MedCrave
Step into the World of Research

MOJ Applied Bionics and Biomechanics

Mini review

Open Access CrossMark

# The relation between posture and fighting style: case of kung fu wushu (sanda)

## Abstract

The aim of this study is to analyze the relationship between initial posture (pre-contact posture) and combat style (boxing, foot and fight); thus, to establish a specific modeling. The descriptive analytical method of the video recordings of the combats organized with our sample (n=6) (2 of each combat style) was used to obtain the initial kinogram via the Dart Fish software. Inter-style postural similarities and extra-style postural differences were found, which helped us to put in place specific postural indices. Knowing the opponent's fighting style may betray some of his combat strategy, but can we hide these postural clues? Or more, can we give false clues (a lure) to deceive the opponent, which will make combat a rather mental challenge.

**Keywords:** fighting, posture, fighting style, sanda

Volume 4 Issue 2 - 2020

Haceini Ayoub
Setif university, Algeria

**Correspondence:** Haceini Ayoub, Setif university, SPAPSA Loboratory, Algeria, Email Ayoub.haceini.mhs@hotmail.fr

**Received:** March 09, 2020 | **Published:** April 30, 2020

## Introduction

The humain body, this extremly complex organic system that is composed of 206 bones, 400 articulations and 600 muscles[1] is directed by a nervous system that is divided into the central nervous system (brain, cerebellum, brainstem and spinal cord) and peripheral formed by ganglia and nerves.[2] Knowing that in this case the brain will have to analyze about $10^{18}$ bits/s of data and that the most developed processor to date can analyze about $10^{12}$ bits/s of data, leads us to ask various intriguing questions about the process used so that the brain can handle all of these muscles that are considered the only and ultimate engine of this human vessel. Is there a comprehensive program applied or it is just a chain of spontaneous reaction to actions taken? The world of sport is a field where man always tries to challenge and push these physical, technical and mental abilities to the highest possible level. Therefore, the management of body movements is very essential. It remains to discover all the chains action- reaction, which passes on the level of the body. Therefore, in the course of this study that is done on a combat sport, we will try to look for the early signals of some movements in the gesture of the eye.

Perception is our window to the inner and outer world; it consists of sensory information that analyzes and compares the data to others anchored in memory, and then by relatively logic makes a decision that turns into electrical signals produced by the SNC to the motor device. Thus, we will seek the existence of mental structures that govern the movement. Combat is a perfect driving situation to see an amalgam of techniques (motor) and strategy (cognitive) that aims at ultimately winning a victory over the opponent or rather to defeat the opposing strategy. But, in order to reach this goal, the combatant must provide himself with a set of perceptive-cognitive information that will be the basis of his decision-making during the fight that will be transformed into motor action.[3] Actually, it is the improvement of the perception-action relation.[4] This study will focus on the perceptual information that interests the fighter, and among them the technical preferences of the opponent (his fighting style). Therefore, a postural analysis could enlighten us on the results of the intra-style and extra-style comparison of Sanda fighters. The objective is to try to find out if the fighters of the same fighting style adopt a specific posture during the combat, and thus this posture will become a characteristic of the style of combat and one will be able to affirm from its detection in a combat during a fight that is of style fist, foot or fight. Modern cognitive theories have had a great impact on sport and its field of application. In our research, it is applied to study our problem on the side of only one vision, the "dynamic approach." More precisely, "Lambda model" that we saw was the most adapted to our research objectives. The dynamic approach arose as a controversy of the classic cognitive approach that had flaws in explaining certain notions such as context, meaning-making, and situational-subject coupling. Still, for a good understanding of the new vision of this approach, it is imperative to review the main successor theories, which are the classical computational approach and the neo-cognitive approach.

The theoretical framework used in this study is the thermodynamic approach[5] for a maximum approach to the reality experienced during a fight. The results of this study will be innovative, because early knowledge of the adversary's fighting style will be (according to the testimony of some Sanda coaches and fighters) a major asset to accelerate and improve the intervention in the adjustment of the chosen strategy. Also, the decrease in the decision-making risk factor, which is under great pressure from this sport characterized by the long duration of combat[6] and the ballistic motor actions (a dynamic situation).[7]

## Epistemological platform

This research is a part of the analysis of nonlinear dynamic systems. It focuses on the formation of behavioral patterns based on the notion of perception-action cycle.[8,9] The perception-action cycle accounts for the fact that there is a symmetrical and unambiguous relationship between information and action. Information specifies motion via forces and motion specifies information through the flow it generates. The information is used directly to control the coordinating structure, which is the functional structure that allows a set of muscles and joints to be managed as a unit. This coordinating structure is dissipative, that is to say; it organizes itself from the energy flows that pass through it. In this context, it is a question of studying the transactions between the informational variables and the kinetic variables through the topology of the coordination and the modeling of its components.[8] The perceptive motor space defines the set of possible relations between the information and the action in the space of the constraints. It is characterized by energy gradients and equilibrium points that correspond to optimal-efficient, and stable solutions of coordination. The further the subject is from the optimal solution, the less stable it is and the less economical it is, too. To learn is to discover and reinforce a relationship between informational variables and kinetic variables of the perceptual-motor space of the task. We learn by exploring the perceptual-motor space. This exploration can be guided by the presence of augmented information.[10] On the other hand, the modification of the coordination corresponding to the optimal solution can be facilitated by the modification of the perceptual-motor space produced by an adjustment of the constraints of the task.

The subject learns an optimal solution, i.e. to discover a specific relationship between informational and kinetic variables. For this reason, he also learns the most effective perceptual-motor space exploration strategies to discover the optimal solution(s). Behaviorally, he learns to master the degrees of freedom of the coordinating structure. The ecological approach, in its various currents, was first built around the questioning of the basic meta-theoretical postulates of the cognitive approach.[11] In fact, it has given new impetus to research on movement control and learning.[12] It also stimulated thinking about the motor program concept limits.[13] However, given the current state of knowledge, it would be premature to consider the ecological approach as an exclusive avenue for the study of motor skills. Some points can be raised to support this statement. First, it seems difficult to exclude the intervention of cognitive regulation in the control of motor skills, even for those that lend themselves to dynamic analysis.[14] Here it is the role of the intention that should be clarified. Considering intention as an additional constraint in the system seems not enough to provide little explanation of the mechanisms that modulate the behavior of this system. Secondly, the level of macroscopic analysis adopted by the ecological approach often leads to the impossibility of deciding between the theoretical models solely on the basis of empirical data. The ecological approach is not concerned with identifying the sensory-motor mechanisms that underlie the perception-action coupling to focus on what is perceived and/or controlled.[11]

The discussion is then shifted to the meta-theoretical aspects which, by their very nature, do not lend themselves to refutation. These are external critics. Other problems, internal to the ecological approach, can also be raised. For example, the methodological paths that can be used to identify the variables actually used at the perceptual and motor level, as part of the perception-action coupling, must be specified. The presence of a correlation between specific variables does not guarantee that these variables are those actually used or controlled by the sensory-motor system. Fourthly, it is necessary to extend the available results to other tasks than those used primarily in the context of the ecological approach (interception in monocular vision of a mobile moving at a constant speed, cyclic tasks involving the coordination of two components). On the other hand, a theory should be proposed to account for learning in the course of direct perception (Table 1).[11] The table below clarifies differences between these approaches.

**Table 1** The table below clarifies differences between these approaches

| | Classical cognitive | New cognitive | Coupling |
|---|---|---|---|
| Context | Pre-established | Done or meaning for actions | Done or meaning for actions |
| Situation | Experimental | Designed in the context of interaction | Local |
| Principles | - Objectif<br>- Contraints<br>- Variables controlled<br>- Repeatable | - Interaction<br>- Includes<br>- Singular<br>- Contingent<br>- Evolutionary<br>- Incertitude<br>- Temporality | - Permanent transformation<br>- Perception<br>- Globality<br>- Interdisciplinarity<br>- Participation |
| Action concept | Inherent | Conduct in perception and realization | - Objective oriented<br>- Actions guides perception<br>- Attract by the novelty |
| Expert | High performance in a given field due to prior skills | Performs actions accepted to the environment | - Coupling expert<br>- Give context meaning and acts of acceptable face the environment |

## Methodology

The method we used in this study is the descriptive analytical method.[15] The video data of the fights, the goal is to take the different initial postures (pre-contact kinograms). Our sample was (6) Sanda fighters (2 for each style "boxing, kicking and wrestling"), activated and healthy, males, aged between 18-20 years (senior category), weight between 70-75kg. We also used 3 cameras (Sony DCR-HC52E camera (top view), Samsung hyperdisk camera (side view), and a Mobile digital camera (side view)). We would like to mention that a preliminary study was done two months before the main study with 3 fighters (one fighter of each style) in order to see the technical feasibility of the study and to find the possibilities of failures. For the main study, we started with a measurement of the lengths of the body segments for more precision when modeling the initial posture, put randomly (2) groups which each has a style of combat, then organize the fighting according to the following diagram: Intra-style: boxing 1 - boxing 2; kicking 1- kicking 2; wrestling 1- wrestling 2; Extra; style: boxing 1 - kicking 2; kicking 1 - wrestling 2; wrestling 1 - boxing 2.

After that, We recorded videos of organized fights and dealt with the film using analysis program Dart fish 4.5.2.0 and takes out the kinograms, we take the initial kinogram of each fighter, we extract the Cartesian data of the study points with a cinematic uncertainty equal to 0.1% of the field of vision, uncertainty of attachment of points equals 0.1 cm.[16] (We take the right ankle as the point of origin of the orthonormal mark) for each fighter. We do a statistical analysis using the ANOVA method to finally create with a rough modeling of this initial posture.

## Results of research

According to the table and the diagrams of the boxing style, one observes various similarities between the two modelizations among the coordinates: For the legs, the line which passes by the legs indicates an angle of approximately 45 with the axis (OX) and the distance between the ankles is less than the length between the shoulders (Table 2) (Figure 1). However, there is a slight flexion in the knees. Concerning the hip, Y has the left side which is advanced compared to the right side. For the center of gravity, its projection on the ground is almost in the middle of the distance between the ankles. On the other hand, the line that goes from the shoulders is parallel to the line that goes through the hip. Yet, for the elbows, great bending at the elbows and the distance between code and hip is small. For the wrists, too close to the head and above the level of the shoulders. According to the table and kicking-style diagrams, we observe various similarities between the two modelizations among the coordinates: For the ankles, the line which passes by the ankles indicates an angle of approximately 0 with the axis (OY) and the distance between the ankles is more than the length between the shoulders. However, there is a big bending at the knees or one of them. For the hip, Y has the left side which is advanced compared to the right side. For the center of gravity, its projection on the ground is a little far from the middle of the distance between the ankles. The line that goes from the shoulders is not parallel to the line that goes through the hip. On the other hand, the medium bending at the elbows and the distance between code and hip is small. For the wrists, too far from the head and below the level of the shoulders (Table 3) (Figure 2).

**Table 2** The table below represents the Cartesian data of the main points of the initial posture in boxing fighters

| **Posture** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cartesian coordinates** | **Ankle** | | **Knee** | | **Hip** | | **Shoulder** | | **Elbow** | | **Wrist** | |
| **1** | **L** | **R** | **L** | **R** | **L** | **R** | **L** | **R** | **L** | **R** | **L** | **R** |
| **X** | 0 | 46 | 5 | 51 | 0 | 40 | 5 | 51 | 16 | 57 | 13 | 35 |
| **Y** | 0 | 85 | 33 | 48 | 18 | 72 | 17 | 68 | 0 | 42 | 17 | 0 |
| **Z** | 0 | -17 | 85 | 76 | 180 | 183 | 273 | 275 | 204 | 206 | 309 | 321 |
| **2** | | | | | | | | | | | | |
| **X** | 0 | 54 | 4 | 51 | 17 | 51 | 11 | 52 | 6 | 42 | 1 | 28 |
| **Y** | 0 | 59 | 15 | 51 | 59 | 34 | 68 | 11 | 68 | 26 | 6 | 43 |
| **Z** | 0 | 0 | 115 | 85 | 236 | 221 | 413 | 395 | 325 | 314 | 376 | 386 |

**Table 3** The table below represents the Cartesian data of the main points of the initial posture in kicking style fighters

| **Posture** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cartesian coordinates** | **Ankle** | | **Knee** | | **Hip** | | **Shoulder** | | **Elbow** | | **Wrist** | |
| **1** | **L** | **R** | **L** | **R** | **L** | **R** | **L** | **R** | **L** | **R** | **L** | **R** |
| **X** | 0 | 39 | 0 | 22 | 12 | 17 | 25 | 14 | 27 | 31 | 18 | 16 |
| **Y** | 0 | 108 | 30 | 98 | 30 | 57 | 68 | 62 | 42 | 51 | 85 | 106 |
| **Z** | 0 | 11 | 70 | 80 | 197 | 199 | 280 | 285 | 208 | 218 | 252 | 225 |
| **2** | | | | | | | | | | | | |
| **X** | 0 | 32 | 8 | 22 | 0 | 30 | 12 | 27 | 9 | 35 | 20 | 20 |
| **Y** | 0 | 188 | 61 | 166 | 65 | 113 | 103 | 149 | 121 | 167 | 160 | 196 |
| **Z** | 0 | 0 | 55 | 65 | 134 | 134 | 205 | 198 | 154 | 151 | 179 | 179 |

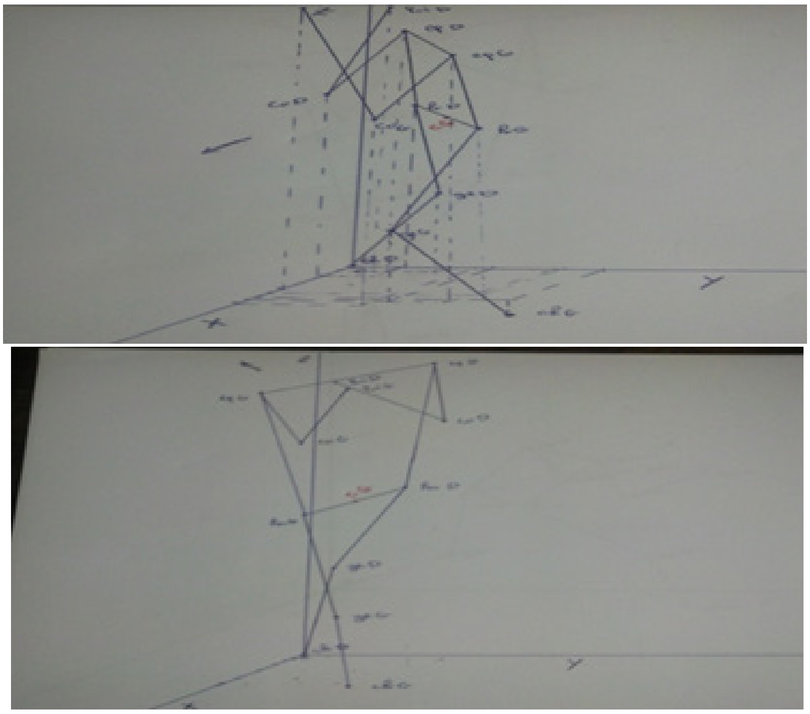

**Figure 1** Diagrams representing the models of the initial postures 1 and 2 of boxing-style fighters.

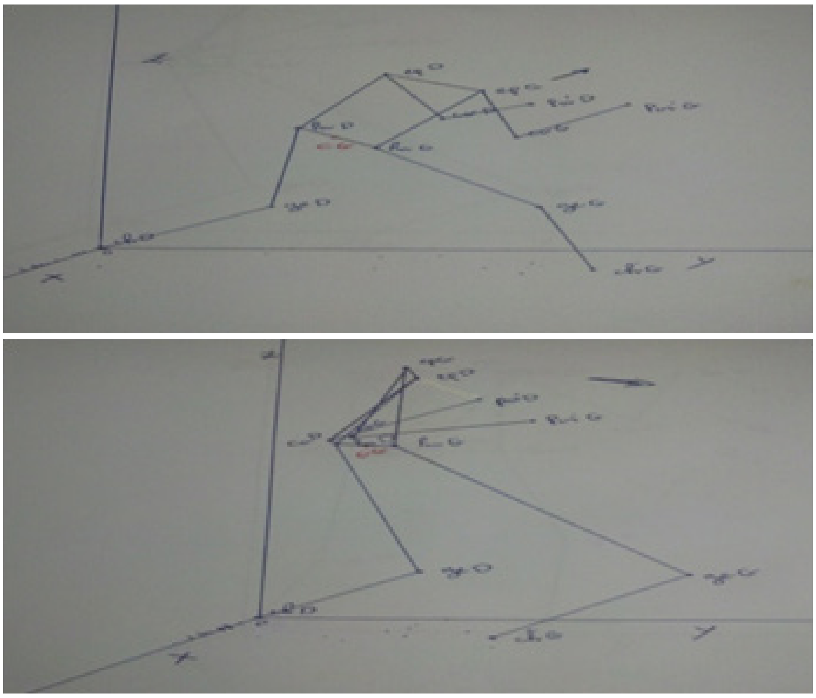

**Figure 2** Diagrams representing the models of the initial postures 1 and 2 of the kicking-style fighters.

According to the table and the schemas of the wrestling style, we observe various similarities between the two modelizations among the coordinates: For the ankles, the line which passes by the ankles indicates an angle of approximately 0 with the axis (OY) and the distance between the ankles is almost equal as the length between the shoulders. Concerning the knees, there is a slight flexion in the knees. For the hip, Y has the left side which is advanced compared to the right side. For the center of gravity, its projection on the ground is almost in the middle of the distance between the ankles. For the shoulders, the line that goes from the shoulders is parallel to the line that goes through the hip. For the elbows, medium bending at the elbows and the distance between code and hip is great. For the wrists, far from the head and at the shoulders (Table 4) (Figure 3).

**Table 4** The table below represents the Cartesian data of the main points of the initial posture in the wrestling style fighters

| **Posture** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cartesian coordinates** | **Ankle** | | **Knee** | | **Hip** | | **Shoulder** | | **Elbow** | | **Wrist** | |
| **1** | **L** | **R** | **L** | **R** | **L** | **R** | **L** | **R** | **L** | **R** | **L** | **R** |
| **X** | 0 | 28 | 11 | 34 | 12 | 20 | 10 | 13 | 31 | 26 | 42 | 35 |
| **Y** | 0 | 93 | 0 | 79 | 9 | 70 | 0 | 76 | 28 | 96 | 19 | 98 |
| **Z** | 0 | 0 | 83 | 79 | 206 | 217 | 323 | 323 | 245 | 232 | 302 | 283 |
| **2** | | | | | | | | | | | | |
| **X** | 0 | 16 | 15 | 8 | 14 | 17 | 20 | 20 | 27 | 30 | 12 | 12 |
| **Y** | 0 | 115 | 34 | 115 | 42 | 98 | 45 | 98 | 83 | 157 | 95 | 155 |
| **Z** | 0 | 21 | 83 | 104 | 204 | 206 | 297 | 304 | 227 | 251 | 291 | 295 |

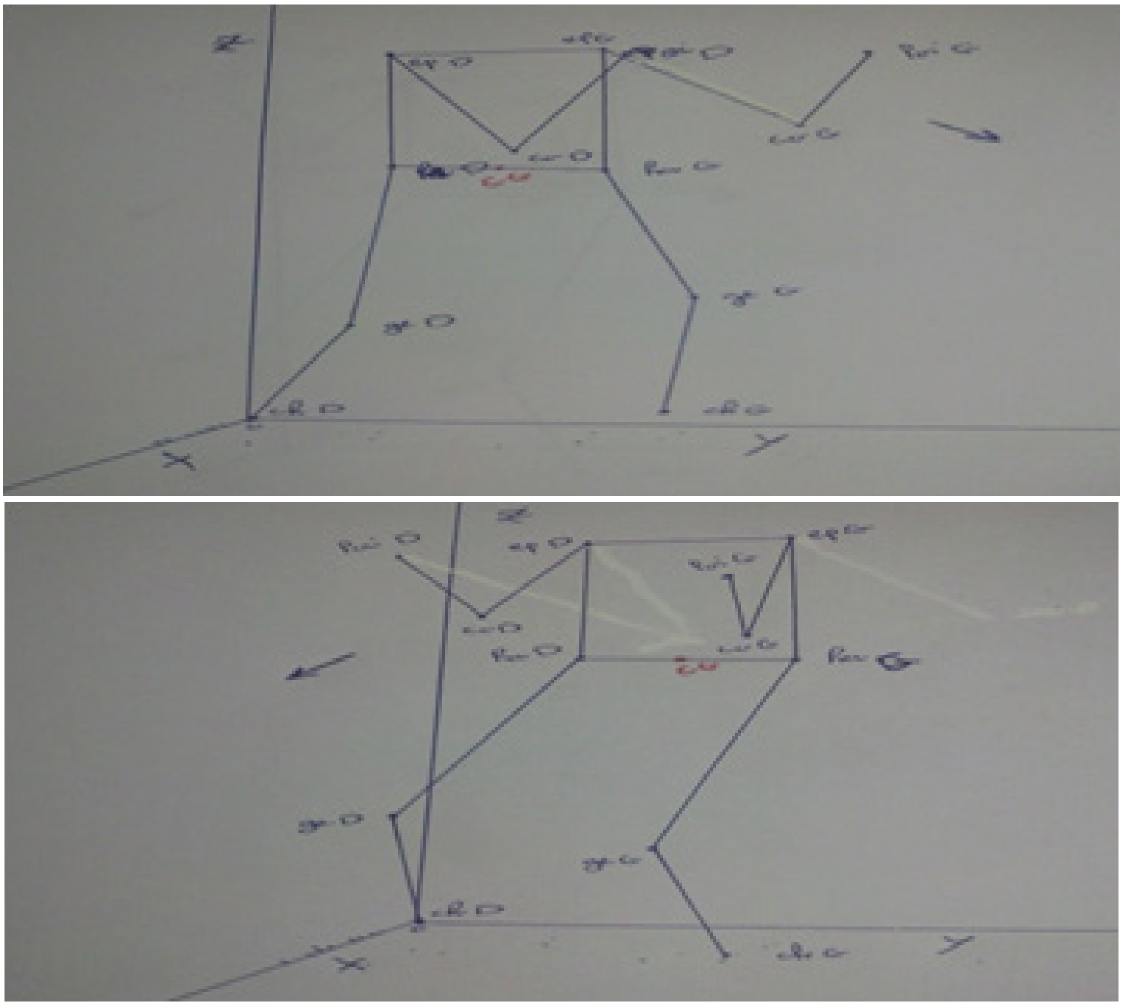

**Figure 3** Diagrams representing models of the initial postures 1 and 2 of wrestling style fighters.

## Discussion

According to our analysis and our explanations for the initial postures of each style, and relying on the interviews made with the combatants, we arrived at the following results: For the first sub-hypothesis that says that "we can perceive the opponent's fighting style according to visual cues in the initial posture", we affirm that, and we have arrived at establishing the following schema: Table representing the analytical results of the initial postures of each style In addition, each motor learning induces a certain posture[17] and that by the acquisition of special techniques Measure, it can be said that there is a relationship between the posture of the fighter and that technical favorable (Table 5).[18]

**Table 5** The table below is a summary of the results obtained

| Style/Posture | Boxing | Kicking | Wrestling |
|---|---|---|---|
| **Supports** | 45° | -45° | -45° |
| **Lowering** | Absence | Presence | Semi |
| **Hip** | Not parallel | Not parallel | Parallel |
| **Offset** | Absence | Presence | Absence |
| **Trunk** | Absence | Presence | Absence |
| **Cover ratings** | Good | Medium | Not good |
| **Face covering** | Good | Not good | Medium |

## Comparative discussion between the initial positions of the fighters of each style

**Boxing style:** We note that the fighters are positioned in a 45° angle with the main axis in order to keep the maximum of balance, because this position decreases the probabilities of Facial or lateral imbalance which is the most difficult,[19] which allows the boxing-style fighters to focus on the fist attacks without fear on the side of the low kick (low kick) cashed. Also, the non flexion of the knees makes it possible to better reach the face of the opponent with the punches, and thus to target the majority of the body and more. The leaning of the hip for the left side is a phenomenon known in the martial arts, to avoid bending the trunk and therefore to reduce the area of impact of the attacks. In addition to the fact that it is easier to retreat in this position, there is also the fact that this position gives a short distance for the left punch and therefore faster impact; while it gives power for the punch right with a long distance, and torsion of the trunk.[20] The point of projection of the center of gravity that is near the center of the distance between the ankles increases the balance of the body. Therefore, the parallelism of the shoulder line and the hip line means no torsion of the trunk. And so, we will have an advanced left fist and the other behind, so the speed will be on the left and power on the right. The angle of flexion of the elbow is sub-maximal, which brings the fists closer to the body, so their short distance with the hip means that there is a good protection of the odds. The position of the wrists that is above the level of the shoulders gives a good protection of the face, more than it increases the attack distance punch and therefore increases the amount of movement that has been generated.

**Kicking style:** The small angle between the ankle line and the main line helps to have a good balance to execute a foot attack and the rotation of the foot of support. Also, the distance between the ankle increases the length of the trajectory kick, which included a large amount of the generated motion. There is great flexion in the knees to lower the body more possible to replace the existing lack of balance because of the wide foot. In addition it is an optimal preparation for triggering a quick kick (model ressors), so adds an elastic energy to muscular kinetic energy. The leaning of the left side of the hip compared to the right side is the same reason as fighters type fist. The distance of the projection of the center of gravity of the middle between the ankles makes the weight shift on one leg called the support leg and the other foot will be freer in the attacks, the kicking fighters have less of error in spatial postures than other styles.[21] The shoulder line is not parallel to the hip line, and therefore there is a greater relaxation of the body because of the shoulders feet compatibility, and there will be more focus on foot attacks, in addition to the advancement of one of the side of the shoulder gives more energy when performing a kick. The average bend of the elbows amounts to the minor number of opposing attacks to the face, because the fighters of the foot type put a distance between them and the opponent to make the foot attacks and so as soon as it feels a danger, it triggers a blow of foot that holds the opponent at bay. And so the risk of receiving an opponent's punch is almost zero. For the wrist which is under the level of the shoulders in order to protect the odds, a zone of risk if the opponent feints laterally a foot attack.

**Wrestling style:** The approach of the ankle line to the main axis is an effect resulting from the strategy used by the fighters of this style, as we saw in the fighting and asserted by the fighters that they take this posture as a bait to sin the rival, the latter as soon as he sees the leg too much advance, it triggers a low kick, and there the fighter tries to catch the battering foot of the opponent, after he will be easy to unbalance it and make it fall. Also, the distance between the ankles is almost equal to the one between shoulders which gives balance without reducing the level of reaction in the fighter. The average flexion of the knees gives a comfortable position for hands-on with judo technique (the discipline for explanatory purposes) and tried to make it fall after, and that is very well known in this discipline. The location of the projection of the center of gravity of the body on the ground is in the middle of the distance between the ankles, which gives a good balance and it is noticed that with each attack adversary, this type of style lowers their center of gravity still more. The shoulder line unlike the other two styles is parallel to the hip line, and that to get the chances of attack with both hands fair by grabbing one leg of the opponent or both, and there is a need for a great coordination between the lower and upper limbs.[22] There is also an average bend in the elbow to have a low position of the hands for more chance to seize the opposing legs, so the risk of attacks on the face are almost safe because this type of fighter when he perceives a danger to the face, he reacts immediately with a hand-to-hand attack to cover himself in the torso of the opponent by breaking the distance, in addition he tries to destabilize him. Also the distance between the elbows and the hips is great which supports the last resonance. The wrists are below the shoulder level, because the fighters of this style do not focus on the fist attacks, but they use that to pretend the opponent and deconcentrate it by camouflaging the melee attack.

Postural sway during human quiet standing is often quantified by measuring the motion of the Center of Pressure (CoP), namely the point of application of the ground reaction force vector. CoP shift profiles are closely related to the sway of the Center of Mass (CoM) during quiet standing.[23] Thus, the motion of the standing body can be estimated from CoP patterns with an acceptable accuracy either in the context of the single inverted pendulum model[24] or the double pendulum

**Citation:** Ayoub H. The relation between posture and fighting style: case of kung fu wushu (sanda). *MOJ App Bio Biomech.* 2020;4(2):42‒49.
DOI: 10.15406/mojabb.2020.04.00132

model with hip and ankle joints.[25] Characterizing CoP motion is of critical importance for understanding neural mechanisms of postural control,[26–30] as well as for better diagnosing severity of neurological diseases with postural instability.[31–34] CoP complex fluctuations can be modeled as a two dimensional stochastic process,[35–37] in the anterior-posterior (AP) and medio-lateral (ML) directions on the horizontal plane. Due to complexity, CoP time series have been characterized by a number of simple, usually scalar valued, measures or indices, such as sway size,[38] mean sway velocity,[39] and scaling exponents.[40,41] Since each index can measure only a limited aspect of the process, two sway time series characterized by the same sway size. For example, it can be accompanied by completely different temporal patterns. A set of indices that capture different (i.e., uncorrelated and/or independent) aspects of sway might be able to describe details of the process.[42] Alternatively, some aspect of sway characterized by an appropriate index might be able to reflect inherent neural control of postural dynamics, and others might represent merely individual motor habits and/or body parameter dependent biomechanics.[43–47]

## Conclusion

Research in the field of biomechanics of combat sports following the thermodynamic approach remains a real and dynamic path that is as close as possible to real combat. The results we obtained confirm the existence of a postural model that is common to each combat style, and the perception of these parameters allows us to better understand the combat style of his opponent, which allows him to establish a combat strategy. Allowing easy access to the weak point of the opponent by reducing the time of analysis of his gestures. One can say that there is a relation between the posture of the combatant and the favorable technical one. But to access more concrete results, we need to expand our sample and make a more detailed analysis. Each motor learning leads to a certain posture and that by the acquisition of particular techniques. The results of this study will be of great help to Sanda coaches or even other combat sports who have a similar combat system, because by having concrete information about the opponent's fighting style, he will be possible to anticipate these actions and to prepare an effective strategy that will lead to victory. It remains to develop the perception of these postural indices with accuracy and speed because the duration of the fight is short. Also a question will arise about the possibility of hiding these postural indices. The time course of the center of pressure (CoP) during human quiet standing, corresponding to body sway, is a stochastic process, influenced by a variety of features of the underlying neuro-musculo skeletal system, such as postural stability and flexibility. Due to complexity of the process, sway patterns have been characterized in an empirical way by a number of indices, such as sway size and mean sway velocity. Here, we describe a statistical approach with the aim of estimating "universal" indices, namely parameters that are independent of individual body characteristics and thus are not "hidden" by the presence of individual, daily, and circadian variations of sway.

In this manner, it is possible to characterize the common aspects of sway dynamics across healthy young adults, in the assumption that they might reflect underlying neural control during quiet standing. Such universal indices are identified by analyzing intra and inter subject variability of various indices, after sorting out individual specific indices that contribute to individual discriminations. It is shown that the universal indices characterize mainly slow components of sway, such as scaling exponents of power law behavior at a low frequency regime. On the other hand, most of the individual specific indices contributing to the individual discriminations exhibit significant correlation with body parameters, and they can be associated with fast oscillatory components of sway. These results are consistent with a mechanistic hypothesis claiming that the slow and the fast components of sway are associated, respectively, with neural control and biomechanics, supporting our assumption that the universal characteristics of postural sway might represent neural control strategies during quiet standing.

## Acknowledgments

None.

## Conflicts of interest

The authors declare there are no conflicts of interest.

## Funding

None.

## References

1. Kendall FP, Creary Mc, Provance KE, et al. Les muscles: bilan et étude fonctionnels, anomalies et douleurs posturales, 5th ed. France: française Pradel. 2007.
2. Bear FM, Connors BW, Paradiso MA. Neurosciences à la découverte du cerveau, 3rd ed. France: française pradel; 2010.
3. Rousseu C, Crémieux J. Perception de l'orientation visuelle chez des experts en taekwondo. *Staps*. 2004/3;65:79–86.
4. Blanchi JP. Biomécanique du mouvement et APS. Vigot Paris. 2000.
5. Temprado JJ, Laurent M. Approches cognitives et écologique de l'apprentissage des habiletés motrices en sport. In: Psychologie du Sport. *Questions actuelles Revue EPS*. 1995.
6. Mc Morris T, Graydon J. Effect of exercise on cognitive performance in soccer specific tests. *J Sports Sci*. 1997;15(5):459–468.
7. Macquet AC. De la compréhension de la situation à la distribution de l'information: la prise de décision en sport de haut niveau. Habilitation a dirigé des recherches. Universite de bretagne-sud, 2016.
8. Beek JP. Task-specific dynamics and the study of perception and action: A reaction to von Hofsten. *Ecological Psychology*. 1989;3(1):35–54.
9. Kugler PN, Turvey MT. Information, natural law, and the self-assembly of rhythmic movement. Hillsdale, NJ: Lawrence Erlbaum Associates; 1987.
10. Newell A, SIMON HA. Human problem solving. Englewood Cliffs NJ: Prentice Hall; 1972.
11. Michaels CF, Carello C. Perception Directe. Englewoodcliffs. NJ: Printicehall; 1981.
12. Abernethy B, Sparrow WA. The rise and fall of dominant paradigms in motor behaviour research. In: Summers JJ, editor. Approaches to the study of motor control and learning. 1992. p. 3–45.
13. Semjen A. Qu'y a-t-il de programmé dans les activités motrices? Les avatars du programme moteur. *Science et Motricité*. 1994;23:48–57.
14. Paillard J. The cognitive penetrability of sensorimotor mechanisms: A key problem in sport research. *International Journal of Sport Psychology*. 1991;22:244–250.
15. Talbot L. Principales and Practice of Nurcing Research, 1995.
16. Moreau B. Comparative mechanical analysis of the same judo projection: Seoi Nage, carried out by five experts from the French Judo Federation. France, 2003.
17. Perrot C, Deviterne D, Perrin P. Influence of training on postural and motor control in a combative sport. *J Hum Mov Studies*. 1998a;35:119–136.

18. Paillard T, Salon MCC, Kerlirzin Y, et al. Réponses posturo-cinétiques du judoka en fonction de sa motricité spécifique en phase offensive. *Science et motricité*. 2002;45:119–124.

19. Amblard B, Cremieux J, Marchand A, et al. Lateral orientation and stabilisation of human stance: static versus dynamic cues. *Exp Brain Res*. 1985;61(1):21–37.

20. Cadière R, Trilles F. JUDO: Analyse et propositions pour la pratique de son enseignement. Paris: Éditions Revue EPS, 1998.

21. Rousseu C, Cremieux J. Perception of verticality in French élite taekwondo athlètes. 1999.

22. Inokuma I, sato N. Best Judo. Tokyo: Kodansha International; 1986.

23. Morasso PG, Spada G, Capra R. Computing the com from the cop in postural sway movements. *Hum Mov Sci*. 1999;18:759– 767.

24. Lafond D, Duarte M, Prince F. Comparison of three methods to estimate the center of mass during balance assessment. *J Biomech*. 2004;37(9):1421–1426.

25. Colobert B, Crétual A, Allard P, et al. Force plate based computation of ankle and hip strategies from double inverted pendulum model. *Clin Biomech*. 2006;21(4):427–434.

26. Winter DA, Patla AE, Prince F, et al. Stiffness control of balance in quiet standing. *J Neurophysiol*. 1998;80(3):1211–1221.

27. Peterka R. Sensorimotor integration in human postural control. *J Neurophysiol*. 2002;88(3):1097–1118.

28. Bottaro A, Casadio M, Morasso PG, et al. Body sway during quiet standing: is it the residual chattering of an intermittent stabilization process? *Hum Mov Sci*. 2005;24:588–615.

29. Kiemel T, Oie KS, Jeka JJ. Slow dynamics of postural sway are in the feedback loop. *J Neurophysiol*. 2006;95:1410–1418.

30. Kim S, Nussbaum MA, Madigan ML. Direct parameterization of postural stability during quiet upright stance: effects of age and altered sensory conditions. *J Biomech*. 2008;41:406–411.

31. Horak F, Nutt J, Nashner L. Postural inflexibility in Parkinsonian subjects. *J Neurol Sci*. 1992;111(1):46–58.

32. Rocchi L, Chiari L, Horak F. Effects of deep brain stimulation and levodopa on postural sway in Parkinson's disease. *J Neurol Neurosurg Psychiatry*. 2002;73:267–274.

33. Maurer C, Mergner T, Xie J, et al. Effect of chronic bilateral subthalamic nucleus (stn) stimulation on postural control in Parkinson's disease. *Brain*. 2003;126(5):1146–1163.

34. Visser JE, Carpenter MG, Dervan Kooij H, et al. The clinical utility of posturography. *Clin Neurophysiol*. 2008;119(11):2424– 2436.

35. Carroll JP, Freedman W. Nonstationary properties of postural sway. *J Biomech*. 1993;26(4-5):409–416.

36. Collins JJ, De Luca CJ. Open loop and closed loop control of posture: a random walk analysis of center of pressure trajectories. *Exp Brain Res*. 1993;95:308–318.

37. Loughlin PJ, Redfern M, Furman J. Time varying characteristics of visually induced postural sway. *IEEE Transact*. 1996;4(4):416–424.

38. Seigle B, Ramdani S, Bernard PL. Dynamical structure of center of pressure fluctuations in elderly people. *Gait Posture*. 2009;30(2):223–226.

39. Raymakers J, Samson M, Verhaar H. The assessment of body sway and the choice of the stability parameter(s). *Gait Posture*. 2005;21(1):48–58.

40. Collins JJ, De Luca CJ. Random walking during quiet standing. *Phys Rev Lett*. 1994;73(5):764–767.

41. Milton J, Townsend JL, King MA, et al. Balancing with positive feedback: the case for discontinuous control. *Philos. Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*. 2009;367(1891):1181–1193.

42. Prieto TE, Myklebust J, Hoffmann R, et al. Measures of postural steadiness: differences between healthy young and elderly adults. *IEEE Trans Biomed Eng*. 1996;43(9):956–966.

43. Chiari L, Rocchi L, Cappello A. Stabilometric parameters are affected by anthropometry and foot placement. *Clin Biomech*. 2002;17(9-10):666–677.

44. Hue O, Simoneau M, Marcotte J, et al. Body weight is a strong predictor of postural stability. *Gait Posture*. 2007;26:32–38.

45. Baratto L, Morasso P, Re C, et al. A new look at posturographic analysis in the clinical context: sway density vs. other parameterization techniques. *Mot Control*. 2002;6(3):246–270.

46. Jacono M, Casadio M, Morasso PG, et al. The sway density curve and the underlying postural stabilization process. Mot Cont Champaign. 2004;8(3):292–311.

47. Van der Kooij H, Campbell AD, Carpenter MG. Sampling duration effects on centre of pressure descriptive measures. *Gait Posture*. 2011;34(1):19–24.