INTRODUCTION

Inflatable Rescue Boats (IRBs) are used by Australian surf lifesavers to patrol beaches, perform rescues, and in training competitions. Previous epidemiological studies of these activities have reported the higher incidence of lower limb injuries compared to injuries to other body regions (Bigby et al., 2000), particularly to the forward of the two crewmembers. A series of investigations was undertaken to identify potential causes of such injuries, and to assess the magnitudes of loads experienced by the lower limbs of surf lifesavers whilst using IRBs. Of particular interest to these studies was the interaction between the feet, foot straps and the floorboard of the IRB.

METHODS

A computer model (Figure 1) of a representative IRB design and modified 50th-percentile Hybrid III dummy (representing the forward crew member) was developed using MADYMO v5.4 (TNO Automotive, Netherlands). Particular attention was placed on finite element modeling of the foams of different thickness and density, which are used to line the floorboard of the IRB. The lower limb joint stiffnesses of the Hybrid III dummy were modified to provide a more biofidelic response to applied loads when in a standing position. Position and orientation data of the IRB for input to the simulations were derived from acceleration data collected from actual IRBs traversing in-shore waves of varying intensity (Ludcke et al., 2001). Dynamic simulations were performed, producing estimates of joint kinematics and kinetics under a range of operating conditions, crew positions and varying physical properties of the IRB (Ludcke, 2001).

A subsequent study involved the design and implementation of a custom-built force plate system for direct measurement of the loads produced under the feet of lifesavers whilst crewing IRBs as they traveled over waves.

RESULTS AND DISCUSSION

Peak axial compression loads for the lower leg, as estimated from the computer simulations over a series of crew positions were in the range 500-1500 N for a wave of moderate intensity. Loads in the right leg were consistently higher than the left, which corresponds with the findings of previous epidemiological studies.

The power in constructing such a computer model is the ability to assess the sensitivity of limb loads to differences in foam and strap material properties, foot strap positions and related fastening systems, and crewing techniques (e.g. sitting versus standing of front crewmember). The ability to assess the effect of a number of design parameters under standardized conditions. This enables optimal configurations to be suggested for subsequent experimental evaluation. As an example, crewmembers and training methods differ in the instruction regarding the use of the right foot strap. By using this simulation, it could be shown that inversion moments on the left ankle were reduced if the strap restraining the right foot was removed. However, this result cannot be considered in isolation, as the effect of this change on other kinematic and kinetic parameters must also be considered.

Preliminary data from the force plate study indicates that the forces measured directly are of the same order of magnitude as those predicted by the computer simulations. Direct measurement of loads under the feet of crewmembers allows the effect of different crewing techniques and level of experience, to be compared in a real-life setting and under intended operating conditions.

REFERENCES


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