Lacrosse Ball Impacts on Women's Headgear

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Introduction:

Participation in women's lacrosse has nearly doubled since 2003 at both high school and collegiate levels, despite the noncontact sport boasting concussion incidences as high as some contact sports. Most head injuries result from ball and stick impacts, whether during passing, shooting, or ground-ball pursuits. Though headgear is not mandated, ASTM F3137 specifies test methods for soft-shell headgear to be approved for optional in-game use. However, the standard evaluates headgear using only linear acceleration, with an 80g passing threshold at one projectile impact speed, which does not account for lower speeds commonly observed in games. Previous research suggests that headgear can reduce overall concussion rate, though the effects during projectile impacts are not understood biomechanically. For short impulse impacts, not only is rigid-body motion (RBM) of interest, but also the vibrational response of the head, which can excite resonant frequencies of the skull. Improving our understanding of projectile impact biomechanics in women's lacrosse can influence rule changes, inform headgear manufacturers, and increase player safety.

Objective:

The goal of this study was to measure biomechanical reductions in both RBM and vibrational responses related to headgear and ball type during women's lacrosse projectile head impacts.

Methodology:

Projectile impact tests were conducted using a pitching machine to launch rubber and polyurethane lacrosse balls at an instrumented 50th percentile NOCSAE headform with a Hybrid III neck and mounted to a linear slide table. The headform was instrumented with three accelerometers to measure linear acceleration. Four locations were impacted (front, frontboss, side, and rearboss), at two speeds, 15m/s and 30m/s, representative of passing and shooting speeds in women's lacrosse, respectively. Bare head and two different headgear conditions were tested. Three trials were conducted per condition combination for a total of 216 tests. Data were sampled at 20kHz and low-pass filtered at CFC180 to isolate RBM and band-pass filtered at 300-3000Hz to isolate the vibrational response. Cranium Resonance Index (CRI), a measure of high-frequency signal energy, was calculated as the integral from 0 to 20ms of the squared magnitude of the band-pass filtered acceleration signals.

Results:

Variations in peak linear acceleration (PLA) due to ball type were minimal. The rearboss and side impacts consistently had the highest measured PLA values for RBM and CRI for vibrations at higher speeds. The maximum average headgear effects, calculated at each combination of location and speed, were 43.3% for RBM and 72.5% for vibrations. At lower speeds, headgear better attenuates RBM across locations, reducing RBM PLA by 29.8%, compared to a 23.9% reduction in CRI for vibrations. At higher speeds, the opposite effect is observed where headgear decreases CRI from vibrations across locations by 25.0%, compared to a 14.4% RBM PLA reduction.

Conclusions:

For projectile impacts, headgear varied in its ability to reduce RBM by speed, but vibrational response was consistently reduced across speeds. Variations in padding and design may influence impact response. Headgear in women's lacrosse, through RBM and vibrational reduction, can decrease concussion risk from projectile impacts and improve overall athlete safety.

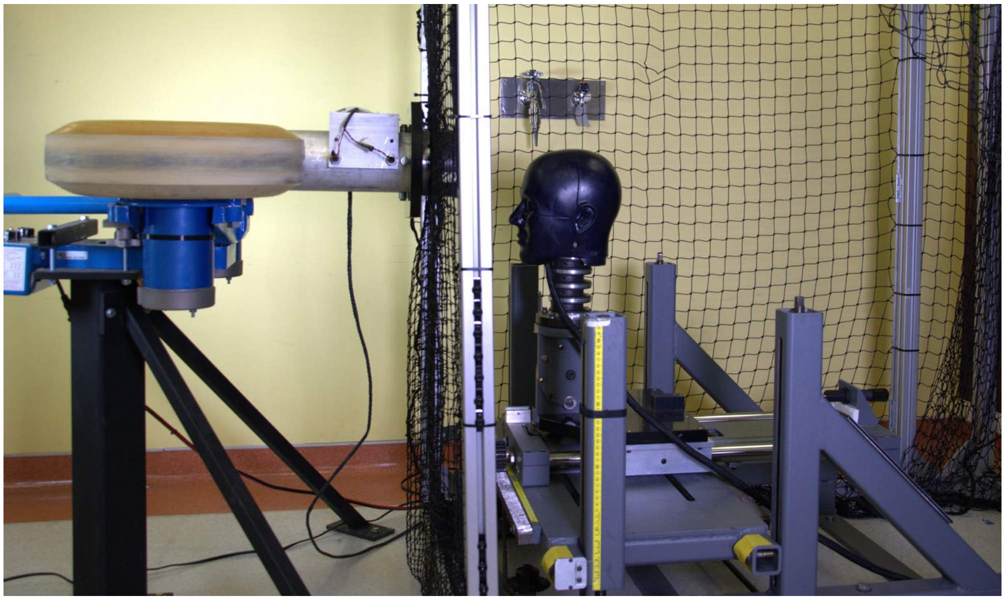

Figure 1: Testing setup used for projectile impact tests.