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JOINT MOTION AND STIFFNESS REGULATION OF THE KNEE JOINT IN CHOICE REACTION SIDESTEP CUT TASKS

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The purpose of this study was to identify the difference of the neuromuscular motor control of the knee joint for sidestep cut performance under two different conditions. A VICON motion analysis system using 12 cameras (250Hz) and a force plate (1kHz) were used to determine the knee joint kinematics and kinetics of 6 subjects during sidestep cut performed under the choice reaction tasks. The reaction signal was displayed 1.8m before the force plate centre (B1.8M) or 0.9m before FP centre (B0.9M). In the accelerating phase, knee extension positive power tended to be greater under B1.8M than B0.9M. The results of this study suggested that the greater stiffness during the decelerating phase in the B1.8M condition causes the greater knee extension power during acceleration.

KEY WORDS: electromyography, pre-landing activity, knee joint moment, knee joint power, muscle-tendon complex.

INTRODUCTION: In many ball game sports such as basketball and soccer, players often change their direction of movement. Players need to change their direction as fast as possible. A sidestep cut or an open-step cut, in which the ongoing path proceeds away from the support leg side, is an effective way to retain fast speed after changing direction (Ohtsuki et al., 1988). Players are often forced to change their running direction in a moment to react to game situations. These reaction movements make it difficult to make postural adjustments because of the short time provided (Besier et al., 2001). Horita et al. (2002) suggested that the pre-landing movement in the drop jump could be associated with the high initial stiffness observed after touchdown coupled with the high series elasticity of the knee joint musculoskeletal system. The purpose of this study was to identify the difference of the sidestep cut performance between a short reaction time and a long reaction time in the neuromuscular motor control of the knee joint.

METHODS: Six university male basketball players (age: 20.0±1.9 years, height: 1.78±0.06 m, body mass: 72.2±7.7 kg) were asked to perform repeated trials of the selected reaction tasks. Subjects were instructed to take one of three directions after the right foot landed on the force plate (FP) following the signals during the approach. These directions were 60 degrees to the left (sidestep cut), 60 degrees to the right (crossover cut), and straight run. The timing of instruction signals was at 1.8m before the FP centre (B1.8M condition) or 0.9m before FP centre (B0.9M condition). The instructions of three directions and two timings were shown randomly by a LED signal at the front (Figure 1). In this study we only analyzed the sidestep cut under the choice reaction tasks. Reflective markers were fixed to lower limb landmarks to record three-dimensional lower limb movements using 12 cameras, 250 Hz VICON motion analysis system (Oxford Metrics, Oxford, UK). Ground reaction forces (GRF) were recorded at 1kHz using a 0.9×0.6 m force plate (Kistler, Switzerland). The average rectified values (ARV) of the wireless electromyography (EMG; 1kHz, S&ME, Japan) of the right lower extremity muscles (Rectus femoris; RF, Vastus medialis; VM, Semimenbranosus; SM, Gluteus medius; GM) during the pre-landing phase that from the left foot (pre-cutting leg) contact to the right foot (cutting leg) contact, and the contact phase of sidestep cut. The joint stiffness obtained as the average ratio of knee moment change divided by the knee angle change, as described in Horita et al. (1996). According to the relationships between knee joint moments and knee joint angles, the foot contact phase was divided into the three phases, namely, P1 phase represents the initial impact phase, extending from minimum knee moment to initial knee moment peak. P2 phase represents transmission phase corresponds to the period from the initial moment peak to the knee flexion angle peak. P3 phase covers the concentric phase (Figure 2). The variables of sidestep cutting manoeuvres were compared using paired *t* tests procedures (α=0.05) between B0.9M and B1.8M conditions.

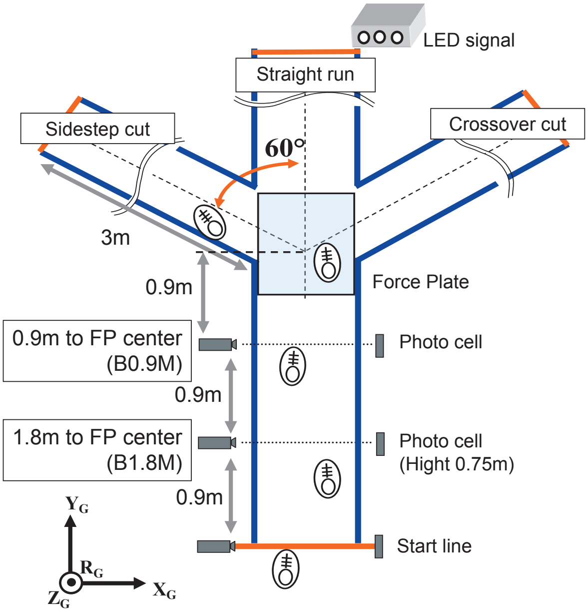

Figure 1: Experimental set up.

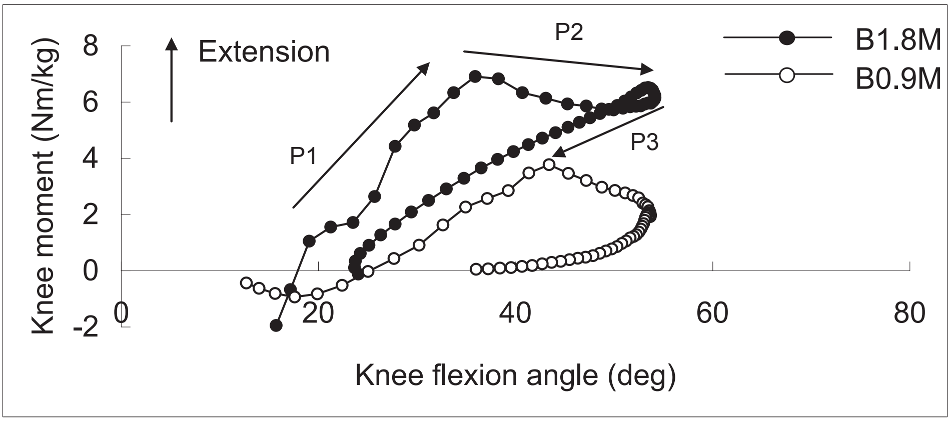

Figure 2: Typical example of knee moment-angular displacement curves. The black circles represent the condition of 1.8m before the FP contact (B1.8M), and the white circles represent the condition of 0.9m before the FP contact (B0.9M).

RESULTS: Mean running speeds at touchdown and toe off under B1.8m were significantly faster than those for B0.9M (B1.8M: 3.92 ± 0.34 m/s, 4.14 ± 0.25 m/s, B0.9M: 3.43 ± 0.28 m/s, 3.72 ± 0.37 m/s) respectively. Table 1 shows the results of the ARV ratios (B0.9M / B1.8M) at each phase. The ARV ratios of the knee extension muscles were significantly greater under B1.8M than B0.9M during the pre-landing phase (RF: 58.9 ± 23.5 %, VM: 58.6 ± 30.7 %). During decelerating phase (P1 and P2 phase) the knee extension peak moment and the negative peak power at knee extension muscles under B1.8M were significantly greater than B0.9M (Figure 3). Under B1.8M at P1 phase the average knee joint stiffness was significantly greater than B0.9M (B1.8M: 0.35 ± 0.07 Nm/deg/kg, B0.9M: 0.20 ± 0.05 Nm/deg/kg). During the acceleration phase (P3 phase) the knee extension positive power tended to be greater under B1.8M than B0.9M, and the ARV ratios of the knee extension muscles were not significantly different under B1.8M than B0.9M (Table 1).

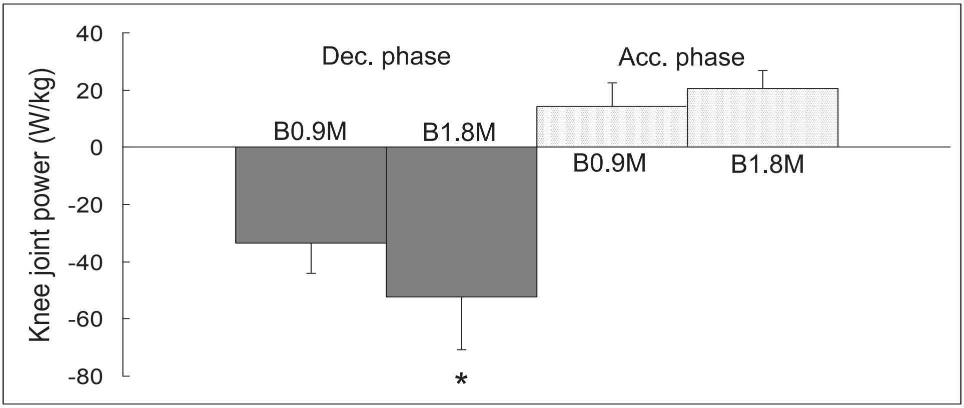

Figure 3: The knee joint peak power at each phase under B0.8M and B1.8M. * denote significant differences between B0.9M and B1.8M condition (p<0.05).

Table 1
The ARV ratios of the EMG at each phase

		Pre-landing phase	Decelerating phase	Accelerating phase
Rectus femoris (RF)	(%)	58.9 (23.5) *	83.4 (38.0)	99.2 (39.1)
Vastus medialis (VM)	(%)	58.6 (30.7) *	86.9 (43.1)	103.8 (33.2)
Semimenbranosus (SM)	(%)	86.2 (38.1)	92.2 (34.4)	106.1 (24.5)
Gluteus medius (GM)	(%)	89.1 (22.6)	83.3 (12.7) *	121.2 (40.3)

Values are average and (S.D.). *Significant differences between B0.9M and B1.8M condition (p<0.05).

DISSCUSSION: This study investigated the difference of the sidestep cut performance between two conditions (B0.9M and B1.8M) from the view point of neuromuscular motor control of the knee joint. Under B1.8M condition, in which subjects have longer time to react, the knee extension muscle activities during the pre-landing phase may contribute to exert the significantly greater negative power at the knee joint and significantly greater knee joint stiffness during decelerating phase compared to B0.9M. It was suggested that the elastic energy of the tendon stored during decelerating phase was released as a knee extension positive power during accelerating phase. The results of similar levels of ARVs under two conditions at RF and VM muscles during accelerating phase suggest that the knee extension positive power during accelerating phase were not caused by the muscle contraction of the knee extension, but by the beneficial effect of the elastic energy of the patella tendon and the aponeurosis of the rectus femoris. The results of the present study were consistent with the earlier studies for the drop jump (Horita et al., 2002). It suggests that the pre-landing activities contribute to stiffen the knee joint during deceleration phase, and produce larger power during the acceleration phase by releasing the elastic energy.

CONCLUSION: This study concluded that it was more difficult to perform the sidestep cut with a shorter reaction time, because of the elastic energy of the knee joint was not able to produce the power during the acceleration phase. The results suggest that getting a longer reaction time would generate greater power during the acceleration phase of cutting maneuvers. The person with faster reaction ability is clearly advantageous to others. We encourage the reaction training for the ball game players such as basketball and soccer.

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