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NERYO-CHAGI KINEMATIC CHARACTERISTICS EVALUATION IN IMPACT SINGLE COMBATS BY EXAMPLE OF WTF TAEKWONDO VIA FEEDBACK TECHNOLOGIES

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Abstract:
This article is dedicated to topical issues related to feedback information technologies. As of now, there is not enough research on the topic of studying the kinematic characteristics of athletes in full-contact martial arts using tracking feedback systems. **Research methodology**: To test the hypothesis concerning the practicability of modern information technologies application, there was held an experiment with WTF taekwondo martial arts athletes. The researchers examined 4 athletes: 2 highly qualified athletes (elite) and 2 sub-elite athletes. The GPS/LPS RealTrack System by Wimu Pro Spain, was chosen to record the motion parameters. Neryo-Chagi was randomly chosen to assess the kinematic characteristics (exploratory study). Neryo-Chagi was considered as an integral motor action, which consists of two types of movement: 1) swing and 2) shock movement (strike). **Research results**: At the moment of Neryo-Chagi strike, there is a linear increase in the angular velocity (degrees/sec) from low to maximum. When performing a swing and a shock movement (strike), the angular velocity (deg / s) is different. The maximum angular speed during the swing is observed when strikes the way they are in a fight are compared to the maximum, medium and slow intensity. Swing time (s) with elite athletes is higher compared to sub-elite ones, while the time to perform a strike movement does not differ. Elite athletes have higher maximum angular velocity during the swing and strike movement. Evaluation of the main motor actions of athletes, classified by kinematic characteristics, allows a new assessment of their effectiveness.

Keywords: athletes, swing, impact movement, angular velocity, parameter, technology, taekwondo

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1. Introduction

Currently, control is the key to planning and managing the training process. The control depends on technologies based on the feedback received from athletes. For example, heart rate (HR), which is an indicator of internal load. When measuring heart rate (HR) beats / min, an athlete normally reaches a certain target value: average heart rate beats / min, maximum heart rate beats / min, the ratio of average to maximum heart rate (%) and holds for some time to comply with a certain range of energy supply mode: aerobic or anaerobic [1]. With the growing number of information technologies and tracking systems, it becomes possible to evaluate the external load, which subsequently determines the internal one. The external load is represented by kinematic parameters typical for translational and rotational types of motion [2]. In this case, the coach has a new tool to improve training and competitive activities. Over the past decades, tracking systems which record motion parameters have become an integral part of obtaining information in various sports, which determines the relevance of this study [3-8]. However, the use of new motion detection technologies in the example of full-contact martial arts and, in particular, WTF taekwondo, has not been sufficiently considered.

2. Literature review

C.D. Gomez-Carmona [8] examined the performance of external load during running with Wimu Pro device. As a result, it was clear that the load indicator (Player Load, PL) is a valid control method and has a certain relationship with internal load - heart rate and muscular oxygen saturation. J. Pino-Ortega [9] and co-authors held a comparative analysis of the assessment of football players' vertical jump using a Wimu device and a special platform, taking the flight time as an assessment. The results of the study showed high reliability, credibility and reproducibility of the data.

Y. Ibata [10] and co-authors studied the three-dimensional trajectory of movement during standing long jumps using the Wimu feedback system. A three-dimensional trajectory of movement was created by fixing wireless devices under the chest, right thigh and right shin. Pressure sensors were synchronized with WIMU and placed under the right heel and toe to tell the difference in body movement between landing and jumping. The initial and final positions of the torso, thigh and lower leg in a stand were obtained using acceleration and geomagnetism. The results of the study showed a high correlation between angular velocities, flight trajectories with indicators measured by optical cameras. Thus, modern feedback information devices are an important and informative tool for assessing the kinematic characteristics of athletes' movement in real-time as well. The results are confirmed by P. Granero-Gil's data [11]. As well, the co-authors studied various factors of the kinematic characteristics of movement in football, on which the result depends. S.J. Ibáñez [12] made his study in basketball. A. A. Medina [3] studied the external load and asymmetry between the body segments when running along a straight

line and along a turn 150 and 300 m. A review of information sources on the topic proves that the data is relevant to various experts.

3. Research methodology

In order to test the hypothesis concerning the practicability of modern information technologies application, there was held an experiment with WTF taekwondo martial arts athletes. The researchers examined 4 athletes: 2 highly qualified athletes (elite) and 2 sub-elite athletes. The age of the athletes was 21.0±1.7 years, height - 167.7±9.0, weight - 61.0±8.2 kg. The GPS/LPS RealTrack System, Wimu Pro, Spain, was chosen to record the motion parameters.

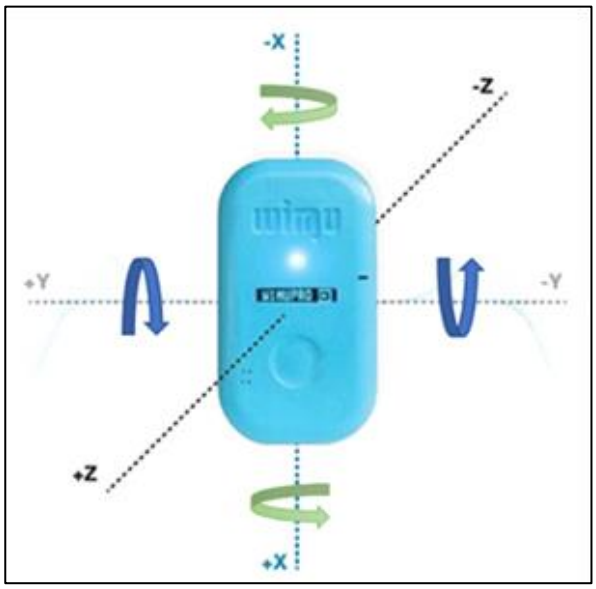

Image 1: How to attach WIMU device and orient the rotation axes for assessment of athlete's movement kinematic characteristics in WTF taekwondo combat sports

The system has a built-in accelerometer (1000 Hz), magnetometer (100 Hz), gyroscope (1000 Hz), barometer (100 Hz). All information is transmitted in real-time to a device 4x8 cm size. If necessary, data can be transmitted in real-time with a resolution of 0.001 sec. A. Bastida-Castillo studied the data acquisition technology for informativeness, reproducibility and reliability [13]. A fight was recorded on digital media using a Go Pro HERO8 Black camera. The resulting video image was integrated into special software (SPRO) for subsequent data synchronization and analysis. The Wimu device was attached to the athlete's back wearing a special vest in order to assess the kinematic characteristics of torso movement and as well on the athlete's lower leg with a special non-elastic tape (Image 1).

To assess the kinematic characteristics of WTF taekwondo wrestlers, Neryo-Chagi was randomly selected (exploratory study). Neryo-Chagi is a direct kick, performed with the foot, usually towards the opponent's head. It is a falling kick from top to bottom and forwards from oneself (Image 2). Neryo-Chagi was considered an integral motor action, which consists of two types of movement: 1) swing and 2) shock movement (strike). The speed of the strike, as a rule, is determined by the purpose of the fight, the coach's assignment, the conditions of the training session and other factors. To estimate the angular velocity of the leg during the swing and impact, the frontal axis Y was chosen, and vertical axis X for torso.

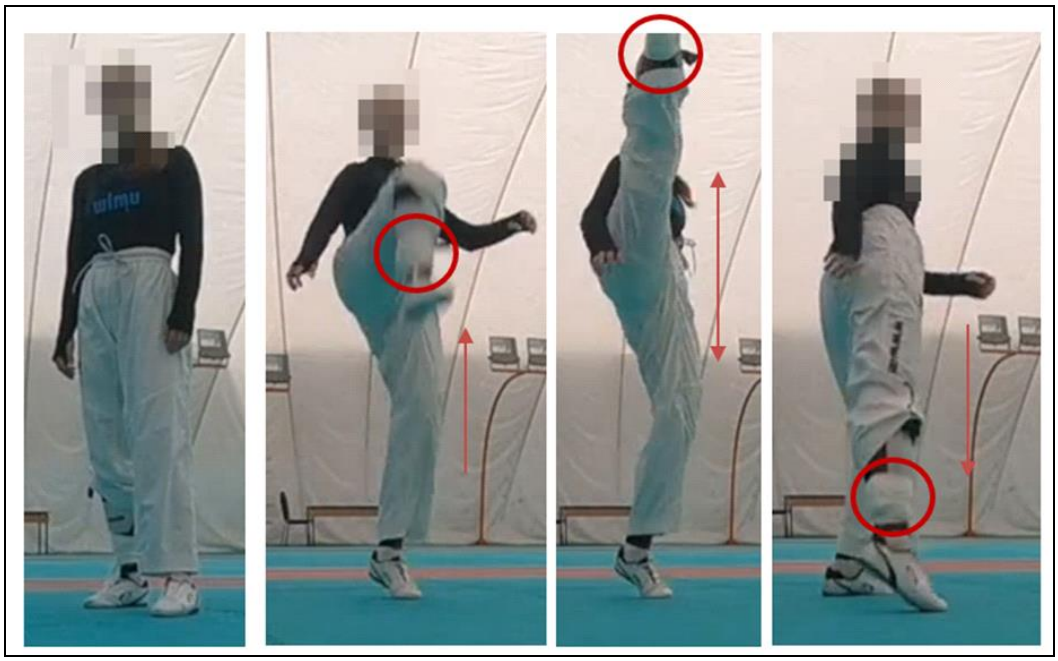

Image 2: Neryo-Chagi phases performed by an athlete of WTF taekwondo full contact martial arts

To standardize the speed of strikes for athletes, a task protocol was drawn (Table 1). Each athlete had to perform Neryo-Chagi with varied intensity, according to their sensations.

Table 1: Research program protocol evaluating the kinematic characteristics of athletes in full contact martial arts by the example of WTF taekwondo

Intensity	Number of repetitions, number of times	Rest interval between repetitions, sec	Rest interval between kicks, min
Slow	3	5	3
Medium	3	5	3
Maximum	3	5	3
As in a fight (full coordination)	3	5	3

Kruskal-Wallis test was used to evaluate significant differences between kicks having different speeds. Mann-Whitney test was used in a comparative analysis of elite and sub-elite athletes. The Statistica 10.0 program was used for the statistical processing of the study results.

4. Results and discussion

The advantage of using the method of registering kinematic characteristics using WIMU mobile devices is to obtain objective information by measuring the main parameters of movement in the process of continuous performance of various motor actions, including translational and rotational movements. The measurement of temporal characteristics allows us to reveal the movement in time: the moment in time and pace and rhythm of movement. The classification of biomechanical characteristics related to kinematics is subdivided into motion, acceleration and speed. These are external load parameters, therefore, it allows us to study the factors that determine the effectiveness (efficiency) of the impact. At the moment of Neryo-Chagi, there is a linear increase in the angular velocity (deg/sec) from low to maximum intensity during the swing and impact movement until it touches the pads (strike) (Image 3).

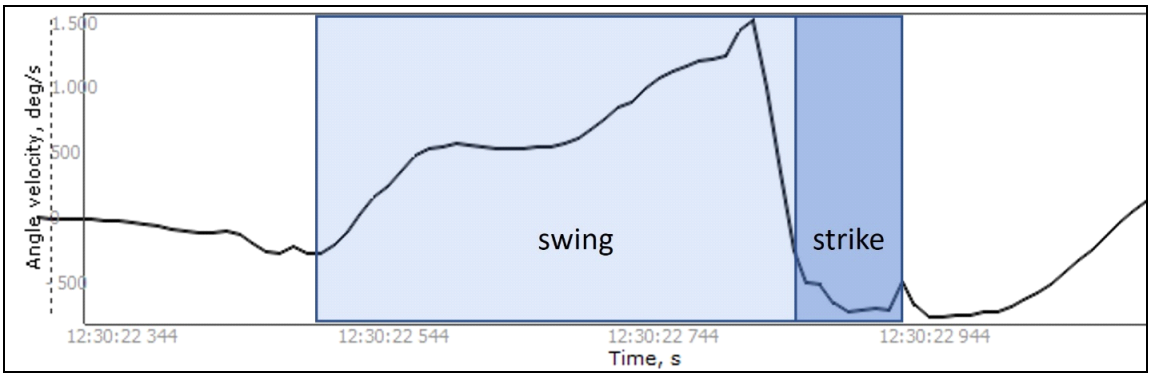

Image 3: Change in the angular velocity of the kicking leg along the Y axis at the moment of Neryo-Chagi being performed by an athlete of full-contact martial arts in WTF taekwondo

When performing a swing and a shock movement (strike), the angular velocity (deg / sec) is different. Table 2 shows that the implementation of the swing and impact movement with different intensity from slow to maximum leads to an increase in angular

velocity ($p<0.05$) when moving the impact leg or lower limb. The maximum angular velocity during the swing is observed when performing strikes as in a fight ($p<0.05$). Consequently, the requirements for the application of greater efforts by the trunk muscles and lower extremities muscles are increasing: namely flexors and extensors of the hip and knee joints. It is assumed that the higher the maximum angular velocity (deg/s) during the swing is applied, the more work the muscles do in the return movement at the moment of impact.

Table 2: Change in the maximum angular velocity (deg/s) of WTF taekwondo athletes when performing a direct Neryo-Chagi with different intensity (mean±standard deviation)

Indicators		**Lower limb**		**Torso**	
		Swing	**Strike move**	**Swing**	**Strike move**
Speed, deg/sec	Slow	707±137	-359±114	201±21	-183±17
	Medium	856±125	-506±40*	216±37	-128±56
	Maximum	1096±78*#	-587±53*#	324±30*	-234±51
	As in a fight	1202±220*#	-633±171*#	586±69*	-284±51
Note: * - above slow, # - over medium; differences are significant at p<0,05					

The next stage of the study shows a comparative analysis of the time spent on the swing and shock movement of the lower limb by elite and sub-elite martial arts athletes (Table 3, Image 4). As a result, the swing time (s) in elite athletes is higher compared to sub-elite ones ($p<0.05$), while the time to perform a strike movement does not differ ($p>0.1$). The increase in swing time for elite athletes leads to a significant difference in maximum angular velocity compared to sub-elite athletes. Elite athletes have a higher maximum angular velocity during the swing. This trend remains when performing a strike movement, where the maximum angular velocity is also higher in elite athletes compared to sub-elite ones ($p<0.05$).

Table 3: Y axis lower limb maximum angular velocity results during Neryo-Chagi performed by WTF taekwondo martial arts athletes (mean±standard deviation)

Indicators	**Execution time, s**		**Maximum angular velocity, deg/s**	
	Swing	**Strike move**	**Swing**	**Strike move**
Sub-elite	0,31±0,02	0,07±0,01	1088±153	554±28
Elite	0,35±0,02*	0,08±0,01	1438±54*	830±45*
Note: * - over sub-elite; differences are significant at p<0,05				

So, the implementation of the first phase of the swing while performing Neryo-Chagi sets high standards for speed-strength abilities. It is obvious that the frequency of using Neryo-Chagi in a fight will depend on the current level of an athlete's speed-strength abilities. In this regard, the training process should be focused on growing strength and speed of flexor and extensor muscles of leg. The following research will be aimed at studying the kinematic characteristics of various body segments when performing impact actions, with a comparative analysis of the maximum angular velocities during various impacts, as well as athletes of different weight categories.

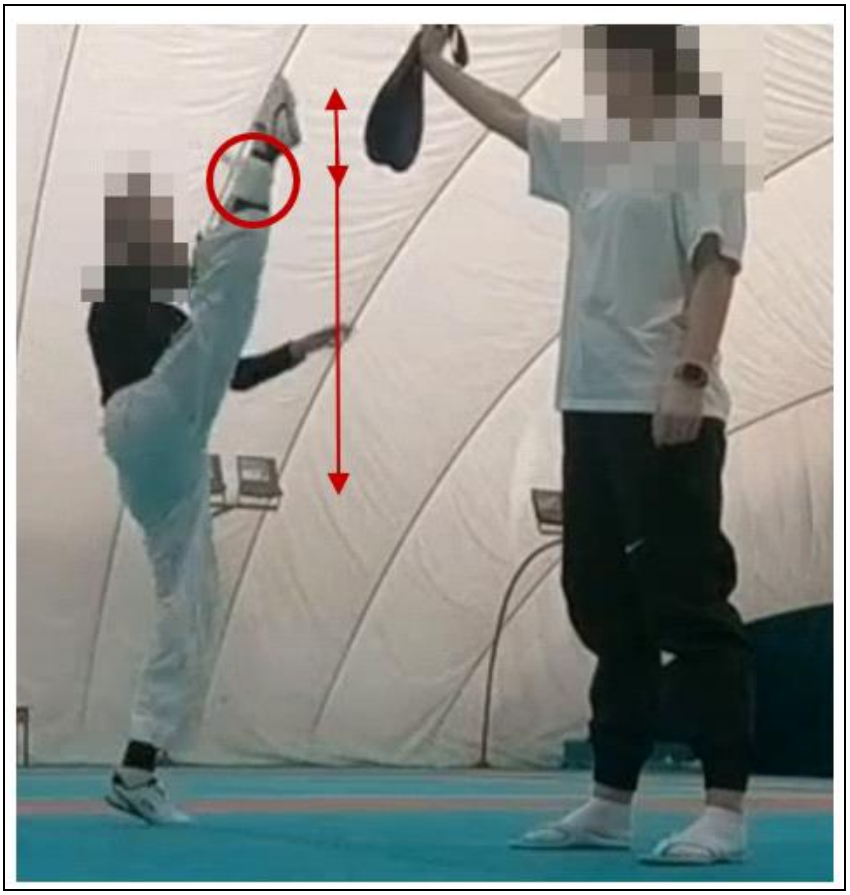

Image 4: Neryo-Chagi schematic performance by a WTF taekwondo martial arts athlete

Evaluation of the main motor actions of athletes, classified by kinematic characteristics, allows a new assessment of their effectiveness. The main advantage when working with feedback information technologies is that the assessment of actions is carried out immediately for two athletes, for example, those in a pair. As well, it allows immediate assessment of those techniques and actions performed against each other in training and competitive activities. Thus, it becomes possible to obtain reliable and objective information about the quality of the exercise being performed, evaluate the integral type of training, minimizing the subjective approach to assessing exercises, and make management decisions based on the information received.

5. Conclusion

The essence of the training process management is expressed in the change in the state of the controlled object (system) in accordance with a given criterion for the effectiveness of its functioning and development. The effective development of such a dynamic system as an athlete is possible only with a competent construction of the training process, which must, first of all, include the determination of the initial parameters of the system. The more parameters of the system are known and the more clear are the patterns of relationships between these parameters, the more predictable for the coach are the results

that an athlete can achieve in the near and distant future. When managing the training process, it is unacceptable to refer to the system-athlete as a "black box", where there are only input data in the form of a training load, and output data include the results of competitive activity. Thus, the use of innovative systems for recording the movement of athletes is relevant at the present time and is used to improve the efficiency of the training process.

Conflict of Interest Statement

The authors declare no conflicts of interest.

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