# Postural Analysis of Male Football Athletes from Different Age Levels of Training

Joana Filipa D.S. Lourenço, José Luís M. A. de Sousa, Denise P. Soares, and Sónia C. Gonçalves-Lopes

# ABSTRACT

Introduction: The definition of body posture involves a relative arrangement of body parts. Football is the most popular sport in the world with an injury rate of 4.47 injuries per 1000 hours of play/training per athlete. Photogrammetry is a valid and reproductive method for evaluating postural differences with quantitative and accurate results. The aim of this study is to present a postural analysis of children and young football players, using photogrammetry.

Method: The sample consisted of 263 athletes (ages between 4 and 18 years) where, through the photographic register and use of SAPO® software the main postural deviations of the children were calculated and subsequently analyzed descriptively in the IBM SPSS software.

Results: The results obtained show deviations in point A1 - alignment of the acromion (21.4% to 50% of athletes on the right (R) and 16.7% to 40.5% of athletes on the left (L); A2 - alignment of the anterosuperior iliac spine (42.9% of athletes to (R) and 14.3% to 64.9% to the left (L); A3 alignment of tibia tuberosities (27.9% to 55% of athletes (R), 27% to 48.5% of athletes (L); A4 and A5 - angle Q (R and L) (50% to 91% of athletes with tendency to knee varus); A6 - horizontal alignment of the pelvis (tendency to hyperlordosis of 28% for juveniles with an average deviation of -15.4°  $\pm$  7.7).

Conclusion: The postural analysis of the athletes allows a better knowledge about the most frequent deviations that, over time, can become painful, being important an intervention and specific planning at this level, trying to prevent future injuries.

**Keywords:** asymmetry, children, SAPO<sup>®</sup>, photogrammetry.

Submitted: May 20, 2021 Published: August 05, 2021

ISSN: 2593-8339

**DOI**: 10.24018/ejmed.2021.3.4.885

#### Joana Filipa D.S. Lourenço \*

KinesioLab, Research unit in human movement, Kinesiolab - Piaget Institute, Portugal.

(e-mail: 55794@ipiaget.pt) José Luís M. A. de Sousa

KinesioLab, Research unit in human movement, Kinesiolab - Piaget Institute,

(e-mail: jose.sousa@gaia.ipiaget.pt)

#### Denise P. Soares

KinesioLab, Research unit in human movement, Kinesiolab - Piaget Institute, Portugal and INEGI: Institute of Science and Innovation in Mechanical and Industrial Engineering, Porto, Portugal.

(e-mail: denise.soares@almada.ipiaget.pt)

## Sónia C. Gonçalves-Lopes

KinesioLab, Research unit in human movement, Kinesiolab - Piaget Institute, Portugal.

(e-mail: sonia.lopes@gaia.ipiaget.pt)

\*Corresponding Author

## I. INTRODUCTION

Body posture is defined as the relative arrangement of body parts [1], [2], and so, bad posture is a defective relationship between the various parts of the body that produces greater tension in the support structures, and where less efficient body balance occurs in the support base [3], the deviations being acquired by the adoption of bad postural habits, muscle shortening, muscle hypertrophy, antalgic positions, causing pain due to the overload of some muscles [4].

Football is the most popular sport in the world with an injury rate of 4.47 injuries per 1000 hours of game / training per athlete[5], [6]. The most common postural changes found in football athletes are changes in the foot, varus or valgus knee, lumbar hyperlordosis, structured scoliosis, limb discrepancies, hips with anteversion or retroversion [1]. The main sites of injuries are correlated to the places that have significant postural changes, with the main site being the lower limbs [2], [7].

Injuries to the knee joint present around 50% of musculoskeletal injuries, within them, the most common is patellofemoral dysfunction [8] as well as low back pain, being considered the most common injury in elite football players [9]. Factors such as the age of the player and underlying structural damage, cause a greater risk of contracting this injury for a long time [10] and so an influence on the performance [11].

Recent surveys reported high prevalence (59%) and recurrence (57-64%) of the low back pain rate in players of this modality [12] and, as a common injury, requires careful analysis and search for a possible cause [13].

The prevalence of children and adolescents with complaints of back pain can reach 70% and its multifactorial impact includes pain and restriction in physical activity, as well as the individual's participation in the modality, being a concern of the scientific community and health organizations

Photogrammetry is a valid and reproductive method for assessing postural differences with quantitative and accurate results, when compared with eye contact, which only allows a qualitative assessment [20], [21]. The gold standard for verifying body asymmetries is the x-ray, however it is a very expensive procedure, and photogrammetry is a more accessible tool that presents reasonably similar results [20]. The use of SAPO® software (Postural Assessment Software) for static postural assessment has been validated [22] and allows an accurate and accessible assessment of postural deviations in different populations, including children [22]-[24].

In this sense, it is important to make a postural assessment of children and young people, to understand the postural changes that may be associated with sports practice, and then proceed with measures to prevent musculoskeletal injuries in this population.

So far, there is no knowledge of any study of this kind in the population of football players with a sample crossing all competitive levels between under 7 and under 19, only a study by Grabara M. [25] was found, but the groups were between 11 and 14 years old, showing that boys who practice football when compared to their untrained peers are characterized by a higher incidence of having the correct alignment of the pelvis in the frontal plane and differences in lumbar lordosis, which is smaller in football players of this group age [25]. Therefore, the objective of this study is to present a postural analysis of children and young football players using photogrammetry.

#### II. METHOD

#### A. Participants

The sample was composed of 263 athletes, predominantly male (98.5%), and data were collected at various football club's and different competitive levels (Table I).

For sample selection, inclusion and exclusion criteria were considered. The inclusion criteria were defined: regular practice of football for at least 6 months and exclusion of the presence of pain or musculoskeletal injuries that were limiting the practice of sports. The sample was subdivided by levels according to the age group, the same being used in the context of football.

The subjects were analyzed in groups according to their age training level, divided into under 7, U-9, U-11, U-13, U-15, U-17, and U-19.

TABLE I: DESCRIPTIVE VALUES FOR SAMPLE CHARACTERIZATION

	Weight	Height	BMI
Level (n)	(kg)	(m)	(kg/cm2)
	mean $\pm$ SD	mean $\pm$ SD	mean $\pm$ SD
U-7 (14)	$25,06 \pm 4,1$	$121,64 \pm 8,5$	$16,90 \pm 1,4$
U-9 (68)	$32,87 \pm 6,6$	$135,91 \pm 7,5$	$17,65 \pm 2,4$
U-11 (93)	$38,20 \pm 7,7$	$142,98 \pm 8,1$	$18,55 \pm 2,7$
U-13 (20)	$48,52 \pm 11,3$	$157,95 \pm 11,8$	$19,22 \pm 2,6$
U-15 (37)	$52,87 \pm 9,9$	$163,59 \pm 9,6$	$19,60 \pm 2,1$
U-17 (25)	$62,04 \pm 13,4$	$173,00 \pm 7,2$	$20,65 \pm 3,7$
U-19 (6)	$63,17 \pm 5,9$	$176,50 \pm 6,6$	$20,25 \pm 1,2$

Legend: U-7 – under 7 years old; U-9 – under 9 years old, U-11 – under 11 years old; U-13 - under 13 years old; U-15 - under 15 years old; U-17 under 17 years old; U-19 – under 19 years old.

#### B. Procedures

The entire procedure was previously authorized by the children's legal guardians - those in charge of education -

with voluntary participation by the children, reinforced by completing the Informed Consent Form. The data collections were all carried out considering the ethical assumptions of research with human beings.

The collection of photographs has been performed between the 18pm and 20pm period selected to match the training of the athletes under study. In addition to capturing the photographs, a personal characterization form proposed by the SAPO® protocol was filled out.

During the capture of the photographs, the children were barefoot, placed in the center of the platform and in an orthostatic position. In this way, photographs of four profiles were obtained (anterior, right lateral, left lateral and posterior) stored in digital support for later analysis.

The anatomical points were defined according to the evaluation protocol of the SAPO® software and marked with polystyrene markers (Fig. 1).

The calculated angles for this study are shown in Table II.

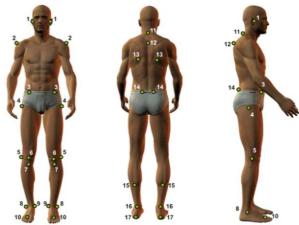


Fig. 1. Bone references of the SAPO software®.

Anterior view: 2, 3 – right and left tragus; 5, 6 – right and left acromion; 12, 13 – right and left anterosuperior iliac spine; 14, 15 – right and left major trochanter; 16, 19 - lateral projection of the right and left knee joint line; 17, 20 - center of the right and left patella; 18, 21 - tuberosity of the right and left tibia; 22, 25 – lateral malleolus; 23, 26 – medial malleolus); Posterior view (7, 8 – lowers angles of the right and left scapula; 17 third thoracic vertebra; 32, 33 medial point of the leg, 35, 39 – intermalleolar line; 37, 41 – calcaneus tendon bilaterally.

Lateral view: 2 – tragus: 8 – seventh cervical vertebra: 5 – acromia: 21 – anterosuperior iliac spine; 22 – posterosuperior iliac spine; 23 – major trochanter; 24 – projection of the knee joint line; 30 – lateral malleolus; 31 – region between the second and third metatarsus.

TABLE II: EVALUATED ANGLES

		A1 – Horizontal alignment of acromia:		
erior ew		5-6 and horizontal		
	Trunk	A2 – Horizontal alignment of		
		anterosuperior iliac spines: 12-13 and		
		horizontal		
		A3 – Horizontal alignment of tibia		
		tuberosities: 18-21 and horizontal		
	Lower	A4 – Right Q Angle: Angle between		
	limbs	12-17 and 17-18.		

		A5 – Left Q angle: angle between 13-20 and 20-21
Side view	Trunk	A6 – Horizontal pelvis alignment: 21-22 and horizontal

## C. Instruments

Ante vie

Two digital cameras - Panasonic® DMCSZ45 with 14.1 megapixels and OLYMPUS SP-720UZ with 14 megapixels. To standardize the capture of the photographs, the camera

was positioned on a universal tripod 85 cm from the ground and at 3m from the platform - black cardboard of 50 cm  $\times$ 50 cm - placed against the white background wall, where a wire was found. plumb line aligned with the side of the platform.

This procedure involved the use of various materials, such as polystyrene markers, black cardboard (50×50cm), white chalk, plumb line, gloves, tape measure, scale (Moulinex®).

#### D. Statistical Analysis

The data were analyzed using IBM SPSS v.27, where a descriptive analysis of the angles evaluated and presented by means and standard deviation and in percentages of children in each step with the respective postural deviations was performed.

#### III. RESULTS

The postural deviations of the total children evaluated present positive and negative inclinations (Fig. 2).

The horizontal alignment of the acromion shows an average of  $2.5^{\circ} \pm 1.7^{\circ}$  on the right and  $2.6^{\circ} \pm 1.9^{\circ}$  on the left.

According to the horizontal alignment anterosuperior iliac spine, mean values of  $2.5^{\circ} \pm 1.4^{\circ}$  positive and  $2.7^{\circ} \pm 3.1^{\circ}$  are presented.

Regarding the alignment of the tuberosities of the tibia, an average of  $4.1^{\circ} \pm 4.3^{\circ}$  was obtained on the right and  $3.9^{\circ} \pm$ 3.3° on the left.

The Q angles presented  $19.2^{\circ}$  positive  $\pm 7.4^{\circ}$  positive (knee in range) and negative  $9.2^{\circ} \pm 6.1^{\circ}$  (varus knee) on the right, while on the left were  $15.3^{\circ} \pm 7^{\circ}$  positives and  $9^{\circ} \pm 6.9^{\circ}$ negative.

The horizontal alignment of the pelvis presented  $10.4^{\circ} \pm$ 5.8° of anterior inclination (lumbar hyperlordosis) and 10.4°  $\pm$  8° of posterior inclination (lumbar rectification).

The values shown in the graphs below (Fig. 3 to 8) show the values of postural deviations for each of the angles evaluated and the respective percentages for each competitive level.

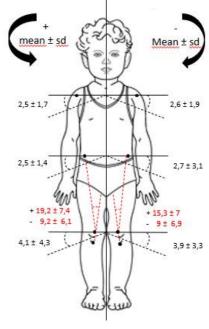
In the results related to the alignment of the acromion (A1) values are shown between 21.4% and 50% of athletes with postural deviation on the right, while 16.7% and 40.5% of those evaluated with left deviation values (Fig. 3).

According to the alignment of the anterosuperior iliac spine (A2), values between 0 and 42.9% of children with right deviations were found and between 14.3 and 64.9% with left postural deviations (Fig. 4).

For the alignment of tibia tuberosities (A3), 27.9% to 55% of the deviations are positive, however, the deviations on the left are between 27% and 48.5% of the evaluated (Fig. 5).

According to the right (A4) and left (A5) angles, there are mostly negative deviations (tendency of varus knee) to 50% to 91% of children in the competitive levels presented (Fig. 6 and 7).

Regarding the horizontal alignment of the pelvis (A6), the values are essentially negative, with a tendency to hyperlordosis of 28% for u-15 with an average deviation of  $-15.4 \pm 7.7^{\circ}$  (Fig. 8).



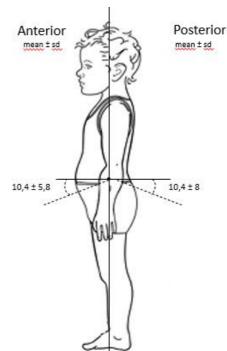


Fig. 2. Mean values and standard deviation of the angles evaluated and their anatomical disposition for the total sample of children.

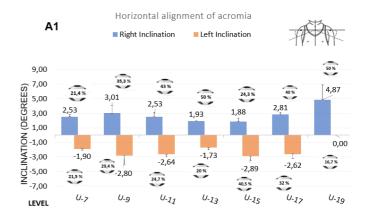


Fig. 3. Horizontal alignment of acromion.

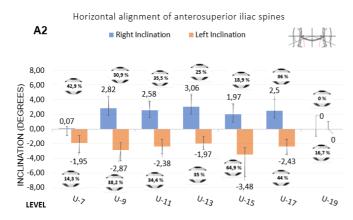


Fig. 4. Horizontal alignment of anterosuperior iliac spines

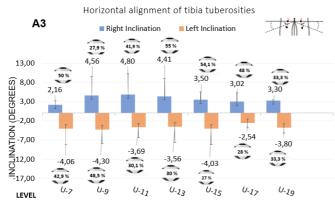


Fig. 5. Horizonal alignment of tibia tuberosities.

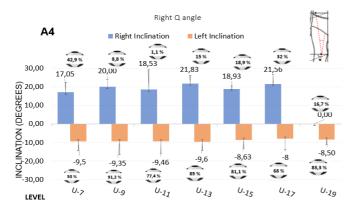


Fig. 6. Right Q Angle.

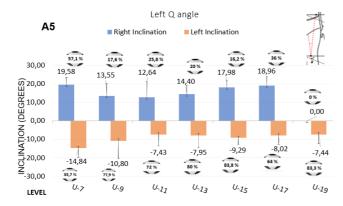


Fig. 7. Left Q Angle.

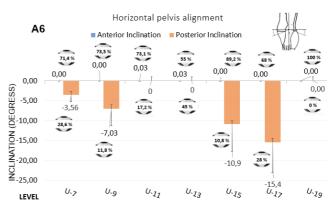


Fig. 8. Horizonal pelvis alignment.

#### IV. DISCUSSION

The aim of this study was to perform a postural analysis of children and young football players of various levels to allow describing possible recurrent deviations within this collective modality. The angles analyzed were determined according to the SAPO® protocol of measurements and the main postural deviations obtained were presented.

Deviations in the alignment of the horizontal alignment of the acromion and the anterosuperior iliac spine may be due to the repetition technique and specific football actions over time, contributing to the strength and reach of movement imbalances. These imbalances are risk factors for postural asymmetries such as shoulder decay and lumbar rectification and scoliosis indexes. Thus, repetitive gestures in young football players who already had postural asymmetries can increase or reduce the magnitude of the asymmetry [26],

The reference values for a more efficient O angle for the quadriceps function is with values close to 10 degrees [28], and for men it is considered efficient between 10 and 14 degrees, and less than 10° is considered genu varus (knee varus) and above the 15th considered genu valgum [28] having higher incidence the vector in greyhound (medial deviation of the distal end of a segment "knee inwards"). The values obtained in this study show that athletes in the evaluated echelons have a tendency between 50% and 91.2% to have a varus knee with values between 8 and 9.6°, and the tendency to male athletes to have varus knee also verified in another study [29].

Differences between younger and older competitive levels present great differences. Under-11 and under-13 players participate in seven against seven in a reduced area and the U15 and U17 compete in eleven against eleven players in a real football field area, making it new requirements for young football players [30].

Contacts and physical requirements tend to increase, depending on the size of the field from  $7 \times 7$  to  $11 \times 11$  players. Thus, the transition of the under-7 teams to the under-11 teams is a risk factor for the magnitude of the asymmetries [31]. However, since human growth is not symmetrical, it can also explain the asymmetries that cross competitive levels. Bass et al. [32], observed that bone growth is not uniform and is affected by bone type, regions, and surfaces as well as in prepubertal age, growth is disproportionately higher in the legs and, in adolescence, is higher in the trunk region [32].

The asymmetries that are possible to observe in the lateral view (sagittal plane) are concretized with the asymmetries of hypercyphosis and hyperlordosis [33]. That said, most of lordosis is associated with low back pain events [33]. In addition, varum hypercyphosis tend to increase muscle stress in the shoulder region. Once again, the great request for football-specific tasks, such as kicking and passing, can lead to easier muscle inflammation and pain events [26], [27].

Increased muscle strength levels have been pointed out as an effective way to prevent low back pain and muscle inflammation events [30]. According to our results, we observed that the majority obtains between 55 and 100% positive asymmetries, however it is in 28% of the juvenile echelon with about 15° of negative deviation, which presents a tendency to the development of hyperlordosis.

The present study has limitations, namely the total time of practice of each child was not determined, i.e., number of trainings per week or individual physical fitness. Only the minimum practice time of 6 months was considered.

Nevertheless, the postural evaluation of the practitioners, being or not related to the practice of football, is relevant for the knowledge of possible postural deviations and future injuries that can be prevented through this type of analysis. In future investigations it would be important to evaluate the effect of physical fitness on postural asymmetries as well as a longitudinal analysis of postural asymmetries.

This study aims to contribute to the knowledge of the postural characteristics of football players of the basic echelons so that they can prescribe training and injury prevention measures that may worsen with poorly executed practice. It is relevant to disseminate these values to the scientific community to promote a better knowledge in the area about the postural deviations that are in the cause of many of the injuries associated with this sport from younger layers.

## V. CONCLUSION

This study presents a description of postural changes in football players of all competitive levels prior to the senior, being an unprecedented study in this field in Portuguese children.

Football athletes tend to present certain postural deviations according to their competitive level, which can affect their performance if these asymmetries when specific exercises are not prescribed in combating these deviations or not diagnosed it can, over time, can cause pain and discomfort on the part of players.

It's important for scientific community to increase knowledge about this issue and develop intervention programs to help prevent some future health problems.

## ACKNOWLEDGMENT

This project was financed by the KinesioLab - Piaget Institute, Lisbon, Portugal. We would like to express our gratitude to the clubs that allowed the study and children's guardians for their participation in the study.

#### REFERENCES

- [1] Penha PJ, João SMA, Casarotto RA, Amino CJ, Penteado DC. Postural assessment of girls between 7 and 10 years of age. Clinics (Sao Paulo) 2005;60(1):9-16. Available https://doi.org/10.1590/S1807-59322005000100004 %0A.
- Żuk B, Sutkowski M, Paśko S, Grudniewski T. Posture correctness of young female soccer players. Sci Rep [Internet]. 2019;9(1):11179. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6671990/.
- Kendall F, McCreary E, Provance P. Músculos provas e funções. Editora Manole, editor. São Paulo; 1995
- Ribeiro IQB, Santos A, Gomes CA. Análise postural em trabalhadores do serviço geral. Universidade Católica do Salvador - UCSAL; 2006.
- Ribeiro RN, Vilaça F, Oliveira HU de, Vieira LS, Silva AA da. Prevalência de lesões no futebol em atletas jovens: estudo comparativo entre diferentes categorias. Rev Bras Educ Física e Esporte [Internet]. 2007:21(3):189-94. Available from: https://www.revistas.usp.br/rbefe/article/download/16655/18368/198
- [6] Wong P, Hong Y. Soccer injury in the lower extremities. Br J Sports 2005;39(8):473-82. Med [Internet]. Available https://pubmed.ncbi.nlm.nih.gov/16046325/.
- Fronza FO, Teixeira LR. Padrão Postural De Atletas Adolescentes De Futebol E a Relação De Alterações Com Lesão: Rev Barasileira Ciências da Saúde [Internet]. 2009;22(VII):96-101. Available from: https://seer.uscs.edu.br/index.php/revista\_ciencias\_saude/article/view /528.
- Belchior ACG, Arakaki JC, Bevilaqua-Grossi D, Reis FA, Carvalho PTC. Efeitos na medida do ângulo Q com a contração isométrica voluntária máxima do músculo quadricipital. Rev Bras Med do 2006:12(1):6-10. Esporte [Internet]. Available http://www.luzimarteixeira.com.br/wpcontent/uploads/2009/08/contracao-isometrica-e-disfuncaopatelar1.pdf.
- Waldén M, Hägglund M, Ekstrand J. UEFA Champions League study: A prospective study of injuries in professional football during the 2001-2002 season. Br J Sports Med [Internet]. 2005;39(8):542-6. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1725291/.
- [10] Moradi V, Memari A-H, ShayestehFar M, Kordi R. Low Back Pain in Athletes Is Associated with General and Sport Specific Risk Factors: A Comprehensive Review of Longitudinal Studies, Rehabil Res Pract [Internet]. 2015:2015:1-10. Available https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4691487/
- [11] Marencakova J, Maly T, Sugimoto D, Gryc T, Zahalka F. Foot typology, body weight distribution, and postural stability of adolescent elite soccer players: A 3-year longitudinal study. PLoS One [Internet]. 2018;13(9):1-12. Available https://pubmed.ncbi.nlm.nih.gov/30265689/.
- [12] Tunås P, Nilstad A, Myklebust G. Low back pain in female elite football and handball players compared with an active control group. Knee Surgery, Sport Traumatol Arthrosc [Internet]. 2015;23(9):2540-7. Available from: https://pubmed.ncbi.nlm.nih.gov/24839041/.
- [13] Madić D, Obradović B, Golik-Perić D, Marinković D, Trajković N, Gojković Z. The isokinetic strength profile of semi-professional soccer players according to low back pain. J Back Musculoskelet Rehabil Available [Internet]. 2020:33(3):501-6. https://pubmed.ncbi.nlm.nih.gov/31524139/.
- [14] Ayanniyi O, Mbada CE, Muolokwu CA. Prevalence and profile of back pain in Nigerian adolescents. Med Princ Pract [Internet]. 2011;20(4):368-73. Available https://pubmed.ncbi.nlm.nih.gov/21576999/.
- [15] Korovessis P, Koureas G, Zacharatos S, Papazisis Z. Backpacks, back pain, sagittal spinal curves and trunk alignment in adolescents: A logistic and multinomial logistic analysis. Spine (Phila Pa 1976) [Internet]. 2005;30(2):247-55. Available https://pubmed.ncbi.nlm.nih.gov/15644765/.
- [16] Kovacs FM, Gestoso M, Gil Del Real MT, López J, Mufraggi N, Méndez JI. Risk factors for non-specific low back pain in schoolchildren and their parents: A population based study. Pain 2003;103(3):259-68. [Internet]. Available https://pubmed.ncbi.nlm.nih.gov/12791432/.
- [17] Masiero S, Carraro E, Celia A, Sarto D, Ermani M. Prevalence of nonspecific low back pain in schoolchildren aged between 13 and 15 years. Acta Paediatr Int J Paediatr [Internet]. 2008;97(2):212-6. Available from: https://pubmed.ncbi.nlm.nih.gov/18177442/
- [18] Shehab DK, Al-Jarallah KF. Nonspecific low-back pain in Kuwaiti children and adolescents: Associated factors. J Adolesc Heal [Internet]. 2005;36(1):32-5. Available from:

- https://pubmed.ncbi.nlm.nih.gov/15661594/.
- [19] Watson KD, Papageorgiou AC, Jones GT, Taylor S, Symmons DPM, Silman AJ, et al. Low back pain in schoolchildren: Occurrence and characteristics. Pain [Internet]. 2002;97(1-2):87-92. Available from: https://pubmed.ncbi.nlm.nih.gov/12031782/.
- [20] Alves ME, Marinho DA, Carneiro DN, Alves J, Forte P, Nevill AM, et al. A visual scan analysis protocol for postural assessment at school in young students. Int J Environ Res Public Health [Internet]. 2020;17(8):1-9. Available https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7215995/.
- [21] Chockalingam N, Dangerfield PH, Giakas G, Cochrane T, Dorgan JC. Computer-assisted Cobb measurement of scoliosis. Eur Spine J [Internet]. 2002;11(4):353-7. Available https://www.researchgate.net/publication/11194231\_Computerassisted\_Cobb\_measurement\_of\_scoliosis.
- [22] Souza JA, Pasinato F, Basso D, Corrêa ECR, da Silva AMT. Biofotogrametria confiabilidade das medidas do protocolo do software para avaliação postural (SAPO). Rev Bras Cineantropometria e Desempenho Hum [Internet]. 2011;13(4):299-305. Available from: https://www.scielo.br/pdf/rbcdh/v13n4/09.pdf.
- [23] Desouzart G, Gagulic S. Analysis of Postural Changes in 2nd Cycle Students of Elementary School. J Spine. 2017;06(01):0-6.
- [24] Ferreira EA, Duarte M, Maldonado EP, Bersanetti AA, Marques AP. Quantitative assessment of postural alignment in young adults based on photographs of anterior, posterior, and lateral views. J Manipulative Physiol Ther [Internet]. 2011;34(6):371–80. Available from: http://dx.doi.org/10.1016/j.jmpt.2011.05.018.
- [25] Grabara M. Analysis of Body Posture Between Young Football Players and their Untrained Peers. Hum Mov [Internet]. 2012 [cited 19];13(2):120-6. Available 2021 https://www.researchgate.net/publication/230793110\_Analysis\_of\_B ody\_Posture\_Between\_Young\_Football\_Players\_and\_their\_Untraine d\_Peers.
- [26] Aruin AS. The effect of asymmetry of posture on anticipatory postural adjustments. Neurosci Lett. 2006;401(1-2):150-3.
- [27] Wojtys EM, Ashton-Miller JA, Huston LJ, Moga PJ. The association between athletic training time and the sagittal curvature of the immature spine. Am J Sports Med [Internet]. 2000;28(4):490-8. Available from: https://pubmed.ncbi.nlm.nih.gov/10921639/
- [28] Hamill J, Knutzen K. Bases biomecânicas do movimento humano. 1ª. Barueri(SP): Manole; 1999.
- [29] De Abreu A V., Pinto Barbosa JR, De Paiva Coelho FJ. Alinhamento Dos Joelhos No Plano Frontal Dos 12 Aos 17 Anos. Rev Bras Ortop [Internet]. 1996;31(1):83-8. Available from: no-plano-frontal-dos-12-aos-17-anos-.
- [30] Forte P, Morais JE, Barbosa TM, Reis A. Análise da magnitude das assimetrias posturais em crianças e jovens futebolistas. Rev Bras Futeb [Internet]. 2020;13(3):3-6. Available https://pubmed.ncbi.nlm.nih.gov/16569481/.
- [31] Witvrouw E, Danneels L, Thijs Y, Cambier D, Bellemans J. Does soccer participation lead to genu varum? Knee Surgery, Sport Traumatol Arthrosc [Internet]. 2009;17(4):422-7. Available from: https://pubmed.ncbi.nlm.nih.gov/19183958/.
- [32] Bass S, Delmas PD, Pearce G, Hendrich E, Tabensky A, Seeman E. The differing tempo of growth in bone size, mass, and density in girls is region-specific. J Clin Invest [Internet]. 1999;104(6):795-804. Available from: https://pubmed.ncbi.nlm.nih.gov/10491415/.
- [33] Watson A. Sports injuries in footballers related to defects of posture and body mechanics. he J Sport Med Phys Fit [Internet]. 1995;35(4):289-94. Available from: https://pubmed.ncbi.nlm.nih.gov/8776077/.