HEAD ACCELERATION IS LESS THAN 10 PERCENT OF HELMET ACCELERATION DURING A FOOTBALL IMPACT

Sarah Manoogian, David McNeely, Mike Goforth, Gunnar Brolinson and Stefan Duma
Virginia Tech – Wake Forest, Center for Injury Biomechanics; Email: manoogsj@vt.edu, Web: www.CIB.vt.edu

INTRODUCTION

Sports-related concussions constitute 20 percent of brain injuries each year in the United States.[1] Concussion research has included a variety of instrumentation and techniques to measure head accelerations. These include headbands, helmet attachments, and video reconstructions. Most recently, the Head Impact Telemetry (HIT) System (Simbex, Lebanon, NH), a wireless system that provides real-time data from impacts, is used to measure *in-situ* head accelerations in collegiate football.[2] The purpose of this study is to measure linear head acceleration of a Hybrid III dummy using both accelerometers mounted at the center of gravity of the HIII head and the in-helmet HIT System. By comparing these two measured head accelerations and the helmet acceleration during a pendulum impact, it is shown that the response of the head and the helmet vary greatly and the in-helmet system matches the head and not helmet acceleration.

METHODS

A study of 50 helmet to helmet tests was performed with the impacting helmet mounted on a Hybrid III headform and neck (Figure 1). This assembly was mounted on a pendulum, 20 kg total mass, that impacted at a range of velocities from 3 m/s to 6 m/s. The impacted helmet was mounted to a HIII headform and neck and then to a full HIII body. Instrumentation included an accelerometer mounted directly to the inside of helmet at the location of contact and two measures of head cg acceleration, a triaxial accelerometer cube in the HIII head and the HIT System. Four locations on the struck helmet were tested by rotating the full HIII body while keeping the pendulum configuration the same.

Figure 1: The impacted helmet was mounted to a HIII headform and neck and then to a full HIII body.

RESULTS AND DISCUSSION

These tests illustrated that the helmet acceleration in response to impact varies from the head cg acceleration in amplitude and the time to peak. Overall the peak acceleration for the helmet at the point of contact was 16.6 (+/- 3.2) times greater than the head cg peak linear acceleration for that impact. For example, Figure 2 illustrates that for one impact, the helmet acceleration was approximately 500 g compared the actual head cg of 32 g measured by the dummy. Moreover, the HIT System measured nearly identical to the dummy peak value and curve shape as the HIT System recorded a peak 33 g for the same impact. Additionally, the time from contact to peak head acceleration, 5.82ms (+/-.78ms), is longer than time to peak helmet acceleration, .42ms (+/-.17 ms). The peak magnitude, time to peak, and waveform shape of the HIT System measure match the in head acceleration values and not the helmet shell acceleration values.

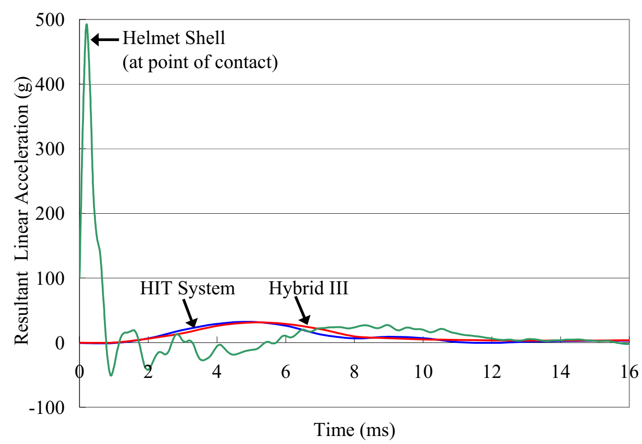

Figure 2: For the same impact, the helmet acceleration was approximately 500 g compared to the Hybrid III cg measure of 32 g and the HIT System measure of 33 g.

CONCLUSIONS

In summary, both the HIT System and the accelerometers in the HIII head measure a similar head acceleration response which varies greatly in magnitude and shape from the helmet response. In 2001 Lewis did a study that proved that wearing a helmet reduced the peak acceleration of the head by approximately a third since the helmet would absorb part of the impact's energy.[3] Therefore this paper presents consistent findings that the impact response of the head cg is much less than that of the helmet.

REFERENCES

1. McCrea, M; et al. JAMA 2003; 290:2556-2563.
2. Duma, SM; et al. Clinical Journal of Sport Medicine 2005; 15(1):3-8.
3. Lewis, LM; et al. Academic Emergency Medicine 2001; 8(6):604-609.

ACKNOWLEDGEMENTS

Simbex, Lebanon, NH