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Mawashi Geri in Karate Junior Cadet Class: Kinematic Analysis

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Abstract: A basic technique must be understood as early as possible to minimize injuries and improve athlete performance. The Mawashi Geri kick is one potentially dangerous but highly effective move used in a karate match. The purpose of this study was to analyze the kinematics of Mawashi Geri in the Junior Karate Cadet class. This study used descriptive quantitative analysis, and the samples used were ten Karate Cadet Junior athletes. Each subject in this study had also expressed their willingness to fill out an informed consent. This study used the Dartfish software analysis technique (version 8 GEAR software B.V., Helmond) to determine Mawashi Geri kinematic data. The research results indicated that the Mawashi Geri speed has an average of $6.53 \pm 2,300$ m/s, the kick time in the Mawashi Geri motion series is 0.77 ± 0.070 seconds. This research confirms that Mawashi Geri kick motions are included in the less appropriate research kinematic data analysis category because Mawashi Geri performed shows a leg position that is too wide, affecting the time and speed of the kick produced at impact. However, there are still limitations in this study that only display kicking kinematic data. It is expected that further researchers measure kinetic data and motion tracking in a full match to find out what sorts of kicks become athletes' strengths or weaknesses when competing.

Keywords: motion analysis, kinematics, Mawashi Geri, karate.

马瓦希盖里空手道少年班：运动学分析

摘要：必须尽早了解基本技术，以尽量减少伤害并提高运动员的表现。马瓦希盖里踢是空手道比赛中使用的一种潜在危险但非常有效的动作。本研究的目的是分析初级空手道学员班马瓦希盖里的运动学。本研究使用描述性定量分析，使用的样本是十名空手道少年运动员。本研究中的每个受试者也表示愿意填写知情同意书。本研究使用镖鱼软件分析技术（第8版齿轮软件乙·伏，赫尔蒙德）确定马瓦希盖里运动学数据。研究结果表明，马瓦希盖里速度平均为 $6.53 \pm 2,300$ 多发性硬化症，马瓦希盖里运动系列的踢腿时间为 0.77 ± 0.070 秒。该研究证实，马瓦希盖里踢腿动作被包含在不太合适的研究运动学数据分析类别中，因为马瓦希盖里表演的腿位置太宽，影响了击球时踢腿的时间和速度。然而，这项研究仍然存在局限性，仅显示踢腿运动数据。预计进一步的研究人员会在整场比赛中测量动力学数据和运动跟踪，以找出运动员在比赛时的优势或劣势。

关键词：运动分析，运动学，马瓦希盖里，空手道。

1. Introduction

Athletes must understand a basic technique as early as possible to minimize injuries and improving their

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performance. As revealed in [11], combining techniques to achieve the best results can be applied correctly and routinely. It potentially reduces the occurrence of sports injuries by up to 50%. This strategy also applies to martial arts. The Mawashi Geri kick is one of the potentially dangerous but highly effective moves used in a karate match. Karate has many effective kick techniques to earn points in a match with a value of 3 points. Mawashi Geri kick in a karate match cannot be performed well without sufficient training because the skill in doing this kick can only be trained through intensive practice.

The Mawashi Geri kick technique is carried out centered on the lower extremity of the body. This part has an important role in providing balance and supporting the body when performing kick techniques. The kicking technique requires balance and coordination in a range of motion involving the trunk, hips, knees, ankles, and feet that allow hip-to-toe linkage due to activation of neuromuscular support in the lower extremities [6]. When performing the Mawashi Geri kick, one foot remains on the floor so that the balance of the body is maintained. The foot of support becomes the center of balance which helps provide power to the other foot, used for kicking.

Looking at the 2012 INKANAS National Championship results held in Bandung, the data obtained from the 65 kicks made by male athletes only three kicks resulted in points, and the remaining 62 kicks did not produce points at all. The percentage of success of the Mawashi Geri kick attack technique in male athletes was 5%. Meanwhile, the senior female athletes performed kicking attack technique as many as 45 kicks, resulting in 1 kick that resulted in points and 44 kicks that did not produce points. The percentage of the Mawashi Geri kick attack techniques in senior female athletes was then only 2%. In line with that, [7] mentioned that the kick attacks in a karate match that earns points were only 34%, while the kick attacks in a karate match that did not earn points were 66%. Several factors affect the accuracy and speed of the Mawashi Geri kick; they are as follows; 1) distance, 2) leg muscle endurance, 3) leg muscle strength, and 4) timing. As also revealed in [7], the dominant kick taken was Mawashi Geri with a percentage of 11%, making it more efficient to get points.

Regarding the effectiveness of a certain kick, [12] stated that the feet are more stable when standing by distributing body weight evenly over a wider area, increasing speed and agility when walking, and providing stability and flexibility. Balance in the body is the goal of the arcus pedis shape possessed by humans. Research related to kicking technique was conducted in [7], [8], [17] that discussed the percentage of kick techniques that earn points and the efficiency of kicking techniques as

well. Mawashi Geri kick motion analysis was also discussed in [2] and [5], which provided the results of the kick speed, and angle of the body segment focused on the lower extremity body segment for this study. This background underlies the appropriateness of the discussion regarding the Mawashi Geri kick on karate. The kick results from previous studies are not related to kinematic data from the Mawashi Geri kicks that have a good contribution in analyzing the suitability of motion in kicks or the effectiveness of the Mawashi Geri kicks related to the athlete's performance.

BKC Dojo Nekapora has an undoubted contribution in making achievements in West Java. With 11 Dojos owned, Dojo Nekapora has the potential to create outstanding athletes. The last accomplishment of the event results at the Bandung Karate Club Regional Championship, West Java, in 2018; it was noted that the athletes got three gold medals, nine silver medals, and seven bronze medals. Three gold medals were contributed by 2 Kata athletes and one gold medal from a Kumite athlete. The target of Kumite athletes to get five gold had not been achieved. However, the results achieved are still not in line with the target for the Kumite class. Based on the results of observations and notes from the coach, it was found that the Junior Cadet Class athletes still had deficiencies in mastering the correct Mawashi Geri kick technique and several obstacles such as the standard of effective movement as a benchmark for the movement that did not meet the coach's expectations. This makes researchers interested in knowing more about the kinematic data analysis of the Mawashi Geri kick in Karate. This study aims to analyze the kinematics of the Mawashi Geri kick in the Junior Cadet class. The researcher hopes that athletes and coaches obtain relevant information and data related to kinematic analysis that can be used as a reference and evaluation in optimizing the Mawashi Geri kick.

2. Research Methodology

The type of research used in this study is descriptive quantitative. The data in this study were obtained through kinematic data derived from the analysis of the Mawashi Geri kick motion by using video recording [1]. To analyze the biomechanics of the Mawashi Geri kick, the researchers used the Dartfish software application (version 8, GEAR software B.V, Helmond). The sampling technique used in this study is the purposive sampling technique, according to [21] that comprises BKC Dojo Nekapora Junior Cadet athlete, Bogor City. The total sample includes ten athletes as the subjects of this study, such as Junior Cadet class athletes (14-17 years) with the criteria that they had participated in centralized training or training centers at the Bogor City BKC level. This research had been approved by the

Research Ethics Commission of Universitas Negeri Semarang, Indonesia, with the number 024KPEK/EC/2021 based on the Operational Standard and Guidance for Human Participant at WHO in 2011.

The research instruments used in this study include 1) Canon EOS M3 video recording camera, 2) Tripod Camera, 3) 100 cm long tape, and 4) Laptop with Dartfish software version 8. Stages of data analysis using video recording, which is inserted into the laptop for later analysis. The analysis procedure is as follows: 1) inserting a video file using a card reader into a laptop, 2) using Dartfish version 8 software to analyze the motion of the Mawashi Geri karate kick with slow motion according to the stage of the motion to be observed, 3) performing data analysis [13]. The research procedure includes a video recording of the Mawashi Geri kick, which is then input into the analyzer (Dartfish) containing a menu to calculate distance, time, speed, angle, and devices to accelerate and slow down zoom in and focus on segments in the video. This video analysis aims to discover the shortcomings or errors of the athlete's motion and the athlete's strengths through the numbers in this software. This Mawashi Geri kick analysis focuses on kicking speed, kicking time, the distance between legs, right elbow flexion angle, kick angle, left knee flexion angle, torso angle in each preparatory phase, active and final phase.

3. Results

Based on the research results, the data obtained in the form of the average age of the sample is 15.6 ± 1.260 years, with an average height of 161.2 ± 9.100 cm and an average weight of 52.9 ± 10.240 kg (Table 1).

Table 1 Personal data of *Karateka*

n = 10	Mean \pm SD	Minimum	Maximum
Age (year)	15.6 ± 1.260	14	17
Height (Centimeter)	161.2 ± 9.100	149	180
Weight (Kilogram)	52.9 ± 10.240	43	78
BMI (Kg/m ²)	20.78 ± 2.100	17.89	24.5

The researchers then divided the Mawashi Geri kick phase into several phases such as; 1) preparation phase, 2) active phase, and 3) final phase. The data in this study also describes kinematic data consisting of kick speed,

kick time, distance between legs, elbow flexion angle, kick angle, knee flexion angle, and torso angle (Table 1).

Table 2 Kinematic results of Mawashi Geri Kick

n = 10	Mean \pm SD	Minimum	Maximum
Kick Speed (m/s)	6.53 ± 2.300	4.18	12.03
Kick time (s)	0.77 ± 0.070	0.77	0.96
Preparation phase			
Kick speed (s)	0.24 ± 0.200	02	0.36
Distance between legs (m)	1.2 ± 0.300	0.82	155
Right elbow flexion angle (°)	82.5 ± 34.400	38.5	143.4
Degree of Kick (°)	64 ± 9.900	49.9	75.8
Left knee flexion angle (°)	117.05 ± 15.600	97.7	138.5
Torso angle (°)	139.6 ± 6.800	130	150.9
Active phase			
Kick speed (s)	0.20 ± 0.030	0.16	0.28
Kick width (m)	2.4 ± 0.300	1.38	2.68
Kick height (m)	2.3 ± 0.200	1.98	2.54
Right elbow flexion angle (°)	91.5 ± 32.400	51.2	153.9
Right knee flexion angle (°)	166 ± 12.200	142	179.7
Degree of kick (°)	119.3 ± 5.400	110.4	128.1
Torso angle (°)	128.5 ± 12.900	115.2	151.3
Final phase			
Kick time (s)	0.30 ± 0.040	0.28	0.44
Distance between legs (m)	0.93 ± 0.400	0.52	1.65
Right elbow flexion angle (°)	93.75 ± 28.900	55.6	142.5
Torso angle (°)	146.1 ± 10.700	129.6	166.8

The results of Mawashi Geri kick kinematic data in table 1 show that Mawashi Geri kick speed has an average is 6.53 ± 2.300 m/s, the kick time in the Mawashi Geri motion sequence is 0.77 ± 0.070 seconds. Mawashi Geri kick which was taken in the preparation phase, showed a kick time of 0.24 ± 0.200 seconds, with a distance between the legs is 1.2 ± 0.300 meters.

In the preparation phase, the right elbow flexion angle is 82.5 ± 34.400 degrees, the kick angle is 64 ± 9.900 degrees, the left knee flexion angle is 117.05 ± 15.600 degrees, and the torso angle is 139.6 ± 6.800 degrees.

Data in the active phase shows that the kick time taken is 0.20 ± 0.030 seconds, with a kick height is 2.4 ± 0.200 meters. The elbow flexion angle in the active phase is 91.5 ± 32.400 degrees, the knee flexion angle is 166 ± 12.200 degrees, the kick angle is 119.3 ± 5.400 degrees, and the torso angle is 128.5 ± 12.900 degrees. While the final phase of the Mawashi Geri kick in this study showed a time of 0.30 ± 0.040 seconds and a distance between legs is 0.93 ± 0.040 meters. The elbow flexion angle obtained in this phase is 93.75 ± 28.900 degrees, and the torso angle is 146.1 ± 129.6 degrees.

4. Discussion

This study analyzes the kinematics of the Mawashi Geri kick motion in the BKC Bogor Junior Karate Cadet athletes by measuring based on the karate kick motion indicators, which refers to previous research conducted in [14], [22], [23], with a series of motions consisting of a preparation phase, an active phase, and a final phase.

According to the kinematic results of the Mawashi Geri kicks presented in Table 2, the results of kick analysis of ten junior cadet athletes showed a maximum kick speed of 12.03 m/s, a minimum kick speed of 4.18 m/s, and an average speed kick was 6.53 ± 2.300 m/s. Previous research [14] explained that the six karate athletes showed a maximum kick speed of 15.95 m/s, a minimum speed of 10.14 m/s, and an average kick speed of 12.58 m/s. The results of the comparison data conclude that the results of the kick speed obtained were still in the poor category. These results have not reached what is expected concerning the technique and how to do Mawashi Geri kicks from previous studies. Studies reported in [3], [6], and [19] showed that the application of many forms of a kick in situations to combat sports affects the results of the kicks taken.

The time required to perform a kick from the preparation phase to the final phase is 0.72 seconds to 0.96 seconds, with an average value of 0.77 ± 0.070 seconds. The time of the kick starting was measured in [22] when the back foot moves forward; then the front foot begins to lift and hits the target of the kick. The kick time stops when the front foot hits the ground, with an average kick time of 0.66 seconds. Another research indicated that the time taken to perform a Mawashi Geri kick from the starting position to the end was 0.40 seconds to 0.70 seconds, with an average time of 0.54 seconds [14]. Compared to the two previous studies, the current research seems to be not optimal in dealing with the implementation of the kicks. However, this study obtained better results when compared to the results of research conducted by Wasik [24] since the time used for kicks to impact was 0.75 seconds. It is said better because, in this study, the Mawashi Geri was performed by junior cadet athletes.

The results of the kinematic data of Mawashi Geri kicks which also affect the research data are indicators of each phase. In the preparation phase, the kick time ranged from 0.2 seconds to 0.36 seconds with an average of 0.24 ± 0.200 seconds. At the same time, the distance between legs was 0.82 meters to 1.55 meters with an average of 1.2 ± 0.300 meters. The right elbow flexion angle is 38.5 degrees to 143.4 degrees with a mean of 82.5 ± 34.400 degrees. The kick angle in the preparation phase is 49.9 degrees to 75.8 degrees with an average of 64 ± 9.900 degrees. The left knee flexion angle shown is 97.7 degrees to 138.5 degrees with an average of 117.05 ± 15.600 degrees. While the angle of the trunk obtained is 130 degrees to 150.9 degrees with an average of 139.6 ± 6.800 degrees.

The kinematic data in the active phase shows that the kick time taken is 0.16 seconds to 0.28 seconds while the average time obtained is 0.20 ± 0.030 seconds. The kick width is 1.38 meters to 2.68 meters, with an average kick width of 2.4 ± 0.300 meters. The kick height is 1.98 meters to 2.54 meters, with an average kick height of 2.3 ± 0.200 meters. The right elbow flexion angle is 51.2 degrees to 153.9 degrees with an average of 91.5 ± 32.400 degrees. The right knee flexion angle was 142 degrees to 179.9 degrees with an average of 166 ± 12.200 degrees. The Mawashi Geri kick angle in the active phase is 110.4 degrees to 128.1 degrees with an average of 119.3 ± 5.400 degrees. The torso angle in this active phase is 115.2 degrees to 151.3 degrees with an average of 128.5 ± 12.900 degrees. The final phase shows that the kick time needed is 0.28 seconds to 0.44 seconds with an average time of 0.30 ± 0.040 seconds, for the distance between feet 0.52 meters to 1.65 meters with an average distance of 0.93 ± 0.400 meters. The right elbow flexion angle is 55.6 degrees to 142.5 degrees with an average of 93.75 ± 28.900 degrees. While the angle of the trunk in the final phase is 129.6 to 166.8 degrees, with an average angle of 146.1 ± 10.700 degrees.

Based on the results obtained in this study, it can be concluded that the athlete did the Mawashi Geri kick in the poor category. This can be seen from the results of the kick time and speed performed. These results have not met the criteria as expected in the previous research [14], [22].

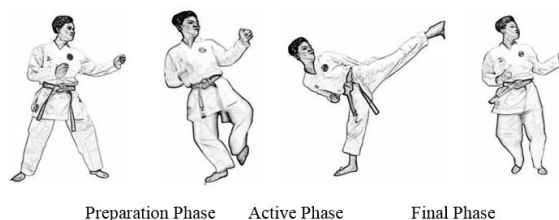


Fig. 1 Mawashi Geri motion phase

The motion phase of the Mawashi Geri kick is divided into three phases, as shown in Figure 1. The preparation phase starts from the initial position to approach the opponent. The active phase begins when the foot begins to lift, and the foot releases from the ground until it reaches the target or commonly called impact. The final phase is a movement when the foot returns to the ground and back to the starting position. In the preparation phase, the distance between the legs can affect the time to take a kick and can affect the kicking speed. The farther the distance between the legs, the longer it will take to kick, and vice versa, the closer the distance between the legs, the less time is used to kick.

The results of previous studies stated that the longer a person's legs, the stronger the kick [4]. Anatomical aspects of the human body affect the proportions of a person's body, one of which is the length of the legs. Long legs will provide a relatively better advantage than short legs. However, with the body composition and anthropometry of the athletes in this study, Mawashi Geri kicks can be performed more effectively and produce optimal kick speed because of the shorter legs of the athlete, which also affects the range of the kick motion. The range of motion of the kicks made has a shorter distance and time so that the kicks are carried out to optimize time and speed more effectively.

The explosive power of the leg muscles is needed to make a quick and effective kick, according to [15] and [20]. The better explosive power of leg muscles will produce strong and fast kicks; on the contrary, the lower the leg muscle power, the lower the effectiveness of the Mawashi Geri kicks performed. In addition, [10] emphasized that improving the effective Mawashi Geri technique can be achieved by minimizing the time and increasing the knee speed when doing the kick. As stated in [25], an increase in the control of flexor and extensor muscles in the lower extremities is influenced by the provision of exercises that are applied regularly. Not all muscle fibers change at the same rate, but the larger changes are fast-twitch muscle fibers, which cause an increase in the speed of muscle contraction [19]. In addition to explosive muscle power, another study stated that the hips are an important component in helping to move smoothly, quickly, or vigorously [9]. The hips are used to support, push, and rotate both punches and kicks. This opinion is also evidenced in [16], which suggested a relationship between hip joint flexibility and the Mawashi Geri ability.

Every athlete and coach must possess the mastery of basic mechanical concepts. An understanding of these

two things is believed to be able to help in improving the performance of athletes during competition as well as athletes' achievements. The coach must also monitor every form and mechanics of every movement the athlete performs. Motion errors that are made will be detected quickly, so it will be faster to fix them. This is the basis for evaluation, especially to minimize athletes' injuries and improve athlete's performance

6. Conclusions

Based on the results obtained and the discussion in this study, it can be summed up that the Mawashi Geri kick motion performed by the sample is included in the unsuitable category regarding the kinematic data analysis. In this study, the Mawashi Geri kick performed showed a foot position that was too wide, so that it affected the timing and speed of the kick produced at the time of impact. The explosive power of the leg muscles is needed to make a quick and effective kick. The limitation of this study is that the researcher only displays kinematic data. Future researchers are expected to measure kinetic data and movement tracking in a full match to find out what kicks belong to athletes' strengths or weaknesses when competing.

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