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The Impact of Discrepancies Between Chronological Age and Biological Maturity on Physical and Technical Performance Indicators Among Algerian Youth Athletes Aged 12–16 Years

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Abstract:

This study examined biological maturity's impact on physical and technical performance among 45 Algerian youth athletes (12–16 years) across football, basketball, and handball. Maturity was assessed via the Tanner scale; data analyzed via ANOVA and MANOVA ($\alpha \leq 0.05$). Results favored biologically advanced athletes, with large effects in explosive strength ($d = 1.23$) and speed ($d = 1.03$), weak in endurance ($d = 0.35$). Technical differences were greatest in basketball ($d = 1.32$) and football ($d = 1.19$). The maturity-by-sport interaction ($\eta^2 = 0.466$) showed explosive sports are more sensitive to biological variation. Chronological age alone is deficient; integrating maturity indicators and bio-banding is recommended for fairer selection.

Keywords: Chronological Age; Biological Maturity; Physical Performance; Technical Performance; Youth Athletes; Grassroots Sport; Talent Selection; Bio-banding; Sports Training; Algeria.

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1. INTRODUCTION

Sports training integrates medicine, anatomy, and biomechanics to elevate athletes physically, tactically, and psychologically through physical loads that produce functional or structural adaptation (Belkacemi et al., 2026, p. 449; Belamri et al., 2026, p. 492). The adolescence phase (12–16 years) is particularly critical for athletic development, marked by accelerated physical and motor changes; however, chronological age remains the common administrative criterion for grouping athletes despite failing to reflect individual differences in biological maturity—the actual progression toward the adult state that acquires greater explanatory value than chronological age in accounting for performance differences (Malina et al., 2015; Sport NSW, 2023). Same-age athletes often differ significantly in strength, speed, and motor control due to varying puberty-related changes, with advanced-maturing athletes demonstrating better neuromuscular coordination and more precise activation timing than delayed-maturing peers, producing variations in the ability to execute high-intensity muscular contractions and consequently affecting technical performance levels (Malina et al., 2015; Figueiredo et al., 2021). Relying solely on chronological age risks selection biases, as advanced-maturing athletes may be perceived as more talented due to temporary physical advantages while genuinely gifted yet delayed-maturing athletes are overlooked (Hill et al., 2021; Malina et al., 2015), and recent studies demonstrate that biological advancement is frequently associated with superiority in strength- and speed-related components, whereas technical aspects are influenced by the interplay between maturity, training experience, and sporting environment (Sport NSW, 2023; Figueiredo et al., 2021; Roma-Dona et al., 2022). Combining chronological age with biological maturity thus provides a more scientifically accurate foundation for understanding performance differences and enables more objective decision-making in talent selection and training planning (Roma-Dona et al., 2022; Figueiredo et al., 2021). In the Algerian context, developing grassroots sport requires accounting for these developmental specificities rather than relying on temporary superiority for premature judgments; accordingly, this study examines how discrepancies between chronological age and biological maturity affect physical and technical performance among Algerian

youth athletes aged 12–16, aiming to inform more rational talent selection, individualized training, and improved athletic development during early age categories.

2. Problematic

Growth and biological maturity are key determinants of youth athletic performance, yet classification, selection, and training practices in Algeria remain heavily dependent on chronological age, which poorly reflects actual biological status; consequently, a 14-year-old athlete may be biologically advanced or delayed relative to peers, directly affecting their physical and technical capacities and raising a critical question of whether performance differences among age-matched athletes reflect true talent or merely maturity variations, leading to inaccurate selection judgments that favor advanced-maturing athletes for temporary advantages while overlooking genuinely talented late-maturing individuals—an issue further complicated by sport-specific demands, as strength- and speed-based activities are more affected by biological maturity whereas other sports show greater dependence on skill and training, and despite these well-documented discrepancies, training programs in Algeria continue to apply uniform loads based solely on chronological age categories without accounting for individual biological maturity status, posing a significant problem whereby advanced-maturing athletes may develop poor technical foundations due to reliance on physical superiority while delayed-maturing athletes may be discouraged by constant comparison with physically superior peers, so the absence of individualized training adjustment undermines long-term athletic development and perpetuates selection biases at the grassroots level, all of which frames the central research question: **to what extent do discrepancies between chronological age and biological maturity influence physical and technical performance indicators among Algerian youth athletes aged 12–16?**

Based on these considerations, the study problem was formulated around the following **research questions**:

- Are there statistically significant differences in physical performance between biologically advanced and delayed youth athletes of the same chronological age (12–16 years), and how large are these differences?

- Are there statistically significant differences in technical performance between biologically advanced and delayed youth athletes, and do these differences vary by sport type?

- Does the effect of biological maturity on physical and technical performance vary by sport type (strength/speed versus skill/endurance), and does sensitivity to maturity differ across sports among Algerian youth athletes aged 12–16?

2.1 Research Hypotheses

- There is a statistically significant difference in physical and technical performance indicators between biologically advanced and delayed youth athletes, despite their equal chronological age (12–16 years).

2.2 Sub-Hypotheses

- There are statistically significant differences in physical performance indicators between biologically advanced and delayed youth athletes, with larger effects in strength- and speed-dependent indicators.

- There are statistically significant differences in technical performance between biologically advanced and delayed youth athletes, varying by sport type and its technical demands.

- The effect of biological maturity on performance indicators varies by sport type and its demands (strength/speed versus skill/endurance).

3. Significance of the Study: This study examines how biological maturity affects physical and technical performance among Algerian athletes aged 12–16, enriching scientific literature by linking biological growth to sport-specific demands. Practically, it equips coaches with evidence-based tools for individualized training, fairer talent identification, and load management—distinguishing temporary biological advantage from genuine potential. By integrating maturity indicators into selection protocols, the study helps prevent exclusion of late developers and overvaluation of early maturers, supporting more equitable, science-driven grassroots sport development in Algeria.

4. Methodological Approaches

4.1 Pilot Study : The pilot study was conducted from October 15–30, 2025, in Bordj Bou Arréridj on 15 players equally distributed across football, basketball, and handball. Following interviews with club administrations and coaches, biological maturity tests (anthropometric measurements and Tanner scale), physical tests (vertical jump, 30-meter sprint, Illinois agility, and Yo-Yo endurance), and sport-specific technical tests were administered. Results revealed clear variation favoring biologically advanced players in strength and speed, with less pronounced technical differences. Reliability calibration via test-retest (October 23 and 30, 2025) showed high quality for vertical jump (0.94) and speed (0.91) versus lower reliability for Yo-Yo (0.68), necessitating its replacement with the Cooper test in the main study, along with adding practice trials before technical tests and fixing additional markers in the agility course. Correlation coefficients are shown in the following table:

Table 1. : Reliability Coefficients via Test-Retest Method

Test	Reliability Coefficient	Evaluation	Note
Vertical Jump	0.94	Excellent	Retained in the main application
30-Meter Sprint	0.91	Excellent	Retained in the main application
Illinois Agility Test	0.82	Acceptable	Additional ground markers added
Yo-Yo Endurance Test	0.68	Poor	Replaced with Cooper test in the main ap

Source: Author's calculation, 2025

The table reveals considerable variation in test stability upon re-administration. Physical tests were administered on October 23, 2025, and re-administered on October 30, 2025, to the same 15 players. The vertical jump (0.94) and 30-meter sprint (0.91) achieved excellent reliability (above 0.90), indicating consistent results suitable for the main study without modification. The

Illinois agility test recorded 0.82, within the acceptable threshold (0.80–0.89) but less stable; additional ground markers and a practice trial were added before actual administration. The Yo-Yo endurance test yielded the lowest value at 0.68, below the minimum threshold (0.70), due to susceptibility to fatigue and motivation factors; it was excluded and replaced with the Cooper test in the main study. In summary, highly reliable tests were retained, moderately reliable ones revised, and poor ones replaced to ensure result reliability.

4.2 Main Study : Research Sample : The main study sample comprised 45 players selected via purposive sampling, equally distributed across football, basketball, and handball (15 per sport). Football players were from Union Bordj Bou Arréridj (under-14 to under-16: 8 advanced, 7 delayed). Basketball players were from Union Sportive Bordj Bou Arréridj (under-12 to under-16: 9 advanced, 6 delayed). Handball players were from Bordj Bou Arréridj Handball Club (under-13 to under-15: 7 advanced, 8 delayed). Players with injuries, chronic illnesses, intensive other-sport practice in the preceding six months, or more than three absences during the application month were excluded. Additionally, players biologically advanced or delayed by more than three years were excluded to avoid outliers.

4.3 Population: The research population comprised 186 players aged 12–16 years across three Bordj Bou Arréridj clubs: Union Bordj Bou Arréridj football (68 players, under-14 to under-16), Union Sportive Bordj Bou Arréridj basketball (72 players, under-12 to under-16), and Bordj Bou Arréridj Handball Club (46 players, under-13 to under-15). Population was determined from 2025–2026 official registration records, with verified regular attendance of at least three weekly training sessions.

4.4 Methodology: The study adopted a quasi-experimental design suited to biological maturity as a non-manipulable variable, with the researcher observing natural variation and classifying athletes accordingly. The experiment followed a non-equivalent groups design with two factors: biological maturity (advanced/delayed) and sport type (football/basketball/handball), aiming to reveal

the causal relationship between maturity and performance indicators, and whether this effect varies by sport nature and motor demands.

4.5 Research Domains

- **Human Domain:** The human domain comprised 45 youth athletes aged 12–16 years, equally distributed across football, basketball, and handball (15 players each) at three clubs in Bordj Bou Arréridj.
- **Spatial Domain:** The study was conducted at three venues in Bordj Bou Arréridj: 20 August 1955 Stadium (football and shared physical tests), Mohamed Boudiaf Hall (basketball), and 20 August 1955 Indoor Hall (handball)—the same venues used for team training and competitions.
- **Temporal Domain:** The field study was conducted from October 15 to November 15, 2025, in two phases as follows
- **Pilot Study:** Tests were administered and re-administered one week apart (October 23 and 30, 2025) to a pilot sample of 15 players (5 per sport) to calculate reliability coefficients. This group was excluded from the main study to ensure sample independence.
- **Main Study:** Final tests were administered to the full sample of 45 players from November 5–15, 2025, with a 48-hour rest period between physical and technical tests.

4.6 Research Instruments

- Stadiometer (height and sitting height) (World Health Organization, 2006).
- Simplified Tanner Puberty Scale (Marshall & Tanner, 1969).
- Measuring tape (shoulder width) (Weiner & Lourie, 1969).
- Hand dynamometer (for grip strength measurement) (American Society of Hand Therapists, 1992).
- Vertical Jump Test (Sargent Jump) (Harman et al., 1991).
- Standing Sprint Test over 30 meters (Currell & Jeukendrup, 2008).
- Illinois Agility Test (Hachana et al., 2013).
- Cooper Endurance Test (12-minute run) (Kline et al., 1987).
- Accurate Passing Test to Fixed Targets (for football) (Reilly et al., 2000).

- Five-Position Shooting Test (basketball) (Miller & Bartlett, 1996).
- Rapid passing to a stationary teammate (handball) (Gruia et al., 2011).

4.7 Statistical Methods : The study used descriptive statistics (means, standard deviations) and inferential analyses: Independent Samples t-test for group comparisons, Two-Way ANOVA to examine maturity, sport, and interaction effects with Scheffé Post-Hoc for pairwise comparisons, Eta Squared (η^2) for effect size, and MANOVA for collective physical and technical variable analysis, all via SPSS 26 ($\alpha \leq 0.05$).

5. Results

5.1 Results of the First Sub-Hypothesis : The first hypothesis posited significant physical performance differences between biologically advanced and delayed youth athletes, with larger effects in strength- and speed-dependent indicators. Independent Samples t-tests compared these groups across physical indicators, as shown below.

Table 2: Results of t-test: Advanced vs. Delayed Athletes on Physical Performance Indicators

Variable	Biologically Advanced (M ± SD)	Biologically Delayed (M ± SD)	t	df	p	Effect Size (d)
Vertical Jump (cm)	48.32 ± 6.14	36.18 ± 5.72	8.234	43	< 0.001	1.23
30-Meter Sprint (sec)	4.21 ± 0.38	4.89 ± 0.45	-6.891	43	< 0.001	1.03
Illinois Agility Test (sec)	15.84 ± 1.26	17.42 ± 1.38	-4.756	43	< 0.001	0.71
Cooper Endurance Test (m)	2486 ± 312	2314 ± 298	2.312	43	0.026	0.35

Source: Author's calculation, 2025

Biologically advanced athletes significantly outperformed delayed peers in vertical jump ($t = 8.234$, $p < 0.001$, $d = 1.23$), sprint ($t = -6.891$, $p < 0.001$, $d = 1.03$), and agility ($t = -4.756$, $p < 0.001$, $d = 0.71$), but showed only weak endurance differences ($p = 0.026$, $d = 0.35$). This partially confirms the first hypothesis, with biological maturity exerting greater influence on explosive strength and speed than cardiorespiratory capacity.

5.2 Results of the Second Sub-Hypothesis : The second hypothesis posited that technical performance differences between biologically advanced and delayed youth athletes vary by sport. Independent Samples t-tests compared these groups across technical indicators by sport, as shown below.

Table 3: Results of t-test: Advanced vs. Delayed Athletes on Technical Performance by Sport

Sport	Technical Variable	Biologicall Advanced (M ± SD)	Biologically Delayed (M ± SD)	t	df	p	Effect Size (d)
Football	Accurate Passing (%)	78.45 ± 8.32	71.23 ± 9.14	2.876	28	0.007	0.83
Football	Ball Control (sec)	12.14 ± 1.28	13.89 ± 1.56	-4.123	28	< 0.001	1.19
Basketball	Consecutive Shooting (points)	11.67 ± 2.14	8.42 ± 2.38	4.567	28	< 0.001	1.32
Basketball	Shooting Accuracy (%)	62.38 ± 9.42	54.17 ± 10.28	2.678	28	0.012	0.77
Handball	Rapid Passing (number)	24.18 ± 3.26	20.45 ± 3.84	3.234	28	0.003	0.94
Handball	Shooting on Goal (%)	71.25 ± 7.84	64.38 ± 8.92	2.456	28	0.019	0.93

Source: Author's calculation, 2025

Significant technical differences emerged across all three sports, with basketball showing the largest effect in consecutive shooting (d = 1.32), followed by football in ball control (d = 1.19), and handball in rapid passing (d = 0.94). Differences are greater in sports demanding explosive power or response speed versus repetition and precision, confirming the second hypothesis.

5.3 Results of the Third Sub-Hypothesis: The third hypothesis posited that biological maturity's effect on performance varies by sport type (strength/speed versus skill/endurance). Two-Way ANOVA was applied to vertical jump as an explosive strength indicator, as shown below.

Table 4: Results of the Two-Way ANOVA for the Vertical Jump as an Indicator of Explosive Strength

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	p	η^2
Biological Maturity (A)	1256.34	1	1256.34	26.52	< 0.001***	0.405
Sport (B)	342.18	2	171.09	3.61	0.037*	0.156
Interaction (A × B)	568.92	2	284.46	6.00	0.005**	0.235
Within-Cell Error	1847.56	39	47.37	--	--	--
Total	4015.00	44	--	--	--	--

Source: Author's calculation, 2025

The table reveals that the main effect of biological maturity was statistically significant ($F = 26.52$, $p < 0.001$, $\eta^2 = 0.405$), indicating that it explains 40.5% of the variance in the vertical jump. The main effect of sport was also significant ($F = 3.61$, $p = 0.037$, $\eta^2 = 0.156$). Most importantly, the interaction between biological maturity and sport was statistically significant ($F = 6.00$, $p = 0.005$, $\eta^2 =$

0.235), meaning that the effect of biological maturity differs depending on the sport, as shown in the following table:

Table 5: Results of the Scheffé Post-Hoc Comparisons for the Vertical Jump Test

Scheffé Coefficient for Post-Hoc Comparisons				
Comparison	**Mean Difference**	**Standard Error**	**Scheffé**	**p**
Advanced Football vs Delayed Football	14.28	2.14	6.67	< 0.001*
Advanced Basketball vs Delayed Basketball	16.42	2.38	6.90	< 0.001*
Advanced Handball vs Delayed Handball	12.18	2.06	5.91	< 0.001*
Advanced Football vs Advanced Basketball	3.24	2.28	1.42	0.412
Advanced Basketball vs Advanced Handball	2.86	2.15	1.33	0.456
Delayed Football vs Delayed Basketball	1.45	2.31	0.63	0.892

Source: Author's calculation, 2025

Post-hoc comparisons revealed significant differences between advanced and delayed athletes across all three sports ($p < 0.001$), with larger gaps in basketball (16.42 cm) and football (14.28 cm) versus handball (12.18 cm). Inter-sport differences within the same maturity level were non-significant ($p > 0.05$), indicating biological maturity as the primary variance source rather than sport type. Biological maturity thus exerts greater influence in explosive strength-dependent sports, necessitating MANOVA for all physical variables collectively, as shown below.

Table 6: Results of the Multivariate Analysis of Variance (MANOVA) for All Physical Variables Combined

Effect	Wilks' Lambda (Λ)	F	df (Numerator)	df (Denominator)	p	η^2
Biological Maturity	0.412	8.234	4	38	< 0.001*	0.588
Sport	0.678	3.456	8	76	0.002*	0.322
Interaction (Maturity × Sport)	0.534	4.123	8	76	< 0.001	0.466

Source: Author's calculation, 2025

MANOVA analysis confirmed the preceding results, with the main effect of biological maturity being significant ($\Lambda = 0.412$, $F = 8.234$, $p < 0.001$, $\eta^2 = 0.588$) with a large effect size explaining 58.8% of the variance in the composite. The main effect of sport was also significant ($\Lambda = 0.678$, $F = 3.456$, $p = 0.002$, $\eta^2 = 0.322$). Most importantly, the interaction was significant ($\Lambda = 0.534$, $F = 4.123$, $p < 0.001$, $\eta^2 = 0.466$) with a large effect size, confirming that the effect of biological maturity on physical performance differs substantively according to sport nature. These results thus fully confirm the third hypothesis.

6. Discussion

6.1 Discussion of Results in Light of the First Hypothesis: Results showed significant differences in three of four physical indicators. Vertical jump displayed the largest effect ($d = 1.23$, +12.14 cm), aligning with Malina et al. (2015) on maturity explaining explosive strength variance through pubertal structural and neural changes. Speed showed large effects ($d = 1.03$), corroborating Parr et al. (2020) that maturity exceeds relative age in influencing speed. Agility was moderate ($d = 0.71$), indicating lesser maturity influence than strength and speed. Endurance was weak ($d = 0.35$), consistent with Teixeira et al.

(2015) that cardiorespiratory capacity is less maturity-dependent than neuromuscular capacities.

The researcher attributes these results to temporary physical advantages in advanced athletes, including increased muscle mass and improved neuromuscular coordination, leading to superiority in explosive power and speed. However, this reflects developmental stage rather than genuine talent, and may dissipate as peers mature (Malina et al., 2015; Figueiredo et al., 2021). These results partially confirm the first hypothesis, with larger differences in strength- and speed-dependent indicators and diminished effects in endurance.

6.2 Discussion of Results in Light of the Second Hypothesis: Results showed significant differences across all technical skills, with varying magnitudes. Basketball displayed the largest effect in consecutive shooting ($d = 1.32$), as greater vertical jump height advantages advanced athletes in shooting over defenders, aligning with Guimarães et al. (2019). Football showed the largest effect in ball control ($d = 1.19$), linked to speed and strength facilitating rapid maneuvering. Handball showed the lowest effect in rapid passing ($d = 0.94$).

The researcher contends that technical differences depend on sport-specific demands: explosive power (basketball) and response speed (football) sports prove more sensitive to biological maturity, whereas precision-reliant sports (handball) are less affected, consistent with Sport NSW (2023). Training experience and sporting environment also influence technical aspects, explaining variation in effect sizes across sports (Roma-Dona et al., 2022), thus confirming the second hypothesis.

6.3 Discussion of Results in Light of the Third Hypothesis: Results confirmed a significant maturity-by-sport interaction ($F = 6.00$, $p = 0.005$, $\eta^2 = 0.235$), indicating that maturity effects differ by sport nature. Post-hoc comparisons revealed significant differences across all three sports, with larger gaps in basketball (16.42 cm) and football (14.28 cm) versus handball (12.18 cm), aligning with Hill et al. (2021) that maturity explains greater variance in strength- and speed-dependent sports.

The researcher considers this finding underscores the importance of accounting for sport-specific characteristics when adjusting training loads. In football and basketball, coaches must exercise caution when comparing age-matched players differing in maturity, as physical disparities may lead to inequity in selection and assessment. In handball, the lesser influence of maturity affords greater scope for biologically delayed athletes to compete and develop. MANOVA analysis confirmed these results, with the interaction significant at a large effect size ($\eta^2 = 0.466$), substantiating that biological maturity's effect differs substantively by sport nature.

7. CONCLUSION

• Biological maturity exerts a significant effect on physical performance, with greater impact on explosive strength ($d = 1.23$) and speed ($d = 1.03$) compared to agility ($d = 0.71$) and endurance ($d = 0.35$), necessitating a review of selection criteria based solely on chronological age.

• Biological maturity influences technical performance to varying degrees depending on the sport, with larger effects in basketball ($d = 1.32$) and football ($d = 1.19$) compared to handball ($d = 0.94$), owing to differences in motor demands.

• The effect of biological maturity differs substantively according to sport ($\eta^2 = 0.466$), with explosive sports proving more sensitive to it than tactical-precision sports.

• Reliance on chronological age alone constitutes a deficient criterion that produces biases against maturationally delayed athletes; integrating biological maturity indicators and implementing bio-banding is recommended to achieve greater equity.

• Future longitudinal studies tracking the same athletes across multiple years are advised to verify whether maturity-related differences dissipate upon the completion of maturation in all individuals.

8. Bibliography List :

1) American Society of Hand Therapists. (1992). Clinical assessment recommendations (2nd ed.). American Society of Hand Therapists.
2) Aouiss, A., & Amrouche, M. (2017). Preparing youth categories between growth demands and competition requirements. Journal of Sciences and Practices Related to Physical, Sports and Artistic Activities, 6 (2). https://asjp.cerist.dz/en/article/17880
3) Belamri, Y., Hadj Azzem, A., & Nemroud, B. (2026). The effect of speed–strength training on improving dribbling speed in football (soccer). Sport System Journal, 13 (1), 492. https://asjp.cerist.dz/en/article/289291
4) Belkacemi, B., Feghouli, S., & Meddah, R. (2026). The effect of a plyometric training program on enhancing explosive strength (jump height and speed) in under-17 (U17) football players. Sport System Journal, 13 (1), 449. https://asjp.cerist.dz/en/article/289289
5) Ben Issa, A. J. (2017). The effect of morphological characteristics on the talent selection process in football: A comparative study between a professional team (US Biskra) and an amateur team (Al-Rayyan Biskra Club), under-15 category [Unpublished master's thesis]. Institute of Physical and Sports Activity Sciences and Techniques, University of Mohamed Khider Biskra.
6) Cooper, K. H. (1968). A means of assessing maximal oxygen intake: Correlation between field and treadmill testing. Journal of the American Medical Association, 203 (3), 201–204. https://doi.org/10.1001/jama.1968.03140030033006
7) Cumming, S. P., Scott, S., & McGee, D. (2021). Are relative age and biological ages associated with coaches' evaluations of match performance in male academy soccer players? International Journal of Sports Science & Coaching, 16 (3), 679–689. https://doi.org/10.1177/1747954120966886
8) Cumming, S. P., Searle, C., Hemsley, J. K., Haswell, F., Edwards, H., Scott, S., & Malina, R. M. (2018). Biological maturation, relative age and self-regulation in male professional academy soccer players: A test of the underdog hypothesis. Psychology of Sport and Exercise, 39, 147–153.

9) Currell, K., & Jeukendrup, A. E. (2008). Validity, reliability and sensitivity of measures of sporting performance. Sports Medicine, 38 (4), 297–316. https://doi.org/10.2165/00007256-200838040-00003

10) Figueiredo, A. J., Coelho-e-Silva, M. J., Cumming, S. P., & Malina, R. M. (2021). Size and maturity mismatch in youth soccer players 11- to 14-years-old. Pediatric Exercise Science. https://pubmed.ncbi.nlm.nih.gov/33808077/

11) Figueiredo, A. J., Gonçalves, C. E., Coelho E Silva, M. J., & Malina, R. M. (2009). Youth soccer players, 11–14 years: Maturity, size, function, skill and goal orientation. Annals of Human Biology, 36 (1), 60–73.

12) Getchell, B. (1979). Physical fitness: A way of life (2nd ed.). John Wiley and Sons.

13) Gruia, D. C., Păunescu, C., & Tudora, E. (2011). Study regarding the level of manifestation of the basic motor skills in handball. Ovidius University Annals, Series Physical Education and Sport/Science, Movement and Health, 11 (2), 107–112.

14) Guimarães, E., Ramos, A., Janeira, M. A., Baxter-Jones, A. D. G., & Maia, J. (2019). How does biological maturation and training experience impact the physical and technical performance of 11–14-year-old male basketball players? Sports, 7 (12), 243. https://pubmed.ncbi.nlm.nih.gov/33225823/

15) Hachana, Y., Chaabène, H., Nabli, M. A., Attia, A., Moualhi, J., Farhat, N., & Elloumi, M. (2013). Test-retest reliability, criterion-related validity, and minimal detectable change of the Illinois agility test in male team sport athletes. Journal of Strength and Conditioning Research, 27 (10), 2752–2759. https://doi.org/10.1519/JSC.0b013e31827f5fd3

16) Harman, E. A., Rosenstein, M. T., Frykman, P. N., & Rosenstein, R. M. (1991). The effects of arms and countermovement on vertical jumping. Medicine and Science in Sports and Exercise, 23 (3), 367–373. https://doi.org/10.1249/00005768-199103000-00015

17) Hill, M., Scott, S., McGee, D., & Cumming, S. P. (2021). Are relative age and biological ages associated with coaches' evaluations of match performance in male academy soccer players? International Journal of Sports Science & Coaching, 16 (3), 679–689. https://doi.org/10.1177/1747954120966886

18) Kline, G. M., Porcari, J. P., Hintermeister, R., Freedson, P. S., Ward, A., McCarron, R., Ross, J., & Rippe, J. M. (1987). Estimation of VO2max from a one-mile track walk, gender, age, and body weight. Medicine and Science in Sports and Exercise, 19 (3), 253–259. https://doi.org/10.1249/00005768-198706000-00014

19) Malina, R. M., Bouchard, C., & Bar-Or, O. (2015). Growth, maturation, and physical activity (2nd ed.). Human Kinetics.

20) Malina, R. M., Coelho E Silva, M. J., Figueiredo, A. J., Carling, C., & Beunen, G. P. (2012). Interrelationships among invasive and non-invasive indicators of biological maturation in adolescent male soccer players. Journal of Sports Sciences, 30 (15), 1705–1717.

21) Marshall, W. A., & Tanner, J. M. (1969). Variations in pattern of pubertal changes in girls. Archives of Disease in Childhood, 44 (235), 291–303. https://doi.org/10.1136/adc.44.235.291

22) Marshall, W. A., & Tanner, J. M. (1970). Variations in the pattern of pubertal changes in boys. Archives of Disease in Childhood, 45 (239), 13–23. https://doi.org/10.1136/adc.45.239.13

23) Miller, S., & Bartlett, R. (1996). The relationship between basketball shooting kinematics, distance and playing position. Journal of Sports Sciences, 14 (3), 243–253. https://doi.org/10.1080/02640419608727717

24) Parr, J., Winwood, K., Hodson-Tole, E., Deconinck, F. J. A., Hill, J. P., Teunissen, J. W., & Cumming, S. P. (2020). The main and interactive effects of biological maturity and relative age on physical performance in elite youth soccer players. Journal of Sports Medicine, 2020, 1957636. https://doi.org/10.1155/2020/1957636

25) Reilly, T., Williams, A. M., Nevill, A., & Franks, A. (2000). A multidisciplinary approach to talent identification in soccer. Journal of Sports Sciences, 18 (9), 695–702. https://doi.org/10.1080/02640410050120078

26) Roma-Dona, I., García-Calvo, T., Leo, F. M., & Sánchez-Oliva, D. (2022). The influence of biological maturity on physical and technical performance in youth soccer players. Journal of Human Kinetics. https://pmc.ncbi.nlm.nih.gov/articles/PMC9804799/

27) Sargent, D. A. (1921). The physical test of a man. American Physical Education Review, 26 (4), 188–194. https://doi.org/10.1080/23267224.1921.10650828

28) Sport NSW. (2023). Biological maturation resource for sporting stakeholders. NSW Government. https://www.sport.nsw.gov.au/sites/default/files/2023-02/Biological-Maturation-Resource-for-Sporting-Stakeholders.pdf

29) Tanner, J. M. (1962). Growth at adolescence (2nd ed.). Blackwell Scientific Publications.

30) Weiner, J. S., & Lourie, J. A. (Eds.). (1969). Human biology: A guide to field methods. Blackwell Scientific Publications.

31) Whiteley, M., et al. (2017). Biological maturity influences physical capacities during early adolescence, but its impact diminishes as players age. OUCI. https://ouci.dntb.gov.ua/en/works/lRgQX3j9/

32) World Health Organization. (2006). WHO child growth standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: Methods and development. World Health Organization.