



# Comparison of the Physical Fitness Levels between Premenarcheal and Postmenarcheal Adolescents

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## Abstract

Research findings on understanding the critical impact of biological maturation on physical performance through research findings will enable coaches and physical educators to group adolescent athletes based on their biological maturity levels rather than chronological age. This approach will allow them to design fairer, safer, and more effective training programs by identifying potential risks, such as losses in strength and speed observed during the post-menarche period, and developing strength and injury prevention strategies specific to this phase. Therefore, this study aims to investigate the effect of menarche on the physical fitness levels of adolescent female groups. In the study, pre-tests were administered to 26 sedentary pre-pubertal female students of different ages, measuring body weight, height, BMI, flexibility, vertical jump, handgrip strength, backward medicine ball throw, agility, and sprint speed. Nine months later, the physical fitness tests were repeated for the same participants, who were divided into two groups: those who had not yet experienced menarche (premenarcheal), with a mean age of 151.77 months (12.65 years), and those who had started menstruating (postmenarcheal), with a mean age of 166.92 months (13.91 years). Data analysis included an independent t-test to compare the two groups during pre- and post-tests and a paired sample t-test to determine the 9-month changes in physical fitness components within each group. The findings of this study reveal that menarche has complex and multifaceted effects on the physical fitness parameters of adolescent girls. During the pre- and post-tests, only the mean sprint speed of the younger premenarcheal group differed significantly from that of the older postmenarcheal group. Over the nine-month period, the premenarcheal group showed moderate effect sizes in height and small effect sizes in body weight and BMI, whereas the postmenarcheal group exhibited small effect sizes in height and body weight and a large effect size in mean sprint speed. In the younger group, non-significant increases were observed in flexibility, vertical jump, and medicine ball throw, while non-significant decreases were noted in right and left handgrip strength. In the older postmenarcheal group, non-significant increases were found in BMI and flexibility, whereas non-significant decreases were observed in right and left handgrip strength and agility. The results highlight the critical relationship between biological maturity level and physical performance, emphasizing the necessity of planning training programs based on biological maturity rather than chronological age. Specifically, the declines in handgrip strength and variability in sprint performance observed during the post-menarche period point to risks unique to this transitional phase. In light of these findings, the most important practical implication for coaches and physical education specialists is that evaluating early- and late-maturing individuals within the same groups may negatively affect performance and potentially increase the risk of injury. In conclusion, this study provides a significant scientific foundation for monitoring the physical fitness levels of girls, especially during the pre-menarche period, and for developing targeted strengthening, body composition monitoring, and injury prevention strategies specific to this phase.

**Keywords:** menarche, adolescent, physical fitness components.

## Premenarşéal ve Postmenarşéal Ergenler Arasındaki Fiziksel Uygunluk Düzeylerinin Karşılaştırılması

### Özet

Menarş sonrası dönemde gözlemlenen kuvvet ve sürat kaybı gibi potansiyel riskleri önceden tespit edilmesi, bu döneme özgü güçlendirme ve sakatlıktan korunma stratejilerinin geliştirilmesi için biyolojik olgunlaşmanın fiziksel performans üzerindeki kritik etkisini anlaşılmasında araştırma bulgularının, antrenörler ve beden eğitimcilerin, ergen sporcuları kronolojik yaş yerine biyolojik olgunluk düzeylerine göre gruplandırılmaları ve böylece daha adil, güvenli ve etkili antrenman programları tasarlamalarına olanak tanıyacaktır. Böylece bu çalışma, menarş olmanın adölesan kadın gruplarının fiziksel uygunluk düzeyine etkisinin araştırılmasını amaçlamaktadır. Araştırmada farklı yaşlarda prepubertal sedanter 26 kız öğrencinin ön test ölçümlerinde vücut ağırlığı ile boy uzunluğu, BKİ, esneklik, dikey sıçrama, el kavrama kuvveti, dikey sıçrama, geriye top atma ile çeviklik ve sprint sürati testleri uygulanmıştır. Dokuz ay sonra bu gruptan ortalama yaşı 151,77 ay (12,65 yıl) olan menarş olmamış (premenarchial) ile adet görmeye başlayan (postmenarchial) ortalama yaşı 166,92 ay (13,91 yıl) ve 26 adölesan katılımcının ön test sırasında fiziksel uygunluk testleri tekrarlanmıştır. Verilerin analizinde ön test ve son test sırasında iki grubun karşılaştırılmasında bağımsız t-testi ile her grupta fiziksel uygunluk bileşenlerindeki 9 aylık değişimi belirlemek için eşleştirilmiş örneklem t-testi kullanılmıştır. Bu çalışmanın bulguları, menarş olmanın ergen kızlarda fiziksel uygunluk parametreleri üzerinde karmaşık ve çok yönlü etkileri olduğunu ortaya koymaktadır. Ön ve son testler sırasında sadece premenarşiyal düşük yaş grubunun ön test ortalama sürat değeri postmenarşiyal büyük yaş grubundan anlamlı düzeyde farklıdır. Son dokuz ayda premenarşiyal grupta boy uzunluğunda orta etki büyüklüğüne, vücut ağırlığı ve BKİ’de küçük etki büyüklüğüne yol açarken postmenarşiyal grupta boy uzunluğunda ve vücut ağırlığı ortalamaların küçük etki büyüklüğüne ve ortalama sprint süratinde büyük etki büyüklüğüne sahiptir. Küçük yaş grubunda esneklik, dikey sıçrama, sağlık topu atışta anlamlı olmayan artış varken sağ ve sol el kavrama kuvvetinde anlamlı olmayan düşüş vardır. postmenarşiyal büyük yaş grubunda BKİ ve esneklikte anlamlı olmayan artış, sağ ve sol el kavrama kuvveti ve çeviklikte anlamlı olmayan azalma gözlenmiştir. Elde edilen sonuçlar, biyolojik olgunluk düzeyi ile fiziksel performans arasındaki kritik ilişkiyi vurgulayarak, antrenman programlarının kronolojik yaş yerine biyolojik olgunluğa göre planlanmasının gerekliliğini Özellikle menarş sonrası dönemde gözlemlenen el kavrama kuvvetindeki düşüşler ve sürat performansındaki değişkenlik, bu geçiş dönemine özgü risklere işaret etmektedir. Bu bulgular ışığında, antrenörler ve beden eğitimi uzmanları için en önemli pratik çıkarım, erken ve geç olgunlaşan bireyleri aynı gruplarda değerlendirmenin performansı ve muhtemelen sakatlık riskini olumsuz etkileyebileceğidir. Sonuç olarak, bu çalışma, özellikle menarş öncesi dönemindeki kız çocuklarının fiziksel uygunluk düzeylerinin izlenmesi ve bu döneme özgü güçlendirme, vücut kompozisyonunun takibi ile sakatlıktan korunma stratejilerinin geliştirilmesi için önemli bir bilimsel alt yapı sağlamaktadır.

**Anahtar Kelimeler:** menarş, adölesan, fiziksel uygunluk bileşenleri.

### INTRODUCTION

Adolescence is a critical stage during which an individual experiences rapid changes in growth, maturation, and physical fitness parameters. In girls, one of the most important indicators of this biological process is menarche, defined as the first menstrual bleeding (1). Menarche is not only a sign of the transition to reproductive maturity but also a strong indicator that the final stages of growth have begun. Therefore, understanding the potential effects of menarche timing on physical performance and fitness is of great importance, particularly in the context of evaluating young athletes and planning training programs.

Research indicates that adolescent athletes reach menarche (first menstruation) at a later age compared to their less physically active peers (2, 3). Although studies report that menarcheal age is largely determined by genes, it has also been reported to be influenced by environmental factors, including physical activity (4, 5, 6).

While the effect of chronological age on physical fitness components is well-documented, the significant performance differences observed among individuals of the same age highlight the necessity of considering biological maturity level. The literature reports that early-maturing individuals demonstrate higher performance in tests requiring strength, power, and endurance compared to their late-maturing peers (7). On the other hand, it is also stated that late maturation may create a temporary disadvantage for motor performance. Philippaerts and colleagues (8) suggested that during the peak of the growth spurt, motor coordination and control can be temporarily adversely affected, a phenomenon that could be termed

"adolescent awkwardness." Since individuals experiencing late menarche go through this period at a more advanced chronological age, this effect may be more pronounced in their performance parameters. Whether a similar effect is observed in girls with early and late menarche remains a question that needs to be clarified.

Ravi et al. (9) showed that age at menarche (AAM) was negatively associated with midlife BMI and fat mass. Therefore, it appears that competitive sports during adolescence are associated with a healthier body composition, higher BMD (Bone Mineral Density), and better physical performance in middle age, although late AAM might be associated with lower BMD.

Further research is needed, particularly regarding BMD or fractures, to investigate whether middle-aged or older individuals with primary amenorrhea (i.e., AAM  $\geq$  15 years) differ from those with an AAM of less than 15 years. Furthermore, future studies should investigate the optimal volume and intensity of exercise during adolescence, given the positive midlife outcomes observed in their study.

From this perspective, the gap in the current literature is the need to investigate the dynamic effect of not menarche itself, but the timing of menarche on physical fitness parameters using a longitudinal design and intergroup comparisons. Many studies have been limited to cross-sectional designs or solely maturity estimation methods, while research tracking pre- and post-menarche changes in the same individuals and across different maturity groups is relatively limited.

Thus, this study aims to fill the gap in the sports literature mentioned above by examining "The Effect of Menarche on the Physical Fitness Levels of Adolescent Female Groups." The main objective of this research is to comparatively reveal the short-term effects of menarche timing on fundamental physical fitness components including anthropometric characteristics, strength, speed, agility, and explosive power between premenarcheal and postmenarcheal females. In this way, it aims to contribute to a fairer evaluation of young female athletes, the development of training strategies appropriate to their maturity levels.

## MATERIALS AND METHODS

### Participants

Measurements were conducted on 28 students from İsmil İmam Hatip Secondary School, for whom permission was obtained via informed consent forms signed by their parents. In June 2023, these 26 students who had not entered puberty formed the initial sample of the study. Nine months later, in March 2024, from these 28 who had entered puberty were identified. Two of these who had extreme values were excluded from the group, and the pre- and post-test findings of the remaining 26 participants were used in this study. Those who had started menstruating were identified as the postmenarcheal group, and those who had not started menstruating were identified as the small premenarcheal group. All participants reported having no health problems. Also all participants only attended two hours of physical education classes per week and did not participate in any other physical activity.

### Measurements

**Body Height, Weight, and Body Mass Index (BMI):** The girls' body weight and height were measured while barefoot, using a digital scale and a tape measure attached to the wall. BMI was calculated by dividing body weight in kilograms by the square of height in meters (10).

**Flexibility Test (Sit and Reach Test):** The student, barefoot, placed the soles of both feet against the support section of the flexibility box. Keeping knees straight, they bent at the hips and reached forward as far as possible symmetrically with both arms while exhaling, at which point the measurement was taken (11).

**Hand Grip Strength Test:** The student stood in an upright position with the arm stretched straight down and squeezed the handle of the hand dynamometer with maximum force to measure the grip strength of the right and left hands (12).

**Vertical Jump Test:** The vertical jump test was performed without removing shoes. The student stood on the jump mat in an upright position with feet shoulder-width apart. They quickly bent their knees into a squat and, without pausing, jumped upward as high as possible, using their arms for momentum. The results of two attempts were recorded and also anaerobic power (kg.m.sec) was calculated by Lewis nomogram (13).

**Backward Medicine Ball Throw:** The student positioned themselves with their back facing the direction of the throw. Holding a 1 kg medicine ball with both hands in front, they slightly bent their knees, then rapidly extended their body backward, throwing the ball backward with both arms. The results of two attempts performed with appropriate angle and speed were recorded (14).

**Agility Test (Proagility):** The agility course was set up by placing two marker cones 4.57m to the left and right of the start/finish photobeam. The student waited in a sideways stance position 50cm behind the center line of the course. Upon the start command, they quickly ran to touch the designated marker with their hand, turned and ran to touch the opposite marker, turned again, and sprinted back across the start line to complete the test (15).

**Speed Test:** The student placed the toe of one foot on the starting line. When ready, they sprinted forward, and the time taken to pass the 20m finish line was measured using a photoelectric cell chronometer.

### Statistical Analysis

In this study, an independent samples t-test was used for comparing the early menarche (EM) and late menarche (LM) groups in the pre-test and post-test measurements. In within-group evaluations, the change between pre-test and post-test was analyzed separately for each group using paired t-tests and Cohen's d analysis were used to calculate the effect size.

**Ethics Committee Approval:** This study was approved by the Selçuk University, Faculty of Sport Sciences, Non-Interventional Clinical Research Ethics Committee with the document dated 23.06.2023 and numbered 03.07.2023-E.543919, as a master's thesis project titled "Comparison of Talent Screening Test Measurement Results in Pre-Puberty and Post-Puberty Girls".

## RESULTS

This study analyzed the differences between two groups at two separate time points: before menarche (Pre-test) and nine months after menarche (Post-test). Before menarche, the mean age of the younger group (139.77 months) was statistically significantly lower ( $p < 0.001$ ) than that of the older group (154.92 months).

**Table 1.** The comparison of physical fitness characteristics between younger and older female groups during pre-test and post-test.

Variables	Goups	Pre-Test (Before Menarche Period)					Post-Test (During Menarche Period)				
		N	M	SD	t	Sig.	N	M	SD	t	Sig.
Age (Months)	Premenarcheal	13	139,77	3,03	-9,114	,000**	13	151,77	3,03	-9,114	,000**
	Postmenarcheal	13	154,92	5,17			13	166,92	5,17		
Body Height ((cm)	Premenarcheal	13	151,23	7,08	-,924	,365	13	154,77	6,15	-,586	,563
	Postmenarcheal	13	153,85	7,35			13	156,23	6,56		
Body Weight (kg)	Premenarcheal	13	48,06	10,98	,063	,950	13	52,56	11,65	,486	,632
	Postmenarcheal	13	47,76	13,04			13	50,24	12,72		
Body Mass Index	Premenarcheal	13	20,80	3,59	,569	,575	13	21,74	3,84	,933	,360
	Postmenarcheal	13	19,94	4,09			13	20,35	3,76		
Sit and Reach (cm)	Premenarcheal	13	19,92	5,75	-2,244	,810	13	20,69	6,65	-1,095	,284
	Postmenarcheal	13	20,50	6,31			13	23,08	4,17		
Vertical Jump (cm)	Premenarcheal	13	17,32	3,75	-,771	,448	13	19,25	5,59	593	,559
	Postmenarcheal	13	18,74	5,45			13	17,98	5,26		
Anaerobic Power (kg.m.sec)	Premenarcheal	13	63,35	10,88	-,318	,753	13	69,00	10,92	1,023	,316
	Postmenarcheal	13	64,60	9,02			13	64,91	9,43		
Right Handgrip Strength (kg)	Premenarcheal	13	19,95	4,49	-1,344	,192	13	18,68	3,66	-,870	,393
	Postmenarcheal	13	22,58	5,47			13	20,62	7,15		
Left Handgrip Strength (kg)	Premenarcheal	13	20,58	4,57	-1,082	,290	13	19,28	5,45	-,844	,407
	Postmenarcheal	13	22,43	4,11			13	21,05	5,24		
Medicine Ball Throw (cm)	Premenarcheal	13	534,62	152,73	-,849	,405	13	546,92	137,92	-1,699	,102
	Postmenarcheal	13	576,92	94,81			13	636,92	132,19		
Mean Proagility Speed (m/sn)	Premenarcheal	13	2,99	0,21	-1,118	,275	13	2,91	0,27	-1,990	,058
	Postmenarcheal	13	3,12	0,37			13	3,08	0,15		
	Premenarcheal	13	4,36	0,64	-2,180	,039*	13	4,70	0,87	2,010	,056

Mean Sprint Speed (m/sn)	Postmenarcheal	13	4,77	0,21		13	4,20	0,19
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\*p< 0.05; \*\*p< 0.01,

**Table 2. Change in the variables of physical fitness in the Premenarcheal younger group with a mean age ranging from 139.77 months (11.58 years) to 151.77 months (12.65 years) during pre-test and post-tests.**

Variables	Tests	N	M	SD	Diff.	% diff	t	Sig	Cohen's d
Age (Months)	Pre	13	139,76	3,03	12	7,91	-	-	-
	Post	13	151,76	3,03					
Body Height (cm)	Pre	13	151,23	7,08	3,54	2,29	-5,743	,000**	0.534 <sup>M</sup>
	Post	13	154,77	6,15					
Body Weight (kg)	Pre	13	48,06	10,98	4,5	8,56	-6,418	,000**	0.398 <sup>S</sup>
	Post	13	52,56	11,65					
Body Mass Index	Pre	13	20,80	3,59	0,94	4,32	-3,090	,009**	0.253 <sup>S</sup>
	Post	13	21,74	3,84					
Sit and Reach (cm)	Pre	13	19,92	5,75	0,77	3,72	-,536	,602	N/A
	Post	13	20,69	6,65					
Vertical Jump (cm)	Pre	13	17,32	3,75	1,93	10,03	-1,193	,256	N/A
	Post	13	19,25	5,59					
Anaerobic Power (kg.m.sec)	Pre	13	63,35	10,88	5,65	8,19	-2,121	,055	N/A
	Post	13	69,00	10,92					
Right Handgrip Strength (kg)	Pre	13	19,95	4,49	-1,27	-6,80	2,126	,055	N/A
	Post	13	18,68	3,66					
Left Handgrip Strength (kg)	Pre	13	20,58	4,57	-1,3	-6,74	1,378	,193	N/A
	Post	13	19,28	5,45					
Medicine Ball Throw (cm)	Pre	13	534,62	152,73	12,3	2,25	-,299	,770	N/A
	Post	13	546,92	137,92					
Mean Proagility Speed (m/sn)	Pre	13	2,99	0,21	-0,08	-2,75	1,060	,310	N/A
	Post	13	2,91	0,27					
Mean Sprint Speed (m/sn)	Pre	13	4,36	0,64	0,34	7,23	-,803	,438	N/A
	Post	13	4,70	0,87					

\*p< 0.05; \*\*p< 0.01; N/A = Not Applicable ES=Effect Size, <sup>S</sup>If Cohen's d is between 0.200 and 0.499, it indicates a small effect size (S). <sup>M</sup>If Cohen's d is between 0.500 and 0.799, it indicates a medium effect size (M). <sup>L</sup> If Cohen's d is 0.800 or above, it indicates a large effect size (L).

**Table 3. Change in the variables of physical fitness in the Postmenarcheal older group with a mean age ranging from 154.92 months (12.83 years) to 166.92 months (13.91 years) during pre-test and post-test.**

Variables	Tests	N	M	SD	Diff.	% diff	t	Sig	Cohen's d
Age (Months)	Pre	13	154,92	5,17	12	7,19	-	-	-
	Post	13	166,92	5,17					
Body Height (cm)	Pre	13	153,85	7,35	2,38	1,52	-2,878	,014*	0.342 <sup>S</sup>
	Post	13	156,23	6,56					
Body Weight (kg)	Pre	13	47,76	13,04	2,48	4,94	-2,280	,042*	0.193 <sup>S</sup>
	Post	13	50,24	12,72					
Body Mass Index	Pre	13	19,94	4,09	0,41	2,01	-,781	,450	N/A
	Post	13	20,35	3,76					
Sit and Reach (cm)	Pre	13	20,50	6,31	2,58	11,18	-1,759	,104	N/A
	Post	13	23,08	4,17					
Vertical Jump (cm)	Pre	13	18,74	5,45	-0,76	-4,23	,432	,673	N/A
	Post	13	17,98	5,26					
Anaerobic Power (kg.m.sec)	Pre	13	64,60	9,02	0,31	0,48	-,119	,907	N/A
	Post	13	64,91	9,43					

Right Handgrip Strength (kg)	Pre	13	22,58	5,47	-1,96	-9,51	2,052	,063	N/A
	Post	13	20,62	7,15					
Left Handgrip Strength (kg)	Pre	13	22,43	4,11	-1,38	-6,56	2,033	,065	N/A
	Post	13	21,05	5,24					
Medicine Ball Throw (cm)	Pre	13	576,92	94,81	60	9,42	-1,733	,109	N/A
	Post	13	636,92	132,19					
Mean Proagility Speed (m/sn)	Pre	13	3,12	0,37	-0,04	-1,30	,359	,726	N/A
	Post	13	3,08	0,15					
Mean Sprint Speed (m/sn)	Pre	13	4,77	0,21	-0,57	-13,57	5,150	,000**	2.846 <sup>L</sup>
	Post	13	4,20	0,19					

\* $p < 0.05$ ; \*\* $p < 0.01$  N/A = Not Applicable ES=Effect Size, <sup>5</sup>If Cohen's d is between 0.200 and 0.499, it indicates a small effect size (S). <sup>M</sup>If Cohen's d is between 0.500 and 0.799, it indicates a medium effect size (M). <sup>L</sup> If Cohen's d is 0.800 or above, it indicates a large effect size (L).

There was no statistically significant difference between the two groups in terms of height, body weight, and Body Mass Index (BMI) in Pre-test ( $p > 0.05$ ). This indicates that the anthropometric characteristics before menarche were similar between the groups. Similarly, no significant difference was found between the two groups in flexibility, vertical jump, anaerobic power, right and left handgrip strengths, medicine ball throw and agility speed tests ( $p > 0.05$ ). In the pre-test, the mean sprint speed of the postmenarcheal older age group (4.77 m/s) was statistically significantly higher than that of the premenarcheal younger age group (4.36 m/s) ( $p < 0.05$ ). This shows that the naturally postmenarcheal older age group was faster before menarche.

During menarche in the Post-test, the age difference between the groups naturally persisted. During post-menarche period, no statistically significant difference emerged between the two groups regarding height, body weight, and BMI ( $p > 0.05$ ). Significant differences did not appear between the premenarcheal and postmenarcheal groups during menarche period in flexibility, vertical jump, anaerobic power, right and left handgrip strength, medicine ball throw, and mean agility speed tests either in Table 1 ( $p > 0.05$ ).

The significant difference in mean sprint speed that existed before menarche disappeared in the post-menarche period ( $p > 0.05$ ). This change suggests that the postmenarcheal older age group experienced a mathematical decrease in mean sprint speed, thus closing the intergroup gap.(Table 1).

Overall, it shows that the effect of menarche timing on physical fitness is limited and specific to certain parameters. The most notable difference between the two groups was observed in pre-menarche sprint performance, but this difference disappeared in the post-menarche period. In other physical fitness components, the groups exhibited similar profiles both before and after menarche. This situation indicates that considering the level of biological maturity instead of chronological age in performance evaluations could lead to fairer and more accurate results, especially during the menarche transition period (Table 1).

In this study, differences between two groups were analyzed at two separate time points: before menarche (Pre-test) and nine months later during menarche in post-test. Before menarche, the mean age of the premenarcheal younger group (139.77 months) was statistically significantly lower ( $p < 0.001$ ) than the mean age of the postmenarcheal older group (154.92 months). There was no statistically significant difference between the two groups in terms of height, body weight, and body mass index in post test (Table 1).

In the premenarcheal group between pre-test and post-test had a moderate effect size was observed in height change over the 9-months post-menarche period ( $d = 0.534$  "M"). This finding indicates that premenarcheal group had a statistically significant ( $p < 0.01$ ) and relatively pronounced increase in body height. For body weight, a small effect size was detected ( $d = 0.398$  "S"). Although the increase in body weight was statistically significant ( $p < 0.01$ ), its practical magnitude is limited. Furthermore, a small effect size was found for body mass index ( $d = 0.253$  "S"). The effect size of the significant increase in BMI ( $p < 0.01$ ) also remained small (Table 2).

For the other variables including flexibility, vertical jump, anaerobic power, right and left handgrip strength, medicine ball throw, agility, and speed tests—effect sizes were not calculated or reported as the changes over the 9-month period were not statistically significant. The non-significant declining trend

observed in both handgrip strength measures, in particular, aligns with the "relative strength loss observed in the menarche period" emphasized (Table 2).

In general, the most prominent physical change in the premenarcheal younger age group during the period following menarche was height gain, and this change had a moderate effect size. Although the increases in body weight and BMI were statistically significant, their effect sizes were small. These results highlight the primary contribution of early menarche to height in this group (Table 2).

In the postmenarcheal older age group between pre-test and post-test, with mean ages ~12.8 years during pre-test and ~13.9 years during post-test, had a statistically non-significant, a decrease in mean sprint speed was recorded over the 9-month post-menarche period, with a very large effect size ( $d = 2.846$  "L",  $p < 0.001$ ). This finding is the most striking result of the study and clearly demonstrates that the post-menarche period has an extremely strong and negative effect on speed performance in this postmenarcheal group. The "variability in speed performance" and "potential risks" mentioned in the summary are substantiated by this finding. A significant increase in height was also observed with a small effect size ( $d = 0.342$  "S",  $p < 0.05$ ). This indicates that late menarche also contributed to increased height in this postmenarcheal group, but the effect was lower compared to the premenarcheal younger age group ( $d=0.534$ ). Additionally, a significant increase in body weight was observed with a small effect size ( $d = 0.193$  "S",  $p < 0.05$ ). The effect of this increase is also small (Table 3).

Effect sizes were not calculated for changes observed in BMI, flexibility, vertical jump, anaerobic power, right and left handgrip strength, medicine ball throw, and agility speed, as they were not statistically significant. The declining trend in both handgrip strength measures, in particular, parallels the emphasized "relative strength loss" (Table 3).

In general assessment, the most distinct and powerful effect of the post-menarche period in the postmenarcheal older age group was the dramatic decrease in sprint speed. This situation supports the conclusion that biological maturation can significantly affect different physical parameters at different ages and that training programs should be planned according to individual maturity level rather than chronological age. Athletes in this late-maturing group may require specific support and monitoring for speed performance in the post-menarche period.

When all participants are considered, the most consistent and significant effects of menarche are the expected changes in body composition including increases in body height, body weight, and BMI and a notable non-significant upper extremity strength loss that warrants particular attention. However, the fact that the effect sizes of these changes generally fall into the "small" category suggests that individual differences and the variations between groups (as seen in Tables 2 and 3) influence the overall result. This supports the idea that training programs should be personalized based on an individual's biological maturity level and menarche timing, rather than relying on universal rules.

## DISCUSSION

This study aimed to examine the effect of menarche timing on the physical fitness parameters of adolescent girls. Our findings showed that in the pre-menarche period, girls in the older age group had a significant superiority in sprint speed compared to the younger age group, but this difference disappeared during the nine-month post-menarche period. This change stems from the mathematical decline in sprint performance observed particularly in the older age postmenarcheal group. On the other hand, there were also mathematical differences in anthropometric measurements including height, body weight, and BMI and on other physical fitness components such as flexibility, strength, and agility.

Our most striking finding was the significant decrease in sprint speed observed in the postmenarcheal group (older age group), which had a very large effect size ( $d = 2.846$ ). This finding highlights the complex effects of biological maturation on motor performance. In the literature, during the adolescent growth spurt, coordination and motor control can be temporarily adversely affected, a situation referred to as "*adolescent awkwardness*" by Philippaerts et al. (8). The fact that late-maturing individuals experience this period at a more advanced chronological age may cause this temporary performance decline to become more pronounced.

Similarly, Lloyd et al. (7) suggested that late-maturing young athletes might experience a temporary disadvantage in skills requiring speed and agility compared to their peers.

However, this finding of ours partially contradicts some research. For example, in a longitudinal study, Figueiredo et al. (16) reported that early-maturing girls showed a more pronounced increase in strength and power during the peak height velocity (PHV) period of puberty compared to late-maturing girls, but changes in speed performance did not show a significant difference between maturity groups. This discrepancy may be due to the characteristics of the study population, the length of the follow-up period, and the maturity assessment methods.

Another important finding of our study was the observation of a moderate increase in height ( $d = 0.534$ ) in the premenarcheal group. This is consistent with menarche being a sign that growth is nearing completion. Malina et al. (1) stated that menarche usually occurs after the peak height velocity period and indicates a phase where height increase begins to slow down. The fact that individuals experiencing early menarche enter this growth phase at a relatively earlier chronological age may explain the relatively more pronounced height increase in our study.

On the other hand, no significant difference related to menarche timing was found in other physical fitness parameters such as flexibility, vertical jump, and handgrip strength in either group. This situation suggests that these components may be more strongly influenced by factors such as genetic predisposition, physical activity level, and training history (17). Furthermore, a non-significant decreasing trend in handgrip strength was observed in both groups. This finding could be interpreted as a temporary decrease in relative strength (strength/body weight) due to increased body weight in the post-menarche period (18).

In a study similar to ours, the work of Fu et al. (19) demonstrates that early menarche has a dual effect on the physical fitness of adolescent girls. While early-menarche girls showed higher performance in parameters like speed, explosive strength, and abdominal muscle strength compared to their biologically less mature peers, they demonstrated lower performance in the cardiorespiratory endurance test. The observed strength and power advantage can be explained by accelerated biological maturation. Round et al. (18) noted that the increase in strength in girls is fundamentally related to growth in body size. Early-menarche girls may have gained a temporary advantage in strength-requiring tasks by achieving muscle mass and bone maturity at an earlier age, thanks to the enhancing effect of increased estrogen on the Growth Hormone (GH)/Insulin-like Growth Factor-1 (IGF-1) axis (20). This situation is consistent with the findings of Lloyd et al. (7) that early-maturing individuals may exhibit a temporary superiority. The low endurance, however, is most likely linked to differences in body composition. Early menarche is associated with a higher body fat percentage (21). This metabolically inactive extra load can negatively affect performance in endurance tests that require carrying body weight. Additionally, girls' aerobic capacity may plateau during adolescence (22), and early-menarche girls may have entered this period earlier. Conversely, Malina et al. (23) suggested that the independent effect of maturity level on aerobic fitness may be limited. Low endurance may not be a consequence of early menarche itself, but rather the effect of a shared underlying factor like high body fat. Furthermore, important confounding variables such as physical activity level were not controlled for.

The study by Ravi et al. (21) shows that participation in competitive sports at ages 13-16 is associated with higher lean body mass, femoral neck bone mineral density (BMD), and better physical performance in middle age, compared to not engaging in regular physical activity or exercise during adolescence. They also found that participating in competitive sports at ages 13-16 was associated with later menarche compared to not exercising at these ages. This study also showed that, for all participants, menarcheal age was negatively associated with middle-age BMI and body fat mass, independent of confounding factors, and was negatively associated with femoral neck BMD in premenopausal and perimenopausal women. Therefore, competitive sports during adolescence appear to be associated with a healthier body composition, higher BMD, and better performance in middle age; however, it was noted that later menarcheal age may be associated with lower BMD.

In conclusion, the findings of this study reveal that the effect of menarche timing on physical fitness varies depending on the parameter and the maturity timing. The pronounced decline in sprint performance observed in the postmenarcheal group, especially in older age groups, is a critical warning for coaches and pedagogues.

Therefore, it is recommended that biological maturity level must be taken into account alongside chronological age in the evaluation of young athletes and the planning of training programs. Furthermore, future studies should include the regular monitoring of the development and physical fitness levels of those who participate in regular physical and sporting activities before and after puberty versus sedentary individuals, and the investigation of the optimal volume and intensity of exercise programs.

## CONCLUSION

This study compared the physical fitness levels of premenarcheal and postmenarcheal adolescent girls at two time points: before menarche and nine months later during the postmenarche period. The findings indicate that the influence of menarche timing on physical fitness is specific and limited to certain parameters. The most notable difference was observed in sprint speed, where the postmenarcheal (older) group demonstrated superior performance before menarche, but this advantage disappeared post-menarche due to a significant decline in their speed performance. This decline, characterized by a very large effect size, highlights a critical period of vulnerability for speed development in late-maturing girls, aligning with the concept of "adolescent awkwardness." In contrast, other fitness components—including flexibility, vertical jump, anaerobic power, handgrip strength, medicine ball throw, and agility—did not show significant differences between groups either before or after menarche. Anthropometric changes, such as increases in height, weight, and BMI, were observed in both groups following menarche, with the most pronounced effect being a moderate increase in height within the premenarcheal group. However, the overall effect sizes for most physical changes were small, underscoring the role of individual variability.

The results collectively emphasize that biological maturity status, rather than chronological age alone, is a crucial factor influencing motor performance during puberty. The transient decline in sprint speed in postmenarcheal girls and the nonsignificant trends of strength loss point to the nuanced impact of maturation on fitness.

## RECOMMENDATIONS

Based on the findings, the following recommendations are proposed:

**1. Individualized Training Programs:** Coaches and physical educators should assess biological maturity (e.g., via menarche status or maturity offset) in addition to chronological age when designing training and talent identification programs for adolescent girls. Personalized approaches can better address the specific needs and vulnerabilities associated with different maturation timings.

**2. Monitoring Speed Development:** Particular attention should be paid to monitoring and supporting speed performance in late-maturing girls during the postmenarche period. Training interventions should focus on maintaining coordination and speed through exercises that accommodate temporary declines in motor control.

**3. Longitudinal Fitness Tracking:** Schools and sports clubs should implement regular longitudinal monitoring of physical fitness and anthropometric measures throughout puberty. This would help identify individual growth patterns and adjust physical activity prescriptions accordingly.

**4. Promotion of Lifelong Physical Activity:** Given the association between adolescent physical activity, later menarche, and positive long-term health outcomes (e.g., healthier body composition and bone health), adolescents—especially those with sedentary lifestyles—should be encouraged to engage in regular, moderate-to-vigorous physical activity and, where possible, structured sports.

**5. Future Research Directions:** Subsequent studies should:

- Include larger and more diverse samples to generalize findings.
- Compare physically active versus sedentary adolescents to disentangle the effects of maturation from those of training.

- Investigate the optimal type, volume, and intensity of exercise to support fitness development across different maturity stages.
- Explore the physiological mechanisms (e.g., hormonal changes, body composition shifts) behind the observed decline in speed and strength post-menarche.

In summary, acknowledging biological maturation in athletic development can lead to fairer evaluations, more effective training, and ultimately, better support for the health and performance of all adolescent girls.

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