Special Warfare Combatant-craft Crewman Tibial Acceleration During Open Ocean Transit in Small Boats

Darcie L. Yount*, Katherine A. Perlweig*, Takashi Nagai*, Nicholas R. Heebner*, Timothy C. Sell*, Scott M. Lephart FACSM †
*Department of Sports Medicine and Nutrition, School of Health and Rehabilitation Sciences, University of Pittsburgh, Pittsburgh, PA
†College of Health Sciences, University of Kentucky, Lexington, KY

ABSTRACT

PURPOSE: To evaluate tibial accelerations experienced by SWCC Boat Captains during open ocean transit in RHIBs during Crewman Qualification Training exercises.

METHODS: Seven SWCC Boat Captains (age: 29.71 ± 2.5 years, height: 179.06 ± 7.5 cm, weight: 80.4 ± 12 kg) participated. Boat Captains wore two tri-axial accelerometers on the right tibia just medial to the tibial tuberosity, with the x-axis in line with the long axis of the tibia. The accelerometers had static ranges of ±16g and ±18g, and collected at a sampling frequency of 1000 Hz for two hours during transit three, five, and thirty miles off shore. Peak accelerations in all three directions were averaged across each wave for each transit.

RESULTS:

• Acceleration values (VA) were highest during transit in protected bays (≤ four foot seas) compared to during transit in two to three foot seas or four foot seas. During transit in a protected bay, average vertical acceleration (VA) was 3.81g ± 0.43 with 1.94g ± 0.43 and 1.76g ± 0.41 accelerations in the horizontal axes (H1A and H2A). In four foot seas, average VA was 7.49g ± 4.60 with 2.92g ± 1.56 H1A and 2.21g ± 1.54 H2A. Maximum VA for these transits was approximately 16g, with maximum H1A and H2A of 10g and 11g.

• Maximum VA for these transits was approximately 16g, with maximum H1A and H2A of 10g and 11g.

• Peak accelerations in all three directions were averaged across each wave for each transit.

SUMMARY AND CONCLUSIONS

• Boat Captains experience high accelerations at the proximal tibia, even in calm seas.
• The maximum accelerations observed during transit were similar to those observed during a single Military Free Fall Operation using the same accelerometer placement (VA: 24.06g, H1A: 10.32g, H2A: 4.20g). Attenuating these accelerations may cause high joint loading, which may contribute to the risk of injury development over the course of a SWCC’s career.

INTRODUCTION

• SWCC Operators perform special missions on small, high speed water craft on ocean and small river water systems.
• RHIBs are particularly susceptible to sea state and coastal weather due to their small size and light weight.

• Musculoskeletal injuries are common among SWCCs, with a high incidence of low back and knee pain among coastal operators. Quantifying accelerations experienced during ocean transit could help guide injury prevention initiatives.

METHODS

• All subjects were recruited as a part of a comprehensive biomechanical, musculoskeletal, physiological, and nutritional laboratory testing protocol.

• A total of 7 SWCC Boat Captains were enrolled in this study (Table 1)

SUBJECTS

• Table 1: Demographics - Mean ± Standard Deviation

<table>
<thead>
<tr>
<th>Subject</th>
<th>Age (yrs)</th>
<th>Height (cm)</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males (n = 7)</td>
<td>29.71 ± 2.5</td>
<td>179.06 ± 7.5</td>
<td>82.49 ± 12.8</td>
</tr>
</tbody>
</table>

EXPERIMENTAL DESIGN AND PROCEDURES

• Seven SWCC Boat Captains were given a tri-axial accelerometer on the right tibia just medial to the tibial tuberosity.
• The accelerometers had static ranges of ±16g and ±18g, and collected at a sampling frequency of 1000Hz during transits three, five, and thirty miles off shore.

• During transit in a protected bay (≤ four foot seas), average vertical acceleration (VA) was 3.81g ± 0.43 with 1.94g ± 0.43 and 1.76g ± 0.41 accelerations in the horizontal axes (H1A and H2A).

• In four foot seas, average VA was 7.49g ± 4.60 with 2.92g ± 1.56 H1A and 2.21g ± 1.54 H2A. Maximum VA for these transits was approximately 16g, with maximum H1A and H2A of 10g and 11g. Maximum VA for these transits was approximately 16g, with maximum H1A and H2A of 10g and 11g.

• During transit three, five, and thirty miles off shore.

• Peak accelerations in all three directions were averaged across each wave for each transit.

• Attenuating these accelerations may cause high joint loading, which may contribute to the risk of injury development over the course of a SWCC’s career.

RESULTS

• Table 2: Average Tibial Accelerations – Mean ± Standard Deviation

<table>
<thead>
<tr>
<th>Acceleration Values</th>
<th>VA (g)</th>
<th>H1A (g)</th>
<th>H2A (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ft waves</td>
<td>3.81 ± 0.43</td>
<td>1.94 ± 0.43</td>
<td>1.76 ± 0.41</td>
</tr>
<tr>
<td>2-3 ft waves</td>
<td>5.84 ± 0.12</td>
<td>2.44 ± 0.55</td>
<td>2.23 ± 0.46</td>
</tr>
<tr>
<td>4 ft waves</td>
<td>7.49 ± 4.60</td>
<td>2.92 ± 1.56</td>
<td>2.21 ± 1.54</td>
</tr>
<tr>
<td>MAX</td>
<td>16</td>
<td>10</td>
<td>11</td>
</tr>
</tbody>
</table>