

Motor learning and training strategy effect on motor control; Comparison between Taekwondo and Karate front kick (Ap Chagi and Mae Geri)

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Abstract

The aims of the current study were first, to evaluate whether there were differences in the front kicking kinematics executed by professional Taekwondo and Karate athletes. Second, biomechanical evaluations aimed to determine the kinematic variables of effective front kicking performance between different training strategies. Sixteen elite Taekwondo and fourteen Karate athletes performed front kick. Kinematics and kinetics were recorded using a ten high-speed camera and two force plates. Taekwondo and karate groups present significant kinematic and repeatability differences, which significant differences observed in the range of motion, angular velocity, and peak values of lower limb angular positions and velocities. Although, the movement pattern of a front kick in group was similar. Based on our results, different training strategies for one movement (front kick) can change neuromuscular, motor control, and kicking efficacy. Analyzing this kind of research and comparison between two different groups that executes the same action with two different learning methods can improve the knowledge of athletics and coaches to better performance in training and learning strategies. In addition, this type of study of training strategy and motor control can reduce sports mistakes in coaching, particularly in the primary period of athletics training, and decrease injury probability.

Keywords: Taekwondo, Karate, Front Kick, Motor control, training strategy

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Introduction

Martial arts are recognized as traditions of combat practiced for several reasons (H. Barnamehei, Razaghi, et al. 2018; Barnamei and Kharazi 2015; Kim, Kim, and Im 2011)(Gavagan and Sayers 2017). Martial arts training can develop physical and mental health benefits in a wide range of ages and abilities (Pozo, Bastien, and Dierick 2011b). Two common and popular martial arts are Karate and Taekwondo that widely practiced forms of martial arts (Azizi et al. 2015). Taekwondo has been an Olympic sport since 2000 and recently Karate has been an Olympic event and it will be at the 2020 Olympic games (H. Barnamehei, Ghomsheh, et al. 2018). In these martial arts, athletics train stances and ways to punch, kick, and block an opponent in the fighting (Barnamehei and Safaei 2017b). The Karate fighting emphasizes punch (hand) techniques and uses kicks (leg) as a backup in different positions of fighting. Although, Taekwondo includes more kicking (leg) techniques than Karate. Taekwondo athletics emphasis kicks (leg) and uses hands as backup and they use a wide range of high-speed kick movements, including jumping kicks and spinning (Barnamei and Kharazi 2015)(Golfeshan, M. Barnamehei, et al. 2020). Both Taekwondo and Karate competitions have specific guidelines and rules that control athletics (Barnamehei and Safaei 2017a). In a competition, Taekwondo includes higher points to kicks, so players execute more kicking in taekwondo tournaments (Barnamehei and Safaei 2017c). On the other hand, Karate basically gives points equally for both kicks and punches in Karate competitions.

The front kick is a popular kick in martial arts performed by lifting the knee straight forward, while keeping the foot hanging freely or pulled to the hip joint, and then straightening the leg in front of the practitioner and striking the target (Robertson et al. 2002). The front kick is one of the basic techniques of martial arts can also be described mainly as a straightforward kick directly to the front side of the opponent or target. The front kick has a different name in different martial art sports; for example, the name of the front kick in Taekwondo is Ap Chagi and the name of a front kick in Karate is Mae Geri (Gavagan and Sayers 2017). These names came from the original language of these sports which Karate came from Japan and Taekwondo came from Korea (Wąsik and Góra 2016a). The Ap Chagi and Mae Geri are Korean and Japanese words respectively which consist of two words; Ap and Mae mean front and Chagi and Geri mean kick in Korean and Japanese language respectively (Barnamehei 2018). The front kick consists of many movements in different directions during the front kick cycle whose goal is to create high velocities motions of the segments and joints. According to the linear relationship between circumference and radius, kicking segment length calculates the radius of the rotational motion of the human body, consequently affecting the linear velocity of the kicking segment.

Previous research analyzed front kick with different methods and approaches. Some studies analyzed front kick separately in Taekwondo and Karate (SŌ rensen et al. 1996) (Robertson et al. 2002; Wąsik1ABCDE et al. n.d.).The majority of the previous studies of front kick evaluated the lower extremity joints (hip, knee, and ankle) (Andrzejewski and Elbaum 2005; Błaszczyzyn et al. 2019; Cynarski et al. 2018; Doke and Kuo 2005; Gordon, Robertson, and Carlos Fernando n.d.; Jacek Wąsik 2015; Kim 1998; Pozo, Bastien, and Dierick 2011a; Pozo et al. 2011b; Robertson et al. 2002; SŌ rensen et al. 1996; Sorensen et al. 1996; VencesBrito et al. 2014; Wąsik and Góra 2016a). The biomechanical studies of front kick consist of kinematics (Wąsik1ABCDE et al. n.d.), kinetics, and electromyographic researches (Sorensen et al. 1996). Some previous studies compared front kick between athletics groups (Błaszczyzyn et al. 2019; Pozo et al. 2011a; VencesBrito et al. 2014). Some previous studies compared the different kicking tasks such as roundhouse kick, front kick, side kick, hook kick, and axe kick in different combat sports (Gavagan

and Sayers 2017) (Zetaruk et al. 2005). Some other researchers compared the different skill levels of athletics to fine motor training strategies (Hamidreza Barnamehei et al. 2018; Błaszczyński et al. 2019; Matsunaga and Kaneoka 2018). Many of research in combat sports include analyzing the roundhouse kick motion because this kick is very popular and have more application in fighting in different sports such as Taekwondo, Karate, Mui Thai, Kickboxing, and Kong FU (Vences Brito et al. 2014) (Romanenko et al. 2018) (H. Barnamehei, Razaghi, et al. 2018; Barnamei and Kharazi 2015; Falco et al. 2009; Gavagan and Sayers 2017; Quinzi et al. 2013). The risk of injury may depend on motor learning and training strategy which may differ in Karate and Taekwondo (Alizadeh, Shirzad, and Sedaghati 2012; Birrer and Birrer 1983; Pieter 2005; Zetaruk et al. 2005). In recent years many researchers focused on the kinematics coordination variabilities and muscle synergy studies (H. Barnamehei, Razaghi, et al. 2018; Barnamei and Kharazi 2015; Bianchi et al. 1998; Cowley and Gates 2017)(Kim et al. 2011)(Quinzi et al. 2014).

By comparing kinematics differences of a same kick in different training strategy may lead to better biomechanical results to understand the significance of lower limb kinematic variables, exclusion of errors in the training program, determination of weak points of training protocols in order to improve training programs, and prevention of probable injuries that happen during competitions or training (Macan, Bundalo-Vrbanac, and Romić 2006; Pappas 2007; Picerno 2017; Pieter 2005; Zetaruk et al. 2005). Therefore, this study will be addressed how coaches and players can design the training in both taekwondo and karate according to kinematics information. As well, this study is important and needed because there are many motor control variables between taekwondo and karate front kick, and after finding these differences coaches and players can enhance their skills and performances. Consequently, the goal of the current study was to compare the lower extremity kinematic differences of a front kick in Taekwondo and Karate martial arts. The specific objects of the current effort were: (1) to determinate the lower limb kinematics of hip, knee, and ankle joints during a front kick executed by professional Taekwondo and Karate players in three-dimensional space; (2) to compare differences between Taekwondo front kick (Ap Chagi) and Karate front kick (Mae Geri) movement patterns in medial-lateral, anterior-posterior, and superior-inferior directions. We hypothesized that the Taekwondo group perform the front kick in a shorter time, with a higher range of motion in lower extremity joints, and Karate group perform the front kick with higher repeatability of lower extremity kinematics than Taekwondo group.

Methods and materials

Subjects

Sixteen elite Taekwondo athletics and fourteen elite Karate athletics participated in the current experimental research. All of the participants in each group have more than ten years of experience. Anthropometrics and experiences information of each group represented in Table 1. All Taekwondo and Karate participants were excluded if they had any injury or comorbidity affecting kicking such as orthopedic surgery, previous musculoskeletal injuries or a history of pathologic or neurologic disorders. Written informed consent was obtained from all Taekwondo and Karate volunteers. The current study protocols were in accordance with Washington State University and the Declaration of Helsinki

Table 1. Anthropometrics and experience information for Taekwondo and Karate groups

	Taekwondo (n = 16)	Karate (n = 14)
	Mean (± SD)	Mean (± SD)
Gender	M = 9/F = 7	M = 8/F = 6

Age (years)	24.50 (7.50)	26.50 (5.50)
Weight (kg)	68.35 (7.18)	71.00 (8.82)
Height (cm)	166 (6.40)	165 (5.90)
Experience (years)	14 (3.50)	12 (1.50)

Experimental Setup

Figure 1 shows the experimental equipment, which included ten high-speed motion cameras (VICON, Vicon Motion Analysis Systems Ltd., Oxford, UK) with sampling frequency 200 Hz were placed around the athletics to record subjects' motion during Ap Chagi and Mae Geri (front kicks) and two force platform fixed in the floor (Kistler Instrumente AG, Winterthur, Switzerland, sampling rate 2000 Hz) in order to distinguish of onset and offset of front kicks (Bagheri, Barnamehei, et al. 2020; H Barnamehei, Shamloo, et al. 2020)

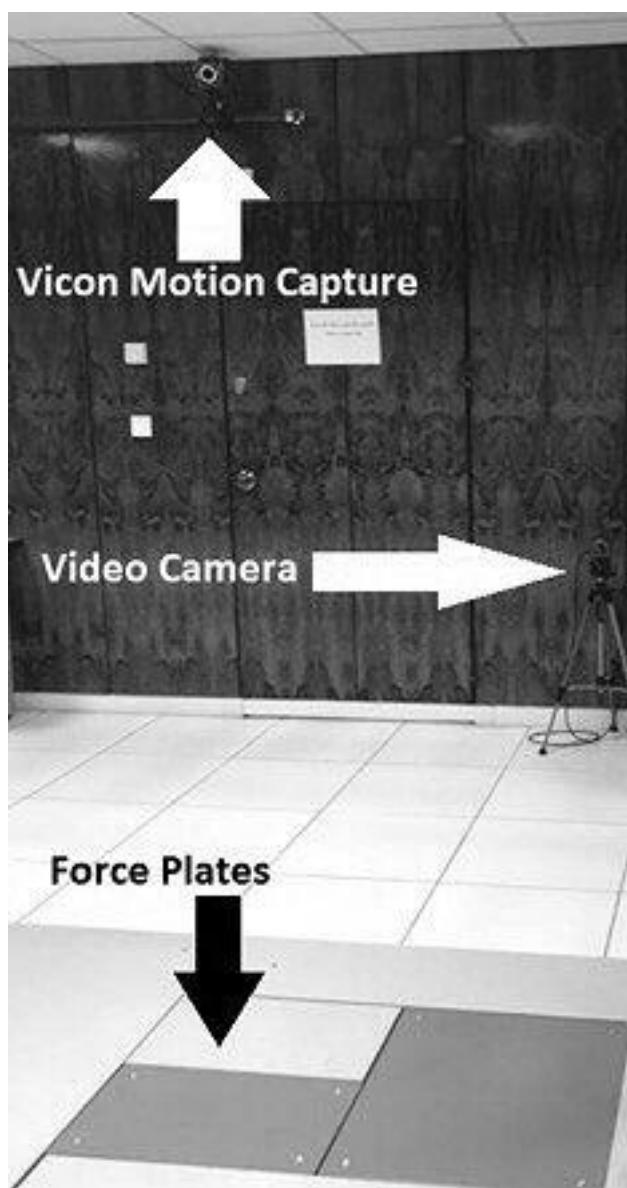


Figure 1: Motion analysis lab for kinematics and kinetics measurements in biomedical and rehabilitation engineering laboratory center at the Movafaghian (Sharif University of Technology) consist of ten high-speed motion capture (VICON, Vicon Motion Analysis Systems Ltd., Oxford, UK) with sampling frequency 200 Hz and two force plate fixed in the floor of lab (Kistler Instrumente AG, Winterthur, Switzerland, sampling rate 2000 Hz) and one video camera (Hamidreza Barnamehei et al. 2018, 2020).

Experimental procedures

Before preparing the motion analysis lab and before experiments, subjects performed a 15 min standard individual warm-up consist of running on the treadmill and stretching exercises. Subjects were instructed to perform five front kick in front of their chests in the air (without target pad or opponent) using their dominant kicking leg. In order to decrease the effect of fatigue on the performance of athletics, a 1 min rest period between each trial was instructed.

As shown in figure 2, 39 reflective passive surface markers were installed on the body landmarks base on the full body plug-in gait markers arrangements (Vicon Documentation) (Kharazi et al. 2015). The players segments were simulated as rigid bodies that constructed interconnected chain during the front kick. All biomechanical data recorded in the Movafaghian (Sharif University of Technology) (H. Barnamehei, Alimadad, et al. 2018). All the surface reflective markers were attached on the skin of athletics at the end of the warm-up training and the stretching exercises.



Figure 2: marker placement on the body of athletics in the three different viewpoints: medial-lateral, anterior, and posterior (39 reflective passive markers were installed on the body landmarks base on the full body plug-in gait markers arrangements).

Martial arts masters (coaches) often teach the front kick to the athletics by step by step teaching methods because martial arts techniques are difficult and include many important details,

therefore athletics need to learn step by step and slowly during several times. Therefore, they divide the martial arts techniques into several phases to easier learning. According to martial arts principles, front kick divided to five phases. Figure 3 presents front kicks that were divided into five phases: (A) preparation, (B) extension, (C) recoil, (D) flexion, and (E) return to the initial position. It is important to learn these different phases to athletics because with this learning method they can distinguish their motions characteristics.

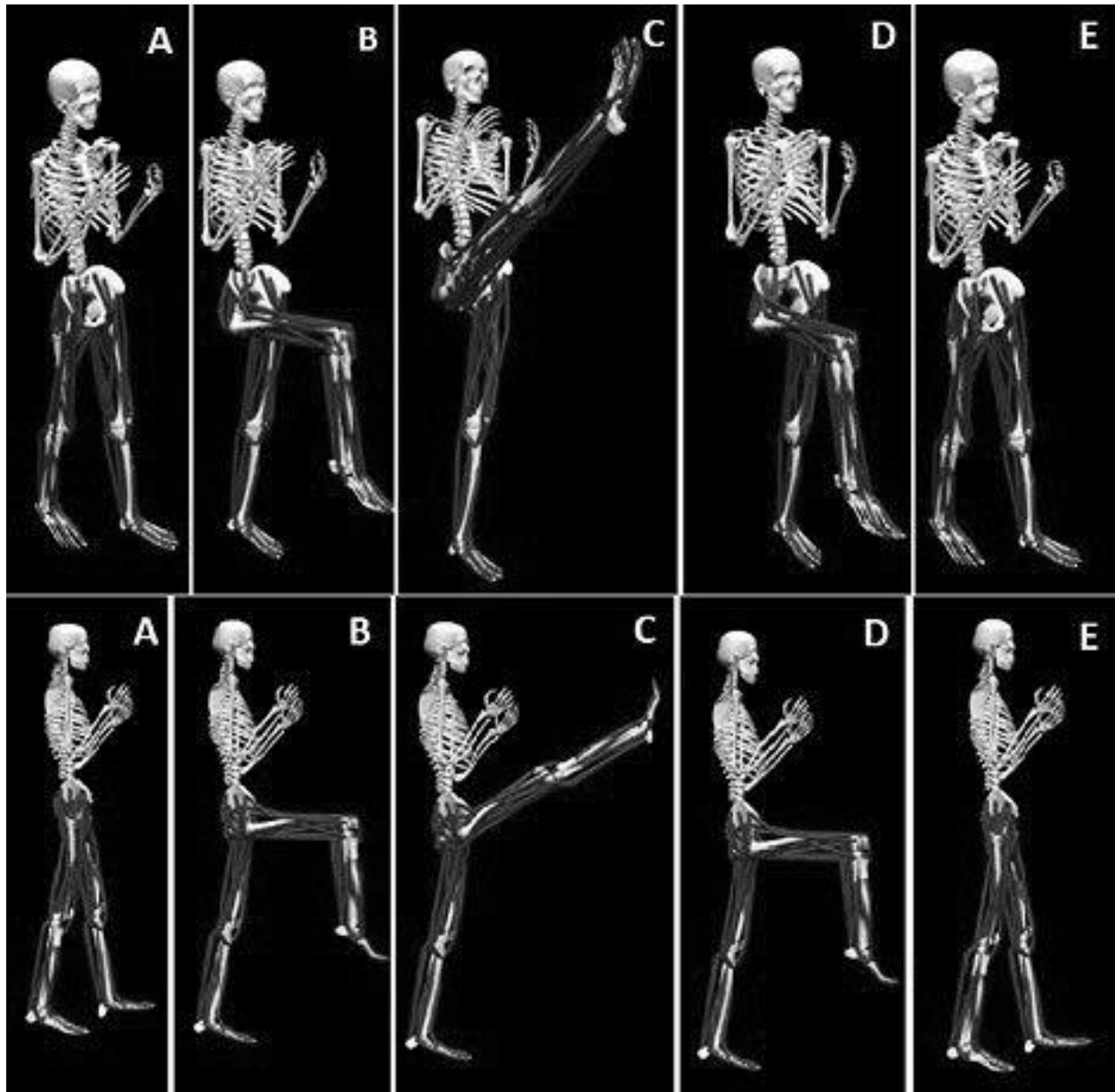


Figure 2: schematics of different phases of a front kick in different viewpoints: (A) preparation, (B) extension, (C) recoil, (D) flexion, and (E) return to the initial position.

Data Analysis

The motion data were recorded for each group with biomechanical motion analysis system. In order to data analysis Mokka software, Nexus 2.6.1 (Vicon-Nexus, Vicon Motion Analysis

Systems Ltd., Oxford, UK), the Microsoft Excel 2019 (Version 16.33), and MATLAB 2019b with the BTK (Biomechanics Tool Kit) library were used to analyze the biomechanical data (H Barnamehei, Karimidastjerdi, et al. 2020). The recognition of the onset/offset of front kick trials was determined by the evaluation of kinetics values and kinematics location of the lower extremity with Mokka software (visualization of tracked markers) (Hamidreza Barnamehei et al. 2020). There are five phases of front kicking: kicking heel off from the ground, flexion of kicking knee and hip joints, full extension of the kicking knee joint and full flexion of the kicking hip joint (peak kick), flexion of the kicking knee joint and joint extension of the kicking hip, joint extension of the knee and hip and putting the heel on the ground (heel strike of the kicking leg). Peak kick events (contact points) are achieved from the separate kinematics data of front kick for a maximum value of the reflective marker (Figure 2, C).

For the best biomechanical comparison of the front kick between the Taekwondo and Karate groups, time was normalized to percentages for the kinematics comparison and evaluation results. Normalized time zero percentage (0%) corresponded to the beginning of (preparation phase) the first phase and a hundred percentage (100%) to the end of the fifth phase (return to the initial position phase) (Golfeshan, S. Fatemigarakani, et al. 2020). In order to the calculation time normalization for each trial, after the onset/offset Interp syntax of MATLAB software was used to time normalization (Bagheri, Barnamehei, et al. 2020; Bagheri, Rostami, and Shojaei 2020).

In a 3-D motion analysis, to determine the joint angular velocity, the joint angular position is simply differentiated with respect to time. The derivative of the angular positions of lower limb joints (hip, knee, and ankle) was utilized to evaluate the lower extremity angular velocity during a front kick in each group (Taekwondo and Karate). The joint angular velocity at the i th frame (ω_i) was determined as

$$\omega_i = \frac{\theta_{i+1} - \theta_{i-1}}{2\Delta t}$$

where θ_i is the joint angle at the i th frame and Δt is the time interval between two frames. In addition, peaks angular velocities of lower limb joints were analyzed in order to compare Taekwondo and Karate group's differences (H Barnamehei, Derakhshan, et al. 2020).

Statistical analysis

The statistics analysis was determined for the kinematics of lower extremity signals with kinetics variables for subjects and each Taekwondo and Karate groups (Aminishahsavarani et al. 2020). The results are present at average values and standard deviation (SD) with a confidence level of 95%. The Shapiro-Wilk and Levene test was used in order to a normal distribution (assumptions of normality) and equal variances (homoscedasticity) calculations, respectively (Bagheri, Barnamehei, et al. 2020). The significance of differences between the two Taekwondo and Karate groups was calculated by the use of Student's t-tests. The significant values were set to p-values below 0.05. All statistical analyses and calculations were calculated by MATLAB 2019b (Golfeshan, H. Barnamehei, et al. 2020).

Results

The current study shows a kinematic comparison of the front kick between Taekwondo and Karate martial art sports executed by elite Taekwondo and Karate athletics. Typical dynamics motion of hip, knee, and ankle joint angular position are represented as a function of percentage time of front kick trial in Figure 4. Our results show angular positions of the lower extremity of Taekwondo and Karate players are different significantly in knee extension-flexion amplitude in

an extreme range of motion during front kick. Taekwondo group shows more knee extension related to the Karate group.

Taekwondo and Karate hip extension-flexion and abduction-adduction present no significant differences. On the other hand, hip rotation represents different patterns of variation between Taekwondo and Karate groups. In addition, the general pattern of hip kinematics between the two groups is the same except for internal-external rotation. Figure 4 shows two angular positions of ankle peaks of plantar flexion and two of dorsiflexion for the ankle joint, in addition, two angle peaks of extension and two of flexion can be noticed for the hip angular position during execution of front kick by Taekwondo and Karate Players. However, figure 4, presents three angular position peaks of extension and three flexions for the knee angular position during the front kick. None of the times of incidence of those angular positions in hip, knee, and ankle joint peaks were significantly different between the groups in all of the anatomical planes. Significant results for the times of incidence of those angular positions were observed in hip extension flexion and ankle plantarflexion dorsiflexion ($P < 0.05$). In addition, figure 4 shows the lowest knee flexion/extension angular position in Taekwondo athletics was less than that in Karate athletics. Though, the largest knee adduction/abduction in the Taekwondo group was higher than the Karate group. Therefore, it is noticeable that Taekwondo athletics performed large knee flexion more than the Karate group. More knee flexion diminished the radius gyration of the kicking leg and therefore the rotational inertia decreased. This happening can make faster kicking performance in the same muscle strengths.

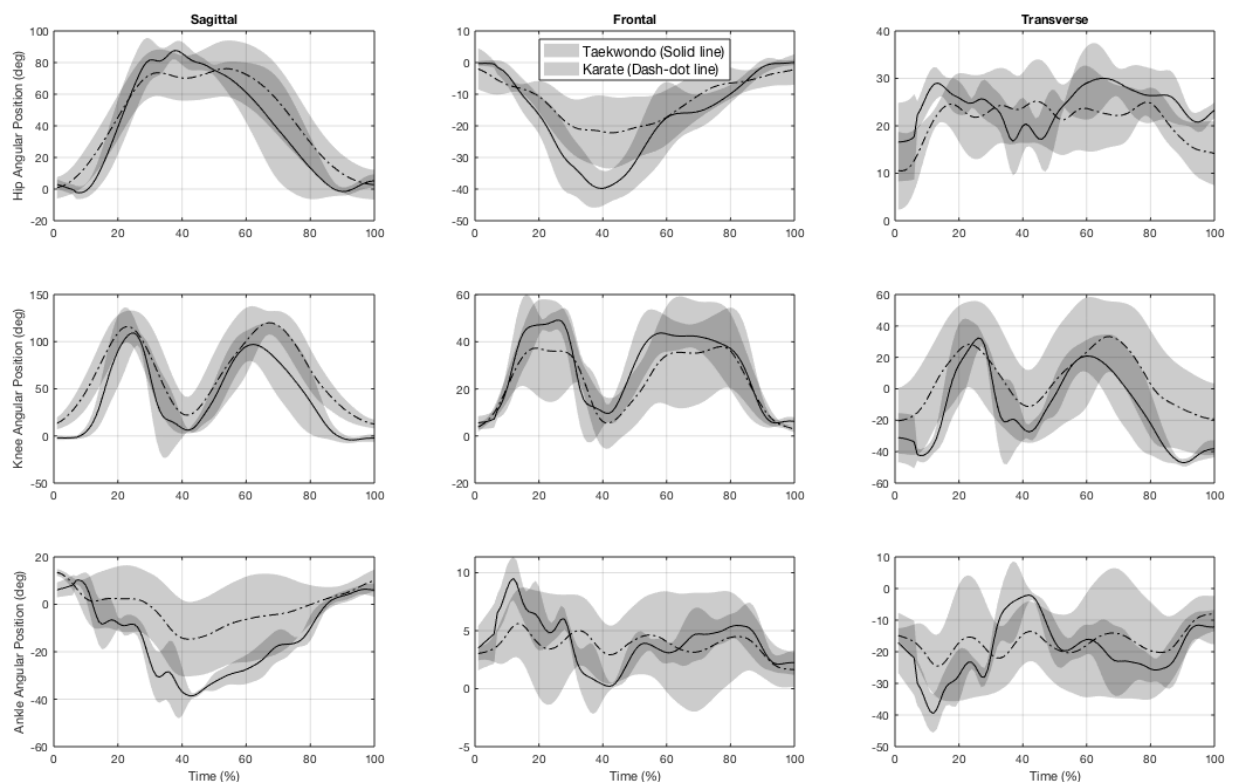


Figure 4. Mean and standard deviation typical dynamics motion of lower extremity joints (hip, knee, and ankle joint) angular position of kicking leg is represented as a function of percentage time of front kick trial (%) in different anatomical directions for Taekwondo (solid line) and Karate (dash-dot line) groups. A comparison of the angular position between Taekwondo and Karate athlete is represented by the mean and standard deviation of participants.

A comparative evaluation was determined to the minimum, maximum, and mean values of lower limb angular position in the important joint of martial arts athletics: ankle, knee, and hip. Table 2 presents a comparative analysis of Taekwondo and Karate athletes based on lower limb joints (Hip, Knee, and Ankle) angular position include meaning, standard deviation, and p-value of each anatomical direction, joints, and martial arts types. In the hip joint (Table 2), Taekwondo and Karate group shows statistically significant differences in an average angular position in abduction-adduction and internal-external rotation movements ($P < 0.05$). In the knee joint (Table 2), based on statistical results from table 2, significant differences between Taekwondo and Karate athletics in the mean value of the angular position in different anatomical directions were detected ($P < 0.05$). In the ankle joint (Table 2), differences between Taekwondo and Karate groups in the average value of the angular position in dorsiflexion-plantarflexion and internal-external rotation were statistically significant ($P < 0.05$).

Results for the angular amplitude of the peaks are presented in table 3. In addition, table 3, represent comparative analysis of Taekwondo and Karate athletes based on lower limb range of motion for elective lower extremity joints (Hip, Knee, and Ankle) and Figure 4, shows ANOVA table results of comparative analysis of Taekwondo and Karate athletes based on lower and upper range of motion limit include p-value of comparison between Taekwondo and Karate groups and also comparison among range of motion of joint type motion and comparison among interaction between Taekwondo and Karate.

Table 2. Comparative analysis of Taekwondo and Karate athletes based on lower limb joints (Hip, Knee, and Ankle) angular position

		Taekwondo		karate		P value
		Mean	SD	Mean	SD	
Hip	Flexion-Extension	39.439	32.785	44.663	27.355	0.223
	Abduction-Adduction	-	13.097	-	6.896	0.002
		16.869		12.093		
	Internal-External Rotation	24.252	3.980	21.154	3.950	0.000
Knee	Flexion-Extension	41.241	37.941	65.235	35.454	0.000
	Abduction-Adduction	28.536	15.458	23.527	12.394	0.012
	Internal-External Rotation	-	24.008	5.557	17.069	0.000
		12.138				
Ankle	Dorsiflexion-Plantarflexion	-	15.317	-1.540	7.242	0.000
		13.884				
	Abduction-Adduction	4.055	2.098	3.787	0.894	0.243
	Internal-External Rotation	-	8.808	-	3.677	0.013
		19.518		17.126		

None of the results for the times of incidence, some lower limb angular position peaks were significantly different between Taekwondo and Karate groups. Regarding the angular amplitude of the peaks, Taekwondo and Karate groups differed by a significant amount for some joints in different directions. Statistically, range of motion comparison between Taekwondo and Karate group (Table 3) presents statistically significant values for the lower limit (minimum) range of motions ($p = 0.027$) although our result represents no statistically significant differences between

Taekwondo and Karate group for an upper limit (maximum) range of motions ($p=0.287$). Based on our results, in the frontal anatomical plane (medial-lateral kicking motion) significant differences in the hip joint ($p=0.002$) and knee joint ($p=0.012$) for angular motion values were observed. In the frontal anatomical plane (medial-lateral kicking motion) significant differences in the hip ($p=0.002$) and knee ($p=0.012$) joint for angular motion values were observed. In addition, significant differences in external-internal motion were observed in the lower limb joints (hip, knee, and ankle). However, in the sagittal anatomical plane (extension-flexion kicking motion) significant differences just in ankle and knee joints were found. Besides, absolute values of the range of motion (ROM) defined upper limit minus lower limit are significant ($p<0.05$). The higher value of the upper limit (maximum) range of motion of the hip joint was observed among the Taekwondo group in extension-flexion, internal-external rotation, and abduction-adduction movement. Although, a higher value of the upper limit (maximum) range of motion of knee joint angular position was found among Karate group in internal-external rotation and extension-flexion motion, though the higher value of knee abduction-adduction movement observed in Taekwondo players. Also, the higher value of the maximum range of motion of ankle angle was found among Taekwondo athletics in internal-external rotation and abduction-adduction motion, although higher value in extension-flexion movement observed in Karate athletics. On the other hand, the lower value of the lower limit (minimum) range of motion of hip joint was found among the Taekwondo group in extension-flexion and abduction-adduction movement and it observed in the Karate group in internal-external rotation. Though, lower value of lower limit (minimum) range of motion of knee joint angular position were observed among the Taekwondo group in internal-external rotation and extension-flexion motion, although the higher value of knee abduction-adduction movement found in Karate players. Besides, the lower value of the minimum range of motion of ankle angle was observed among Taekwondo athletics in all of the directions of motions

Table 3. Comparative analysis of mean Taekwondo and Karate athletes based on the upper and lower limit of the range of motion and mean values of the range of motion (ROM) of lower limb joints (Hip joint, Knee joint, and Ankle joint) angular position with their standard deviations (SD)

		Taekwon do		Karate		Taekwondo		Karate		Taekwo ndo		Karate	
		Upper limit	SD	Upper limit	SD	Lower limit	SD	Lower limit	SD	RO M	SD	RO M	SD
Hip	Flexion- Extension	87 .6 6	32. 17	76.17	21. 86	-2.32	2.60	0.89	6.8 1	89. 98	29. 57	75. 28	15. 05
	AbductionA dduction	0. 06	12. 25	-2.00	11. 43	-39.76	0.71	- 22.18	1.3 1	39. 81	11. 54	20. 18	10. 12
	Internal- External Rotation	30. 02	8.9 9	25.19	9.0 3	16.58	0.57	10.50	2.0 5	13. 44	8.4 2	14. 69	6.9 8
Kn ee	Flexion- Extension	10 9. 20	43. 85	120.0 6	38. 71	-4.27	0.84	12.53	4.6 1	113 .47	43. 01	107 .53	34. 11
	AbductionA dduction	49. 29	18. 94	38.00	23. 79	5.55	1.31	2.95	1.0 1	43. 74	17. 63	35. 05	22. 78
	Internal- External Rotation	32. 25	27. 03	33.29	35. 92	-46.98	2.10	- 20.40	20. 84	79. 23	24. 93	53. 68	15. 08
An kle	Dorsiflexion Plantarflexion	10. 22	14. 53	13.51	18. 20	-38.61	0.96	-14.70	1.4 5	48. 84	13. 57	28. 21	16. 75

AbductionAdduction	9.49	2.99	5.62	5.12	0.20	0.22	1.63	0.59	9.29	2.77	3.98	4.53
Internal-External Rotation	-2.07	12.77	-7.88	20.55	-39.49	1.17	-24.49	2.31	37.43	11.60	16.61	18.24

Mean angular velocities of the hip, knee, and ankle joints are represented as a function of normalization time (%) in Figure 5 for Taekwondo and Karate groups with their standard deviations. As shown in figure 5, in all of the lower limb joints (hip, knee, and ankle) peak values of angular velocity during a front kick in the Taekwondo group were higher than the Karate group. Four peaks in absolute angular velocity in hip abduction-adduction and two absolute peaks in hip extension-flexion can be observed, whereas knee and ankle angular velocity peaks in different directions weren't detectable certainly. Without notice to the times of happening of lower limb joints, angular velocity peaks were significantly different between the Taekwondo and Karate groups, except for the hip joint in flexion/extension and adduction/abduction angular velocity and also knee joint in flexion/extension and adduction/abduction angular velocity ($P < 0.05$). Angular velocity of all lower limb joints (hip, knee, and ankle) in the Taekwondo group, was faster than that in the Karate group in all three anatomical planes (Figure 5).

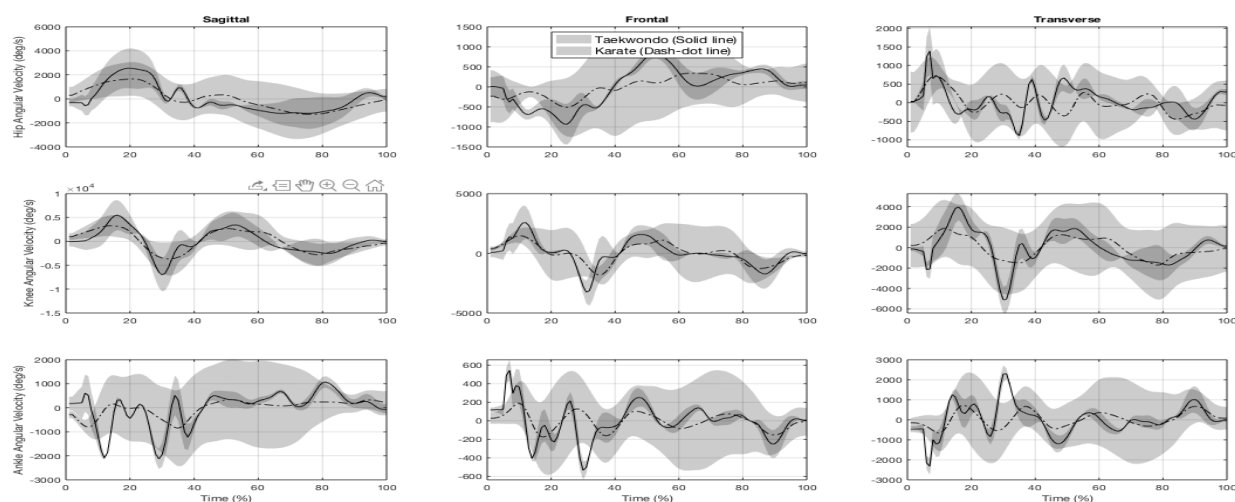


Figure 5. Mean and standard deviation of angular velocity of hip, knee, and ankle joint angular position for kicking leg is represented as a function of normalization time of front kick (%) in different anatomical directions for Taekwondo (solid line) and Karate (dash-dot line) groups. A comparison of the angular position between Taekwondo and Karate athlete is represented by the mean and standard deviation of participants

Discussion

The current study investigated lower body motor training in kicking task (front kick) by comparing kinematic variables between Taekwondo (Ap Chagi) and Karate (Mea Geri) athletics groups. Often Taekwondo and Karate athletics and their coaches call front kick in Taekwondo (Korean) language and Karate (Japanese) language; Ap Chagi and Mae Geri respectively. Although both of the two techniques are the same. The main goals of the current study were to 1) analyze the motor learning and motor control of two different leaning methods in the same action and 2) compare the lower extremity kinematics of front kick between Taekwondo (Ap Chagi) and Karate (Mae Geri) groups. In the current study, we analyzed and compared the kinematics

variables include angular positions, angular velocities, range of motions and their statistical values in different anatomical planes between Taekwondo and Karate groups.

Earlier studies in martial arts on kicking executions outline the biomechanical analysis (Abidin and Adam 2013; Buschbacher and Shay 1999; Chen et al. 1998; Fernandes et al. 2011; Machado et al. 2010; de Moraes Fernandes et al. 2017; Polak et al. 2016; Vieten 2008; Yijie 2007). Kinematics results demonstrate that although the kinematics of Ap Chagi and Mae Geri was similar to each other significant differences were noticeable in different kinematics characteristics (Table 2 and 3). Portela et al. and Jacek Wąsik et al. (Portela et al. 2014; Wąsik 2012) indicated players must kick to the opponent with a wedge of the metatarsophalangeal joints in the Karate and Taekwondo respectively. Besides, they show the athletics for performing front kick must flex their hips first and extend knee next and finally bend ankle in plantar directions. Athletics need to maintaining postural stability and balance control in order to perform the correct pattern of the front kick. Therefore, in order to execute front kick with keeping stability and balance control players need to maintain a suitable series of kinematics chains during the perform the front kick. Therefore, athletics in addition to lower body kinematics maintenance, need to maintain the other body joints and segments. The positioning pattern of the upper body is different case by case in a variety of athletics which depend on motor learning parameters. Correct control and maintaining upper body posture in a different phase of front kick guarantees not only to balance control ability but also support body stability; although, this kind of motor control and postural stability need to muscle coactivation and synergy of upper and lower body (Weinberg, Seabourne, and Jackson 1981) (Zago et al. 2015). Professional athletics often use specific motion patterns of upper body segments and joints but non-elite players don't follow certain patterns of movement of the upper limb; although significant differences were observed head and neck kinematics during kicks (Błaszczyszyn et al. 2019).

In the kinematics results, significant differences in the knee and hip angular velocity in extension/flexion and adduction/abduction motions did not found. In addition, we observed larger values for knee extension/flexion and smaller values for hip extension/flexion. Though, larger peaks angular velocity were observed for knee joint during the front kick in the current study. Taekwondo and Karate professional athletics active the muscles with a large number of fast motor units for extensor muscles during the extension phase (before contact) of front kick and for flexor muscles during the flexion phase (after contact or return phase) of the front kick. Taekwondo athletics presented higher peak angular velocity of the knee and they generate a larger knee angular acceleration during the early phase of the extension phase. Although, the Karate group presents sooner first peak values of knee and hip angular velocity related to the Taekwondo group. The other kinematics results of the current study are similar to other studies in the front kick in Taekwondo or Karate in some cases (Błaszczyszyn et al. 2019; Sorensen et al. 1996; Vences Brito et al. 2014; Wąsik and Góra 2016b, 2016a; Wąsik1ABCDE et al. n.d.; Zago et al. 2015).

Study in the motor learning field and comparison in the field learning and training strategy have indicated that the human central nervous system uses muscles to produce the specific motion according to previous repeated training. The significance of training level and kind of training can affect the motion patterns. Although, the human central nervous system in order to control the motion and optimize energy, it tries to modify the motor (Yoo and Ryu 2012) (d'Avella et al. 2006; Muceli et al. 2010; Torres-Oviedo 2006). As the results, in order to optimize the human energy, the human central nervous system instead of the utilization of all muscles and joints, only use some limited muscles and joints and make a synergetic motion for constructed effective motion pattern (Anon 2014; Antuvan et al. 2016; Torres-oviedo et al. 2013).

The current study includes a few limitations. One limitation was using only elite athletics of each Taekwondo and Karate groups. Using the different levels of professionalism of athletics scientists can explain the reason for motor training differences.

Conclusion

In conclusion, after kinematics comparison of the front kick between Taekwondo and Karate athletics, the Taekwondo athletics were faster than their Karate players but executed the front kick with similar angular position patterns in lower extremity (hip, knee, and ankle joints) because the fundamental motion patterns of martial arts are similar and all of them have the same source. In addition, biomechanical results presented in some joints kinematics patterns are basically the same between Taekwondo and Karate because motor control and motor learning strategy, which include better and accurate control of the joint motions. Based on the kinematics comparison between Taekwondo and Karate groups, our results show the type of training and learning strategies can be changed the neuromuscular control. In addition, results of lower extremity velocity presented martial arts athletics need to boost the neuromuscular system of their knee during the front kick in order to acquire the maximum lower limb velocity because they need to minimize the time of the foot takeoff during front kick movement. A current comparison study is part of the important issue and this issue needs comprehensive analysis because several parameters can affect motor training at the same time. Our results represented in the current study may be a part of the information for further study in the field of motor learning and training strategies. Future studies on front kick biomechanics will help Taekwondo and Karate athletics and coaches to use the training strategy of each other in order to approach the specific properties of each other. Analyzing this kind of research and comparison between two different groups that executes the same action with two different learning methods can improve the knowledge of athletics and coaches to better performance in training and learning strategies. In addition, this type of study of training strategy and motor control knowledge can reduce sports mistakes in coaching, particularly in the primary period of athletics training, and decrease injury prevention that happens during matches or training.

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