Revista de Artes Marciales Asiáticas
Volume *21*(1), 95-105 ~ January-June 2026
DOI: 10.18002/rama.v21i1.2605
http://revpubli.unileon.es/ojs/index.php/artesmarciales

RAMA
I.S.S.N. 2174-0747

The role of head movement in capoeira's *armada* performance

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Received: 24/02/2025; Accepted: 21/02/2026; Published: 25/02/2026

ORIGINAL PAPER

Abstract

During *armada* performance, capoeira player breaks the visual coupling with the opponent because of the turning movement. This study investigated if a phenomenon named "head marking" would characterize as a potential strategy for capoeira player deal with such a break in the informational coupling. The head marking refers to the act of, in turning movements, the head being the last part of the body to move, but the first to finish. Forty experienced volunteers, [male (n = 10) and female (n = 10) beginners, and male (n = 10) and female (n = 10) advanced *capoeira* players], with an average age of 24.0 ±5.0 years took part in this experiment. The head marking was analysed in relation to *armada* speed (slow and fast), opponent (with and without), attacking leg (preferred and non-preferred) and learning phase (beginner and advanced). The latter classification was based on the cordon graduations of the Brazilian Capoeira Confederation. Head movement time was smaller than armada movement time (758.8 ms vs. 1916.6 ms, respectively, $p < 0.01$). Head movement occurred within the *armada* movement, since it involved negative (-330.47 ms) and positive (806.66 ms) average values for the starting and ending of the head movement, respectively. It was observed that the armadas performed with the preferred lower member had greater average value of head movement time than those performed with non-preferred member (740.41 ms vs. 678.72 ms, respectively, $p < 0.05$). And, when armadas were performed against a virtual opponent, they involved greater head movement time than those performed without a virtual opponent (758.58 ms vs. 669.43 ms, respectively, $p < 0.05$). The findings of this study suggest that head movement had functioned as a head marking phenomenon as an *armada*'s critical component, which vary depending on performers' lateral dominance and presence of an opponent. They also contribute to the comprehension of motor skill functioning and the elucidation of its underlying mechanisms.

Keywords: Martial arts; combat sports; head movement; motor skill; expertise; sensory system.

El papel del movimiento de la cabeza en la ejecución de la *armada* de capoeira

Resumen

Durante la ejecución de la *armada*, el practicante de capoeira pierde la conexión visual con el oponente debido al movimiento de giro. Este estudio investigó si el fenómeno denominado "marcación de cabeza" podría ser una estrategia potencial para que el capoeira maneje dicha ruptura en la conexión informativa. La marcación de cabeza se refiere al acto de que, en los movimientos de giro, la cabeza sea la última parte del cuerpo en moverse, pero la primera en terminar. Cuarenta voluntarios, (10 hombres y 10 mujeres principiantes, y 10 hombres y 10 mujeres veteranos], con una edad promedio de 24,0 ± 5,0 años, participaron en este experimento. La marcación de cabeza se analizó en relación con la velocidad de la armada (lenta y rápida), el oponente (con y sin), la pierna de ataque (preferida y no preferida) y la fase de aprendizaje (principiante y avanzado). La última

O papel do movimento da cabeça na performance da *armada* da capoeira

Resumo

Durante a execução da armada, o praticante de capoeira quebra o acoplamento visual com o oponente devido ao movimento de giro. Este estudo investigou se um fenômeno denominado "marcação de cabeça" caracterizaria uma estratégia potencial para o praticante de capoeira lidar com essa quebra no acoplamento informacional. A marcação de cabeça refere-se ao ato de, em movimentos de giro, a cabeça ser a última parte do corpo a se mover, mas a primeira a terminar. Quarenta voluntários experientes [homens (n = 10) e mulheres (n = 10) iniciantes, e homens (n = 10) e mulheres (n = 10) praticantes avançados de capoeira], com idade média de 24,0 ± 5,0 anos, participaram deste experimento. A marcação de cabeça foi analisada em relação à velocidade da armada (lenta e rápida), ao oponente (com e sem), à perna de ataque (preferencial e não preferencial) e à fase de aprendizado (iniciante e

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Funding: This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001.

Conflicts of interest: No potential conflict of interest was reported by the authors.

clasificación se basó en las graduaciones de cordón de la Confederación Brasileña de Capoeira. El tiempo de movimiento de cabeza fue menor que el tiempo de movimiento de armada (758,8 ms vs. 1916,6 ms, respectivamente, $p < 0,01$). El movimiento de cabeza ocurrió dentro del movimiento de la *armada*, ya que implicó valores promedio negativos (-330,47 ms) y positivos (806,66 ms) para el inicio y el final del movimiento de cabeza, respectivamente. Se observó que las *armadas* realizadas con el miembro inferior preferido tuvieron un mayor valor promedio de tiempo de movimiento de cabeza que las realizadas con el miembro no preferido (740,41 ms vs. 678,72 ms, respectivamente, $p < 0,05$). Y, cuando las armadas se realizaron contra un oponente virtual, implicaron un mayor tiempo de movimiento de cabeza que las realizadas sin él (758,58 vs. 669,43 ms, respectivamente, $p < 0,05$). Los hallazgos de este estudio sugieren que el movimiento de la cabeza funciona como un fenómeno de marcaje cefálico, componente crítico de la *armada*, que varía según el dominio lateral de los participantes y la presencia de un oponente. También contribuyen a la comprensión del funcionamiento de las habilidades motoras y a la elucidación de sus mecanismos subyacentes.

Palabras clave: Artes marciales; deportes de combate; movimiento de la cabeza; habilidad motora; pericia; sistema sensorial.

avançado). Esta última classificação foi baseada nas graduações de cordão da Confederação Brasileira de Capoeira. O tempo de movimento da cabeça foi menor que o tempo de movimento da armada (758,8 ms vs. 1916,6 ms, respectivamente, $p < 0,01$). O movimento da cabeça ocorreu dentro do movimento da armada, visto que apresentou valores médios negativos (-330,47 ms) e positivos (806,66 ms) para o início e o fim do movimento da cabeça, respectivamente. Observou-se que as armadas realizadas com o membro inferior preferido apresentaram um valor médio de tempo de movimento da cabeça maior do que aquelas realizadas com o membro não preferido (740,41 ms vs. 678,72 ms, respectivamente, $p < 0,05$). Além disso, quando as armadas foram realizadas contra um oponente virtual, apresentaram um tempo de movimento da cabeça maior do que aquelas realizadas sem um oponente virtual (758,58 ms vs. 669,43 ms, respectivamente, $p < 0,05$). Os resultados deste estudo sugerem que o movimento da cabeça funcionou como um fenômeno de marcação de posição, sendo um componente crítico de uma armada, que varia dependendo da dominância lateral dos praticantes e da presença de um oponente. Eles também contribuem para a compreensão do funcionamento da habilidade motora e para a elucidação de seus mecanismos subjacentes.

Palavras-chave: Artes marciais; desportos de combate; movimento da cabeça; habilidade motora; expertise; sistema sensorial.

1. Introduction

Capoeira is a Brazilian martial art characterized as a game in which two players perform motor skills of attacking, counterattacking, and defending against each other in the middle of a circle formed by people playing percussion instruments (e.g., *berimbau, atabaque* and *pandeiro*), singing, responding to a choir, and clapping their hands (Areias 1983; Assunção, 2005; Corrêa & Walter, 2016; Lipiainen, 2015; Miranda, 2012).

Over the past few decades, capoeira has increasingly been the focus of investigations in different areas of knowledge (e.g., Social Sciences, Life Sciences, Arts and Humanities, and Biomedicine) (da Cruz & Corrêa, 2024; Lima & Brasileiro, 2020). However, notwithstanding the advances provided by such investigations, the understanding of how capoeira's motor skills are performed considering their underlying mechanisms and processes (motor control) still requires investigation (da Cruz & Corrêa, 2024).

The importance of understanding how capoeira's motor skills are controlled is based on the fact they involve high informational demand for performance (e.g., visual and somatosensory information) (Corrêa & Walter, 2016). For instance, the *armada* is one of the strikes most often performed in the game of capoeira. It refers to a traumatic strike in which the capoeira player tries to hit the opponent with the outside of the foot (Figure 1). In the *armada* performance, the capoeira player rotates on the longitudinal axis on a support foot while moving the extended leg, describing a circular trajectory towards the moving opponent (Capoeira, 2015). Therefore, such performance demands coordination among different parts/components (actions of the feet and legs, trunk and hips, arms, and head) during a dynamic balance, i.e. body turn, to hit an opponent moving continually in different directions and speeds, meaning that, at some point during the body turn, the capoeira player has his/her back to the opponent. For the 360° turn to be completed around the longitudinal axis of the body, the head movement necessarily causes a break in the performer's visual coupling with the opponent.

In this study, a phenomenon named "head marking" was investigated as a potential strategy for a capoeira player to deal with such a break in the informational coupling to his/her opponent. This refers to the act of, in turning movements, the head being the last part of the body to move, but the first to finish (Denardi & Corrêa, 2013; Denardi et al., 2008; Komiyama et al., 2011; Rodrigues et

al., 2010). For example, a study by Denardi et al. (2008) investigated the effects of gaze on postural stability in the pirouette performance. To this end, eight experienced women dancers performed a pirouette with and without (blindfolded) visual information available. Results showed a clear sequence of the pirouette's components. They were trunk, head, and gaze in the pirouette beginning, and gaze, head, and trunk in the pirouette ending. According to the authors, this sequencing would have allowed dancers to try their best to keep their gazes fixed and stable in the frontal reference. However, it is important to note that, excepting the gaze, this sequence was the same in both conditions with and without visual information. Thus, despite the importance of vision to control of turning in motor skills, it seems that it would not be the most essential aspect, but rather the head. Therefore, we hypothesised that head marking would be a strategy that capoeira player would employ for dealing with the informational demands on the *armada* performance.

On the one hand, this hypothesis could be based on the functioning of interacting visual and vestibular systems, both located in the head and closely related to the maintenance of balance. The vestibular system is responsible for feeding the central nervous system about the relative displacement characteristics of the head (e.g. acceleration) and stabilizing the visual image when the individual is in motion (Bent et al., 2000; Cromwell, 2003; Cullen, 2012; Pozzo et al., 1995). It detects head rotations and immediately commands a compensatory eye movement in the opposite direction (vestibulo-ocular reflex). Its efficiency depends on the complex connections of the semicircular canals in the vestibular nucleus (Bear et al., 2016). Examples of movements to which the semicircular canals are sensitive are quick turns, shaking from side to side and tilting back and forth from the head. In case of consecutive turning movements, visual image is stabilized more quickly, mainly for the maintenance of balance, which causes an increase in the rotation speed and, consequently, in the head speed (Bent et al., 2000; Cullen, 2012; Komiyama et al., 2011; Pozzo et al., 1995). Based on the above, it can be thought that head marking would have the main function of making the vestibular system feel as little as possible the changes caused by the turning.

On the other hand, head marking could be associated with visual coupling between capoeira players due to task specificity (Breslin et al., 2012; Barros et al., 2017). For instance, while the goal of the pirouette is the movement pattern itself, the purpose of armada is external to it: to hit an opponent moving dynamically. Therefore, to be visually attuned to the opponent is *sine qua non* for the armada to be successful. Since vision feeds the brain information about environment for the subsequent decision and performance of actions (Vickers, 2011), head marking could be considered as a strategy that allows capoeira player to minimize the time spent without visual contact with the opponent. By considering that capoeira is a dynamic game, it is possible that one of the most important aspects for capoeira players is monitoring the location of the opponent in space and time.

In summary, it is possible that the *armada* performance involves head marking because it would contribute to maintain the balance and to monitor the opponent during the game. Importantly, to the best of our knowledge, no study has conducted such an investigation. Therefore, this study sought to investigate whether the head movement during the *armada* performance would characterize a head marking phenomenon. We expected that head movement time would be smaller than the *armada* movement time, which would characterize the head marking. We also expected that, as seen in relation to expert dancers (Komiyama et al., 2011), head movement would be affected by the *armada* speed, limb preference, and player learning stage. Finally, since *armada* performance implies to hit an opponent player with a foot, different head movement times could occur from the presence of an opponent (target).

2. Method

2.1. Participants

Forty experienced volunteers, beginners (n = 20), and advanced (n = 20) capoeira players, with an average age of 24.0 ± 5.0 years took part in this experiment. These learning stages (beginner and advanced) were defined based on the cordon graduations of the Brazilian Capoeira Confederation. Those with green, yellow, and blue cords were considered in the early stages group, and those with green and yellow, green and blue, and yellow and blue cords were classified as in advanced stages group. The inclusion criteria were that the participants: (1) had involvement with a systematic practice of capoeira, that is, they practiced in a specific context (e.g., capoeira school, gym,

or group), in a regular, systematic, and organized manner; and (2) were able to perform the *armada* motor skill. This latter criterion was guaranteed by the fact that the participants had at least the green cordon, that is, they were not completely novice and inexperienced. Written consent was obtained from each participant, and the experimental protocol was approved by the local Ethics Committee of the University of São Paulo (CAAE 12261619.5.0000.5391).

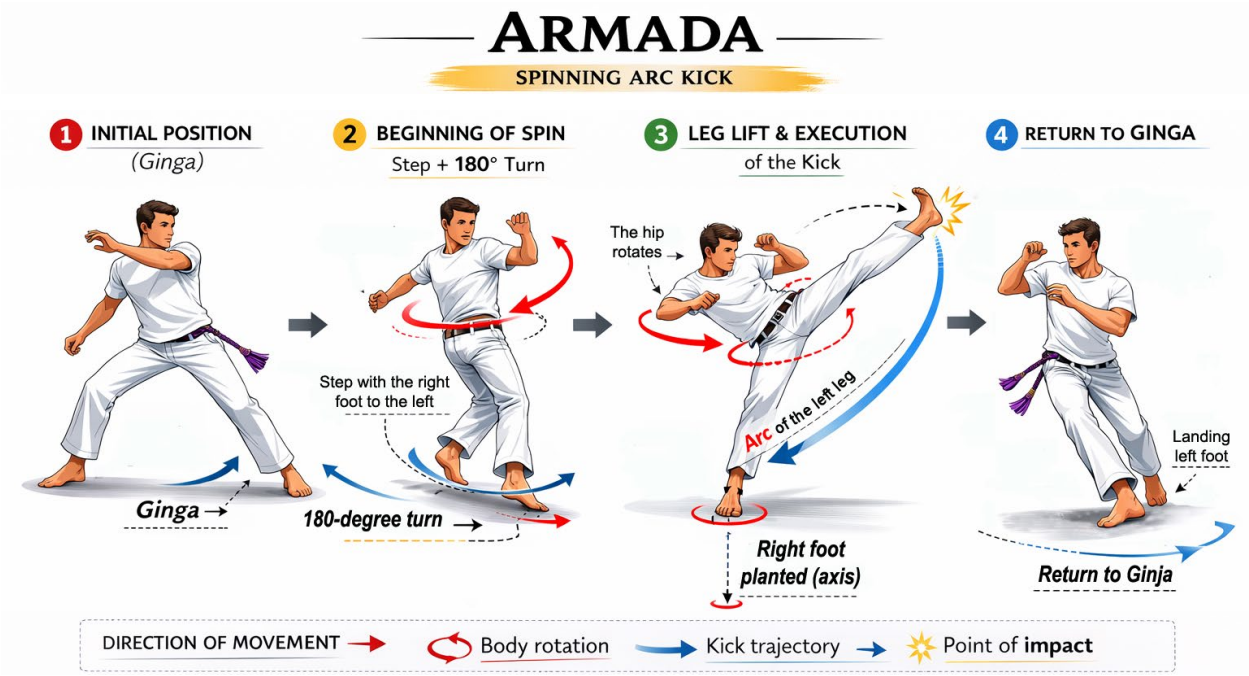
2.2. Instruments

Instruments included: (a) a notebook (Dell Inc., São Paulo, Brazil) to record information about participants and data collection, as well as for data analysis, (b) a GoPro Hero3 digital camera (GoPro Inc., São Paulo, Brazil) positioned in front of the participant, at a distance of 1.5m and a height of 2,6m, to capture the images at 30 FPS, with 1080p quality; and a Datashow (Benq MX666, São Paulo, Brazil) for projecting the moving opponent/target.

2.3. Task

The task consisted of performing the *armada* (Figure 1). As previously described, the *armada* is a motor skill in which the capoeira player seeks to strike the opponent's head with the outside of the foot. Figure 1 illustrates an *armada* performed in a clockwise direction: it comprises of four components (1 - action of the feet and legs; 2 - action of the trunk and hips; 3 - action of the arms; and, 4 - action of the head) that unfold in four phases. In the first phase all the components interact to form the base (swing): (1) the left leg is in front, with a semi-flexed knee and the foot fully supported on the floor. The right leg is at the back with total or partial foot support on the floor; (2) the trunk is facing forward; (3) the left arm is in front of the body with a semi-flexed elbow and the right arm is behind the body, with a small flexion of the elbow; (4) the head is stabilized in the frontal plane. In the second phase, (1) the left leg performs a clockwise stride so that the foot rests on the ground, pointing to the side or back; the right foot rests on the ground pointing backwards; (2) the torso performs a clockwise rotation so that the opponent is partially or totally turned away; (3) the right arm moves down and to the side of the body; the left arm moves up and forward of the body, with the elbow semi-flexed; (4) the head remains as stabilized and forward as possible. The rotation starts at the end of the phase. In the third phase, (1) the right leg is moved clockwise and in elevation, extended, in order to reach the maximum height when reaching the opponent; (2) the torso continues to rotate until it faces the opponent; (3) the right arm moves upwards and the left arm moves downwards, with the elbows semi-flexed; (4) the head ends the forward rotation.

Figure 1. Illustration of capoeira's *armada.*



Source: Image generated using artificial intelligence (OpenAI – DALL·E), based on a prompt by the Editor.

Finally, the fourth phase is characterized by the resumption of the base position in the swing: (a) the right leg ends the rotation supporting all or part of the foot on the floor. And, the left leg ends the forward rotation, with a semi-flexed knee and the foot fully supported on the floor; (b) the trunk remains in the frontal plane; (c) the right arm ends in front of the body with a semi-flexed elbow and the left arm behind the body, with a small flexion of the elbow; (d) the head remains stabilized in the frontal plane.

Because the *capoeira* game is dynamic, it is not uncommon for the *armada* to be started (first stage) with arms and legs in opposite positions, that is, considering Figure 1, with the left leg behind and the left arm in front. However, this does not imply changes in the following phases.

2.4. Design and procedures

Data were collected in a closed 50 m^2 room. Participants were received individually and informed about the research and the task. So, they were familiarized with the research environment and with the task's experimental conditions. Familiarization involved the performance of a trial with each dominant and non-dominant limb, in both performance speeds (fast and slow), totalizing four *armadas* for familiarization. The determination of lateral dominance was based on each participant's response as to whether they preferred to perform the armada with their right or left leg. After that, participants were positioned on the performance place (2 meters away from the wall) and were instructed to perform the *armada* with the aim to strike an opponent who was swinging in front of them, being able to choose the starting pattern, as previously described. The swing refers to the constant change of foot support; it is a basic motor skill in the capoeira game as it assists in the preparation and performance of attacks, counterattacks, and defences in all directions, in addition to the continuity of the game (Corrêa & Walter, 2016; Talmon-Chvaicer, 2008).

Two *armadas* were performed in each of the following conditions, in a counterbalanced order: slow speed with opponent, slow speed without opponent, fast speed with opponent, fast speed without opponent. In addition, they were performed with dominant and non-dominant limbs, for a total of 16 trials per participant. Data were collected in two blocks in the same day by considering the presence of an opponent also counterbalancing the order by participant. The opponent was virtual, that is, an image of a capoeira player performing the swing, which was projected on the wall in front of the participant. The image size was regulated so that the opponent had a height like that of the participant (Gemas Neto et al., 2021).

In the condition involving an opponent, the fast and slow speeds were those involving the 28 and 37 swings per minute, respectively. In addition to the opponent's swing, there were songs that were close to these speeds. And, in the condition without opponent, participants were instructed to perform the *armada* in the speed they considered slow and fast, but they were also constrained by the same capoeira songs. In this block, participants were asked to maintain the *armada*'s direction. The interval between blocks of trials was 60 seconds. The performance sequencing within and between blocks of trials were counterbalanced between participants.

2.5. Measures

All performances were recorded using a digital camera (GoPro Hero 3+; frequency = 30 Hz, 1080p) located centrally positioned 2.60 meters above and in front of the performance place, at 2 meters. Using the Kinovea Video Editor 0.8.15 software (Polak et al., 2015), the following measures were obtained from the calibrated environment based on four vertices of a square in the ground whose center was the participant's initial positioning, frame by frame at a slow-motion frequency of 3% Hz. The software timer was triggered by the analyzer on the first movement (head or foot) and turned off at the end of the last movement (head or foot): (i) starting time of *armada* (AST), (ii) ending time of *armada* (AET), (iii) starting time of head movement (HST), and (iv) ending time of head movement (HET). Regarding the starting and ending times of the *armada*, it referred to the first movement of one foot and ended with the return of the attack foot to the ground, respectively. Likewise, to determine the movement of the head, the beginning and ending of its rotation were considered. From these values, the *armada* movement time (AMT) was obtained by AMT = AET – AST. In addition, the head movement time (HMT) was calculated through HMT = HET – HST. The

inter-analyses reliability was checked by reanalysing by another evaluator (motor behavior researcher and experienced *capoeira* player), of five participants randomly selected (r = 0.92, p < 0.001).

2.6. Data analysis

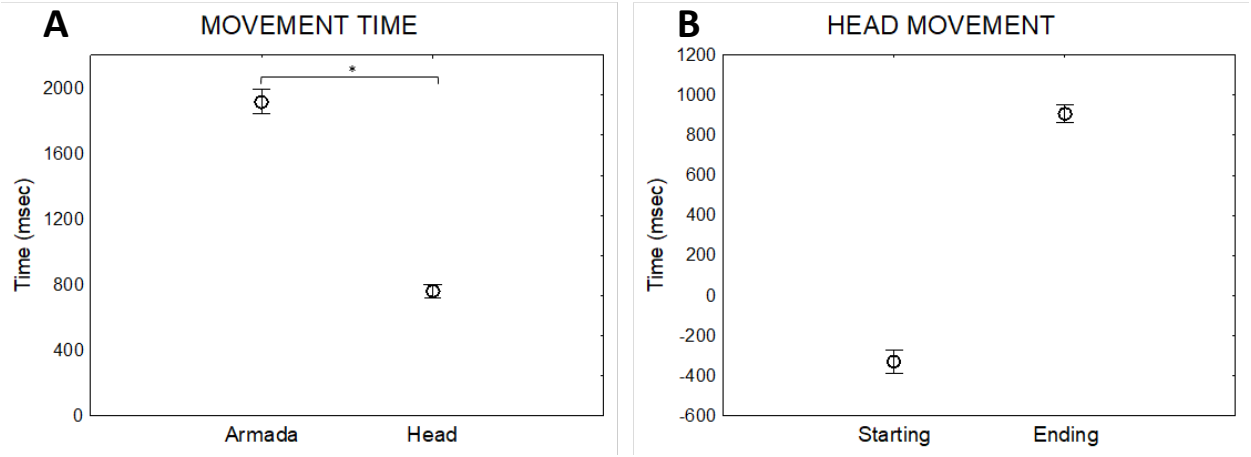
In order to consider the main aim of this study, the first analysis involved the comparison between AMT and HMT. For this purpose, an analysis of variance (ANOVA) was run. In addition, the values of both starting and ending of HMT were presented to verify if it occurred within AMT. It characterized the locus of head movement and was calculated by subtracting the starting and ending head movement times from the starting and ending times of *armada*, respectively. In this case, negative and positive values of HST and HET meant the HMT occurred within AMT and, therefore, *armada* performance involved the head marking. That is, head movement had started after *armada* starting and finished before the *armada* finishing, respectively.

In addition, a series of ANOVAs was run to compare HMT in relation to the following conditions: opponent (with opponent vs. without opponent), preferred limb (preferred vs. non-preferred), learning stage (beginner vs. advanced), and *armada* speed (slow vs. fast). In the opponent, preferred limb, and learning stage conditions the HMT was analysed considering the overall time (ms). For the comparison involving different *armada* speeds the HMT was analysed by considering the relative timing, that is, the proportion the HMT relative to the AMT. For all analyses, the level of significance was set at p < 0.05, using STATISTICA® 13.0 software (Stat Soft Inc., Tulsa, USA).

3. Results

Data presented in Figure 2 show the average values and their respective confidence intervals of AMT and HMT (A), and starting and ending times of HMT related to the locus of head movement (B). The ANOVA revealed $F(1, 36) = 1064.30$, $p < 0.01$, $\eta p^2 = 0.97$, observed power = 1.00, allowing inferring that the HMT was significantly smaller (758.8 ms) than AMT (1916.6 ms). In addition, Figure 2B shows the head movement occurred within the *armada* movement, since it involved negative (-330.47 ms) and positive (806.66 ms) average values for the starting and ending of the head movement, respectively.

Figure 2. Average values and their respective confidence intervals of (A) *armada* movement time and head movement time; (B) starting and ending times of head movement related to the locus of head movement.

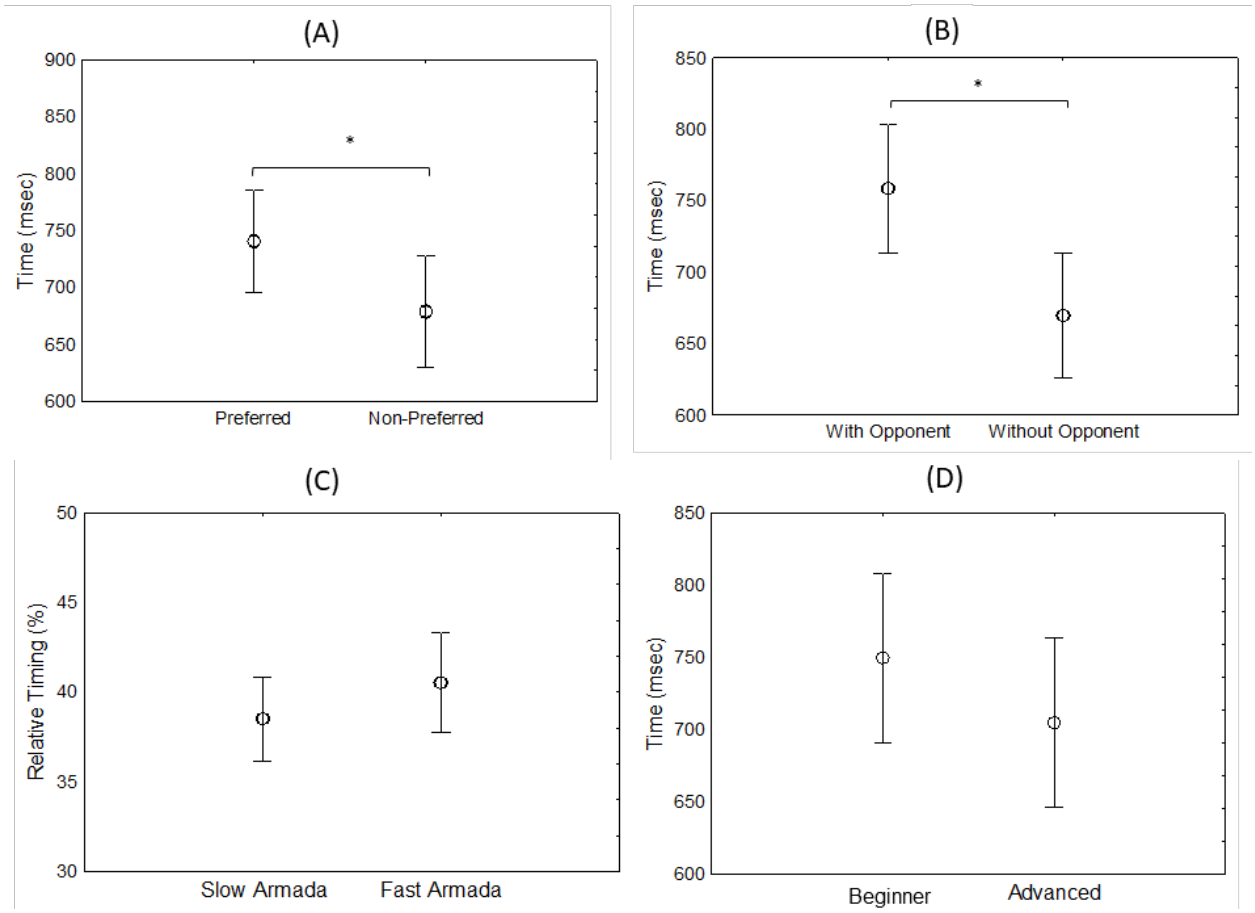


Note: * = Statistically significant difference.

Regarding comparisons considering the performance conditions of the armada (Figure 3), the ANOVAs also revealed the following results: *armada* slow vs. fast [$F(1, 36) = 2.425$, $p > 0.05$, $\eta p^2 = 0.97$, observed power = 0.33]; *armada* with preferred vs. non-preferred limb [$F(1, 36) = 6.237$, $p < 0.05$, $\eta p^2 = 0.15$, observed power = 0.68]; *armada* with opponent vs. without opponent [$F(1, 36) = 18.84$, $p < 0.05$, $\eta p^2 = 0.29$, observed power = 0.96]; and beginner vs. advanced performer [$F(1, 36) = 1.20$, $p > 0.05$, $\eta p^2 = 0.06$, observed power = 0.18]. It was observed that the armadas performed with the preferred lower member had greater average value of HMT (740.41 ms) than those performed

with non-preferred member (678.72 ms). And, when armadas were performed against a virtual opponent, they involved greater head movement time (758.58 ms) than those performed without a virtual opponent (669.43 ms).

Figure 3. Average values and their respective confidence intervals of head movement time related to the (A) member preference, (B) presence of a virtual opponent, (C) speed of armada performance, and (D) learning stage.



Note: * = Statistically significant difference.

4. Discussion

The aim of the study was to investigate if the head movement during the *armada* performance would characterise the head marking phenomenon. Results showed that the head movement occurred within the *armada* movement, that is, it started and ended after the beginning and before the end of this motor skill, respectively. It was revealed similar *armada*'s head movement times during slow and fast *armada*s and beginner and advanced learning stages. Differently, results showed that head movement time in the *armada*s involving a virtual opponent and performed with the dominant limb were longer than those without an opponent and performed with the non-dominant limb, respectively.

First, results suggest that head movement functioned as head marking. Thus, *capoeira* players may have performed it in order to promote the balance and visual attunement to the opponent. Visually following the opponent can be an important strategy for the capoeira player, since keeping the head stable for longer allows him to better monitor the target (Bent et al., 2000; Cullen, 2012; Shanidze, 2010). The head may function as a natural reference for action because it contains two important sensory systems for controlling movement in relation to space, the visual and the vestibular (Pozzo et al., 1995). Therefore, head marking can be a strategy to maintain a more fixed visual reference and facilitate the fusion between visual information and information from otoliths (Bent et al., 2000).

Regarding the speed of *armada* performance, it was found that head markings were similar, proportionally to the *armada* total time, in both slow and fast conditions. It is likely that this

happened because, in order to accommodate the vestibular system during rotational movements such as the *armada*, the head velocity must be less than that of the body. In this way, vestibular system would inform the central nervous system about the positioning of the head in relation to gravity and, then, would stabilize the visual image while the individual was still in motion, thus ensuring the maintenance of balance (Cullen, 2012). Possibly, in order to perform the *armada*, *capoeira* players were able to use the particular characteristics of sensory information and integration between the visual, proprioceptive and vestibular systems, which allowed them to reach and/or maintain the function of the movement, that is, its purposefulness (Golomer et al., 1999).

The second condition investigated was the *capoeira* players' stages of learning, by comparing beginners to advanced ones. Results pointed out that beginners and advanced did not differ in relation to the head marking. In this case, it is possible that practicing in the specific context of capoeira did not cause changes in the visual and vestibular systems or that such systems work independently of the training.

Regarding the lateral dominance of the limbs, i.e., preferred limb, literature indicates that about 90% of people prefer to perform manual tasks with the right hand, while only 25-45% show preference for the right leg (Cuk et al., 2001). Therefore, it cannot be assumed that hand and leg preferences are similar (McGrath et al., 2015). The limb dominance can also be task-specific (Velotta et al., 2011). In order to deal with this issue, in this study capoeira players were asked about their lateral preference to perform the *armada*. It is important to consider that for making this choice, they relied on previous experiences when training capoeira and performing the *armada*. Presumably, the leg chosen as the preferred one for striking was the one that allowed support on the leg in which the capoeira player chose as the most suitable for balance, which could explain the fact that the head movement time related to the dominant limb was higher than that of non-dominant limb. In addition, when performing the *armada* with the preferred limb, capoeira player may have been able to respond better to stable or unstable regulatory environmental conditions (Schmidt et al., 2018).

Finally, results showed that the capoeira players performed *armada* with a longer head marking when there was a target (opponent) as a frontal reference. The target projected in front of the participants may have functioned as a reference for external frontal focus for the visual system. It seems that the head would relate to the gaze in terms of control, and a good performance would involve the delay in the beginning of the turn of the head in relation to the movement of the trunk (Rodrigues et al., 2002). Of course, as part of the rigor of the scientific method, in order to move towards results generalization, this study needs to be replicated, including in the context of capoeira game to advance the limitations of research developed in controlled environments. For example, further study could ask whether the head marking would be affected by the unpredictability of a real opponent's displacement. Furthermore, the use of procedures and technologies that allow greater accuracy of collected data should also be considered (e.g., capture of images at a higher number of frames per second than that of 30 fps).

5. Conclusion

In summary, the results of this study suggest that head movement had functioned as a head marking phenomenon. In addition, they allow inferring that head marking occurred regardless of performance speed and stage of learning of the capoeira player. However, it was affected by the lateral dominance and presence of an opponent. Our findings point out the head marking as an *armada*'s critical component. They also contribute to comprehension of the motor skill functioning and elucidation of its underlying mechanisms.

Based on robustness of the main results, since it revealed a very large effect size (0.97) (Stout & Ruble, 1995), we suggest that our findings provide useful insights into the design of practice tasks insofar as teachers and *senseis* could instruct the performers that, in order to keep the opponent as much as possible in the field of vision, the head should be the last part of the body to start the turning movement, but the first to finish.

Acknowledgments

This article is derived from the first author's Masters' Thesis.

References

Areias, A. (1983). *O que é capoeira* [What is *capoeira*]. Brasiliense.

Assunção, M.R. (2005). *Capoeira: the history of an afro-brazilian martial art*. Routledge.

Barros, J. A. C., Tani, G., & Corrêa, U. C. (2017). Effects of practice schedule and task specificity on the adaptive process of motor learning. *Human Movement Science*, *55*(3), 196-210. https://doi.org/10.1016/j.humov.2017.07.011

Bear, M.F., Connors, B.W., & Paradiso, M.A. (2016). *Neuroscience: exploring the brain*. Wolters Kluwer.

Bent, L. R., McFadyen, B. J., Merkley, V. F., Kennedy, P. M., & Inglis, J. T. (2000). Magnitude effects of galvanic vestibular stimulation on the trajectory of human gait. *Neuroscience Letters, 279*, 157-160. https://doi.org/10.1016/S0304-3940(99)00989-1

Breslin, G., Schmidt, R. A., & Lee, T. (2012). Especial skills: generality and specificity in motor learning. In A. M. Williams & N. J. Hodges (Eds.), *Skill acquisition in sport, research theory and practice* (pp. 337-349). Routledge.

Capoeira N. (2015). *The Little Capoeira Book*. North Academic Books.

Corrêa, U. C., & Walter, C. (2016). Aprendizagem motora e o ensino da *capoeira* [Motor learning and *capoeira* teaching]. In G. Tani & U. C. Corrêa (Eds.), *Aprendizagem motora e o ensino do esporte* (pp. 123-134). Blucher.

Cromwell, R. L. (2003). Movement strategies for head stabilization during incline walking. *Gait Posture*, *17*(3), 246-253. https://doi.org/10.1016/s0966-6362(02)00094-2.

Cuk, T., Leben-Seljak, P., & Stefancic, M. (2001). Lateral asymmetry of human long bones. *Variability and Evolution, 9*(1), 19-23.

Cullen, K. E. (2012). The vestibular system: Multimodal integration and encoding of self-motion for motor control. *Trends in Neuroscience, 35*(3), 185-196. https://doi.org/10.1016/j.tins.2011.12.001

da Cruz, L. M. F. & Corrêa, U. C. (2024). Trends in studies on *capoeira*: a bibliometric analysis. *Ido Movement for Culture Journal of Martial Arts Anthropology*, *24*(2), 75-83. https://doi.org/10.14589/ido.24.2.9

Denardi, R. A., & Corrêa, U. C. (2013). Effects of instructional focus on learning a classical ballet movement, the pirouette. *Journal of Dance Medicine & Science, 17*(1), 18-23. https://doi.org/10.12678/1089-313x.17.1.18

Denardi, R. A., Ferracioli, M. C., & Rodrigues, S. T. (2008). Visual information and postural control during pirouette execution in ballet. *Revista Portuguesa de Ciências do Desporto, 8*(2), 241-250. https://doi.org/10.5628/rpcd.08.02.241

Golomer, E., Crémieux, J., Dupui, P., Isableu, B., & Ohlmann, T. (1999). Visual contribution to self-induced body sway frequencies and visual perception of male professional dancers. *Neuroscience Letters, 267*(3), 189-192. https://doi.org/10.1016/S0304-3940(99)00356-0

Gemas Neto, E., Silveira, S. R., Reis, M. A. M. dos, & Corrêa, U. C. (2021). A perceptual cue on a moving opponent improves the learning of a motor skill from aikido. *Journal of Physical Education, 32*(1), e3244. https://doi.org/10.4025/jphyseduc.v32i1.3244

Komiyama, C., Denardi, R., Monteiro, C. B. de M., & Correa, U. C. (2011). The duration of "spotting" of the classical ballet pirouette. *Brazilian Journal of Motor Behavior*, *6*(2), 8-15. https://doi.org/10.20338/bjmb.v6i2.34

Lima I.T.G., Brasileiro L.T. (2020). Afro-Brazilian culture and Physical Education: a portrait of knowledge production. *Movimento, 26*(1), e26022; https://doi.org/10.22456/1982-8918.93164 [in Portuguese].

Lipiainen T. (2015). Cultural creolisation and playfulness: an example of Capoeira Angola in Russia. *Journal of Intercultural Studies*, *36*(6), 676-692. https://doi.org/10.1080/07256868.2015.1095716

McGrath, T.M., Waddington, G., Scarvell, J.M., Ball, N.B., Creer, R., Woods, K., & Smith, D. (2015). The effect of limb dominance on lower limb functional performance – a systematic review. *Journal of Sports Sciences, 34*(4), 289-302. https://doi.org/10.1080/02640414.2015.1050601

Miranda M. B. (2012). Jogo de capoeira: when actors play a physical dialogue. *Theatre, Dance and Performance Training*, *3*(2), 178-191; https://doi.org/10.1080/19443927.2012.689993

Pozzo, T., Levik, Y., & Berthoz, A. (1995). Head and trunk movements in the frontal plane during complex dynamic equilibrium tasks in humans. *Experimental Brain Research, 106*(2), 327-338. https://doi.org/10.1007/BF00241128

Rodrigues, S., Vickers, J., & Wiliams, A. M. (2002). Head, eye and arm coordination in table tennis. *Journal of Sports Science, 20*(3), 187-200. https://doi.org/10.1080/026404102317284754

Rodrigues, S. T., Ferracioli, M. C., & Denardi, R. A. (2010). Learning a complex motor skill from video and point-light demonstrations. *Perceptual Motor Skills, 111*(2), 307-323. https://doi.org/10.2466/05.11.23.24.25.PMS.111.5.307-323

Schmidt, R. A., Lee, T. D., Winstein, C., Wulf, G., & Zelaznik, H. N. (2018). *Motor control and learning: a behavioral emphasis* (6th ed.). Human Kinetics.

Shanidze, N. (2010). Eye–head coordination in the guinea pig I. Responses to passive whole-body rotations. *Experimental Brain Research, 205*(3), 395-404. https://doi.org/10.1007/s00221-010-2374-4

Stout, D. E., & Ruble, T. L. (1995). Assessing the practical significance of empirical results in accounting education research: The use of effect size information. *Journal of Accounting Education, 13*(3), 281-298. https://doi.org/10.1016/0748-5751(95)00010-J

Talmon-Chvaicer, M. (2008). *The hidden history of capoeira: a collision of cultures in the brazilian battle dance*. University of Texas Press.

Velotta, J., Weyer, J., Ramirez, A., Winstead, J., & Bahamonde, R. (2011). Relationship between leg dominance tests and type of task. *Biomechanics in Sports, 29*(Suppl. 11), 1035-1039.

Vickers, J. N. (2011). Mind over muscle: the role of gaze control, spatial cognition, and the quiet eye in motor expertise. *Cognitive Processing, 12*(3), 219-222. https://doi.org/10.1007/s10339-011-0411-2

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