A. Title Page

Final Report for Measurement of Head Velocities of Boxing Participants

with Wireless Digital Accelerometers

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B. Restatement of problem researched or creative activity

In spite of the rich history of pugilism around the world, the field of sports science has focused virtually no attention on this athletic endeavor. The minimal amount of attention it does receive has been generally focused on the associated injuries (e.g., Valkering et al., 2008) and calls for the ban on the athletic enterprise (e.g., British Medical Association Board of Science Working Party on Boxing, 2007). Dr. Warnick's laboratory has sought to fill in this gap in the research literature by investigating some of the variables believed to be associated with success or failure in the sport of professional boxing (Warnick & Martin, in press; Warnick & Warnick, 2007; 2009; Warnick et al., in press; Warnick, Warnick, et al., in press). This proposal seeks to further expand this laboratory's investigations into combative sports by conducting a series of proof of concept experiments on new technological methods to increase boxer safety.

One of the most common, and most dangerous, boxing injury reported in the medical literature is concussion (Zazryn et al., 2006). While fairly rare, approximately 2 injuries out of 1000 hours of boxing (Zazryn et al., 2006), the effects can be severe (e.g., long-term cognitive impairment, Heilbronner et al., 2009). Further, the accumulative effect of repetitive concussions can result in chronic traumatic brain injury (Rabadi & Jordan, 2001) which is associated with motor, cognitive, and behavioral impairments (Jordan, 2000). Some safety measures have been adopted to try to limit the head trauma inflicted by a punch. For example, headgear is required in amateur boxing, mouthguards are required in amateur and professional boxing, and heavier weight classes have gloves with extra padding in both amateur and professional boxing. While these safety protocols have helped make this sport safer, there are still opportunities to further reduce the potential physical harm associated with the sport.

The focus of this research project was to develop a technological method to aid in the detection of potential concussion. It is well known that punches that create high head acceleration, in particular, high rotational acceleration (i.e., 4500 rad/s^2 and greater), are associated with increased risk of causing concussion (Ommaya et al., 2002). We developed and method of detecting high head acceleration during professional boxing practices or matches. This method could be employed to detect potential concussions occurring in real-time which would be a great medical improvement. Boxing bouts could be stopped at the time of injury and further brain trauma could be prevented.
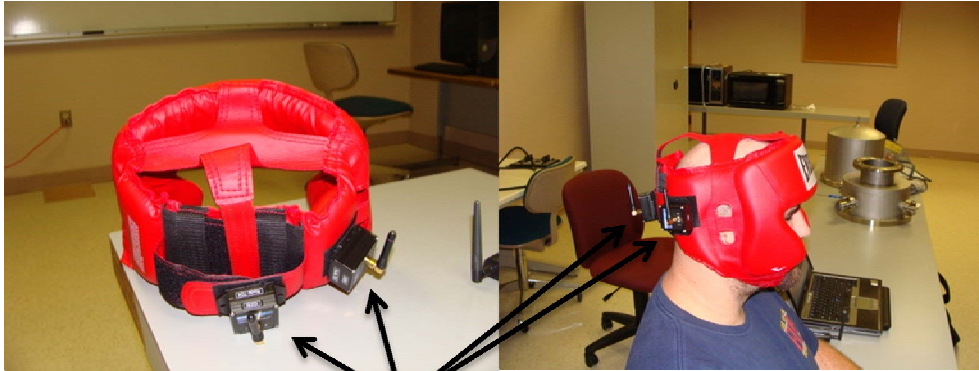
C. Brief review of the research procedure utilized

In this proposal we measured head accelerations using a compact MEMS (Microelectromechanical System) based accelerometer that each boxer could wear during a match. This device transmits data via radio frequencies to a ringside computer station that could be used to calculate forces in real time and allow officials to stop a match if a dangerous punch was landed.

The MEMS accelerometers were attached using Velcro at two different locations on a boxing headset. Each accelerometer measures the *g-force* in three different directions; this means we are able to obtain six different signals in real time from our modified headgear. Additionally, the sensors are wireless and have a range of ~ 100 ft giving the athlete freedom of motion.

D. Summary of findings

Figure 1 below shows the experimental setup of the headgear and sensors.

Figure 1 (LEFT) The rear of the headset with the two wireless accelerometers mounted (RIGHT) The headset and sensors being worn by a user. When the headset is being used the accelerometers are orthogonal to each other.

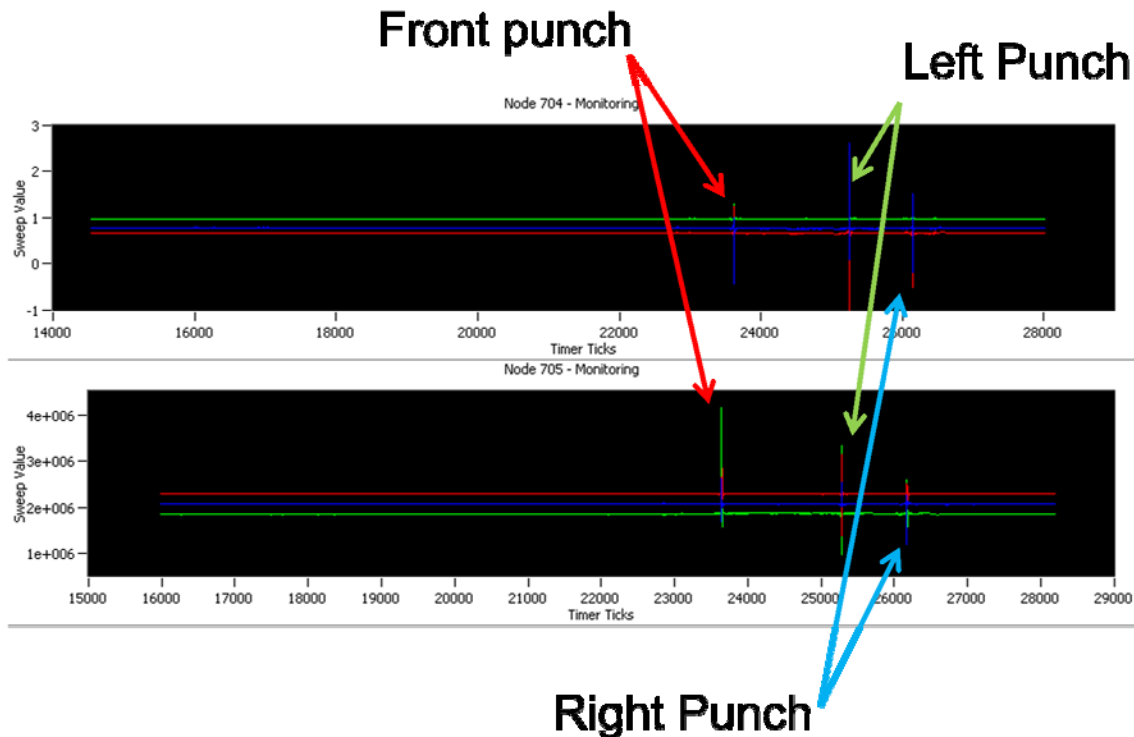Figure 2 show example data taken when a volunteer wore the headset.

Figure 2 (TOP) The real time streaming data from the sensor mounted on the back of the headset.(BOTTOM) The data recorded simultaneously from the sensor mounted on the side of the headset.

E. Conclusions and recommendations

In conclusion we have successfully developed a tool that can assist ringside doctors or boxing officials determine when a critical blow to the head has been received. The next step in our project is to mount it on different participants during a sparring match. Additionally, we would like to incorporate more sensors into the headset. Our future research plan involves weaving pressure sensors into the padding of the head gear as well as designing some wireless accelerometers that would actually fit inside the padding.