DESCRIPTIVE ANALYSIS OF HIP AND KNEE JOINT LOADING DURING REVERSE ROUNDHOUSE KICK (HOOK) KARATE KICK PERFORMED IN TRAINING AND COMPETITION MODES

Riyadh Al-Saeed[1], Matthew TG Pain[2]

School of Sport, Exercise, and Health Sciences, Loughborough University, Loughborough, United Kingdom [1,2]
School of Sport, Basrah University, Iraq [1]

The purpose of this study was to examine hip and knee joint loading during the performance of the common reverse roundhouse or hook kick (Ura Mawash geri. Twenty eight black belt karate players performed hook kicks in two different ways, training kick and competition kick. Motion and force data were collected with a VICON motion analysis system and two Kistler force plates. 3D joint motions and joint moments about the hip and knee of both the support leg and kicking leg for all kicks were calculated in Visual3D. The maximum moments were more varied between kick types for the kicking leg but the joint angles were similar in most cases. Joint loading higher than in the literature for cutting actions were found, with cutting actions considered a risky action.

KEYWORDS: martial arts, sports injuries, kinematics, kinetics

INTRODUCTION: Over many years a wide range of oriental martial arts such as Karate, Taekwondo, Judo and Jujitsu have spread and taken root in a large number of countries worldwide with around 30 million people of both sexes and various ages being in registered karate organizations. There is an oddity in the long term practice of karate in the west as traditionally it has been seen as an activity that can last a lifetime but there are many people who suffer from various chronic complaints of the lower limbs. Most research has looked at acute injuries (Pieter, W., 2005; Sterkowicz, & Sterkowicz-Przybycień K. 2013) in karate but for the most part these injuries are not to the parts of the body that suffer the chronic problems, hips and knees. From this it would seem likely that chronic injuries are due to repetitive training or from minor non-contact injuries repeated intermittently. Studies have recently started looking at the mechanics of kicking in various martial arts but predominately with a goal of understanding and improving performance. (Quinzi, F., at al. 2013). examined the lower limb karate skills of six elite karate players and six amateurs kicking in the air, as is common in traditional training, and to a target they examined neuromuscular activation with electromyography (EMG) and also the kinematics between these two groups at three joints, hip, knee and ankle of the kicking leg. They found there was an effect of karate player group on kicking with higher knee and hip angular velocities, co-activation of hip movements and knee flexion. In 2014 Mariconda looked at femoroacetabular impingement in the Brazilian martial arts (Capoeira) players. Capoeira requires extreme movements of the hip to perform jumps and kicks. They used radiographic assessments to find out the impact of these motions on hip health. There were 24 subjects (10 women and 14 men) all of whom were experienced in Capoeira. Of the 24 subjects 4 had hip pain and 44 of the 48 hips had signs of impingement, so they suggested more research about martial arts hip problems is needed (Mariconda, M., at al. 2014).). The main purpose of this study was to examine hip and knee joint loading during the performance of the common competition kick the hook kick in both a training and competition modes. Hook kicks are used in nearly all competition matches but is one of the latter kicks taught due to its technical difficulty and the hip flexibility required to perform it. It is hypothesised that the competition mode of training will have higher loading to the joints and more extreme ranges of motion and could be more injurious if the player is not suitably conditioned.

METHODS: Following ethical approval 28 black belt karate players (20 men and 8 women, mean ± SD; age: 25.6 ± 9 years, height: 1.75 ± 0.2 m, mass: 78 ±12.7 kg and years training:

14 ± 6.2 years) with no injuries to their knees or hips volunteered for this study. They were from different karate schools or styles (Shotokan, Shito-ryu, Wado-ryu and Ryobu-Kai JKR). They all train and compete under the overall karate name but they use different strategies and philosophies of training to get speed, balance and strength to reach the target. After a personal warm up each karate player performed hook kicks in two different ways, training and competition modes. For each kick mode the players stayed stationary, although foot slide and rotation during the kick necessitated two force plates, and kicked the air at a point of their choosing with the only constraint being that they kept their supporting foot on the force plates. The training kick was as executed as in standard training in their style with 'speed and power' and the competition kick was also executed with 'speed and power' but with their own greater emphasis on speed at the expense of traditional form of execution as they would in competition. There was no other constraint on how the experienced karate players performed the modes of the kick. Motion and force data were collected with a nine T20 camera VICON motion analysis system (VICON, Oxford Metrics Group, UK) set to 250 Hz and two 0.6x0.4 m Kistler type 9281EA force plates (Kistler Instruments AG, Winterthur, Switzerland) set to 1000 Hz. Twenty-one 14 mm retro reflective markers were put on the players bodies. Five on the foot (1 on the big toe, 2 on the foot, medial and lateral sides of the MTP joint on the top surface , 2 on the medial and lateral sides of ankle joint); 2 on the knee joint (medial and lateral sides of knee joint), 1 on the thigh; 5 on the pelvis (2 on the bony protrusion of the right and left anterior super iliac, two on the dimples created by the right and left posterior super iliac and 1 on the left iliac this just to check right and left sides). Data were reconstructed and processed in VICON Nexus and then exported to Visual3D (C-motion, Germantown, MD, USA) to calculate 3D joint motion and joint moments about the hip and knee of both the support leg and kicking leg for all kicks (moment normalised to body mass. Time normalised to kicking duration from a common start point and common end point (Actual kicking time was 1-2 second)). Maximum joint angle and maximum joint moment were calculated and pooled across all 28 karate players. The X axis is flexion-extension, the Y axis is abduction-adduction and Z axis is internal-external rotation.

RESULTS: The maximum X axis angle (mean and standard deviation) of the left (support leg) and the right (kicking leg) hip angles in training and competition modes was very similar (Table 1). The means and standard deviations of the maximum joint angle for the knee and hip of the kicking leg and support leg between the training and the competition mode were generally similar, (Table 1, Figure 1) apart from the support leg and kicking leg knee and hip in one axis (X flexion-extension) the curves look bit different, even though time normalised some of the competition looks to have some quicker change in joints angle or larger moment at the start on one axis such as in right hip moment (table1, figure 1). The maximum moments were slightly similar between kick types for the kicking leg (Table 1, Figure 1). The kicking leg hip moments about all 3 axes were no big different with the competition kick having lower abduction-adduction but higher flexion-extension (Table 1, Figure 1). The kicking leg maximum mean and SD moments for all axes (X, Y and Z) of knee were very similar in both modes. The support leg max mean and SD of hip moments were slightly higher in training mode than competition mode. It should be noted that the support leg hip moments (mean and SD) in abduction-adduction were (1.5 and 2 NM/kg) in training mode were higher verses (1.3 and 1.5 NM/kg) in competition mode but competition mode has higher mean in X axis (1.5 NM/kg) training mode has just (1 NM/kg).

DISCUSSION: The main purpose of this study was to examine hip and knee joint loading during the performance of the common competition hook kick with the expectation that the competition kick would produce greater loading on the joints and at more extreme angles. This was only partly supported by the results as the maximum joint angles were greater in some cases for the training kick and in others for the competition kick. The maximum moments were more often greater for the competition kick compared to the training kick than vice versa, that was right in maximum moments hip and knee but when looking for the mean and SD of hook kick it was similar in both modes (Table 1, Figure 1). In part this lack of a

clear change across all variables can be down to subtle changes in the way the kick is performed when moving from one to the other with the competition mode usually not just being a faster mode of the training kick, but the result shows that in some cases abduction-adduction and internal-external rotation were higher. It can be seen from the moments of the kicking leg that in the training kick the hip moments are similar for Z axis and a bit different in X axis and knee moment Y axis, Knee moment were very similar in all axes (Table 1, Figure 1).

Table 1
Mean and SD of both hips and knee joints for all three axis for both the training and competition moods for hook kick, support leg(left) and kicking leg (right)

	Support hip			Kicking hip			Support knee			Kicking knee		
Training angles/Degrees												
	X	**Y**	**Z**	**X**	**Y**	**Z**	**X**	**Y**	**Z**	**X**	**Y**	**Z**
Max mean	71	51	24	63	46	21	165	3.5	14	130	4	23
Max SD	18	9	13	17	9	10	15	7.5	8	35	11	11
Competition angles/Degrees												
Max mean	77	47	24	66	44	25	160	4	15	128	5	23
Max SD	16	9	11	19	11	9	12	8	8	41	11	11
Training moments/NM/kg (Normalised)												
	Support hip			Kicking hip			Support knee			Kicking knee		
	X	**Y**	**Z**	**X**	**Y**	**Z**	**X**	**Y**	**Z**	**X**	**Y**	**Z**
Max mean	1	1.5	0.8	0.5	0.4	0.3	1.3	1	0.3	0.2	0.1	0.1
Max SD	1	2	1	0.5	0.4	0.3	0.7	0.6	0.3	0.6	0.3	0.1
Competition moments/NM/kg (Normalised)												
Max mean	1.5	1.3	0.8	0.8	0.4	0.3	1.2	1	0.3	0.3	0.3	0.1
Max SD	1	1.5	0.9	0.6	0.6	0.7	0.8	0.5	0.3	0.2	0.2	0.1

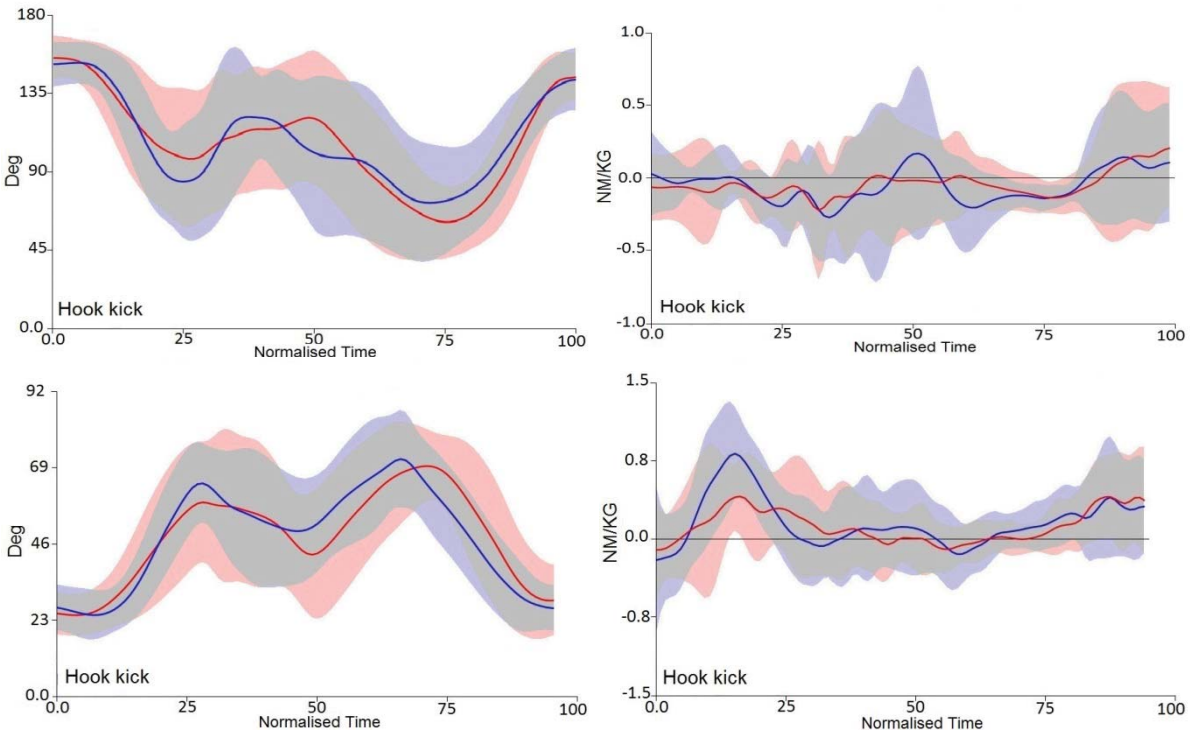

Figure1. Mean joint angle and standard deviation, left, and joint moment, right, throughout the kicks for flexion extension, of the right knee, top, and right hip, bottom during a right leg

hook kick. Red for training mode, blue for competition mode in the title of all subjects during the hook kick. Time normalised so all durations from start to finish equal 100.

For the support leg the training mode had lower knee extension than the competition kick and it is considered good form to have a bent support leg when performing this kick in which the player rotates about the support leg. As the knee joint has a lesser range of internal-external rotation when extended than when flexed, and the peak moment seeming to occur near maximum angle that there is a greater risk of injury to the support leg in the training execution of the hook kick by these players especially in the internal-external rotation of knee and hip. The moments on the support knee normalised to body mass (noting that some studies report normalisation to body mass times height) for abduction-adduction were larger than 1 and this is higher than values seen in cutting actions when running, The support hip also had larger normalised abduction-adduction moments than seen in cutting and turning actions and much greater ranges of motion (Kristianslund, E., at al. 2014).

CONCLUSION: The players generally had ranges of motion that were not excessive or abnormal and had produced well controlled kicks with expected variations between the type do kicking technique. However, there were high moments at maximal around a few joint axes, especially in the hips and the support leg knee and maximum moments in the support leg about the knee and hip that are higher than those seen in other sporting actions such as cutting and landing that are seen as risky with regard to injury. Consideration that it is the supporting leg's knee and hip that may be more at risk from chronic abuse is something that needs bringing to the attention of coaches and athletes especially at the hip as they tend to focus on the kicking leg.

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