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KINEMATIC ANALYSIS OF LOWER LIMBS MOVEMENT IN SOME KARATE TECHNIQUES

Viorel Petru Ardelean (a)*, Pierre Joseph de Hillerin (b), Vasile Liviu Andrei (c),
Viorel Bitang (d), Corina Dulceanu (e)
*Corresponding author

(a) Aurel Vlaicu University of Arad, Faculty of Physical Education and Sport, Revolution Boulevard, no. 77, Arad, Romania, viorel.ardelean@uav.ro,
(b) University of Pitești, Faculty of Sciences, Physical Education and Sport and Informatics, Targul din Vale str, no. 1, Pitești; Center for the Development of Human Performance, București Romania, hillerin@live.com,
(c) Aurel Vlaicu University of Arad, Faculty of Physical Education and Sport, Revolution Boulevard, no. 77, Arad, Romania, liviu.andrei@uav.ro
(d) Aurel Vlaicu University of Arad, Faculty of Physical Education and Sport, Revolution Boulevard, no. 77, Arad, Romania, viorel.bitang@uav.ro
(e) Aurel Vlaicu University of Arad, Faculty of Physical Education and Sport, Revolution Boulevard, no. 77, Arad, Romania, corin.dulceanu@uav.ro

Abstract

Purpose of this paper is to analyse some kata Heian Nidan techniques, to observe differences in execution, especially on lower limbs movement and possible comparison with reference data. Methodology, research was conducted in the biomotric laboratory of the N.I.S.R. Bucharest, and consisted in achieving some tests, 12 repetitions on 6 athletes, with averages: age = 18,83y±1,72, height = 169,33cm±8,57 and weight = 57kg±3,57, relating to kinematic characteristic of motion, in the kata mentioned before. We use an inertial navigation system that contains 17 sensors - MVNBiomech, produced by XSENS Technologies BV. Athletes tested holds a black belt, they practice karate for 8 years. The results obtained refers to the distance between ankles, on a total of 12 repetitions from kata sequence selected. The average values of distance between left and right leg, in kokutsu dachi position is M min = 0,387m ± 0,200 and M max = 0,975m ± 0,490, while C.V. min = 2.189% and C.V. max = 8.605%. Conclusions. We observe that the average values are representative and homogeneity is high. Comparing the result with reference data, which recommend for kokutsu dachi position that the athlete must maintain an ankle distance of maximum 0,91m for seniors, our study has highlighted a higher value - 0,975m (Dif. = 6,5 cm), which is difficult to observe with free eye, especially for the referee. Using such an analysis system will be easier for referee to judge, but also for coaches, to correct the mistakes in real time.

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1. Introduction

Nowadays, when sport experiencing a great development, it is very important how judges evaluate with precision and rightness the winner; also, how coaches and athletes prepare for all the factors of training, but especially for the technical factor.

That is why the role of specialists involved in sports science for finding the best solutions and training methods will be more and more important, and those athletes who will benefit from the discoveries and benefits of the new technologies as well as the contribution of interdisciplinary teams for training will have higher chances to be at the top of the rankings (Gagea & Tiron, 2007).

The kata exercises being of high complexity, require a physical and emotional balance, but also a special coordination (Amălinei, 2010). From kata competitions, we notice that athletes realize technical elements with larger or smaller differences, being scored differently. We believe that appraisal and scoring can sometimes be subjective, especially in competitions with many participants (Fidalgo, 2013; Morris, 2015). Thus, a solution to objectivize the arbitration process (decision-making) we consider to be welcome, both for the referees and especially for the athletes competing.

2. Problem Statement

In karate, especially in the kata category, from a biomechanical point of view it is very important how each movement and technical element is made to achieve victory. We believe that in order to eliminate some mistaken decisions by referees, or to be very correct in the evaluation, it would be appropriate to use kinematic motion analysis systems which work with inertial sensors (Ardelean, Hillerin, & Bidiugan, 2014). Also these systems can be of real use in the training process of athletes, to get the information in real time and to intervene precisely on the wrong part of the movement (Hillerin, 2005).

This type of technology has a wide applicability and can be used in many areas, such as recovery, virtual reality, animation, automotive, etc. In sport, it is also applied successfully in biomechanical analyzes or other applications for sports science (Stergiou, 2004). Also, a number of authors have used this system to analyze the movement in martial arts (Hachaj, Piekarczyk, & Ogiela, 2017; Cynarski, Wajs, & VencesBrito, 2014; Ardelean, 2015).

Through this paper we aim to analyze the fundamental position kokutsu dachi (more precisely, the distance between the ankles of the lower limbs), a position often used by athletes in both kata and kumite competitions (Japan Karate Association, 2017). A too small or to big distance between the ankles can affect both the technical aspect of the execution and the dynamic balance of the athlete. We also want to compare our results with other data related to this parameter in the literature.

So, using this technology with inertial sensors to measure the distance between left and right leg ankles on the y axis, for six experienced karate practitioners, we will actually have the following data: - initial distance between ankles before start; - trajectory which the ankle goes through; and - the end point in which the athlete places his foot on the ground, indicating the maximum distance between the ankles. Regarding the distance between the lower limbs in the kokutsu dachi position, some specialists claim that for a correct execution it can reach certain lengths, such as: - between 30 and 36 inches [76,2 cm şi 91,4cm] (Kirkham , 2001), while other specialists indicate: two shoulder widths or 2-3 basin widths (Doder, 2008),

or a length between heels of 80 cm (Nakayama, 1977). Also note that this distance is not the only feature of this position.

For a better assessment and correctness of the techniques performed by the tested athletes, or the total execution time of the kata sequence, and the time to accomplish the technical elements under my analysis, I have consulted and observed a series of demonstrations by some international masters especially Japanese) who executed the kata element chosen for recording - Heian Nidan. (Kanazawa, 2014; Kagawa, 2014; Kawazoe, 2014).

3. Research Questions

In this paper we worked on hypotheses to answer, among other things, to the following questions:

If we can perform a qualitative analysis (trajectories of the segments or the whole body on the move, on the three coordinates x, y, z), with karateka athletes who perform a technical element from a martial arts kata category exercise, using a inertial sensor equipment from MVN Xsens Technology? Also, we want to find if is possible to obtain some concrete data – a quantitative analysis of the technical elements performed.

If the data obtained by us can be compared with other similar data from the literature and can they provide us with indications regarding the efficiency and the correctness of the execution of the technical element analysed?

4. Purpose of the Study

The purpose of this paper is to investigate (testing, data collection, processing, and comparing with reference data) of the kinematic characteristics of some shotokan kata sequences - Heian Nidan. In this research, we analyze the distance between the lower limbs ankles using the MVN Biomech system produced by the Dutch company Xsens Technologies BV, which uses inertial motion transducers and an advanced mathematical device for identifying motion for a total of 23 body segments, according to the model of segmentation agreed by the International Society of Biomechanics (Wu et al., 2005).

5. Research Methods

This study is a part of a PhD thesis, and the methods used to accomplish this work were multiple, complex and are the following:

After the study of the literature, I tried to link the notions of general biomechanics to kinematics applicable to martial arts using the heuristic method. The analysis of the tested athletes as well as the executions of the big champions, we applied the observation method (spontaneous, systematic, correlative). Through the survey method I conducted the anamnestic interview with each of the athletes. The tests method played a very important role in this study by recording each athlete while performing a shotokan kata sequence equipped with the MVN Biomech system. We also used the mathematical method for some necessary operations, and for the comparison and presentation of the data obtained from the tests we applied the statistical and graphical method (Epuran, 2005).

The research was conducted in the biomotric laboratory of the National Institute of Sport Research Bucharest, and consisted in achieving some tests, 12 repetitions for each one, on 6 athletes (2 boys and 4 girls), with averages: age = 18,83y±1,72, height = 169,33cm±8,57 and weight = 57kg±3,57, relating to

kinematic characteristic of motion, in the kata mentioned before. Due to NISR support, and the involvement of some researchers, we use an inertial navigation system that contains 17 sensors - MVNBiomech, produced by XSENS Technologies BV, Holland. Athletes tested holds a black belt, they practice karate for 8 years, they constantly practice kata and kumite but some of them have a higher affinity for one of the samples.

The statistical parameters calculated in this paper were: maximum and minimum values of the mean (the average trajectory/ path of the 12 executions), the standard deviation, the coefficient of variability, but also other mathematical operations that were imposed (Galea, Ardelean, & Istvan, 2010). We considered a 95% significance (p <0.05).

6. Findings

In this study, we decided to analyze the distance between the left ankle and the right ankle, on the "y" axis, the movement through which the lateral step is made for the kokutsu dachi position, along with the upward movement of the arms. We perform this analysis because the technology with which we performed the tests allows us to measure this distance, and in the literature we have concrete data on this ankle spacing in the kokutsu dachi position, as we specified in chapter 2.

The results obtained refers to the distance between left and right ankles, on a total of 12 reps performed by each athlete from kata sequence selected. The mininum and maximum average values of distance between ankles, standard deviation and coefficient of variability, for each athlete can be seen in table 1.

6.1. Individual results obtained

The means of minimum values recorded for each athlete, which actually represents the initial position, are between 0,298m ± 0,008 and 0,462m ± 0,026, while the means of maximum values recorded, representing the final position of the movement, are between 0,821m ± 0,050 and 1,062m ± 0.042. We note that only the value of a single athlete P.A. (M max = 0.821m±0,050) is within the value recommended by literature, in range of ankle spacing for kokutsu dachi position, up to 0.91m. For other athletes the differences between the results obtained and the reference data have higher values ranging from 4.2 cm to 15.2 cm.

Table 01. Centralized data for each athlete, on the maximum and minimum values of the following calculated indices: mean trajectory, std. dev. and CV, at the distance between the ankles left and right and the notable performance category of athletes.

Nr. crt.	Name/ surname	Sex	Height (m)	Max/ Min	Average path (m)	St. dev.	C.V.[%]	Favorite category
1	A.D.	F	1,67	Min	0.383	0.012	1.146	Kata / kumite
				Max	1.062	0.042	6.970	
2	L.M.	F	1,50	Min	0.353	0.011	1.975	Kata
				Max	0.968	0.043	5.208	
3	E.I.	F	1,70	Min	0.372	0.037	3.974	Kata
				Max	0.952	0.066	12.784	
4	P.A.	F	1,66	Min	0.298	0.008	0.992	Kata / kumite
				Max	0.821	0.050	10.620	
5	N.Ş.	M	1,80	Min	0.462	0.026	2.729	kumite
				Max	0.992	0.055	9.480	
6	P.A.	M	1,80	Min	0.455	0.023	2.319	kumite
				Max	1.055	0.041	6.567	

### 6.2. Results of the whole group

The mean values calculated for the whole group of athletes, also presented in table 2, are as follows: M min = 0,387m ± 0,200 and M max = 0,975m ± 0,490, while C.V. min = 2.189% and C.V. max = 8.605%. It is clear that for the whole group we have a difference of 6.5 cm between the maximum average of the group - 0.975 m and what we found as references in the literature regarding the ankle spacing of 0.91 m.

Table 02. Centralized data for the whole group, on the maximum and minimum values of the following calculated indices: mean trajectory, ab. std. and CV, at the distance between the ankles left and right.
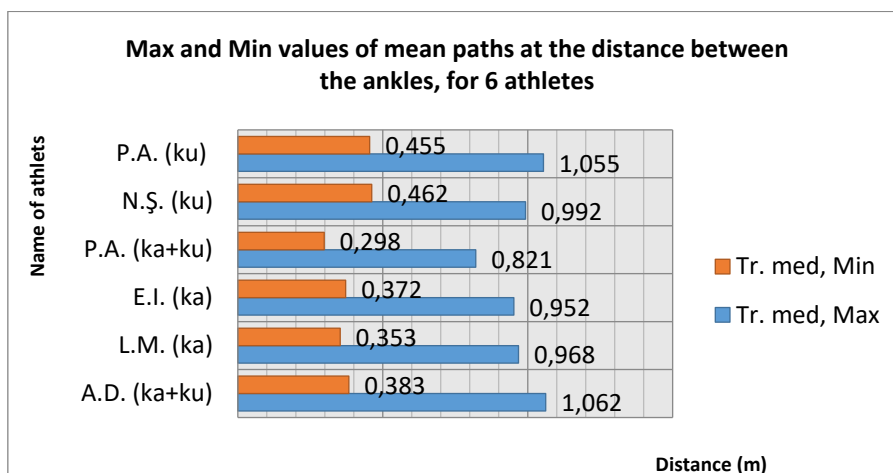
Parameters	Max/ Min	Average path (m)	St. dev.	C.V.[%]
Mean for whole group	Min	0,387	0,200	2,189
	Max	0,975	0,490	8,605
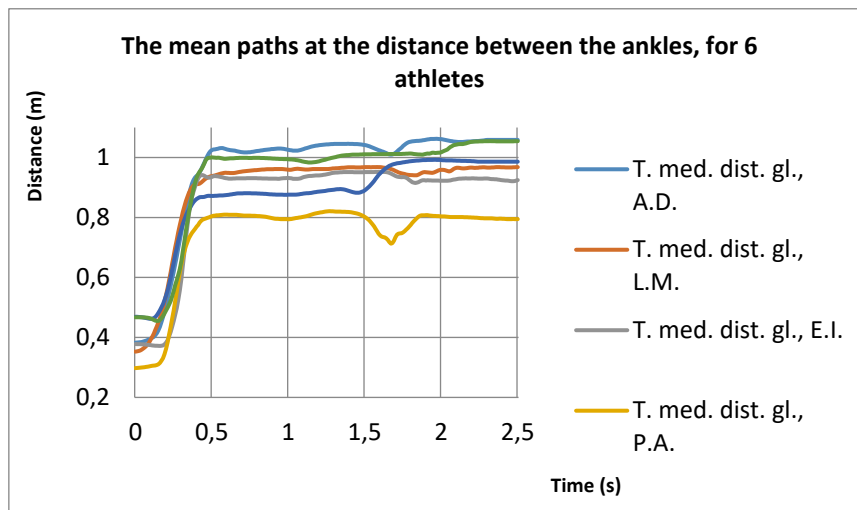
Figure 01. Centralized Diagram of medium paths at the distance between the ankles left and right, for 6 athletes tested.
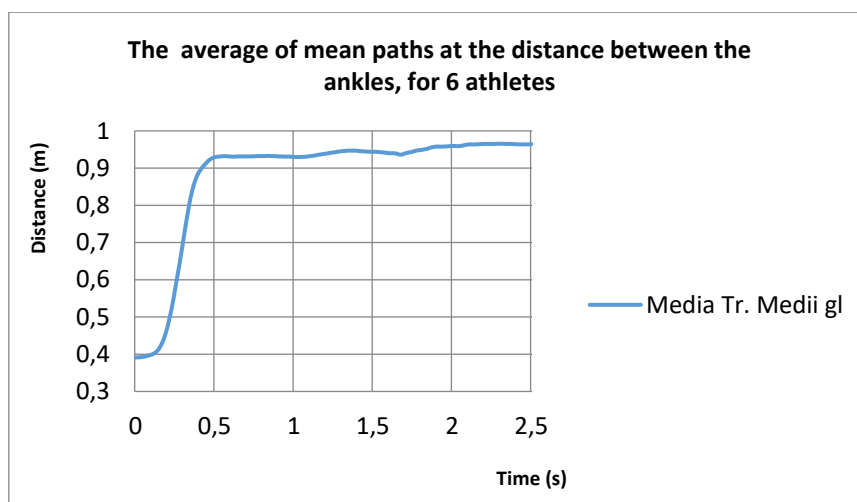
Figure 02. Diagram representing the average of medium paths (for all group) at the distance between the ankles left and right.

Max and Min values of mean paths at the distance between the ankles, for 6 athletes

Name of athlets	Tr. med, Min	Tr. med, Max
P.A. (ku)	0,455	1,055
N.Ş. (ku)	0,462	0,992
P.A. (ka+ku)	0,298	0,821
E.I. (ka)	0,372	0,952
L.M. (ka)	0,353	0,968
A.D. (ka+ku)	0,383	1,062

Distance (m)

Figure 03. Representation of the Max / Min values of the mean paths at the distance between the ankles left and right, for the 6 athletes tested.

7. Conclusion

In conclusion we can assert that the results of the present study answer the questions formulated and confirm the assumptions of the research. With this technology we can measure the kinematics of both qualitative and quantitative motion in martial arts, representing a very precise and valuable correction or evaluation tool.

The averages obtained in the ankles distance parameter have some oscillations at both, the minimum and maximum values, but the standard deviation is small, so we have a very low data scatter and the coefficient of variability in only one athlete is 12%, at others reach values up to 10%, which indicates very high homogeneity.

Comparing the result obtained by us with reference data that indicates in the kokutsu dachi position the athlete must maintain an ankle distance of maximum 0,91m for seniors, we can state that our study has highlighted a higher value (Dif. = 6,5 cm), which is difficult to observe with the free eye , especially for the referee. Using such a analysis system will be easier for referee to judge, but also to correct the mistakes by the coach, exactly when the error occurs, so in real time.

Acknowledgments

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