

ELITE AND SUB ELITE FLAT WATER SPRINT KAYAKERS PERFORMANCE COMPARISON: A PRELIMINARY RESULT

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The purpose of the present study was to compare the effects of using a fixed and swivel seat between elite and sub elite kayakers: conducted on a 200 metre simulation race in the laboratory setting. One elite and one sub elite male sprint kayaker participated in this study, performing on both seat conditions. Significantly increased results were found in paddle force and stroke rate using the swivel seat for the sub elite kayaker ($p < 0.05$). Correlation values of more than 0.6; $p < 0.05$ were obtained in the foot force and paddle force of the sub elite kayaker. Further research with more participants is required to obtain important information of an efficient paddling execution by the kayakers at different skill levels.

KEY WORDS: fixed, swivel, seat, kayak, ergometer, 200 metres.

INTRODUCTION: There has been very limited research conducted on the performance outcomes of using a swivel seat in sprint kayaking. The use of a swivel seat was introduced into the competition in 2005 by the International Canoe Federation Flat Water Racing Committee (Michael, Smith, & Rooney, 2009). It was hypothesised that the design of the swivel seat would help the kayakers to gain more optimal power transfer, with a better hip and trunk rotation for the paddling execution. Several previous studies have been done biomechanically and physiologically on a number of kinematic and kinetic variables. Some significantly increased results were obtained using the swivel seat; where there were greater blade tips' displacements and velocities, greater mean power output, and an increase of footpad forces with a greater knee range of motion (Fohanno, Colloud, Mansour, & Lacouture, 2011; Michael, Smith, & Rooney, 2010; Petrone, Isotti, & Guerrini, 2006). Introduction of the 200 metre race in the 2012 Summer Olympic Games raises new research questions with the men competing in 200 metre and 1000 metre and women competing in 200 metre and 500 metre events. Obviously, physiological demands are different between 200 metre and 1000 metre events and it will be interesting to observe how the performance of an elite and sub elite kayakers differ biomechanically in a selected event. The present study aimed to investigate variables that have a significant effect when using the swivel seat; with a comparison performed on elite and sub elite kayakers during a 200 metre simulation test.

METHODS: A kayak simulator system with modified seat and footrest platform was set up in the laboratory using an air-braked rowing ergometer (Concept II; Morrisville, VT, USA), which is also connected with a kayak paddling adaptor to simulate the kayaking motion (Michael et al., 2010). Strain gauge load cells were connected to each end of the paddle rope connection, attached to the ergometer. The seat and footrest platform were attached onto the Kistler force platforms (type 9281A, Kistler Instruments AG, Winterthur, Switzerland) that measured ground reaction forces. A 14-camera motion capture system (Eagle, Motion Analysis Corporation, Santa Rosa, CA, USA) at a frame rate of 100 Hz was used to collect the kinematic data, where the beginning and end of each stroke were identified for the collection of paddle displacement.

One elite and one sub elite male flatwater sprint kayaker participated in this study. They were required to use their normal paddling technique and perform at a maximal effort on the kayak simulator. They rested for 15 minutes after a self-paced warm up session, before performing a simulated on-water race (i.e. 40 seconds for 200 m event). The kayakers had to perform

the test protocol twice; once using the fixed seat and again on the swivel seat. The order of seat presentation was randomly assigned on the testing day. They rested for one hour after completed the first test and then performed the second test on the alternative type of seat. Detection of the paddling strokes to determine the paddle force, foot force, stroke time and stroke rate were processed through the analysis of data using technical computing software (MatLab 7, Mathworks, USA). The variables were also time normalised to 100% of the pull phase. Analysis was done on all strokes executed by the two kayakers throughout the 40 second simulation test on both seat conditions; with peak forces recorded from every stroke. An alpha level of 0.05 was set for significance when performing the statistical analyses for each variable using SPSS version 20 (SPSS Inc., Chicago, USA). The correlation of the variables for both fixed and swivel seat on the left and right strokes were determined using Pearson product-moment correlation coefficients. Differences in kinematic and kinetic variables between the fixed and swivel seat condition in the 200 m simulated race were tested using paired sample t-tests.

RESULTS: As shown in Table 1 and Table 2, the mean values for the left and right peak paddle force, peak foot force, and stroke rate for both the elite and sub elite kayakers in the 200 m race simulation using both seat conditions are presented. Only the foot force in both left and right strokes showed significant difference ($p < 0.05$) for the elite kayaker using the swivel seat (Table 1). All the variables for the sub elite kayaker were statistically different ($p < 0.05$) except for foot force on the left side (Table 2).

Table 1
Kinematic and kinetic variables for elite kayaker in the 200 m race simulation using the fixed and swivel seat (mean \pm standard deviation)

Level	Elite			
Seat type	Fixed		Swivel	
	Left	Right	Left	Right
Paddle force (N)	421.4 \pm 40.0	260.7 \pm 27.0	419.7 \pm 14.9	271.9 \pm 12.6
Foot force (N)	460.8 \pm 49.8	620.5 \pm 58.8	562.0 \pm 32.3**	549.2 \pm 49.0**
Stroke rate (spm)	70.7 \pm 6.6		70.5 \pm 5.6	

Asterisk (**) denotes significant difference between fixed and swivel seat ($p < 0.01$)

Table 2
Kinematic and kinetic variables for sub elite kayaker in the 200 m race simulation using the fixed and swivel seat (mean \pm standard deviation)

Level	Sub Elite			
Seat type	Fixed		Swivel	
	Left	Right	Left	Right
Paddle force (N)	350.0 \pm 46.2	226.8 \pm 22.4	379.6 \pm 47.8*	239.6 \pm 27.6*
Foot force (N)	538.6 \pm 51.1	495.8 \pm 49.9	524.7 \pm 70.0	454.6 \pm 63.0**
Stroke rate (spm)	56.5 \pm 4.4		60.3 \pm 5.6**	

Asterisk (*) denotes significant difference between fixed and swivel seat ($p < 0.05$)

Asterisks (**) denote significant difference between fixed and swivel seat ($p < 0.01$)

Correlations value of more than 0.4 were found between the peak left paddle force and peak right foot force, while the peak right paddle force showed a correlation of more than 0.6 with peak left foot force in both the fixed and swivel seat conditions.

DISCUSSION: This study presents a comparison of biomechanical analysis in kayak paddling between using the fixed and swivel seat for elite and sub elite kayakers in the 200 metre simulation race. The results for both the elite and sub elite kayakers showed quite a different outcome (see Table 1 and 2). As expected, elite kayaker exhibited a higher stroke rate than the sub elite which is also clearly shown in the study of Brown, Lauder, and Dyson (2011), comparing the ability of kayakers at different competition level. The sub-elite kayaker showed a higher stroke rate while paddling with the swivel seat; however, there was no

difference between seat conditions for the elite kayaker. Stroke rate is one of the important variables that will contribute towards an improvement in the performance, as presented by McDonnell, Hume, and Nolte (2013) this variable had high correlations with 200 metre race time. Although stroke rate is not a direct indicator of performance, it can be useful for the coaches to differentiate the skill level of the kayakers.

A significantly increased left and right paddle force was found for the sub elite kayaker when using the swivel seat compared to the standard seat, however there was no difference between seat conditions for the elite kayaker. This may be associated with the finding of Fohanno et al. (2011) where more degree of rotation on the trunk and pelvis could assist in a greater power transfer. Although trunk and pelvis rotation were not included in this study, the linkage system of power transfer as a whole from the lower limb through the leg pedalling motion plays an important role for a powerful efficient paddling execution in combination with the co-ordination of the upper body motion.

This is clearly shown by the significant difference found on the sub elite kayaker's foot force using the swivel seat. The correlations of the left foot force with the right paddle force and vice versa, showed that there is a relation of contralateral force generation involved. These findings are in line with a previous study where the researchers suggested that the contralateral leg contributed towards force generation through the hip and knee flexion (Brown, Lauder, & Dyson, 2010). Brown et al. (2010) found significant correlations between the left rectus femoris activation and right paddle force demonstrating that lower limbs could contribute towards force production of the paddling stroke.

The different outcome on these limited and selected variables for comparison between the elite and sub elite kayakers will definitely require a future study with a bigger pool of participants for a better and meaningful data analysis. Future research with the profiling of the kayakers' biomechanics performance at different skill level on the breakdown at different phases of the entire race simulation (i.e. start, mid and end of the race) will be an area of interest to observe how the kayakers execute the paddling motion at their optimum level for the sustainability of maximum energy applied using the fixed and swivel seat.

CONCLUSION: The preliminary results of the present comparison study between elite and sub elite kayakers showed that paddle force, foot force and stroke rate might be used as a performance indicator to improve the kayak paddling execution with the usage of swivel seat at different skill level but is only limited to this single subject study.

There was a significant increase in paddle force and stroke rate when using the swivel seat for the sub-elite kayaker. From this limited study of comparison, there is no significant difference result obtained for the elite kayaker using the swivel seat except on the foot force, which might be due to the ability of the elite kayaker to maintain the same paddling technique.

The sub elite kayaker's performance outcome showed some correlations between foot force and contralateral paddle force generation. However, once again we emphasise that the result of this study might be due to the individuality of the single subject from each skill level category. Further research with a bigger pool of participants and the inclusion of more kayaking paddling performance determinants will be required to confirm the finding of this initial study. A more complete guide or indicator will be beneficial to facilitate the coaches with useful information to train the kayakers at different skill levels besides determining how the usage of the swivel seat may affect the paddling performance.

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