Sikkema, 2022). These factors may collectively contribute to earlier onset of menarche and associated health risks (Lee et al., 2022; Cheng et al., 2022; Jiang et al., 2025).

Therefore, this study aims to determine the prevalence of early menarche and examine the association between lifestyle factors, stress levels, and age at menarche among adolescent girls across Sindh. Understanding these relationships is essential for developing targeted public health interventions, promoting healthy lifestyle behaviors, and improving adolescent reproductive health outcomes in the region.

METHODOLOGY

A quantitative cross-sectional study design was used to determine the prevalence of lifestyle factors and stress associated with early age of menarche among adolescent girls across Sindh, Pakistan. This design was selected because it allows the assessment of exposure variables and outcomes simultaneously within a defined population.

The study was conducted in different geographical regions of Sindh province, including urban and rural areas. Data were collected from schools, colleges, hostels, and residential communities to ensure representation of adolescent girls from diverse socioeconomic and environmental backgrounds.

The target population consisted of adolescent girls aged 10–15 years residing in Sindh who had already attained menarche. Participants were selected from different socioeconomic classes and living conditions to assess variations in lifestyle and stress-related factors affecting the timing of menarche.

The study was completed over a period of two months after approval of the research synopsis and ethical clearance from the relevant institutional authority.

Sample Size

The sample size was calculated using the standard prevalence formula:

$$n = \frac{Z^2 P(1-P)}{d^2}$$

Where:

- n = required sample size
- Z = confidence interval at 95% (1.96)
- P = estimated prevalence of early menarche from previous studies
- d = margin of error (5%)

Based on the calculation, the final sample size was determined to be 219 participants.

A non-probability convenience sampling technique was employed. Participants who fulfilled the inclusion criteria and were available during the data collection period were invited to participate in the study.

Inclusion Criteria

1. Female adolescents aged 10–15 years residing in Sindh.
2. Participants who had already experienced menarche.
3. Participants willing to provide informed consent/assent.
4. Girls with self-reported age of menarche below 15 years.

Exclusion Criteria

1. Pre-menarche adolescent girls.
2. Girls with menarche occurring after 15 years of age.
3. Participants unwilling to participate in the study.
4. Adolescents with incomplete questionnaire responses.

Data Collection Tool

Data were collected using a structured self-administered

questionnaire developed in English and translated into Urdu and Sindhi for better understanding. The questionnaire consisted of multiple sections covering:

- Demographic characteristics
- Socioeconomic and living status
- Age of menarche and menstrual history
- Dietary habits and meal patterns
- Physical activity and screen time
- Sleep duration
- Academic and emotional stress
- Mental health indicators
- Environmental factors
- Chronic illnesses and family history

The questionnaire also included the Perceived Stress Scale (PSS-10) to evaluate participants' stress levels. The PSS-10 is a validated tool consisting of 10 items scored on a 5-point Likert scale ranging from 0 (Never) to 4 (Very Often). Total scores ranged from 0–40 and were categorized as:

- Low stress: 0–13
- Moderate stress: 14–26
- High stress: 27–40

Anthropometric Measurements

Height and weight of participants were measured by trained research assistants using standardized equipment. Body Mass Index (BMI) was calculated using the following formula:

$$BMI = \frac{Weight\ (kg)}{Height\ (m)^2}$$

BMI categories were classified according to WHO criteria:

- Underweight: <18.5 kg/m^2
- Normal weight: 18.5–24.9 kg/m^2
- Overweight: 25–29.9 kg/m^2
- Obese: ≥30 kg/m^2

Study Variables

Dependent Variable

- Early age of menarche (<12 years)

Independent Variables

- Dietary habits
- Fast food consumption
- Physical activity
- Screen time
- Sleep duration
- Stress levels (PSS-10)
- Anxiety and depression
- Socioeconomic status
- Environmental exposures
- BMI
- Family history
- Chronic illness

Data Collection Procedure

After obtaining institutional permission and informed consent from participants or guardians, questionnaires were distributed to eligible adolescent girls. Participants were informed regarding the objectives and confidentiality of the study. Research assistants guided respondents whenever clarification was required. Completed questionnaires were checked for completeness before data entry.

Data Analysis

Data were entered and analyzed using Statistical Package for Social Sciences (SPSS) version 29.0. Descriptive statistics were used to summarize participant characteristics. Frequencies and percentages were calculated for categorical variables, while means and standard deviations were computed for continuous variables.

To determine associations between lifestyle factors, stress, and early menarche, inferential statistical tests were applied. The Chi-square test was used to evaluate associations between categorical variables. A p-value of less than 0.05 was considered statistically significant.

Ethical Considerations

Ethical approval was obtained from the relevant institutional review committee before commencement of the study. Written informed consent was obtained from participants and guardians prior to data collection. Participants were assured of confidentiality, anonymity, and their right to withdraw from the study at any stage without any consequences. All collected information was used solely for research purposes.

RESULTS

A total of 219 adolescent girls from different regions of Sindh participated in the study. Data were analyzed using SPSS version 29.0. The findings are presented below in the form of descriptive tables, showing frequency and percentage distributions of key sociodemographic, lifestyle, and stress-related variables.

Figure 1

Methodological Flowchart and Summary of Key Research Findings

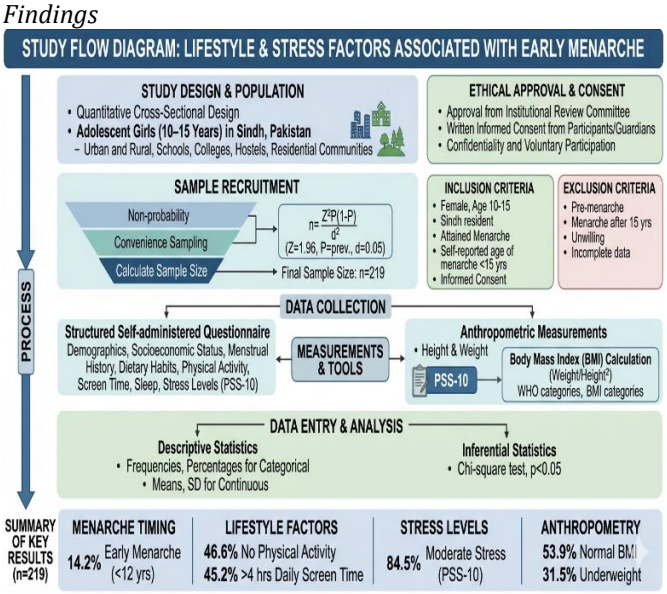

Table 1

Age Distribution of Participants

Age Group (Years)	Frequency	Percent
10	4	1.8%
11–13	39	17.8%
14–15	176	80.4%
Total	219	100%

Most participants (80.4%) were aged 14–15 years.

Table 2
Residence of Participants

Residence	Frequency	Percent
Hostel	47	21.5%
Home	145	66.2%
Rented house	22	10.0%
Relative home	5	2.3%
Total	219	100%

Most participants (66.2%) lived at home.

Table 3
Socioeconomic Status

Status	Frequency	Percent
Low	27	12.3%
Middle	170	77.6%
High	22	10.0%
Total	219	100%

The majority (77.6%) belonged to the middle socioeconomic class.

Table 4
Family History of Early Menarche

Response	Frequency	Percent
Yes	60	27.4%
No	110	50.2%
Don't know	49	22.4%
Total	219	100%

Half of the participants (50.2%) reported no family history.

Table 5
Age at Menarche

Age (years)	Frequency	Percent
10	31	14.2%
11–13	148	67.6%
14–15	40	18.3%
Total	219	100%

Most participants (67.6%) experienced menarche at 11–13 years.

Table 6
Menstrual Cycle Pattern

Pattern	Frequency	Percent
Regular	152	69.4%
Irregular	67	30.6%
Total	219	100%

Table 7
Duration of Menstrual Flow

Duration	Frequency	Percent
<5 days	82	37.4%
5–7 days	102	46.6%
>7 days	35	16.0%
Total	219	100%

Table 8
Physical Activity Frequency

Activity Level	Frequency	Percent
Daily	20	9.1%
3–4 times/week	30	13.7%
Weekly	27	12.3%
Rarely	40	18.3%
None	102	46.6%
Total	219	100%

Nearly half (46.6%) reported no physical activity.

Table 9
Screen Time

Screen Time	Frequency	Percent
2 hours	30	13.7%
2–4 hours	90	41.1%
>4 hours	99	45.2%
Total	219	100%

Most participants (45.2%) reported >4 hours of daily screen time.

Table 10
Sleep Duration

Sleep Duration	Frequency	Percent
<5 hours	26	11.9%
6–7 hours	114	52.1%
>8 hours	79	36.1%
Total	219	100%

Table 11
Fast Food Consumption

Frequency per week	Frequency	Percent
Never	24	11.0%
1–2 times	126	57.5%
3–4 times	49	22.4%
>4 times	20	9.1%
Total	219	100%

Table 12
BMI Distribution

BMI Category	Frequency	Percent
Underweight	69	31.5%
Normal weight	118	53.9%
Overweight	22	10.0%
Obese	10	4.6%
Total	219	100%

Table 13
Stress Level (PSS-10)

Stress Level	Frequency	Percent
Low	12	5.5%
Moderate	185	84.5%
High	22	10.0%
Total	219	100%

Table 14
Smoking Status

Status	Frequency	Percent
Smoker	9	4.1%
Non-smoker	210	95.9%
Total	219	100%

Table 15
Chronic Illness

Status	Frequency	Percent
Yes	18	8.2%
No	201	91.8%
Total	219	100%

Summary of Key Findings

- Early menarche (10 years) was observed in 14.2% of participants.
- Majority experienced menarche at 11–13 years (67.6%).
- High prevalence of sedentary lifestyle (46.6% no physical activity) and high screen time (>4 hours: 45.2%) was observed.
- Moderate stress (84.5%) was highly prevalent among participants.
- Most participants had normal BMI (53.9%) but a significant proportion were underweight (31.5%).

DISCUSSION

The present study was conducted to evaluate the prevalence of lifestyle factors and perceived stress and their association with early age of menarche among adolescent girls across Sindh, Pakistan. The findings highlight that menarche most commonly occurred between 11–13 years (67.6%), while 14.2% of participants experienced early menarche at 10 years. These results are consistent with global evidence showing a gradual decline in menarcheal age over recent decades due to improved nutrition, increased adiposity, and changing environmental exposures (Lee et al., 2022; Cheng et al., 2022; Ramraj & Subramanian, 2021).

One of the most important findings of the current study is the significant burden of unhealthy lifestyle behaviors among adolescents. More than half of the participants reported high consumption of fast food (57.5% consuming 1–2 times weekly) and low physical activity levels, with 46.6% reporting no physical activity at all. Sedentary behavior and high intake of energy-dense foods have been strongly associated with increased body fat and earlier pubertal onset due to increased leptin secretion and estrogen production (Ning et al., 2025; Chen et al., 2022; Calcaterra et al., 2023). Similar findings have been reported, which demonstrated a positive association between higher BMI and earlier menarche (Cho & Han, 2023).

In the present study, 14.6% of participants were overweight or obese, while 31.5% were underweight. Overweight and obesity are known to accelerate menarche through hormonal changes, while undernutrition may delay puberty (Cho & Han, 2023; Matsuo et al., 2022). The dual burden observed in this population reflects the nutritional transition occurring in developing countries such as Pakistan, where both undernutrition and overnutrition coexist. Childhood nutritional status is a key determinant of pubertal timing (Cho & Han, 2023; Matsuo et al., 2022; Mishra et al., 2025).

Screen time was notably high in the study population, with 45.2% of participants reporting more than 4 hours of daily screen exposure. Increased screen time is associated with reduced physical activity, disrupted sleep patterns, and increased exposure to stress-related stimuli, all of which may indirectly influence hypothalamic–pituitary–gonadal (HPG) axis activation (De Angelis et al., 2021; Ning et al., 2025). Sleep deprivation was also evident, as 11.9% of participants reported less than 5 hours of sleep, which may further contribute to hormonal dysregulation and metabolic disturbances.

Psychological stress emerged as a major factor in this study. A large proportion of participants (70.3%) reported academic pressure, while 84.5% had moderate stress levels according to the PSS-10 scale. Chronic stress activates the hypothalamic–pituitary–adrenal (HPA) axis, which may interfere with gonadotropin-releasing hormone (GnRH) secretion, thereby influencing the timing of puberty (Street et al., 2023). Early life stress is significantly associated with earlier pubertal development and altered reproductive hormone patterns (Street et al., 2023; Cherenack & Sikkema, 2022).

Emotional stress and anxiety were also common, with 51.1% of participants reporting emotional stress and 18.3% having a diagnosis of anxiety or depression. Psychological distress during adolescence has been widely linked with hormonal imbalance and altered menstrual function, including irregular cycles and altered menarcheal timing (Jiang et al., 2025; Askelund et al., 2024).

Family history of early menarche was reported in 27.4% of participants, supporting the genetic contribution to pubertal timing. Previous studies have shown that parental and familial patterns play an important role in determining the age of menarche, indicating a strong hereditary component (Nishan et al., 2025; Ramraj & Subramanian, 2021).

Environmental exposures were also significant in this study population, with 21% exposed to second-hand smoke and 25.6% reporting indoor air pollution. Endocrine-disrupting chemicals (EDCs) present in polluted environments and tobacco smoke have been shown to interfere with hormonal regulation and may contribute to earlier pubertal onset (Papadimitriou & Papadimitriou, 2021; Duman et al., 2021).

Overall, the findings suggest that early menarche in adolescent girls in Sindh is influenced by a complex interaction of modifiable lifestyle factors (diet, physical inactivity, screen time), psychological stress, nutritional status, and environmental exposures. These results are consistent with the global literature emphasizing that puberty timing is not solely genetically determined but is highly sensitive to environmental and behavioral influences (Lee et al., 2022; De Angelis et al., 2021; Bolormaa et al., 2024).

The present study has certain limitations. Being cross-sectional in nature, it cannot establish causality between lifestyle factors and early menarche. Data were self-reported, which may introduce recall and reporting bias. Additionally, hormonal and biochemical markers were not assessed, which could have strengthened the findings. Despite these limitations, the study provides important population-based insights into adolescent health in Sindh.

The study highlights that early menarche is significantly associated with modifiable lifestyle factors, including diet, physical inactivity, stress, and environmental exposures. These findings emphasize the need for public health interventions targeting healthy lifestyle promotion, stress management, and environmental awareness among adolescent girls to ensure optimal reproductive health outcomes.

CONCLUSION

The present study highlights that early menarche among adolescent girls in Sindh is influenced by a combination of modifiable lifestyle factors, psychological stress, and environmental exposures. The majority of participants experienced menarche between 11–13 years, while a notable proportion reported early menarche at or before 10 years. Unhealthy dietary habits, high fast-food consumption, physical inactivity, excessive screen time, and inadequate sleep were commonly observed among participants. Additionally, a high prevalence of moderate to severe stress levels was identified, indicating the significant role of psychosocial factors in adolescent health. These findings suggest that both biological and environmental determinants collectively contribute to the timing of menarche. Therefore, promoting healthy dietary practices, regular physical activity, stress management strategies, and awareness regarding environmental health is essential. Public health interventions targeting schools, families, and communities are recommended to improve adolescent well-being and prevent potential long-term reproductive and metabolic complications associated with early puberty.

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