

The Effect of Kayak Foot brace on Forward Stroke and Stability of Boat in the Kayak Sprinting

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Abstract

The aim of this study was to investigate the effect of kayak foot brace on forward stroke and boat's stability. Thirteen male elite kayak athletes participated in this study. They were divided two groups (Foot brace group; FB and no-brace group; NF). All Kayak athletes performed kayak sprinting on flat water condition. Stroke, duration time, knee joint ROM, trunk rotation ROM, and boat stability were measured and analyzed. The results showed that FB group's stroke duration time was significantly shorter than NF group's. Knee joint ROM, trunk rotation ROM were increased, and boat's roll angle ROM was decrease when using foot brace. The result can be utilized to design trunk ROM increasing training program.

Keywords: Kayak, Foot brace, Stroke, Joint ROM Kinematics, EMG

1. Introduction

In the Olympic kayak matches, one hundredth seconds can decide the color of the medals. The small winning margins are often related to equipment or technique. During kayak paddling, the force developed by the paddler is transferred to the kayak against a foot brace and seat. The foot brace and "swivel seat" that makes stroke easier are the most important part of the interior boat design. Kayak athletes generate propulsive force with forward strokes and the force should be effectively transferred through the foot brace in order to maximize outcome (Michael, J. S., Smith, R. & Rooney, K. B., 2009). Previous studies focused on the relationship between foot brace and the rank of athletes in Olympic (Ackland et al., 2003; Alacid, Marfell-Jones, López-Miñarro, Martínez&Muyor, 2011) and suggested that the foot brace is one of the key element for efficient kayaking. However, it is hard to find a study that investigated a specific technique needs for it. Investigating the role of foot brace could help improving kayaking performance and can be used for future design of the foot brace. The purpose of this study was to investigate the effect of kayak foot brace on forward stroke and boat's stability. Furthermore, the results could be used for development of the foot brace design.

2. Method

2.1. Participants

Thirteen male collegiate athletes were selected. They all had at least 4 years of kayaking experience. The participants were divided into two groups depending on usage of foot brace. Foot brace (FB) group had 8 participants and no foot brace (NB) group had 5 participants Table 1.

Table 1. Subject Characteristics (Mean±St.Dev.)

Group	Subject	Height (cm)	Body mass(kg)
Foot Brace(FB)	n=8	176.4±6.6	74.1±7.1
No Foot Brace(NB)	n=5	177.4±6.0	74.1±7.1

2. Experimental Setting and Equipment

All participants performed kayak sprinting on flat water condition. An inflatable boat from Woosung I. B. co., was used (3.8m x 0.7 m, capacity: 193 kg, weight: 12.5 kg; Figure 1). A plastic paddle of 2.30 m length from the same company was used. Participants wore tight fitting clothes. Inertial measurement unit (IMU) sensor, developed by Korea Institute of Science and Technology (KIST) was used to capture the motions of foot brace group (FB). This IMU sensor was a combined sensor unit consisting of accelerometers (LIS3LV02DQ, SPI, 12bit), gyrosensor (L3G4200D, SPI, 16bit, 2000dps), and geomagnetic sensor (Figure 2). Gyrosensor produces angular velocity and rotational matrix of an object with respect to global reference frame. Accelerometers and geomagnetic sensors adjusts rotation matrix created by gyrosensor (Chun, Kang, Choi, Park, Lee & Kim, 2013). In addition, motion capture of no brace group (NF) was performed by Myomotion® and MR3® software (Noraxon, USA).



Figure 1. Portable (inflatable) Boat and Noraxon MyoMotion sensor



Figure 2. Attachment Placement of Gyro Sensor & Electrode

2.3. Procedure

All the participants were stretched and warmed up before testing. The sensors were placed on participants' trunk, thigh, and leg. They performed maximum effort forward strokes for 20 m at indoor swimming pool. Data were collected after initial 5 m phase. A 5 minute break was given between trials.

2.4. Data Analysis

Dependent variables were time duration of 1 stroke cycle, right knee angle ROM, trunk rotation angles, and ROM of rolling angle of boat Figure 3. SPSS version 20.0 was used to perform independent t-test and alpha level was set at $<.05$.

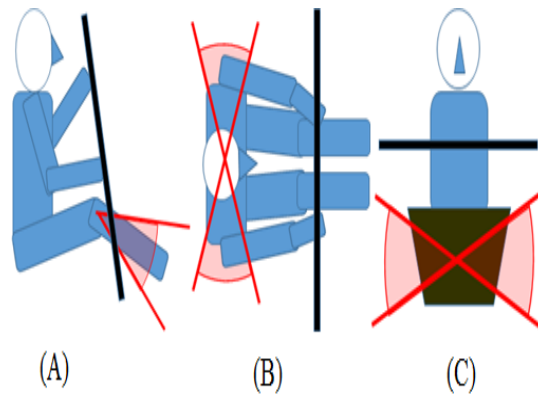


Figure 3. Definition of Experimental Variables (A) Range of Motion (RoM) of Knee Angle, (B) RoM of Trunk Angle in Transverse Plane, (C) RoM of Boat Rolling Angle

3. Results

3.1. Stroke Performance (time duration of 1 cycle)

Time duration of 1 stroke cycle was measured to examine the effect of foot brace on stroke performance <Table 2> <Figure 4>. The foot brace group demonstrated significantly shorter time duration of 1 cycle ($p = .0001$).

Table 2. Forward Stroke Performance Time Duration of 1 Cycle Forward Stroke

	Foot Brace (FB)	No Foot Brace (NB)	P value
Time duration of 1 cycle [sec]	1.06 (0.096)	1.43* (0.16)	.0001

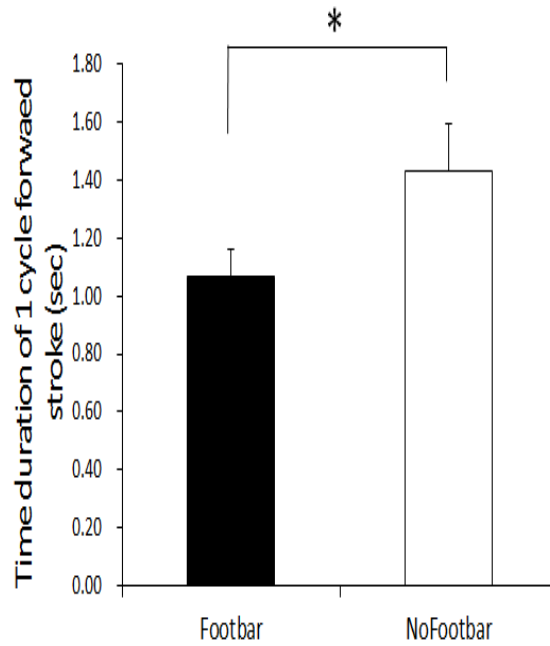


Figure 4. Time Duration of 1 Cycle Forward Stroke

3.2. Kinematics and Boat Stability During Forward Stroke

Knee joint ROM angle (Right side) indicates amount of lower body movement during stroke and trunk movement was examined with trunk rotation angles in transverse plane Table 3, Figure 5. ROM of rolling angle which represents the angle of boat moving in lateral direction measures stability of kayak boat. The knee joint angles, trunk rotation angles, and boat ROM of rolling angles significantly decreased with FB condition($p = .039$, $p = .004$, and $p = .001$, respectively).

Table 3. Joint Angle, RoM and Rolling Angle (mean±SD)

	Foot Brace(FB)	No Foot Brace(NB)	P value
Joint Range of Motion [deg]			
Right Knee Joint angle	14.32±4.37	35.06±27.94	.039
Trunk rotation in transverse plane	19.56±7.95	34.21±7.45	.004
Stability of Kayak Boat	11.54±4.63	2.90±1.75	.001
ROM of Rolling angle [deg]			

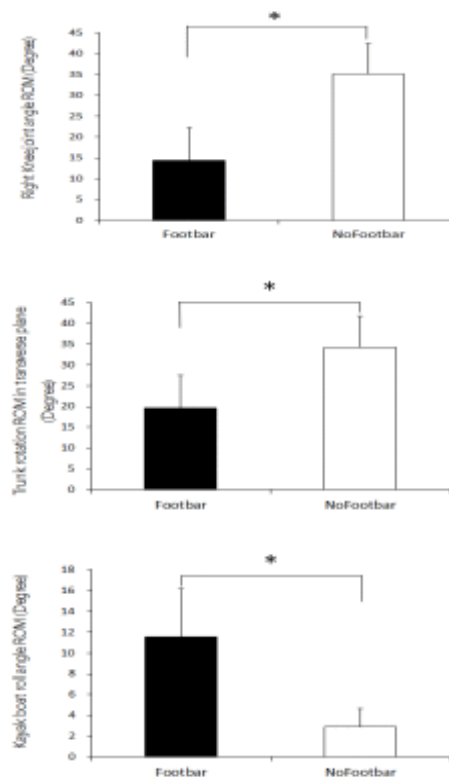


Figure 5. Joint angle, RoM and Rolling Angle (mean±SD)

4. Discussion and Conclusion

This study investigated the effect of kayak foot brace on forward stroke mechanism and boat's stability. Shortened time duration of 1 stroke cycle with FB condition indicates that the foot brace increases frequency and speed of stroke. The results suggest that the foot brace helped transferring power against extending knees and increasing stroke speed.

The boat ROM of rolling angles was smaller in NF condition. Athletes push off opposite foot during forward stroke. However, in the absence of foot brace, less power and lateral movement were created. This information can be utilized by athletes. If one could develop a method to control the lateral stability with the foot brace, it would help increasing speed of boat with less resistance.

The trunk rotation in NB condition resulted in increased trunk rotation. Considering the argument by Michael *et al.*, (2009) that trunk rotation is one of the essential movements for forward stroke, training without foot brace can be utilized to enhance trunk rotation of athletes. Using trunk rotation rather than shoulder extension can allow athletes to use bigger muscles to obtain propulsive force.

Considering that minimizing drag resistance with greater stability needs to be obtained as well as maximizing propulsive force to achieve best performance (Kendal & Sanders, 1992), the result of this study can be used for development of foot brace and training for kayak athletes.

Acknowledgements

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