BICYCLE HELMET IMPACT TEST METHOD DESIGNED TO INDUCE ROTATIONAL ACCELERATION

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INTRODUCTION

Every bicycle helmet sold in the United States (US) must meet the Consumer Products Safety Commission (CPSC) standard. The standard is limited to pass-fail criteria based on peak linear acceleration.

Research has shown that mild Traumatic Brain Injury (mTBI) can be caused by linear and rotational acceleration [1]. Some research has shown that rotational acceleration presents more of a risk for mTBI than linear acceleration [1].

These researchers hypothesize that the CPSC standard could be modified to include rotational acceleration and provide additional valuable criteria to evaluate bicycle helmet efficacy.

METHODS

A CPSC standard drop test system was modified to include rotational acceleration [2]. The surrogate was modified so that it could experience rotational acceleration. The ISO headform described in the standard was attached to a Hybrid III neck (FTSS Inc., Plymouth, MI). The addition of a neck and modifications to the trolley system increased the drop mass from 5.04 to 14.84 kg. Next, the impact surface was tilted to an angle of 30 degrees so that it could induce a rotational acceleration, consistent with previous research [3].

Finally, additional instrumentation was added to facilitate the measurement of rotational injury criteria. The standard specifies one uniaxial accelerometer at the center of gravity (CG) of the headform. In order to measure rotational acceleration, the accelerometer was replaced with a biaxial accelerometer (PCB 356B21, Depew, NY). Another PCB biaxial accelerometer was placed on the midsagittal plane 78.5 mm anterior and 28.1 mm inferior from the CG. Using matrix algebra, the rotational acceleration of the headform was calculated using the measurement of the acceleration at the CG and at a known distance from it. A lower neck load cell (FTSS Inc., Plymouth, MI) was also included in the instrumentation to measure neck compression (F_z), shear (F_x), and bending (M_y) (Figure 1).

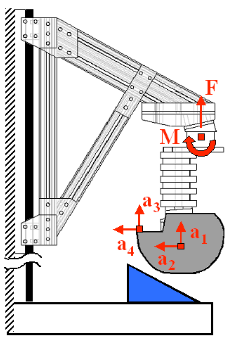

Figure 1: Mechanical test set-up including location of instrumentation.

The impact drop height was reduced from 200 cm to 120 cm. This was based on the increased drop mass, and on impact velocities reported in the literature for head rotational acceleration tests [3]. To validate the system, three commercially available bicycle helmets (Nutcase, Portland, OR) were tested under these conditions.

RESULTS AND DISCUSSION

The mean peak rotational acceleration was 10,066 rad/sec^2 with a standard deviation of 606 rad/sec^2. The mean peak neck shear was 1,920 N with a standard deviation of 35 N. These data can be compared to an existing Injury Risk Function (IRF) for brain injury. According to these data, the helmet tested had a 99.9% risk of mTBI in this test condition [4]. A summary of the results is included in Table 1.

Table 1: Mean and standard deviation (Std Dev) of the peak value for each event for all criteria.

Criteria	Mean	Std Dev
Rotational Accel (rad/s^2)	10,066	606
Fx (N)	1,920	35.3
Fz (N)	5,557	102
My (N-m)	509	13.3
Risk of mTBI (%)	99.9	

CONCLUSIONS

These data indicate that the test method described here provides an effective and consistent rotational acceleration bicycle helmet test. This test method could be used to evaluate the effectiveness of commercially available helmets to mitigate rotational acceleration and to improve helmet designs. These results indicate that the commercially available helmet tested in these conditions provides the user with limited mTBI protection.

REFERENCES

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