The Design, Construction and Assessment of a Sprint Kayaking Balance Training Aid

By

Benderi b. Dasril

A Doctoral Thesis

Submitted in partial fulfilment of the requirement for the award of

Doctor of Philosophy of Loughborough University

November 2013

Abstract

The main purpose of this study was to develop and assess an on-land training aid for learning balance in sprint kayaking. The literature has shown the importance of biomechanical analysis and how training aids can provide a beneficial part in the learning process of new skills. An on-water experimental analysis was conducted on experienced paddlers to establish the kinematic characteristics and the centre of rotation position of the kayak-paddler system. From this analysis it was found that the kayak rolling motion is dependent on the paddler's ability and the centre of rotation of the kayak paddler system relative to the seat of the kayak was found to be between 10 cm – 13 cm above the seat. Findings from this analysis were interpreted into technical requirements and integrated into the design of the training aid. Once built the training aid prototype was evaluated by a series of testing and modification to enhance its ability to replicate the on-water kayak. The evaluation data showed that the stationary sprint kayak on-water medial-lateral rolling motion is affected by weight variations and further evaluation demonstrated that the training aid has the ability to replicate the motion for different weights. An experimental assessment on a group of beginners was carried out and the results showed that the training aid was able to facilitate the learning of balance in sprint kayaking. The experimental subjects who used the balance training aid had the same total number of sessions as the control subjects who learned to balance in the actual sprint kayak (experimental, 9 $\pm$ 1 sessions; control, 9 $\pm$ 1 sessions). However, the experimental subjects only spent half of the total number of sessions learning on-water (4 $\pm$ 1 sessions) and the other half on the training aid (5 $\pm$ 1 sessions).

Key words: sprint kayak, training aid, balance, equipment design.

Publications

Conference Presentations

Dasril, B., King, M.A. and Yeadon, M.R. 2011. "Centre of rotation for sprint kayak medial-lateral (rolling) balancing motion". *Proceeding of the 26th Biomechanics Interest Group of the British Association of Sport and Exercise Sciences*: 2011, pp 24.

Dasril, B., King, M.A. and Yeadon, M.R. 2011. "Kinematics of stationary sprint kayak medial-lateral balance control". *Proceeding of the 27th Biomechanics Interest Group of the British Association of Sport and Exercise Sciences*: 2012, pp 25.

Workshop Presentations

Dasril, B., King, M.A. and Yeadon, M.R. 2011. "Balance control in sprint kayaking and development of sprint kayak balance training aid". *Workshop Leader Proceeding of the 2012 Canoe England Coaching Conference*, 24th and 25th November; pp 2.

Publications

Conference Presentations

Dasril, B., King, M.A. and Yeadon, M.R. 2011. "Centre of rotation for sprint kayak medial-lateral (rolling) balancing motion". *Proceeding of the 26th Biomechanics Interest Group of the British Association of Sport and Exercise Sciences*: 2011, pp 24.

Dasril, B., King, M.A. and Yeadon, M.R. 2011. "Kinematics of stationary sprint kayak medial-lateral balance control". *Proceeding of the 27th Biomechanics Interest Group of the British Association of Sport and Exercise Sciences*: 2012, pp 25.

Workshop Presentations

Dasril, B., King, M.A. and Yeadon, M.R. 2011. "Balance control in sprint kayaking and development of sprint kayak balance training aid". *Workshop Leader Proceeding of the 2012 Canoe England Coaching Conference*, 24th and 25th November; pp 2.

Table of Contents

List of Figures

List of Tables

Chapter 1

Introduction

1.1 Chapter overview

This chapter presents an overview of balance in sprint kayaking. Also included in this chapter are the statement of purpose and specific research questions. To provide an overview of the structure of this thesis, the organisation of chapters is described.

1.2 Background of study

Sprint kayak primary design considerations are acceleration and maximum speed (Szanto & Henderson, 2004). For these reasons sprint kayaks are built relatively long, narrow and lightweight. A long and narrow cross-section of the kayak results in instability but provides greater speed while a short and wide kayak tends to be more stable and slower. The speed and acceleration of the kayak moving over water is a function of the force of the paddling, and the effect of the drag/friction created against the hull of the kayak as it passes through the water. The greater the drag, the more power is required to move the kayak at the same speed. However the International Canoe Federation has established and enforced rules for kayak design to create an equal opportunity and to ensure that the athletes determine the outcome of competition, not the design of the kayak (Szanto & Henderson, 2004).

In sprint kayaking, appropriate balance and orientation of body segments are extremely important in maintaining an upright position while sitting on a long, narrow and unstable sprint kayak (McKean & Burkett, 2010; Michael et al., 2009; Ralph & Jay, 1980). Balance and postural control allows the paddler to stay upright on a rippled water surface or in a strong head wind. From the beginning of their training, paddlers learn to coordinate segment movements to enable the necessary dynamic changes of the body in order to stabilise the sprint boat while in a stationary position (Vescovi et al., 2011b). In view of this, balance and postural control ability can be considered as an important basic skill which must be acquired by a beginner paddler before any other basic skills are learned. Nevertheless, the balance skill gained will facilitate the learning process of other required skills in sprint kayaking.

In explaining the importance of balance in kayaking, the most significant requirement is to minimise the medial-lateral rolling motion of the kayak about its longitudinal (X) axis and to prevent the risk of the kayak being capsized in the water (Baker, 2012). Furthermore, a split second of off-balance motion during the start of a race can have a significant effect on the kayak initial velocity and efficiency of the starting stroke. However, kayak capsizing during competition does happen, so stabilisation and balance control ability is an issue for skilful as well as unskilled paddlers.

In order to fulfil this balance demand, there are a few training approaches that have been practised by coaches and paddlers. By far the most common practice in balance training is repetition training (Vescovi et al., 2011a). This approach

requires more training time in the sprint kayak, enabling the paddler to learn to utilise the required balance control mechanisms. The other method of training requires several progressive learning stages (Edwards, 2005). In the beginning, paddlers are introduced to a more stable kayak and only the hands are used as a stabilising mechanism. After the paddler becomes comfortable with the kayak the paddle is introduced. Otherwise, if the athlete is unable to control the balance, the kayak centre of gravity is lowered by adding weight or filling the kayak with water. Both of these conventional methods of training are dependent on the individual's capabilities to integrate the complex interaction of balance control mechanisms. Furthermore, it is time-consuming and the possibility of capsizing can lead to high drop-out rates.

Currently there is no specific commercial balance training aid for sprint kayaking. A few concept balance training aids have been introduced by individuals and coaches, but their functionality is still in question. A stability ball has also been used as have a couple of commercially available balance simulator devices: the Dansprint Balance (Figure 1-1) and Landkayak Dynamic Balance (Figure 1-2). According to the manufacturer, both of these innovations are designed to optimise on-land training by incorporating the actual degree of roll during on water paddling (Dansprint, 2012; Landkayak Dynamic Balance, 2012). Interestingly, the writer has not found a single publication that has investigated these balance devices; and doubts have been raised over their utility as a training aid for balance performance because of a fixed medial-lateral rolling centre of rotation. This feature may not be applicable to all athletes of different sizes and abilities. This particular problem is the motivation for this study: to develop and

evaluate a balance training aid that can simulate the real medial-lateral angular (rolling) movement of the kayak.

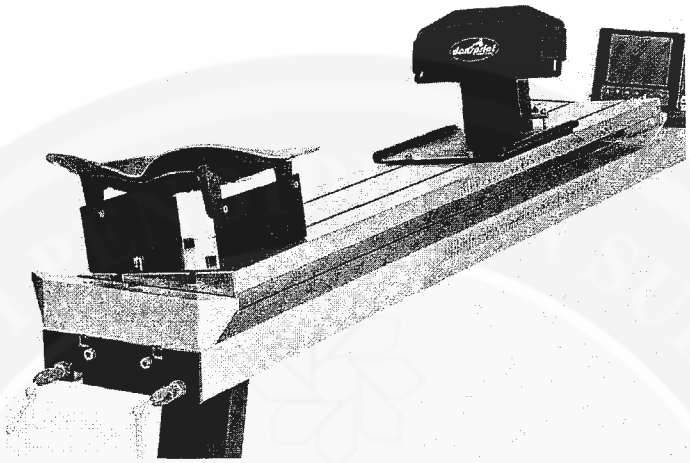

Figure 1-1: Dansprint Balance (adapted from www.dansprint.com).

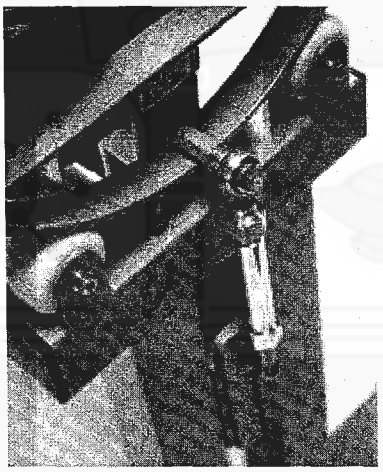

Figure 1-2: Dynamic Balance (adapted from www.landkayak.co.uk).

1.3 Statement of purpose

The purpose of this study is to develop and assess an on-land balance training aid for sprint kayaking.

1.4 Research question

Question 1:- *What are the characteristics of on-water kayak-paddler motion and where is the centre of rotation of the kayak-paddler system relative to the seat of the kayak?*

In order to design a suitable and reliable sprint kayak balance training aid, the fundamental kinematic characteristic of the kayak and the paddler motion during on-water balancing need to be established. It has been determined that the medial-lateral rolling motion has the greatest effects on the kayak balance and stability (Baker, 2012; Michael et al., 2009). Two dimensional motion analysis is the most appropriate method used to determine the on-water kayak-paddler motion characteristic and the optimal centre of rotation height relative to the seat of the kayak.

Question 2:- *Is the on-water kayak rolling motion affected by weight variations?*

The sprint kayak balance training aid should be able to accommodate a wide range of paddler's size and weight. Therefore, further analysis on the kayak medial-lateral rolling motion with additional weight variations is conducted to validate the effects.

Question 3:- *Can the sprint kayak balance training aid prototype replicate the medial-lateral rolling motion of the stationary sprint kayak?*

A training aid should simplify the movement task by permitting individual degree of freedom and should successfully fulfil all identified requirements (Yeadon et al., 2012). Moreover, it should replicate the motion of the task in its real environment.

Therefore, in-depth evaluation of the prototype sprint kayak balance training aid should provide more information on its reliability.

Question 4:- *Does the sprint kayak balance training aid facilitate the learning of balance for a beginner paddler?*

An experimental assessment enables the researcher to determine the functionality of the prototype sprint kayak balance training aid. A balance training programme is administered to complete beginners using the training aid and compared with on-water training using the same programme.

1.5 Chapter organisation

Chapter 2: Literature review

This chapter will discuss details of relevant reviewed literature. It also contains several topics which are considered important in the development process of sprint kayak balance training aids. The chapter also provide information specifically related to this study.

Chapter 3: On-water analysis of stationary sprint kayak.

The purpose of this chapter is to establish scientific information on stationary sprint kayak on-water motions during balancing. The information gained will be integrated into the design of the balance training aid.

Chapter 4: Sprint kayak balance training aid design and construction.

This chapter discusses in detail the design procedure undertaken during the development of the sprint kayak balance training aid. An experimental evaluation