BIOMECHANICAL ANALYSIS OF THE FIGHT BY FRONTAL HEAD PRESSURE ON THE CHEST OF THE OPPONENT IN SUMO

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ABSTRACT
Introduction. The Sumo sport discipline is characterized by incomparable by the nature and character force interactions. The briefness of the fight requires the sumo wrestlers to possess a wide range of sports and technical, almost automated skills to manage their motor action depending on the opponent's qualification.
The present study aims to establish the phase structure, functional features, and mechanical principles of the sport-technical skills of the fight by frontal head pressure on the opponent's chest in sumo.
Methodology. For the purposes of the analysis, the fight is divided into separate phases, using a video computer system for determining the kinematic and energetic parameters of the movements.
Results. Taking into account the fact that the mass of the defeating athlete is 23.5% lower and he is 0.05 m shorter than the opponent, the results show three basic mechanical conditions that contribute to his victory during the fight: generating a powerful power torque from the lower limbs to raise and guide the upper body through the initial acceleration phase; creating and increasing the detour force arm in order to disturb the balance of the opponent in the sagittal plane and use its inertia of movement.
Discussion and Conclusion. The results of the study, on the one hand, justify the use of this sport technique against opponents with higher stature and mass. On the other hand, the resulting quantitative values of the parameters can serve to improve the training process, providing guidance on the qualities required for the competitors to use this technique and also for defensive actions.

Keywords: *Sumo; Biomechanical Parameters, Linear Velocity, Kinetic Energy, Center Of Gravity*

INTRODUCTION

The specificity of one or another type of single combat consists of the nature and content of the technical-tactical actions and the immediate conditions in which they are performed. A distinctive feature of the Sumo competitive combats is the creativity and speed of the fight. It usually lasts from 5 to 15 seconds and the first seconds of the fight are decisive. Secondly, there is a size limitation, with overlapping its limit leading to defeat. Third, there are immediate and significant power contacts of the head and body during the fight between the two sumo wrestlers who are powerless and non-comparable with none of the impact in other types of combat. A number of foreign authors have considered this issue in relation to other sports.

For that reason, many controversies arise related to how it is actually necessary to train the sumo wrestlers. In this regard, coaches generally prepare their athletes – sumo wrestlers intuitively, i.e., they use their experience gained from the technical, tactical actions of their past practice. However, considering the specific rules and distinctiveness of competitive activity in Sumo, this practice is not always appropriate for Sumo Sport.

The lack of specific habits to move competitors into the dojo and their misunderstanding of the particularities for performing the technical-tactical actions often lead to the loss of the most important competitions.

Despite its simplicity, the Sumo fight has several specific features, without which it is impossible to successfully and steadily participate in the competitions.

In today's professional sumo, the competition takes place in an inner circle with a diameter of just over 15 feet. The winner is this competitor, who has forced his opponent to touch the floor or forced him out of the circle. In this case, it is sufficient for the floor to be touched with any part of the body - a knee, a hand, or a head. The rules strictly prohibit any punches with a fist, fingers, or the edge of the palm, as well as kicks in the chest and abdomen, as well as attacking the throat and the area between the legs.

In this sport, competitors are not divided into categories, which often lead to ring meetings between unequal by weight partners. Although the technique undoubtedly plays a big role in sumo, nevertheless, the larger mass is decisive.

It is precisely for the reasons given, in practice it is impossible and inappropriate to compare the actions in sumo with other sporting combats.
Also, due to the lack of weight categories in sumo, the competitor with a higher weight usually has the advantage of winning the fight. For this reason, lighter competitor must use a different tactical technique, within the rules, that would have contributed to his victory.

This study examines this particular case of a significant difference in the weight of the two athletes and is an attempt to analyze and justify the use of a specific technique by the lighter competitor.
The aim of the present study is to identify the specific features and quantitative biomechanical parameters in the sport-technical way of fighting by attacking head pressure frontally on the opponent's chest. The established mechanical correlations would contribute to justifying the use of technical-tactical actions when the significant differences in the weight of the two opponents exist.

METHODS

Two sumo wrestlers took part in the experiments with the following anthropometrics data: participant 1, with a height of 1.85 m and weight of 1700 N, and participant 2, with a height of 1.80 m and weight of 1310 N.

A standard video camera with a cadence of 25 fps, set up stationary and with an optical axis perpendicular to the plane of motion, pre-calibrated within the 2D space used, was used to record motion actions, and the video files obtained were processed with a video computer analysis system (Arakchiiski, 2002). The system registers the vertical and horizontal coordinates in the 2D space of selected points on the body of the sumo wrestlers during the selected exercises. A 14-segmented model of the human body was used for each participant in the combat, the 2D coordinates of the following body points were recorded: in the lower limbs - ankle, knee and hip joints; in upper limbs - wrist, elbow and shoulder joints; private center of the mass of the head. Subsequently, the registered coordinates are processed with the corresponding software module of the system, which determines the trajectory of the Centre of gravity of the sumo wrestlers during the fight. The speeds and accelerations of the points scored, the time structure of the fight, and the kinetic energy of the attacking sumo wrestler are also calculated.

RESULTS AND ANALYSIS

Specific for some used combat techniques in sumo is the relatively unusual way of grip during the development of the combat for both athletes. This analyzed combat mode, shown in Figure 1, is slightly different from the one considered since it cannot be applied simultaneously by both sumo wrestlers. While the motor actions during the initial phase of the fight run similarly to other techniques, in the next phase, one wrestler exerts a pressure force frontal to the upper torso through his head. In this case, this is the left sumo wrestler.

For the purposes of the analysis, in Figure 2, the trajectory of the Centre of gravity of the left sumo wrestler is shown, as well as its linear velocities and kinetic energy – respectively, in Figures 3 and 4.

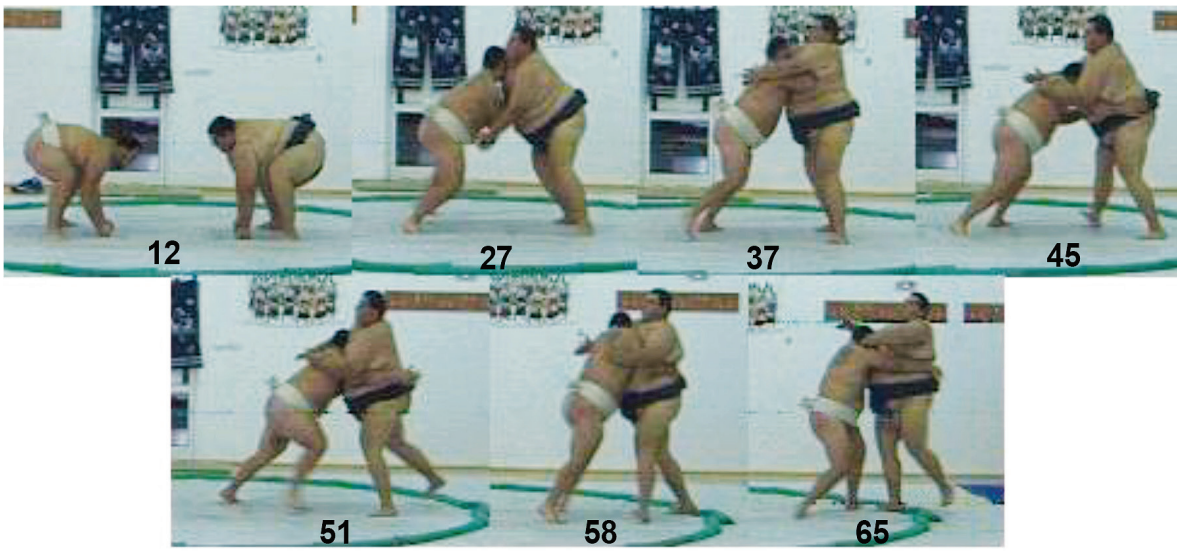


Figure 1. *Typical frames of the development of the fight by pressing the head on the opponent*

In order to accurately evaluate the obtained results, especially when comparing parameters that are the function of weight, it should be noted that the weight of the left wrestler is 23.5% less than the weight of the right one, and he is 0.05 m shorter. If similar parameters are compared between the different techniques, it is necessary to normalize the mass of the sumo wrestlers in advance.

The duration of the first phase (the initial acceleration of contact with the opponent) for the left wrestler here is 0.48 s, with the CG trajectory being "bulging", which means, as can be very accurately determined from the speed chart that the wrestler accelerates the deployment the hip joint (movement of the CG upwards) and subsequently heavily rotated according to knee joint. This mode of movement may be dictated by the objectives of the future attack or is the individual style of the sumo wrestler. Although the horizontal speed is 1.7 m / s, dephasing the maximums and the significantly lower vertical velocity leads to the said non-linearity of the trajectory. The accumulated kinetic energy at the end of the phase has a local maximum of 178 J.

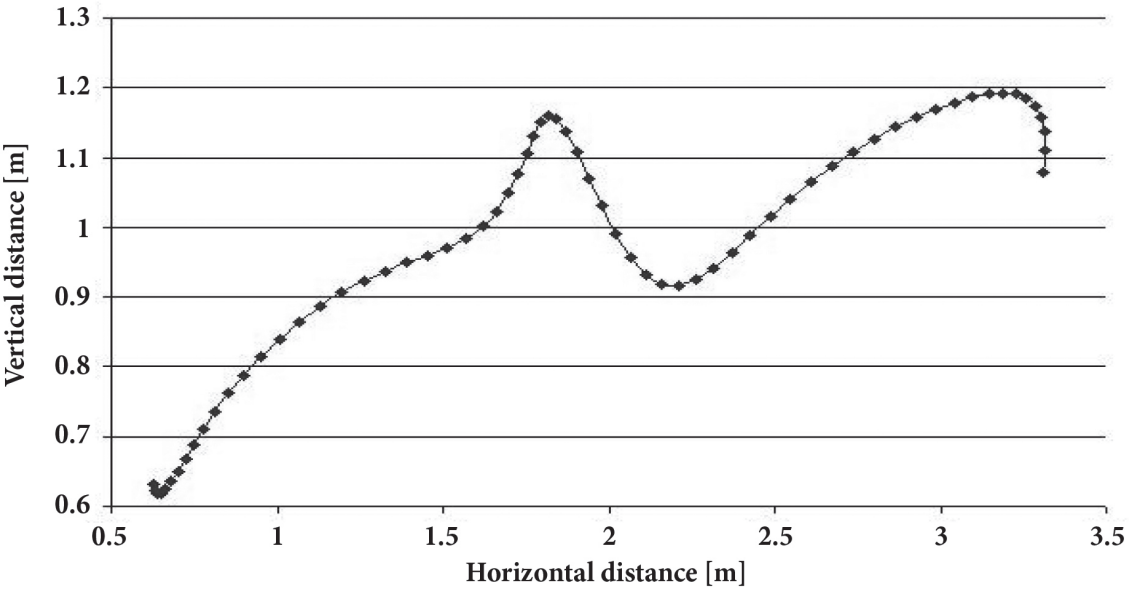


Figure 2. *Trajectory of the CG of the attacking wrestler during the fight by pressing the head on the torso*

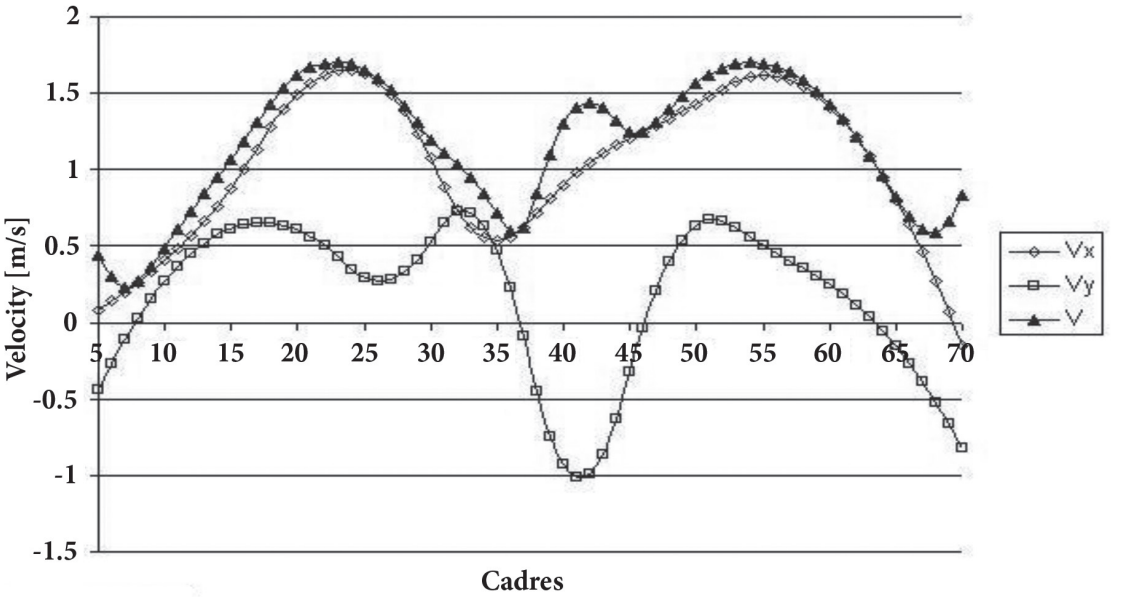


Figure 3. *Linear velocities of the CG the attacker during the fight with the head impact on the torso*

The next contact phase can be divided into two sub-phases. During the first one, the wrestler managed to keep his horizontal speed positive (local minimum of 0.5 m / s) and raise his CG by nearly 0.2 m upwards at the cost of straightening the opponent. In the next sub-phase, for about 0.4 seconds, the left-side sumo wrestler, tilting forward, lowers the CG by nearly 0.25 m and "snaps" his head into the opponent's chest by continuing to push him.

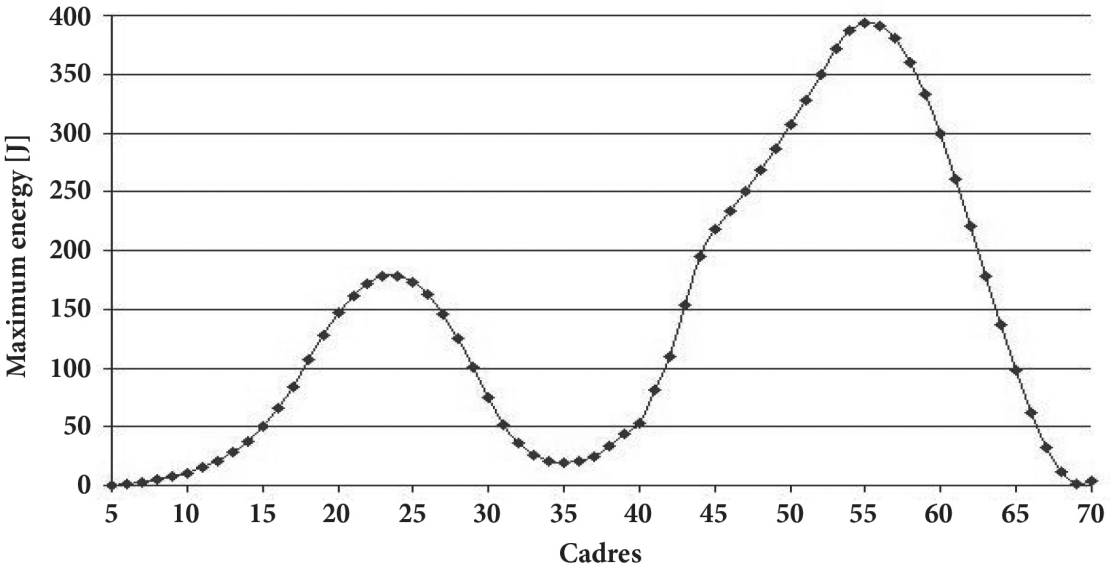


Figure 4. *Kinetic energy in the horizontal direction of the attacking wrestler in the fight with the head impact on the torso*

To keep balance, the attacker takes steps back, increasing the positive speed in the attacker's horizontal direction, with the CG trajectory again moving up and down. Applying the diagonal efforts concentrated in the upper torso, both the straightening of the opponent (which reduces the arm of its resistance torque) and an increase of the attack torque of the attacker are achieved. As a result, the pushing speed increases, which is also helped by the use of the inertia of the opponent in the backward direction. All these prerequisites result in a maximum kinetic energy of 394 J in the final phase, one step before the field limits.

Competitors and coaches can use the resulting quantitative data in various aspects. Generally, they provide information on how the fight takes place and explain the possibility of winning over a considerably heavier opponent. In particular, taking into account the specific data of the investigated participants, the kinematic parameters were obtained to determine the character and direction of the initial accelerator movement in the direction of the opponent and the timing of extension in the knee and hip joints. The CG trajectory gives information about moving the attacking competitor and his posture in the initial contact with the opponent. This determines the size of the attack torque arm, leading to disturbing the opponent's balance. The speed and energy parameters determine the momentum of the attacking competitor associated with the muscle groups used. Thus, through the results obtained, it is possible to learn and improve the motor structure of this sumo combat technique and to pay attention to specific muscle groups responsible for the effectiveness of the movements. This is also the direction of future research.

DISCUSSION

During the sub-phase after the contact, the sumo wrestler manages to keep his horizontal speed positive and raise his CG by nearly 0.2 m upwards. During the next sub-phase, the attacking wrestler tilts forward and lowers the CG by almost 0.25 m. And he sharply puts his head in the opponent's chest, and without changing the movement, he pushes him back. During contact with the attacking head against the opponent's chest, the temporal development of the fight has a wave character with increasing amplitude. The way of applying the force effort allows both the opponent to straighten and the attacker's torque to be raised simultaneously, as well

as the use of the opponent's inertia in the rearward direction. This way of fighting gives priority over higher and heavier opponents.

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