Anthropological Review • Vol. 82(3), 265–272 (2019)

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ANTHROPOLOGICAL REVIEW
Available online at: https://doi.org/10.2478/anre-2019-0019

Variation in menarcheal age of school-aged female athletes engaged in different types of sport

Józef Tatarczuk[1], Artur Wandycz[1], Andrzej Malinowski[2]

[1]Faculty of Biological Sciences, University of Zielona Góra, Poland
[2]Faculty of Biology, Adam Mickiewicz University, Poland

ABSTRACT: It is widely known from the literature that the rate of physical development and sexual maturation is not only determined by genetics but is also modified by physical workload factors. Given the above, this paper aimed at comparing menarcheal age of school-aged athletes engaged in different types of sport (and their respective workloads) after controlling for physical traits such as body height and mass and slenderness ratio. The survey was conducted in 2017 in 6 sports schools in Poland's Lubuskie Voivodeship. Body height and mass were measured and the slenderness index (body height divided by the cubic root of body weight) was used to establish body build. The age of menarche was self-reported by the study participants. In total, 232 girls aged 9–18 were included in the research, of whom 125 reported their age of menarche. The age-adjusted arithmetic means and standard deviations were calculated for the study participants' estimates. The raw data were then transformed into standardized z-score values. The significance of differences was assessed by Mann-Whitney U test as an alternative to the t-test when a given variable was not normally distributed. Pearson's correlation coefficient was used to evaluate linear relations between the workload and age at menarche. It was found that dancers, acrobats and swimmers reported the youngest menarcheal ages. Girls practising most demanding sport disciplines (in terms of strength and endurance) reported the oldest age at menarche. Girls practising more than 3 times per week had menarche later than those practising 3 times a week or less, and the difference was statistically significant. In conclusion it might be stated that the type of sport discipline has a significant effect on age of menarche. Sport disciplines involving heavier physical exertion usually delay the onset of menstruation.

KEY WORDS: puberty, maturation, sport disciplines

Introduction

Puberty defines a period of sexual maturation that occurs in the onset of adolescence and occupies a very special place in human ontogenesis. Sexual maturation is accompanied by profound changes in the whole organism, affecting the body's motor abilities, physiology, morphological development, and body proportions, as well as psychology, personality, and emotional life (Wilczewski 2005; Tatarczuk 2006; Kaczmarek and Wolański 2018). The first signs of female puber-

Original Research Article Received: May 7, 2019; Revised: July 31, 2019; Accepted: August 9, 2019
DOI: 10.2478/anre-2019-0019

ty include an increase in the synthesis of estrogens by the adrenal cortex, resulting in the development of mammary glands. Another changes are marked by rapid increase in body height (the so-called pubertal growth spurt), which tends to occur a year before menarche (Malinowski 2009, Kaczmarek and Wolański 2018). This pubertal spurt is the result of both increased synthesis of growth hormone (GH) and certain effects of androgens in girls and boys alike. In girls, the pubertal spurt commonly lasts a couple weeks to 2 months and manifests itself by accelerated growth in body height and body mass (mainly bone and muscle tissue). The whole period of accelerated pubertal body growth lasts about 5 years.

It should be noted that the age of menarche varies considerably showing high eco-sensitivity. According to Łaska-Mierzejewska and Olszewska (2003), menarche is highly sensitive to changes in living conditions, a concept echoed by numerous publications (Farmosi 1983; Bielicki et al. 1988; Łaska-Mierzejewska and Łuczak 1993; Wilczewski 2013; Malinowski et al. 2014). Various Polish (Żarów et al. 2003) and foreign sources (Kac et al. 2000; Okasha et al. 2001, Meng et al. 2017, Wahab et al. 2018) suggest that over the past century the average age of menarche has decreased by 2–3 years. It is well known that young people now mature sexually earlier than they did 20 years ago (Łaska-Mierzejewska 2002).

Also widely accepted is the idea that properly managed and organised physical activity is a growth incentive for the body, accelerating the development of muscles and bones and improving circulatory, respiratory, nervous, and endocrine systems. However, there is no unequivocal evidence that physical activity has any effect on sexual maturation, accelerating or delaying the biological development of children and youth (Malinowski and Strzałko 1989). Properly age- and sex-adjusted physical activity benefits biological development; too much physical effort, however, produces negative results, such as stunted growth, earlier termination of the growth of epiphyseal plates, and stout body physique.

Given the above, this paper aimed at comparing menarcheal age of school-aged athletes engaged in different types of sport (and their respective workloads) after controlling for physical traits such as body height and weight and slenderness ratio.

Materials and methods

In 2017, a cross-sectional survey was conducted in 6 sports schools in the Lubuskie voivodeship to collect data on age of menarche, body height and mass of female athletes training different types of sport. Girls were asked whether or not they menstruated and if yes, they were asked about the date of their first period (Kaliszewska-Drozdowska et al. 2002). The study involved 232 girls aged 9–18 years training sports on a regular basis, of whom 125 provided the age of their first menstruation. These 125 girls comprise the study group. Using a diagnostic poll and questionnaire, information was obtained about the girls' sports discipline and their training load before menarche. The girls' ideal body weight was assessed using Cole's classification, an international IOTF standard for assessing obesity in children (Cole et al. 2000; 2007). Girls' somatic traits were mean-normalised (M=0), with one standard deviation (SD) for the whole cohort. The mean age of menarche and standard

deviation were calculated for each sport discipline. Additionally, graphic representation of the normalised body height, mass, slenderness index and age at menarche values against athletic disciplines were drawn (Jopkiewicz and Suliga 1995; Piechaczek et al. 1996). The Mann-Whitney U test and Pearson's correlation coefficient were used for testing statistical significance. A *p*-value less than 0.05 implied statistical significance.

The slenderness index was calculated using following formula (Piechaczek et al. 1996):

$$\text{Slenderness index} = \frac{\text{Body height [m]}}{\sqrt[3]{\text{Body mass [kg]}}} \times 100$$

where: x–41.47 scores fell within stout range; 41.48–44.96 within average range, and 44.97–x within slender range.

Results

Table 1 shows proportions of girls who had not yet attained their menarche in subsequent age groups. Generally, age at menarche varied between 10 and 18 years of age, and great majority of girls began menstruating aged between 11 and 14.

Table 1. Proportions of non-menstruating versus menstruating female athletes in subsequent age groups

Age group (years)	Number of subject	Non-menstruating n (%)
9	5	5 (100)
10	36	31 (86.1)
11	48	30 (62.5)
12	73	26 (35.6)
13	37	11 (29.7)
14	21	2 (9.5)
15	9	0 (0)
16	1	0 (0)
17	1	1
18	1	1

Analysis of the girls' somatic traits shows that the tallest were those training in handball, modern pentathlon, track and field, and basketball – while those training in bullseye shooting, badminton, and horse riding did not differ much from the average. It appears that the selection of girls for the last two disciplines was not appropriate. The negative values of standardised height for the girls training in acrobatics and acrobatic rock and roll dance indicated that they were shorter than the average, which is routinely required of acrobats (Fig. 1).

Girls training in handball, track and field, basketball, and bullseye shooting were much heavier than their counterparts – high values in body mass seem to be desired and beneficial. The negative values for body mass among the girls training in acrobatics and acrobatic dance mean that they were properly selected for those disciplines (Fig. 1).

The height-weight proportions defined by the slenderness index point to characteristic body physique for girl athletes in various disciplines. The results showed that the slimmest were the girls training in long-distance running, volleyball, and acrobatics (Fig. 1). In handball players and dancers, the height-weight proportions were similar to the average, whereas negative values of the slenderness index, indicating a stouter body physique, were observed in girls training in bullseye shooting, track and field, and horse riding.

As the data in Figure 2 show, the mean values of the age of menarche highly varied, depending on the athletic discipline. The earliest onset of menstruation was observed among dancers (M=11.55) and acrobats (M=12.01). The latest to ma-

ture were girls doing sports which require considerable endurance and strength – track and field athletes (M=13.08) and pentathletes (M=12.93).

The association of weekly number of training hours with age of menarche is shown in Table 2.

It should be noted that girls with the lowest training load (M=12.01) matured earliest, while the latest to mature were those practising for 11 or more hours per week (M=12.58). The average menarcheal ages did not differ statistically significantly between athletes practising 5 and less hours a week, 6–10 hours a week, and more than 11 hours a week. The Pearson's correlation coefficient between age of menarche and the number of weekly training hours was 0.22.

A similar result was found with regard to the number of training days within the week (Table 3). Girls who trained

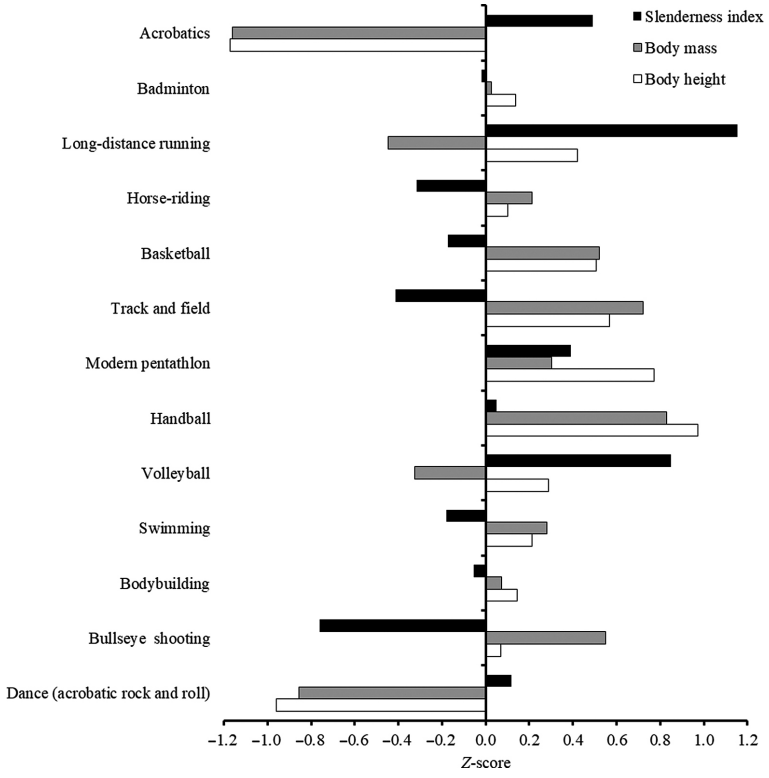

Fig. 1. *Z*-score mean values of body height, body mass and slenderness index of school-aged female athletes across different types of sport disciplines

Table 2. Age of menarche according to number of training hours a week

Training hours per week		n	Mean (years)	SD (years)	U			Pearson's r
					1–2	2–3	1–3	
Up to 5 hours	(1)	18	12.01	1.25				
6–10 hours	(2)	72	12.27	1.12	0.80	0.99	1.69	0.22
11 and more hours	(3)	35	12.58	0.98				

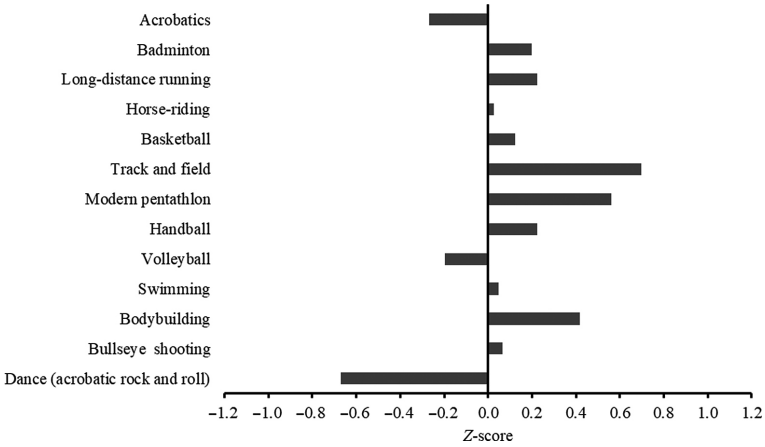

Fig. 2. *Z*-score mean values of menarcheal age of school-aged female athletes across different types of sport disciplines

Table 3. Age of menarche according to number of training days a week

Training days per week		n	Mean (years)	SD (years)	U			Pearson's r
					1–2	2–3	1–3	
Up to 3 days	(1)	27	11.87	1.08				
4–5 days	(2)	61	12.41	1.12	2.14	0.81	2.68	0.24
6–7 days	(3)	37	12.59	1.04				

three times per week matured the earliest (M=11.87), while their counterparts who trained more frequently matured later (M=12.59). A statistically significant difference was found between girls who practised no more than three days per week and those who practised 4, 5, or more times per week. The Pearson's correlation coefficient between the age of menarche and number of training days per week was 0.24, indicating a weak correlation between these two variables.

Discussion

The mean values for the age of menarche of young sportswomen observed in this study are comparable with the results of other studies (Piotrowski et al. 1992; Malina 1983; Ziemilska 1985; Baxter-Jones et al. 1994; Krawczyk et al. 1994; Piechaczek and Lewandowska 1996). Krawczyk et al. (1994) observed that the mean menarcheal age was 12.96 for 2,422 sportswomen practising 12 sports disciplines. Our research found the mean age of menarche to be lower – 12.32 years of age. Other research (Baxter-Jones et al. 1994) has found the mean age of menarche to be 14.3 in gymnasts, 13.3 in swimmers, and 13.2 in tennis players. Piechaczek and Lewandowska's (1996) research conducted in 1990–91 with a cohort of girls in Warsaw's sports schools found their mean age of menarche to be 13.16 – which is different by 0.84 years from the mean age of menarche among girls in sports schools in the province of Lubuskie. Farmosi (1983) presents interesting mean values for the age of menarche in girls practising sports: 13.30±0.90 in gymnasts, 13.25±0.96 in

basketball players, 13.30±0.96 in handball players, 13.73±0.71 in volleyball players,14.00±1.43 in tennis players. Kovalčikowa et al. (1981a; 1981b) found the mean age of menarche to be 15.38 in gymnasts, 14.30 in basketball players, 14.20 in skaters, 12.50 in volleyball players, and 13.30 in swimmers. Malina (1983) found the following mean values for the age of menarche: 14.50±0.82 in gymnasts, 13.40±2.14 in jumpers, 14.18±0.94 in volleyball players, 13.10±1.31 in swimmers, 13.70±1.14 in rowers.

This study found that the earliest age of menarche was observed in girls practising acrobatics, swimming, and acrobatic dance, while the latest to begin menstruating were those practising track and field, modern pentathlon, and exercising in the gym.

As the results show, girls practising different sports disciplines have varied body physiques. Intense exercise on a regular basis results in adaptive changes according to the form of physical exertion. The choice of discipline is made on the basis of the body physique appropriate for that particular discipline, so in this respect certain selection can be observed. Therefore, establishing causal relationships is difficult. While a certain sport may cause the development of specific physical traits, such traits may also incline girls to take up or excel at the sport. However, humans are among the most complicated natural organisms. All body functions must be considered jointly, but they can only be examined separately in order to facilitate the achievement of the goals of scientific research. Therefore, sports results must not be attributed solely to morphological features: they are just one of the factors affecting performance, but the scope of their influence varies between disciplines.

Conclusions

In conclusion it might be stated that the type of sport discipline has a significant effect on age of menarche. Sport disciplines involving heavier physical exertion usually delay the onset of menstruation.

The results of the study conducted on girls from sports schools in the province of Lubuskie allow us to draw following conclusions:

1. Sport discipline has a significant effect on age of menarche . Average menarcheal age of young female athletes from sports schools in the Lubuskie voivodeship was 12.32 years. The earliest menarcheal age was reported by girls practising acrobatic dancing (rock and roll), acrobatics, and swimming. The oldest menarcheal age was reported by young strength and endurance athletes, such as track and field, modern pentathlon, and bodybuilding.
2. Menarche occurred the earliest in girls with a solid body physique and later in those with a leptosomic body physique.
3. Girls training in long-distance running, swimming, and acrobatics were the slimmest. The most solid bodybuild was observed among those training in archery and track and field.
4. In the terms of morphological parameters (body height and weight), the most effective selection was observed among athletes training in handball, modern pentathlon, and track and field. Relatively effective selection was also observed in dance and acrobatics, which require low height and body weight.
5. High training load and number of training sessions per week seem to be the factors that delay menarcheal age in young female athletes.

Authors' contributions

JT and AM proposed the objectives and plan of the paper. JT supervised the work. AW was the major contributor in the statistical analysis and writing the manuscript; JT participated in collecting the required data and performed statistical analysis. All participants wrote, read and approved the final manuscript.

Conflict of interest

The Authors declare that they have no conflicts of interest in the present article. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

Corresponding author

Józef Tatarczuk, Faculty of Biological Sciences, University of Zielona Góra, Prof. Z. Szafrana str. 1, 65-516 Zielona Góra, Poland
e-mail: sekretariat@kspz.uz.zgora.pl

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