



Research Article

Anatomical Profile and Postural Changes in Young Athletes Practicing Individual Sports: What Segments Pattern?

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Abstract

The objective of this study was to investigate the relationship between anatomical profiles and postural deviations in young athletes participating in individual sports. The sample comprised 183 athletes aged 11 to 19 years, stratified by sex, all of whom engaged in training routines consisting of five sessions per week, each lasting between 90 and 120 minutes. Postural assessment was conducted using four standardized photographs (anterior, right lateral, posterior, and left lateral views), evaluating the following body segments: eyes, shoulders, spinal column, hips, knees, and feet. Digital photogrammetry was employed, with horizontal and vertical reference lines to aid in the analysis. Statistical procedures included the Shapiro-Wilk test, Levene's test, MANOVA, Bonferroni post hoc test, and Chi-square (χ^2) test. Results, expressed as percentage frequencies, indicated that the most prevalent postural alterations were right-eye dominance ($\geq 71.0\%$), forward head posture ($\geq 78.0\%$), pelvic tilt ($\geq 70.0\%$), and knee hyperextension ($\geq 91.0\%$). Among females, significant asymmetries were observed in the shoulders ($\geq 86.7\%$), spinal column ($\geq 76.0\%$), and feet ($\geq 64.0\%$). It is concluded that there is a significant association between anatomical profiles and postural deviations in young athletes, with clinically relevant and pronounced findings, underscoring the need for targeted musculoskeletal rebalancing strategies.

Keywords: Postural assessment; Posture; Sport; Young athletes; Adolescents

Introduction

Research indicates that sensory systems—particularly ocular (vision) and podal (feet) receptors—play a central role in receiving proprioceptive and exteroceptive information, contributing to body structuring, positioning, alignment, and the maintenance of the postural tonic system in both static and dynamic situations [1–8].

Imbalances in the oculomotor or foot musculature may lead to compensatory movements in anatomical segments, manifested as tilts and rotations, thereby compromising posture and potentially resulting in musculoskeletal dysfunctions. Posture is regulated by musculoskeletal chains—comprising muscles and joints—and dysfunctions within these chains can lead to functional adaptations, alterations in postural tone, and muscular imbalances. These changes may modify the structure of striated muscles and connective tissue, reducing range of motion and maximal contraction strength, thus contributing to the onset of pain and injury [3,8,9].

During adolescence, accurate postural assessment is essential, as motor patterns may be compromised, leading to misalignments and musculoskeletal dysfunctions [10,11]. This developmental period is marked by the onset of specialized training and is accompanied by significant biopsychosocial changes, such as rapid physical growth, sexual maturation, social development, and heightened body image perception. These factors directly influence physical activity, sports performance, and the capacity to adapt to training loads [12–18].

Sports training during this phase may contribute to postural deviations and musculoskeletal injuries due to high physical demands, unilateral movement patterns, and mechanical overload, reinforcing the need for systematic assessment and monitoring protocols [19–23].

Postural assessment using digital biophotogrammetry has emerged as an effective diagnostic tool, enabling the identification of postural misalignments, musculoskeletal

imbalances, and injury risks. Additionally, it supports the monitoring of body growth and development in individuals aged 6 to 18 years [11,23–28].

In the context of youth sports, significant gaps remain in integrating postural assessment with training prescription. This study aimed to investigate the relationship between anatomical profiles and postural deviations in young athletes engaged in individual sports.

Materials and Methods

Sample Characterization

A total of 183 young athletes participated in this study, including 98 females and 85 males, aged 11 to 19 years. Participants were engaged in six individual sports disciplines: athletics, combat sports, artistic and rhythmic gymnastics, swimming, and tennis. All athletes competed at the regional, national, or international level and followed a training schedule consisting of five weekly sessions, each lasting 90 to 120 minutes. The sample was stratified into two age groups: 11–14 years and 15–19 years.

Ethical Considerations

All participants, or their legal guardians, signed an informed consent form in accordance with Resolution CNS No. 466/2012 [29]. The study was approved by the Research Ethics Committee of Universidade São Judas Tadeu (protocol No. 1.051.414).

Data Collection Procedures

Sociodemographic and sport-related data were collected using a structured anamnesis form, recorded in Microsoft Excel 2016. The information gathered included sex, age, place of birth, previous medical diagnoses (such as sprains, musculoskeletal pain, fractures, surgeries, and diseases), years of education, years of sports participation, best competition results, body mass (kg), and height (cm).

The anatomical segments assessed included the eyes, shoulders, spinal column, hips, knees, and feet. The anatomical reference standards used for evaluation are presented in Table 1.

Anatomical Segment	Anatomical Reference (Bone)
Eyes	Lacrimal (superior edge of lacrimal fossa)
Shoulders	Clavicle (superior surface of acromial extremity)
Spinal column	7th cervical vertebra (C7)
Hips	Ilium (superior edge of anterior superior iliac spine)
Knees	Fibula (head and lateral malleolus)
Feet	Tibia (medial malleolus)
	Calcaneus

Table 1: Anatomical reference standards for postural assessment

Postural assessment was conducted using digital biophotogrammetry

Athletes were positioned in orthostatic posture and photographed from anterior, right lateral, posterior views and left lateral. Horizontal and vertical reference lines were drawn between anatomical segments to identify symmetries and asymmetries (Figure 1).

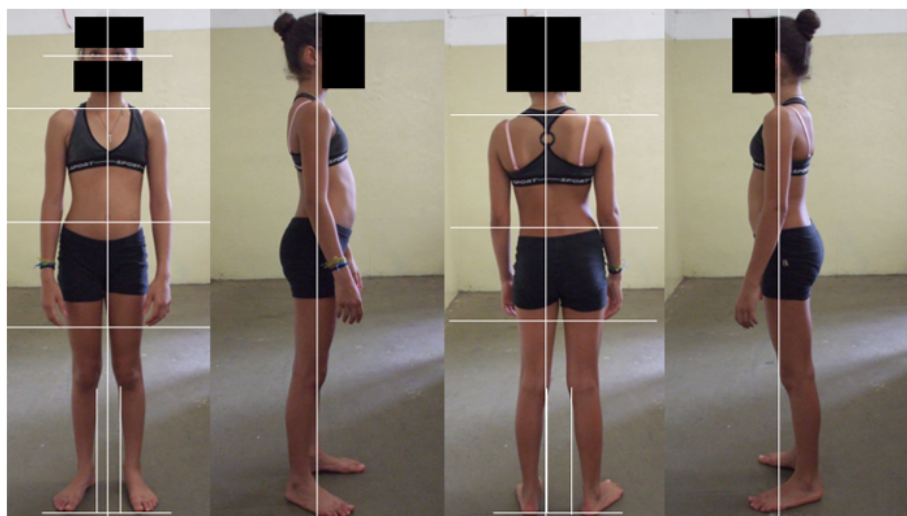


Figure 1: Model of positions adopted for postural assessment via digital biophotogrammetry with horizontal and vertical axes.

During the assessment, female athletes wore shorts and sports tops, while male athletes wore shorts or swim briefs. All participants were barefoot. Athletes with long hair were instructed to tie it back to facilitate observation of the cervical region.

Image Acquisition and Analysis

Images were captured using a Lenovo Vibe K5 smartphone equipped with a 13-megapixel camera, positioned 1.5 meters from the athlete and 1 meter above ground level. The analysis was conducted using CorelDRAW X7® (2016) software, following the principles of biophotogrammetry—a technique that enables precise and reliable metric assessment of body alignment [24,25,30,31].

Statistical Analysis

Data normality was assessed using the Shapiro–Wilk test, and homogeneity of variances was evaluated with Levene’s test. Continuous variables were expressed as means and standard deviations, while categorical variables were

presented as percentage frequencies. Group comparisons were performed using Multivariate Analysis of Variance (MANOVA), with sex (male and female), age group (11–14 and 15–19 years), and their interaction as factors. When significant differences were found, Bonferroni post hoc tests were applied. The Chi-square (χ^2) test was used to examine the distribution of postural deviations by sex and age group. The significance level was set at $p < 0.05$. All statistical analyses were conducted using SPSS® version 22.0.

Results

Table 2 presents the profile of the young athletes, stratified by sex and age group. Statistically significant differences ($p < 0.05$) were found for all analyzed variables: age, years of schooling (YS), years of sports practice (YSP), body mass (BM), and height. Older athletes (15–19 years) exhibited higher averages in all variables for both sexes. Significant differences between sexes were also observed, particularly in height and body mass, both of which were higher among males.

	11 – 14 Years old	15 – 19 Years old	Gender		Age Group		Interaction	
			F	P	F	P	F	P
Age (years)								
Male	13.2± 0.8†	16.7± 1.2*	404.3	0.0	8.1	0.0	4.3	0.0
Female	12.3± 1.2	16.5± 1.3*						
Years of Education (YE)								
Male	6.7 ± 1.2†	9.6± 1.3*	262.4	0.0	5.4	0.0	2.3	0.1
Female	5.9 ± 1.3	9.5± 1.1*						
Years of Sports Praticce								
Male	4.0± 3.0	4.4± 2.8†	6.1	0.0	4.8	0.0	2.2	0.1
Female	4.3± 2.3	6.1± 3.5*						
Body Mass (kg)								
Male	60.7± 11.0†	69.6±11.4*†	42.5	0.0	65.1	0.0	2.6	0.1
Female	43.0± 11.5	57.9± 11.0*						
Height (m)								
Male	1.65± 0.1†	1.76± 0.1*†	72.0	0.0	73.6	0.0	0.1	0.7
Female	1.52± 0.1	1.65± 0.1*						

Statistical analysis was performed using a multivariate MANOVA test (GLM), with Bonferroni post hoc. From this, the critical value (F) and the level of significance (p) were obtained for the factors of gender, age group, and their interaction;

*Significant difference compared to the 11–14-year-old group; † Significant difference compared to the female group

Table 2: Profile of young athletes practicing individual sports, by sex and age group

Table 3 presents the frequency of the anatomical profile across different body segments. A predominance of right-eye dominance was observed (72.9% in boys and 69.4% in girls), with no significant difference between sexes. However, statistically significant differences were found in the shoulders, spinal column, and feet segments exclusively among females, with high percentages of asymmetries, particularly in athletes aged 11 to 14 years. Notably, 95.9% of the girls exhibited shoulder asymmetries, 88.8% in the spinal column, and 70.4% in the feet.

	Male			Female		
	11 – 14 years old (n = 64)	15 – 19 years old (n = 34)	Total (n = 98)	11 – 14 years old (n = 24)	15 – 19 years old (n = 61)	Total (n = 85)
Right Eye	87.5	67.2	72.9	70.3	67.6	69.4
Left Eye	12.5	32.8	27.1	29.7	32.4	30.6
Shoulders	87.5	73.8	77.6	96.9	94.1 B	95.9 C
Spine	79.2	57.4	63.5	92.2	82.4 B	88.8 C
Hip	91.7	78.7	82.4	84.4	70.6	79.6
Knees	100	91.8	94.1	98.4	94.1	96.9
Right Foot	91.7	96.7	95.3	71.9	67.6 B	70.4C
Left Foot	91.7	91.8	91.8	70.3 A	64.7 B	68.4C

Table 3: Anatomical profile by percentage frequency (%) in young athletes practicing individual sports, according to sex and age group

Table 4 presents the types of postural alterations identified, categorized by sex and age group. Forward head posture was the most prevalent alteration in both sexes (80.0% in boys and 79.6% in girls), followed by pelvic lateral rotation (94.1% and 70.4%, respectively) and knee hyperextension (94.1% in boys and 96.9% in girls).

	Male			Female		
	11 – 14 years old (n = 23)	15 – 19 years old (n = 31)	Total (n = 54)	11 – 14 years old (n = 28)	15 – 19 years old (n = 22)	Total (n = 50)
Lateral Head Rotation	37.5	18	23.5	21.9	17.6	20.4
Head Anteriorization	83.3	78.7	80	78.1	82.4	79.6
Thoracic Scoliosis	79.2	57.4	63.5	92.2	82.4 B	88.8 C
Thoracic Hyperkyphosis	29.2	21.3	23.5	3.1 A	11.8	6.1 C
Lumbar Hyperlordosis	25	18	20	18.8	20.6	19.4
Lateral Hip Tilt	91.7	78.7	82.4	84.4	70.6	79.6
Knee Hyperextension	100	91.8	94.1	98.4	94.1	96.9
Lateral Hip Rotation	91.7	95.1	94.1	71.9 A	67.6 B	70.4 C

A Significant difference compared to the 11–14 years age group of the male sex.

B Significant difference compared to the 15–19 years age group of the male sex.

C Significant difference compared to the total male group.

Table 4. Percentage frequency (%) of postural alterations by age group and sex in young athletes engaged in individual sports

In the female group, statistically significant differences were observed in specific postural alterations:

- **Thoracic scoliosis** was more prevalent among girls aged 11 to 14 years (92.2%) and remained high in the 15 to 19-year age group (82.4%).
- **Pelvic lateral rotation** was also significant among girls, especially in the younger subgroup (71.9%).
- **Thoracic hyperkyphosis** was more common in boys, with a prevalence of 23.5%, and less frequent among girls (6.1%).

These findings reinforce the presence of distinct patterns of postural deviations based on sex and age group, highlighting the importance of individualized monitoring of postural development in young athletes.

Discussion

This study aimed to investigate the relationship between anatomical profile and postural deviations in young athletes engaged in individual sports. The results demonstrated a significant association between these variables, with a higher prevalence of alterations among females, particularly in the upper limbs, spinal column, and feet.

Head Region

Ocular asymmetry with right-eye dominance (71%) was observed, suggesting visual dominance. This finding corroborates the data from Arcanjo et al., who also reported a predominance of right-eye dominance [6]. Visual alterations may influence head positioning and trigger compensatory mechanisms in the cervical, thoracic, and pelvic muscle chains [3,8].

The most frequent postural deviations in the head region were **forward head posture** (78%) and **lateral head tilt** (17%). Prolonged use of electronic devices in inadequate postures—sitting, lying down, or semi-reclined—may contribute to these dysfunctions, as discussed by Bento et al. and Marques, Hallal, & Gonçalves [32,33]. The literature suggests that excessive sedentary behavior is associated with musculoskeletal pain and postural misalignments in adolescents [34].

Upper Limbs and Spinal Column

The greatest asymmetries were observed in the shoulders, with a prevalence of 94% in girls and 73% in boys, with statistical significance noted only in the female group. **Thoracic scoliosis** was the most common spinal deviation and showed a tendency to decrease with age. These alterations may be related to lateral dominance and repeated unilateral training movements [35,8].

Thoracic hyperkyphosis was more prevalent in boys (23%), potentially associated with shortening of the abdominal and

spinal extensor muscles, use of inadequate school furniture, or psychosocial factors such as introspection and low self-esteem, especially among girls [36,37].

Pelvis

Pelvic lateral tilt was identified in 70% of the sample, with an overall asymmetry rate of 78%. This pattern may be linked to unilateral weakness of the hip abductor muscles, gluteus maximus atrophy, or imbalances in trunk postural control [38]. Deviations in this segment increase joint overload and promote the development of degenerative processes [39].

Lower Limbs

Knee hyperextension was the most prevalent alteration (91%) and is considered a clinically relevant finding. This condition may result from strength imbalances between the anterior and posterior thigh muscles, as well as joint hypermobility. Misalignment of the knee compromises the function of the lower limb kinetic chain and may lead to injuries in adjacent joints [40].

Pelvic lateral rotation, observed in 94% of boys and 70% of girls, was statistically significant. The habit of resting with feet in abduction may contribute to this deviation. Fialho et al. emphasized that parallel foot positioning favors anteroposterior stability, while misalignments impair balance and postural symmetry [41].

Conclusion

It is concluded that young athletes present significant postural asymmetries and deviations, with higher frequency and statistical significance observed among females. The most affected anatomical segments were the shoulders, spinal column, and feet. These findings indicate that musculoskeletal imbalances are already present during adolescence, even among physically active individuals with structured sports routines.

It is recommended that specific guidelines for postural assessment and musculoskeletal rebalancing be integrated into sports training periodization. Preventive, corrective, and compensatory strategies should be included throughout the stages of motor and technical development. Ongoing postural monitoring may contribute to improved athletic performance, injury prevention, and enhanced sports longevity.

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