"High speed force measurement system for evaluation of helmet impact load distribution"

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Abstract

Multiple-impact helmet certification standards in sport rely on metrics of global acceleration and puncture prevention (CSA, ISO,NOCSAE). However, there exist situations where high velocity, low mass projectiles (e.g. hockey puck) may cause extremely high focal forces at the impact site while global acceleration remains within the 'safe' zone (Bishop & Arnold, 1993). Of particular concern are stiff padding materials that perform well for high energy impacts however at mid to low energy impacts result in high focal forces to the cranium. To assess the helmet-to-head force transfer, conventional force matrix sensor 'mats' can provide high spatial resolution; however, they typically lack high sampling rates and durability for multi-impact measurements. Hence, to address this deficit the purpose of this study was to develop a capable measurement system. A custom amplifier was designed to power an array of 16 Flexiforce® sensors (Tekscan, Boston, MA). A USB data acquisition device powered by a portable laptop records (16-bit@15kHz/channel) synchronized force readings providing both higher speed and signal resolution than any available commercial system. The nature of the acquisition device allows for synchronized inputs of acceleration and other desired metrics. Power is obtained from the laptop battery hence the unit is portable for field testing. Each sensor is dynamically calibrated from 0-1000N using a material testing machine. Five calibrations are performed for each of the 16 sensors and correlated to force. The average linear correlation is acceptable (R^2=0.995±0.003, RMSE= 16.3±4.69N), however using 3rd order polynomials this improves to (0.9997±0.0002, 4.58±1.18N). To date, preliminary testing involving over six hundred impact trials have been recorded on ten different padding materials for conditions of energy, temperature and repeated impact. The system is durable and when necessary, sensor replacement is simple and cost-effective. In summary, this tool can directly measure spatial and temporal force distributions resulting from impacts.

References: Bishop, P. and J.Arnold. 1993. The effectiveness of hockey helmets. Safety in Ice Hockey: 2 ASTM STP 1212-EB
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A poster presentation is preferred, thank you.