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Translated from the original in spanish **Original article**

Postural profile in elite water polo players

Perfil postural en jugadores élite de polo acuático

Perfil postural em jogadores de elite de polo aquático

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ABSTRACT

Body posture is the result of the complex interaction of the musculoskeletal and nervous system that allows the body to remain in an adequate position, with ergonomic balance and minimal energy expenditure. The technical demands and the morphofunctional profile of the polo player complement each other as internal factors predisposing to injuries due to overuse. The objective of the study was to analyze the postural profile in elite water polo players. A descriptive, prospective and cross-sectional study was designed. The selected

scientific methods were at the theoretical, empirical and statistical-mathematical level. 18 elite male polo players, aged 18 to 33, were evaluated. In the frontal plane, the predominant profile was centered head (13; 72.2%), with higher left shoulder (14; 77.8%), higher ipsilateral anterior superior iliac spine (10; 55.6%), triangle right thoracic larger than the left (10; 55.6%) and both knees with correct frontal alignment (10; 55.6%). In the sagittal plane, the head was observed forward (18; 100%), neutral pelvis (14; 77.78%), both knees in *recurvatum* (10; 55.6%) and anterior body inclination (18; 100%) with an angulation range of 2-6 degrees. In the posterior frontal plane, the head was neutral (14; 77.78 %) with left body inclination (12; 66.67 %). The evaluation of the posture profile in polo players is useful to diagnose misalignments in body segments, generating a tool in the biomedical control of sports training.

Keywords: sports, water sports, posture, water polo.

RESUMEN

La postura corporal es el resultado de la compleja interacción del sistema músculo-esquelético y nervioso que permite al cuerpo mantenerse en una posición adecuada, con un balance ergonómico y un gasto de energía mínimo. Las exigencias técnicas y el perfil morfofuncional del polista se complementan como factores internos predisponentes a lesiones por sobreuso. El objetivo del estudio consistió en analizar el perfil postural en jugadores élite de polo acuático. Se diseñó un estudio descriptivo, prospectivo y transversal. Los métodos científicos seleccionados estuvieron en el nivel teórico, empírico y estadístico-matemático. Se evaluaron 18 polistas masculinos, de élite, de 18 a 33 años de edad. En el plano frontal, el perfil predominante fue cabeza centrada (13; 72,2 %), con hombro izquierdo más alto (14; 77,8 %), espina iliaca anterosuperior homolateral más alta (10; 55,6 %), triángulo torácico derecho más grande que el izquierdo (10; 55,6%) y ambas rodillas con correcta alineación frontal (10; 55,6 %). En el plano sagital la cabeza se observó adelantada (18; 100 %), pelvis neutra (14; 77,78 %), ambas rodillas en *recurvatum* (10; 55,6 %) e inclinación corporal anterior (18; 100 %) con un rango de angulación de 2-6 grados. En el plano frontal posterior la cabeza se encontró neutra (14; 77,78 %) con inclinación corporal izquierda (12;

66,67 %). La evaluación del perfil de postura en polistas es útil para diagnosticar desalineaciones en los segmentos corporales, al generar una herramienta en el control biomédico del entrenamiento deportivo.

Palabras clave: deportes, deportes acuáticos, postura, polo acuático.

RESUMO

A postura corporal é resultado da complexa interação do sistema musculoesquelético e nervoso que permite ao corpo permanecer em uma posição adequada, com equilíbrio ergonômico e mínimo gasto energético. As exigências técnicas e o perfil morfofuncional do jogador de pólo complementam-se como fatores internos predisponentes a lesões por uso excessivo. O objetivo do estudo foi analisar o perfil postural em jogadores de elite de pólo aquático. Foi desenhado um estudo descritivo, prospectivo e transversal. Os métodos científicos selecionados foram de nível teórico, empírico e estatístico-matemático. Foram avaliados 18 jogadores de pólo de elite do sexo masculino, com idades entre 18 e 33 anos. No plano frontal, o perfil predominante foi cabeça centrada (13; 72,2%), com ombro esquerdo mais alto (14; 77,8%), espinha ilíaca ântero-superior ipsilateral mais alta (10; 55,6%), triângulo torácico direito maior que o esquerdo (10; 55,6%) e ambos os joelhos com alinhamento frontal correto (10; 55,6%). No plano sagital observou-se cabeça para frente (18; 100%), pelve neutra (14; 77,78%), ambos os joelhos em recurvatum (10; 55,6%) e inclinação anterior do corpo (18; 100%) com amplitude de angulação de 2-6 graus. No plano frontal posterior a cabeça estava neutra (14; 77,78 %) com inclinação do corpo para a esquerda (12; 66,67 %). A avaliação do perfil postural em jogadores de pólo é útil para diagnosticar desalinhamentos em segmentos corporais, gerando uma ferramenta no controle biomédico do treinamento esportivo.

Palavras-chave: esportes, esportes náuticos, postura, pólo aquático.

INTRODUCTION

Body posture is the result of the complex interaction of the musculoskeletal and nervous system that allows the body to maintain an adequate position and have an ergonomic balance, with minimal energy expenditure according to Bricot (2008) and Marchi. *et al.* (2016). Correct posture reduces the risk of injuries and improves the proper functioning of all organs (Duclos, *et al.,* 2017) and (Kendall, *et al.,* 2000). The authors González *et al.* (2011), Lutterotti (2021) and Valencia and Venegas (2021) refer to the diagnosis and reevaluation of posture, focused on the analysis of balance disorders.

The role of posture is extremely important in daily life and in sports activities, where studies are carried out through plantographic and postural evaluation, defined by some as a component of biomedical control (Pérez and Morales, 2014).

It is considered that in the field of sports medicine, posture analysis should be a tool that is used more, in the functional assessment of the athlete and, above all, in the conception of injury prevention and recruitment action programs of talents, since good posture is an integrated morphofunctional process for quality movement. In the case of sport, it can be concluded that the rest of the sequences performed in a certain sporting gesture have a price, in terms of energy expenditure.

Water polo (water *polo)* is the longest-running team competition in the modern Olympic Games, it was first introduced in Paris in 1900 (Schroeder, *et al.,* 2022); this sport consists of two teams of six players and a goalkeeper, who compete against each other crossing a pool, until they throw the ball into the opponent's net (Croteau, *et al.,* 2021; Spittler and Keeling, 2016 and Stromberg, 2017).

In the case of water polo, a large number of movements, changes of direction, passes and throws are carried out, where high levels of strength, power and speed are required to execute blocks, pushes and grabs (López, *et al.,* 2022). Water polo is made up of a set of movements, including the beater kick that form the platform for many skills and techniques in this sport (Girdwood and Webster, 2021).

Authors like Croteau *et al.* (2021) have shown that in addition to technical and tactical skills, in water polo anthropometric characteristics are also determining factors for competitive success, to which are added, according to the criteria of the authors of this article, other morphofunctional aspects such as posture.

Based on the aforementioned statements, it is deduced that morphofunctional profile of the polo player complement each other, as internal factors predisposing to injuries due to overuse. Generally speaking, a limited amount of information is available on the postural profiles of water polo players; however, to a certain extent it has been recommended to use swimmer profiles as a reference guide (Witwer and Sauers, 2006), an issue that incurs inadequacies, given the biomechanical and morphological differences between both types of athletes.

Based on the previous precepts, and as part of the tasks of the "Functional Morphological Evaluation System" Project (Code: PS242LH001-024), it was decided to carry out postural evaluations in the male population of the Cuban national team, by specialists from the Center for Cuban Sports Research (CIDC in Spanish) and the Institute of Sports Medicine (IMD in Spanish), with the objective of analyzing the postural profile in elite water polo players.

MATERIALS AND METHODS

A descriptive, prospective, cross-sectional study was designed. The universe and sample consisted of 18 elite male athletes. The selected scientific methods were at the theoretical, empirical and statistical-mathematical level.

From the theoretical level, the following methods were used: a) Analysis-Synthesis, based on the cognitive processes of postural evaluation as a diagnostic method, posture and its different positions from the vision of its authors; b) Historical-Logical: it allowed the management of information to establish the theoretical-methodological foundations of the postural evaluation. The *PubMed, Scopus, Dimensions, OpenAire* databases were consulted and the PubReMiner and Zotero tools were used. The search strategy was used: (Posture),

(Sport) and (Water *Polo)*, based on keyword suggestions from the UNESCO thesauri, as well as the Descriptors in Health Sciences (DeSC in Spanish).

The empirical methods used were: a) Structure observation of postural alterations and b) Direct and indirect measurement: they allowed the individual's weight to be obtained through the Seca 286 dp scale (accuracy of 50 g and high load capacity of up to 300 kg), the height was measured with a mechanical stadiometer for children and adults Seca-216 (Measurement range 3.5-230 cm), a Harpenden brand anthropometer was used to measure foot length. All measurements were performed by the main author who has international certification (level-1) by the International Society for the Advancement of Kinanthropometry (ISAK).

Statistical processing was performed with *SPSS Statistics* V-25 with descriptive data analysis.

The least amount of clothing possible was worn, without jewels and barefoot. Three standing photographs were taken in the anterior frontal, posterior frontal, right sagittal and left views respectively, according to the recommendations of the PAS/SAPO software Ferreira *et al*. (2010) (Figure 1).

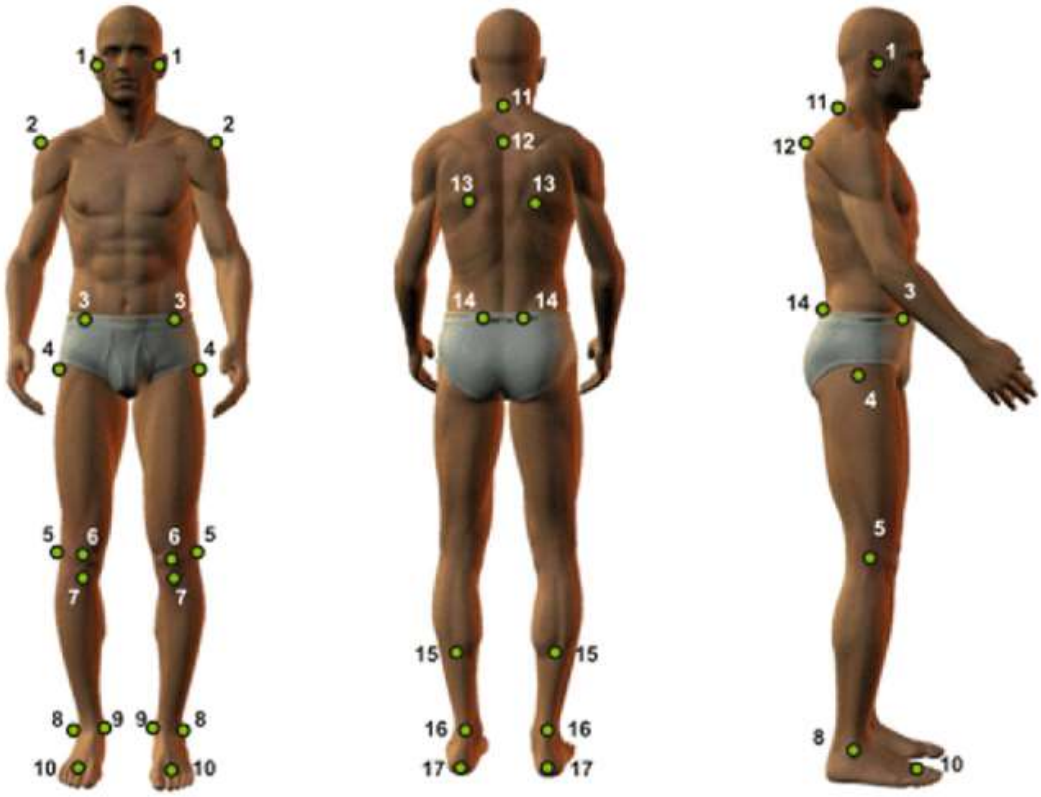

Fig. 1. *- Anatomical marking points for PAS/SAPO: tragus (1); midpoint, acromion (2); anterior superior iliac spine (ASIS) (3); femur, greater trochanter (4); knee, joint line (5); patella, midpoint (6); tibial tuberosity (7); lateral malleoli (8); medial malleolus (9); midpoint between second and third metatarsals (10); spinous process of C7 (11) and T3 (12); scapula, inferior angle (13); posterosuperior iliac spine (14); leg, point to a medial line (15); calcaneal tendon between malleolus (16); and calcaneus (17).*

Source: Translated from the original.

The subject was located in a plane perpendicular to the axis of the camera (Panasonic HC WX970), supported on a tripod with "level bubbles", at a minimum distance of three meters and at a height of approximately half the height of the subject.

- The image of the subject was framed with the plumb line (which should appear next to the subject) in the camera and left in the image approximately half a meter above and below the subject.

- A black rubber mat was used on which the subject freely rested to capture the photos.
- On the subject, a series of markings were made with colored adhesive tape, according to the PAS/SAPO protocol (Figure 1).
- The photos were transferred to the computer for evaluation.

For the execution of the tests, informed consent was received from the subjects examined, they were based on the ethical recommendations raised for research on human beings.

RESULTS AND DISCUSSION

Joint misalignments and arthromuscular imbalances are frequent sources of injuries. Preventive and biomedical control programs must include a complete and exhaustive postural and arthromuscular assessment (Casáis, 2008 and Marquet, *et al.*, 2021). In the present research, the postural adaptations in polo players were described through a static analysis in standing position.

Data from 18 elite male polo players between 18 and 33 years old, with an average time in the sport of 12 years, were analyzed. From an anthropometric point of view, a height of 1.85 ± 0.6 m, weight 84.61 ± 9.95 kg and foot length of 27.5 ± 1.57 cm were recorded (Table 1).

Table 1. - General characteristics of male polo players evaluated using static posturology. Havana; 2022

	Minimum	**Maximum**	**Mean**	**Deviation**
Age (years)	18	33	21.4	3.5
Sports Age (years)	6	19	12.00	3.91
Foot length	25.0	29.5	27.5	1.57
Size (cm)	1,740	1.95	1.85	0.06
Weight (Kg)	70.20	102.00	84.61	9.95

***Source**: Data collection form. Department of Functional Morphology; CIDC.*

The measurements of the international water polo players showed records between 190.92±5.95 cm in height and 91.08±7.69 kg in weight, with 24.08±3.32 years of chronological age; average values that exceed those found in the present study. On the other hand, data published by Iturriaga *et al.* (2009) where 22 players belonging to the Spanish team participated, reporting an average age of 24.77±5.69, weight 89.24±11.57 kg and height of 187.41±6.63 cm; data that agree with those found in the present study.

According to Zurita and Cabello (2002), to maintain the standing attitude the individual must be in balance, and for this it is necessary that the vertical that passes through the center of gravity falls within the support base. The foot is an elemental piece of statics, being the support element; thus, all its variations influence the statics.

According to the data presented in table 2, in the frontal plane, the predominant profile was a centered head (13; 72.2 %), with a higher left shoulder (14; 77.8 %), a higher anterior superior iliac spine (10; 55.6 %), right thoracic triangle larger than the left (10; 55.6 %) and both knees with correct alignment (10; 55.6 %) (Table 2).

Table 2. - Characteristics in the anterior frontal plane of male polo players evaluated using static posturology. Havana; 2022

		Count	%
Bipupillary plane	Neutral	13	72.2
	Higher left	4	22.2
	Higher right	1	5.6
Clavicular plane	Neutral	3	16.7
	Higher left	14	77.8
	Higher right	1	5.6
Biiliac plane	Neutral	5	27.8
	Higher left	10	55.6
	Higher right	3	16.7
Thoracic Triangle	Same	-	-
	Right greater than left	10	55.6

	Left greater than right	8	44.4
Right knee	valgo	6	33.3
	Neutral	10	55.6
	Varus	2	11.1
Left knee	valgo	6	33.3
	Neutral	10	55.6
	Varus	2	11.1

***Source**: Data collection form. Department of Functional Morphology; CIDC.*

In accordance with the observations made in the present series of cases, polo players tend to develop an adaptation to the swimming gesture, with a distinctive characteristic of their kyphotic posture (Cebula, *et al.*, 2009); they have raised shoulders that protrude forward, as well as a head that stretches beyond normal plumb alignment (Kreulen, *et al.*, 2022 and Schlueter, *et al.*, 2021). The previous approach contrasts with the gesture of throwing the ball into the net, by the opponent with one hand on the ball (the goalkeeper can use two), while staying afloat.

Hams`s studies *et al.,* (2019) to a group of 76 elite polo players in Australia concluded that injured cases showed a lower total range of motion of the dominant shoulder, compared to non-injured players. In throwing sports, including water polo, altered scapular posture is related to shoulder pain, according to Croteau *et al.* (2021) and it is hypothesized that the head-up swimming pattern, typical during water polo, may also lead to impingement syndromes (Miller, *et al.*, 2018).

When considering the peculiarities of the movement of this sport, different biomechanical requirements are proposed for each side of the body, which brings with it misalignments in the postural profile of the polo player. On the one hand, the throwing arm requires great mobility to guarantee muscle activation and relaxation in the dynamic explosive actions of throwing; on the other hand, the contralateral player is mainly subject to the action of swimming and passing the ball.

Two-dimensional measurements of scapular upward rotation have also shown good to excellent reliability, according to Johnson *et al.* (2001), which has been implemented to evaluate water polo players. Mukhtyar *et al.* (*2014*) compared the scapular abduction position, by measuring the distance between the scapular angles and the spine, after training in healthy polo players (n=16) against players with impingement symptoms (n=14). The shoulder impingement group showed significantly reduced values of scapular abduction and scapular upward rotation ($p < 0.05$) at 45° or more of shoulder abduction.

At the biiliac plane, a predominance of misalignments was observed, which in theory are attributed to the large amount of time the polo player spends kicking the mixer, which implies the development of symptoms, according to Girdwood and Webster (2021) and Spittler and Keeling (2016). The beater kick involves rapid cyclical revolutions of the feet, with the movement creating an inward rotation cycle (Sanders, 1999). This occurs as a result of repetitive internal and external rotation of the hip, in combination with hip flexion and abduction (Löllgen and Leyk, 2018). Water polo players spend a lot of time training and performing the beater kick, as it is a crucial performance variable, as is the jump height of a volleyball player.

Among the most likely risk factors that predispose polo players to frequent musculoskeletal injuries are proprioceptive deficits, vertebral instability, asymmetry and incorrect postural control (López, *et al.*, 2022).

In table 3, in the sagittal plane, the predominant profile was a forward head (18; 100 %), neutral pelvis (14; 77.78 %) and both knees in *recurvatum* (10; 55.6 %) and body inclination anterior (18; 100 %) with an angulation range of 2-6 degrees. In the posterior frontal plane, the head is neutral (14; 77.78 %) with a left body inclination (12; 66.67 %) (Table 3).

Table 3. - Characteristics in the sagittal and posterior frontal plane of male polo players evaluated using static posturology. Havana; 2022

		Count	%
Sagittal Plane			
Head position	Former	18	100.00
	Neutral	-	-
	Later	-	-
Right Iliac Plane	Rear tilt	-	-
	Neutral pelvis	14	77.78
	Front tilt	4	22.22
Left Iliac Plane	Rear tilt	-	-
	Neutral pelvis	14	77.78
	Front tilt	4	22.22
Body tilt	Former	18	100.00
	Neutral	-	-
	Later	-	-
Left knee	Recurvatum	9	50.00
	Neutral	8	44.44
	Flexion	1	5.56
Right knee	Recurvatum	7	38.89
	Neutral	7	38.89
	Flexion	4	22.22
Frontal Plane			
OM Plane	Neutral	14	77.78
	Right	2	11.11
	Left	1	5.56
Body tilt	Neutral	6	33.33
	Right	-	-
	Left	12	66.67

***Source**: Data collection form. Department of Functional Morphology; CIDC.*

Environmental stress in sports that occur in an aquatic environment, in the face of daily training loads, generate muscular imbalances in the upper waist, which break the muscular synergy necessary for correct scapulo-humeral movement (Peris, 2017). These structural changes caused by water sports alter scapular kinematics, reduce the subacromial space, the flexion capacity (-25 %) and the capacity to generate strength (-16 %) of the shoulder joint (Díaz, *et al.,* 2010 and Mendieta and Yañez, 2022).

In sports, there is research that refers to how posture influences a certain technique, which may be related to a decrease in sports performance or the appearance of injuries.

The conceptualization of good posture is closely related to the biomechanical foundations of sport. The athlete needs to have knowledge of his body and very precise control of his movements, to correctly execute the sporting gesture. At first glance, it seems a contradiction to talk about posture in a rather static concept, in relation to physical exercise that involves repeated, planned and structured movements, therefore, dynamic; the point is that these are only two evaluation phases of the same process.

According to Almeira (2016) and Peris (2017), society has increasingly stressful lifestyle habits that are associated with neglect of postural hygiene. Rethinking from the base (lower categories) greater attention to postural aspects increases the ability to assimilate different loads and therefore, improves physical performance.

CONCLUSIONS

The evaluation of the posture profile in polo players is useful to diagnose misalignments in body segments, generating a tool for the diagnosis, correction and biomedical control of sports training. A specific sporting gesture, or a sequence of similar and repeated movements, leads to automated learning of the same, based on a body structure with certain morphofunctional characteristics, which adapt to the aforementioned conditions.

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***Conflict of interests*:**

The authors declare not to have any interest conflicts. Raydel Pérez Castillo, Patricia Martí-Estévez, Giselle Elizabeth Ricardo-Fuste, Amílcar Aníbal Andrés-Bravo

***Authors' contribution*:**

The authors have participated in the writing of the work and analysis of the documents

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