

From detection to protection: A systematic review of instrumented mouthguard performance in head injury analysis

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Statement of the Problem: The rising prevalence of chronic traumatic encephalopathy (CTE) in contact sports highlights the urgent need for reliable concussion detection methods. Instrumented mouth guards, equipped with accelerometers and gyroscopes, offer a promising solution by measuring impact data and providing real-time feedback. Following PRISMA guidelines, a comprehensive PubMed search identified 436 articles, with 26 studies (2013-2024) meeting the inclusion criteria, primarily in American football (46%), rugby (31%), and boxing (23%). The Stanford MiG-C was the most frequently studied mouth guard, with 38.5% of studies addressing kinematic parameters exclusively, while 34.6% focused solely on accuracy metrics. Trends emerged in both accuracy and kinematic detection across studied sports. Customized mouth guards exhibited varying mean angular acceleration relative error percentages (REPM). For instance, the Stanford MiG-C achieved a 5.2% REPM in American football, 6.4% in rugby, and 7.8% in boxing, influenced by high-velocity impacts. In contrast, Prevent Biometrics' customized mouthguard (PRE-C) recorded a 4.9% REPM in American football and a 6.7% REPM in rugby. Kinematic detection metrics revealed variability in head impacts across sports. Rugby players exhibited a median peak linear acceleration (PLA) of 21.5 g, reaching up to 171 g. In American football, the average PLA was 26 g, with a peak of 53 g. Soccer PLAs ranged from 14.2 g to 52.1 g, while boxing and MMA averaged 19.3 g and 17.7 g, respectively, but could also peak significantly. Rotational acceleration (PRA) was particularly high in rugby, exceeding 1,700 rad/s², while American football averaged around 1,900 rad/s², with peaks hitting 5,200 rad/s². Current instrumented mouthguard technology shows promise in accuracy and kinematic detection across sports. However, performance variations necessitate sport-specific designs. Further research is essential to enhance mouthguard efficacy and improve head injury management and athlete safety in contact sports.

Biography

Hersh Punjani is a dedicated junior doctor with a strong passion for sports medicine and a commitment to improving athlete safety. As an aspiring sports and exercise medicine clinician, he is actively focused on injury prevention and rehabilitation. Leveraging a solid foundation in clinical practice, Dr. Punjani engages in research to develop innovative strategies that address the unique challenges faced by athletes in contact sports. Through these efforts, he aims to contribute to the evolving field of sports medicine, ultimately enhancing performance, safety, and recovery for athletes across all levels.

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