Asymmetry Force Sensor for Rowing Biomechanics

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Many members of the University of Wisconsin Women's Rowing team have been dealing with lower back pain and other injuries, possibly due to asymmetric force output while rowing. Rotational twisting at the hips and torso are the lead causes for back pain in rowers, but is currently only qualitatively studied by the University of Wisconsin personal trainers. Many rowers experience back injury due to various reasons including consistently exerting force when the back is flexed, repetition of the rowing movement, and not properly adapting to the size of the ergometer or boat.

The client, Dr. Jill Thein-Nissenbaum, has tasked the team with creating a force plate system that can collect biomechanical data from rowers' lower extremities and display it to a rower in real-time as biofeedback. Current devices on the market include the Bertec Force Plate, which cannot be mounted to the ergometer that is used by the UW Rowing Team, or the BioRow Force Sensor, which is far too expensive for the client's needs and cannot be mounted to the existing ergometer. These devices also do not provide real-time data specifically regarding asymmetry of force between the rower's lower extremities.

The team had initially proposed a design involving the use of load cells, but after consulting with a load cell manufacturer's design engineer, decided not to move forward with this prototype due to cost and accuracy constraints. Load cells would not have worked for this application due to their sensitivity to dynamic and off-axis loading, which are heavily involved in rowing. The team then pivoted to an indirect force-sensing method using a rotating plate. The new proposed design involves a plate attached to a shaft in the center. The rower places their feet on either side of the shaft, and if they apply more force to one foot than the other, the shaft will rotate. This rotation will be sensed by an angular encoder, which can convert the angle into force difference and display this using a graphical user interface providing real time data. The team built an initial prototype using scrap wood to gauge the feasibility and investigate the fabrication process before ordering final materials.

Testing of the device involved both qualitative and quantitative analysis of the device's efficacy. Rowers from the lightweight, openweight, and men's divisions of the UW Rowing Team will row on the device at steady state for two minutes to collect baseline data, then row harder on their right foot for one minute, then harder on their left foot for one minute. Afterwards, they will return to steady state for one minute. This will allow rowers to see the graphical user interface at all configurations and will allow the physicians to see both symmetrical and asymmetrical data.

The design provides the client with clinically relevant data that can be used to treat injury. The force difference, as calculated by the device, can be normalized by patient factors such as height, body weight, torso to leg length ratio so physicians can investigate the root cause of asymmetry. This will help physicians identify rowers at higher risk of back pain and force asymmetry so they can be targeted for special training using the device. The biofeedback from the device will allow these high-risk rowers to adapt their technique and row symmetrically, thereby reducing their risk for injury.