HIP AND KNEE LOADING OF KARATE PLAYERS PERFORMING TRAINING AND COMPETITION STYLE VERSIONS OF A ROUNDHOUSE KICK

Riyadh Al-Saeed, Matthew TG Pain and Martin Lindley

School of Sport, Exercise, and Health Sciences, Loughborough University, Loughborough, United Kingdom

The main purpose of this study was to examine hip and knee joint loading during the performance of the common roundhouse kicking technique in both a training mode and in a competition mode. 15 black belt karate players performed roundhouse kicks in two different ways, basic 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. The maximum moments were more varied between kick types for the kicking leg but the joint angles were similar in most cases. Joint loading comparable to the literature was found for joint previously examined but several high joint moments at extremes of motion were found in the supporting leg.

KEYWORDS: martial arts, sports injuries, kinematics, kinetics

INTRODUCTION: Over many years, oriental martial arts such as Karate, Taekwondo, Judo and Jujitsu have spread and taken root in a large number of countries worldwide around with over 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 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, 2005; Sterkowicz, 2013) in karate but for the most part these injuries are not to the parts of the body that suffer the chronic problems, knees, hips and elbows. 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 understating and improving performance. For example (Quinzi et al., 2013) examined the lower limb karate skills of six elite karate players and six amateurs kicking to the air, as is common in traditional training, and to a target (Quinzi et al., 2013) 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 et al. looked at femoroacetabular impingement in the Brazilian martial arts (Capoeira) players. Capoeira requires extreme movements of the hip to perform jumps and kicks. Mariconda et al. 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 had a lot of experience in Capoeira. Of the 24 subjects 4 had hip pain and 44 of the 48 hips had signs of impingement, and they suggested doing more research about martial arts hip problems. (Mariconda et al., 2014).

The main purpose of this study was to examine hip and knee joint loading during the performance of the common roundhouse kicking technique in both a training mode and in a competition mode. 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 15 black belt karate players (10 men and 5 women, mean ± SD; age: 24.4 ± 8.1 years, height: 1.7 ± 0.1 m, mass: 73 ±11.3 kg and years training: 11 ± 8.2 years) with no injuries to their knees or hips volunteered for this study. They were from different karate schools or styles (Shotokan, Shitoryu and Wadoryu). 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 roundhouse kicks in two different ways, basic kick and competition. For both kicks the players stayed stationary and kicked to the air at a point of their choosing with the only constraint being that they kept their supporting foot on the force plates. The basic kick was as executed as in standard training in their style with 'speed and power' and the competition kick was also with 'speed and power' but with their own greater emphasis on speed of execution as they would in competition.
Motion and force data were collected with a nine T20 camera VICON motion analysis system (VICON, Oxford Metrics Group, UK) set to 250Hz and two 0.6x0.4 m Kistler Type 9281EA force plates (Kistler Instruments AG, Winterthur, Switzerland) set to 1000Hz. Twenty-one 14mm retro reflective markers were put on the players bodies 5 on the foot (1 on the Toe, 2 on the Medial and Lateral sides of foot, 2 on the Medial and lateral sides of ankle), 2 on the knee joint (Medial and lateral sides of knee joint, 1 on the thigh, these 8*2=16 markers on both legs and 5 on the pelvis (2 on the bony protrusion of the right and left anterior super iliac, Dimple created by the right and left posterior super iliac and 1 on the left iliac). 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. Maximum joint angle, maximum joint moment and joint moment at maximum joint angle were calculated and pooled across all 15 karate players. The X axis is flexion-extension, Y axis is abduction-adduction and Z axis is internal-external rotation.

RESULTS: The means and standard deviations of the maximum joint angle for the knee and hip of the kicking leg and support leg between the basic version and the competition version were generally similar, (Table 1, Figure 1) apart from the support leg knee flexion-extension and the kicking leg knee internal-external rotation. The maximum moments were more varied between kick types for the kicking leg (Table 1, Figure 1). The kicking leg hip moments about all 3 axes were different with the competition kick having lower abduction-adduction but higher flexion-extension and internal-external rotation (Table 1, Figure 1). The kicking leg knee maximum moment for extension-flexion was nearly double in the competition version than the basic version, 101 N.m versus 58.8 N.m. It should be noted that the support leg knee moments in abduction-adduction were close to 100 N.m. Joint moment at maximum joint angle were generally much lower than the maximum moments apart from, kicking leg hip abduction-adduction for competition kicks and support hip internal rotation for the competition and basic kicks, and left support knee internal-external rotation for the basic kick. The absolute values for the support leg hip at maximum angle were high for flexion-extension and abduction-adduction.

DISCUSSION: The main purpose of this study was to examine hip and knee joint loading during the performance of the common roundhouse kicking technique 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 basic kick and in others for the competition kick. The maximum moments were more often greater for the competition kick compared to the basic kick than vice versa. 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 version usually not just being a faster version of the basic kick. It can be seen from the moments of the kicking leg that in the basic kick the hip moments are similar for all three axes. In the competition version there are greater hip flexion and internal rotation moments and less abduction moment as in order to reduce total execution time the emphasis is on getting a straighter line to the target with little early hip abduction and suddenly trying to rotate the leg internally to get the foot into position. This often results in a round kick that kicks more up rather than round.

Table 1. Mean and SD of maximum joint angles, maximum moment, and moment at maximum angle for all three axis of both hips and knees for both the basic and competition style kicks

Training													
		Right hip			Right knee			Left hip			Left knee		
	AXIS	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
Mean	Max Angle	66.2	52.4	36.6	167	9	13.7	65.5	50.9	50.7	174	7.3	14.1
SD	Max Angle	11.9	7.6	5.4	11.6	3.3	7.6	9.2	7.8	10.4	4.7	2.2	3.6
Mean	Max moment	79.4	77.9	77.8	58.8	53.2	93.2	148.5	147	41.3	83.8	90.4	26.5
SD	Max moment	14.3	16.2	17.9	16.1	15.2	17.9	18.7	17.2	16.6	11.6	15.1	8.7
Competition													
		Right hip			Right knee			Left hip			Left knee		
	AXIS	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
Mean	Max Angle	70	50	26.5	160	14.1	26.9	66.4	54.7	39.3	157	7.5	15.1
SD	Max Angle	14.1	11.5	10.1	16.7	5.8	13.6	10.7	13.4	9.3	17.3	3.1	5.1
Mean	Max moment	110	43.6	109	101	40.4	92.9	150	130.3	40.6	97.7	98.8	35.5
SD	Max moment	20.5	14.2	20.2	21.2	17.1	19.2	20	22.5	7.5	20.1	15.9	17.4

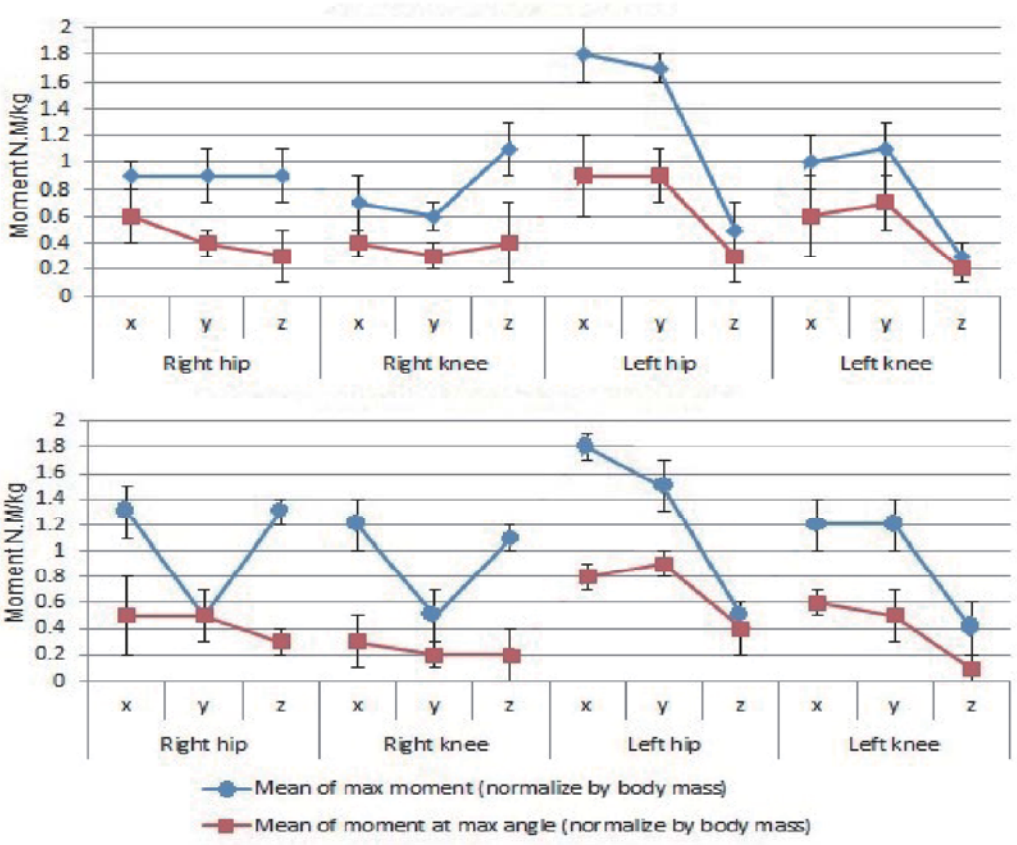

Figure 1. Top basic kick for all joints and axes. Group mean and standard deviation of the maximum moment (blue circles) and the moment at maximum angle (red squares) normalised to body mass. Bottom competition kick for all joints and axes. Group mean and standard deviation of the maximum moment (blue circles) and the moment at maximum angle (red squares) normalised to body mass. See charts 1 and 2.

The moment at maximum joint angle for the kicking hip is also slightly higher in this version. For the support leg the basic kick had greater 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 basic execution of the round kick by these players. 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 (Kristianslund et al., 2014). The support hip also had larger normalised abduction-adduction moments than seen in cutting and turning actions (Kristianslund et al., 2014) and much greater ranges of motion.

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 joint angles 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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