FORCES ON THE LOWER BACK DURING ROWING PERFORMANCE IN A SINGLE SCULL

Christie Munro and Toshimasa Yanai
School of Physical Education, University of Otago, Dunedin, New Zealand

The purpose of this study was to determine the compressive force on the lower back during rowing performance during trials in which Hatchet sculling blades were used and trials in which Macon sculling blades were used. Compressive force was determined using an inverse dynamics approach using the lower back model developed by Chaffin (Chaffin and Andersson, 1990). The results indicate that: (1) the peak compressive force on the lower back was found to be 5344N and 4876N for Macon and Hatchet blades respectively, (2) there was no difference in peak compressive force between the trials with Hatchet blades and Macon blades; (3) with the Hatchet blades the compressive force increased immediately after the entry of the blade.

KEY WORDS: compressive force, sculling, Hatchet sculling blades, Macon sculling blades

INTRODUCTION: The rowing technique used for 'a single scull' requires repetitive flexion and extension of the trunk, upper and lower limbs. This technique predisposes the rower to injury to the structures of the lower back. In fact, the lower back has been the most common site of injury and pain for rowers (Motto, 1994; Reid, 1997; Soghikian, 1995). A number of factors have been proposed to explain why back pain has been a common complaint: (1) evolution of the modern style of rowing, which puts more strain on the back (Stallard, 1980), (2) introduction of continuous, high intensity training techniques (Stallard, 1980), (3) increased volume of training, (4) lack of proper supervision during weight training sessions, and (5) the introduction of bigger blades (Hatchet blades) for the oars. It has been speculated that the Hatchet blades increase the load on the lower back, particularly during the beginning of the stroke (Nolte, 1993), which has implications for injury. The purpose of this study was to determine the compressive force developed in the lower back during the rowing performance and compare the magnitudes between the trials with Macon sculling blades and with Hatchet sculling blades.

METHODS: Ten competitive 'single scull' rowers at New Zealand national level participated in this study (mean age 18.8 ± 2.20 years, mean height 1.71m ±.038m, and mean mass 66kg ± 5.97kg). Each rower was asked to perform ten 200m sprint trials at the maximum effort. Hatchet blades were used for five trials and Macon blades were used for the other five trials. A strain gauge was mounted on the shaft of the left oar to measure the magnitude of bending of the shaft, which was used to determine the normal component of the force exerted by the hand. The strain gauge was connected to a portable amplifier and a radio transmitter (Noraxon Telemyo System, AZ, USA), both of which were carried by the rower. With this arrangement, the amplified data from the strain gauge were transmitted to the receiver device on shore as radio-waves and recorded digitally into the Peak Motus system (Peak Performance Technologies, Denver, CO, USA).

A two-dimensional videography technique was used to determine the position of each body segment of the left-hand side of each rower for one complete cycle of each trial. The video camera was fixed on a tripod on shore and was perpendicular to the movement of the boat. The videotapes of the performance were manually digitised using the Peak Motus System. In each digitised field, body landmarks were digitised. Assuming that the body was laterally symmetrical a 12-segment model of the human body was defined. Two fixed points on the boat were digitised to determine the scaling factor and the proximal and distal ends of the oar handle were digitised to determine the position and the orientation of the oar handle in three-dimensional space. The hand force was determined such that it could generate the magnitude of the normal component for every given instant. It was assumed that the hand force was directed posteriorly along the length of the forearm. The resulting sets of two-dimensional coordinate data were used as input to custom software that generated kinematic data (linear velocity, linear acceleration, angular velocity, angular acceleration), joint resultant forces, and joint resultant torques. Normalised and scaled anthropometric parameters (Clauser, McConville, and Young, 1969; Hinrichs, 1990) were used to define the segmental parameters for each subject. The hip joint resultant torque and hip joint angle were used to determine the compressive force at the L5-S1 level in accordance with the low back model described by Chaffin and Andersson (1991).

In the present study, a "stroke" was defined as the period from the instant at which the blade made the first contact with the water to the instant at which the blade was completely extracted from the water. The stroke was subdivided into three phases (Redgrave, 1990) as shown in Figure 1. (a) The catch began when the tip of the blade made a contact with water at the beginning of the stroke and ended when the blade was completely immersed in the water. (b) The drive phase began when the catch finished and ended when the velocity of the trunk was zero, relative to the boat. (c) The finish phase began when the drive phase finished and ended when the blade was completely extracted from the water.

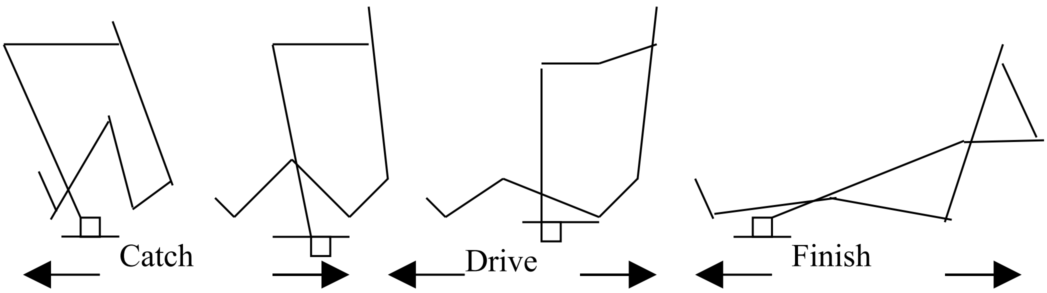

Figure 1 - Catch phase, drive phase, and finish phase of the stroke cycle.

For statistical analysis, the following variables were determined: (a) the maximum compressive force recorded in each phase; (b) the average compressive force over each phase. These variables were determined for each trial for each subject. A two-factor analysis of variance was used to test for the effects and the interaction of the blade type and the phase on the magnitude of compressive force. Post-hoc tests were then conducted to identify specific effect of blade type and the phase. The level of significance was set at 0.05.

RESULTS: The time course of change in the compressive force for the two blades are presented in Figure 2, and the numerical results presented in Table 1. On average, the peak compressive force was developed 50%±5.2% and 56%±3.7% of the way through the stroke cycle for Hatchet blades and Macon blades.

Table 1 Mean Value Across the Subjects for the Peak Compressive Force [N] and the Average Compressive Force [N]

	Catch	Drive	Finish	Overall
Peak - Macon	2490	5272	3371	5344
Peak - Hatchet	4099	4505	2789	4876
Average - Macon	1998	4039	1177	2396
Average - Hatchet	3142	3771	1267	2763

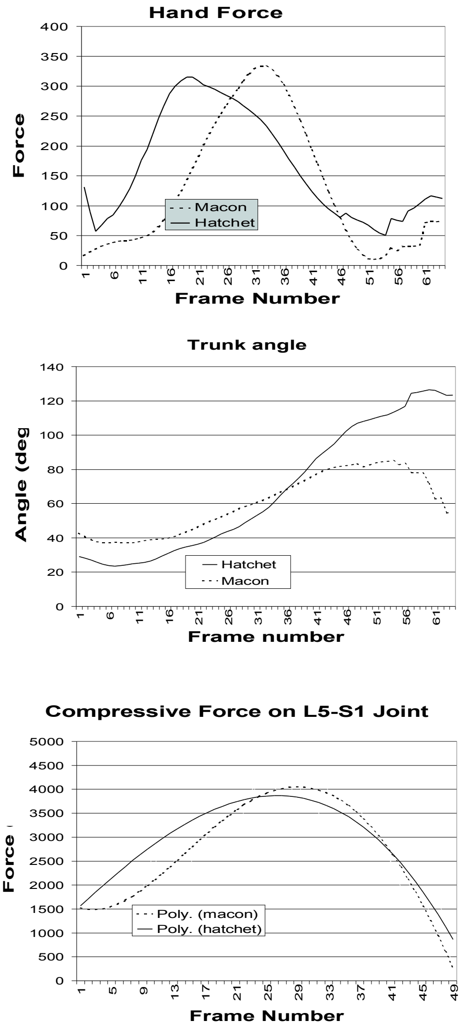

Figure 2 – Hand force, trunk angle, and compressive force over the duration of the stroke.

On average, the peak compressive force was developed, for Hatchet and Macon blades respectively at 96.8%±7.6% and 100% ±0% of the way through the catch phase, at 63.2%±22.3% and 69%±205 of the way through the drive phase, and at 13%±6.3 and 10%±3% of the way through the finish phase. There was no difference in the peak and average compressive force between the trials with the Hatchet blade and the Macon blade, throughout the duration of the stroke ($p>0.847$). There was a difference in the peak and average compressive force between the trials with Hatchet blades and Macon blades, between the three phases ($p<0.000$). There is also a significant interaction effect of blade type and phase ($p<0.000$). The average compressive force over the catch phase was significantly greater ($p<0.000$) when the Hatchet blades were used than when Macon blades were used, whereas that over the drive phase was significantly greater ($p<0.005$) when the Macon blades were used than when the Hatchet blades were used. There was no difference ($p>0.415$) in the mean value for the average compressive force over the stroke (Macon: 2351N & Hatchet: 2463N).

There was no significant difference in the velocity of the boat (4.72s or 42s for 200m) for trials with Macon blades and Hatchet blades. There were no significant individual differences in boat velocity (Mean =0.87±0.093).

DISCUSSION: There has been a postulation within the rowing community that the use of Hatchet blades may increase the risk of developing low back pain. An attempt was made in this study to determine the effect of blade types (Macon & Hatchet blades) on the compressive force developed in lower back during rowing performance.

The safe level for loads on the lower back, recommended by the National Institute of Safety and Health (NIOSH) is 3700N, which was exceeded in this study (Hatchet blades: 4876N & Macon blades: 5344N). The excessive amount of compressive force developed in rowing may lead to an injury to the structures of the lower back and cause low back pain. The values of the mean peak compressive force and the average value of the mean compressive force obtained in this study were comparable, but higher than the values obtained by Morris, Payne, Smith, Galloway, & Wark (1996). The greater force values measured in this study may be due to the differences in the characteristics of the rowers used in each study. In the present study the rowers were of national level and were of a greater stature than those rowers who participated in the study by Morris, et al., (1996). Morris, et al., (1996) found the mean value for peak compressive force on the lower back was 4-5 times the bodyweight of the rowers, compared to six times the bodyweight of the rowers as was found in this study.

The results showed that blade type did not cause significant difference in the peak compressive force developed during the stroke cycle. However, the compressive force was increased immediately after the entry of the blade in the trials with Hatchet blades, whereas the increase in compressive force was delayed. This might explain the perception of rowers that there is a greater force on the lower back at the beginning of the stroke when the Hatchet blades are used. However, overall there is no significant difference in the peak and average compressive force throughout the duration of the stroke. This result does not support the guideline given by the Marlow Rowing Club in Britain that the use of Hatchet blades may be linked to disc-related lower back problems, and thus should be restricted for their young rowers.

CONCLUSION: (1) The peak compressive force on the lower back was 4876N and 5344N for trials with Hatchet blades and Macon blades respectively. This degree of force is considered hazardous and may cause injury (NIOSH); (2) There is no difference in peak compressive force between Hatchet and Macon blades ($p>0.847$); (3) With the Hatchet blades the compressive force increased immediately after the entry of the blade into the water.

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Acknowledgements

The present study was partially funded by Sports Science New Zealand.