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Measuring Head Acceleration Like a CHAMP

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Keen interest has arisen in developing data-driven strategies to mitigate head injury and reduce repetitive head impacts in sports owing to concerns about the potential short-term and long-term neurologic consequences of these loads on the brain. Interventions can include advancements in equipment design, modifications to the rules of the game and training regimens, and enhancements to clinical assessments after an athlete sustains a concussive impact. One key to driving these improvements in athlete safety is the quantitative biomechanical measurement of head impact kinematics. Over the past 2 decades, technological advances in head kinematic measurement devices have made implementation more feasible, and as a result, these devices are sold commercially and used regularly across a range of scientific disciplines, including athletic training, exercise and sport science, physical therapy, neuroscience, and biomechanics. In addition, the price point of such devices has been reduced such that they are marketed to and used by parents and teams under the auspices of monitoring and protecting their athletes. The authors[1] of a recent systematic review highlighted the exponential increase in peer-reviewed publications using such technology to quantify head loading in athletes and correlate kinematic measures with relevant clinical, physiological, and neuropsychological outcomes.

As the use of these devices proliferates, so have concerns about their accuracy and specific methodologic challenges that can limit the rigor of the data collected.[2–5] Inaccurate data or insufficiently or poorly processed data can slow the deployment of beneficial interventions, limiting research and clinical advances, or, in the worst-case scenario, increasing the neurologic risk. As a result, we need methodologic guidelines to improve the rigor and consistency of the research on head acceleration measurement and reduce the risk of scientific bias. Further, improved research rigor in this area provides a strong evidence base for practitioners as they develop protocols and recommendations and interface with patients, athletes, and families regarding head injury mitigation.

To this end, the Consensus Head Acceleration Measurement Practices (CHAMP) group was founded to develop and recommend best practices for the collection, analysis, and reporting of head acceleration measurement data in sport. Comprising scientists and clinicians from a variety of backgrounds (including industry representation), the group undertook a comprehensive effort to define current best practices in head kinematic measurement, culminating in a series of manuscripts outlining consensus methods.[6–10] Six areas of focus were prioritized:

- Study design and statistical analysis in research on head acceleration measurement
- Laboratory validation of wearable head kinematic devices
- On-field validation and use of wearable head kinematic devices
- Video analysis of head acceleration events
- Physical reconstruction of head acceleration events
- Computational modeling of head acceleration events

Work groups for each focus area, led by experts in the field, drafted consensus statements that outlined the currently recommended best practices for many aspects of head acceleration measurement. The CHAMP workgroups and key stakeholders convened at a consensus conference held in Philadelphia in March 2022. All attendees participated in an open scientific discussion of the key concepts and then formally voted on each consensus statement. Details of this process and all participants are summarized here.[11]

Products from this conference included reporting checklists that align with technical manuscripts.[11] The checklists, or "CHAMP 2022 Reporting Guidelines," provide the elements necessary for transparent reporting in the peer-reviewed literature of studies using these methods. The CHAMP guidelines are not intended as the final word in head impact measurement reporting but rather as an accessible means for scientists who use head kinematics measurement devices in their research to translate the best practices summarized in technical manuscripts as they prospectively consider study designs and report the results of such work in the peer-reviewed literature. As readers and reviewers of that literature, we should all consider these checklists in our evaluation and interpretation of published work in the field. Other fields have developed checklists outlining reporting recommendations (eg, CONSORT [www.consort-statement.org] and EQUATOR [www.equator-network.org]), and their use has increased the comprehensiveness of reporting and the transparency of research.[12,13]

We are in an exciting time, when advances in head acceleration measurement technology have offered

tremendous opportunities to apply quantitative biomechanical analyses to head injury mitigation strategies for athletes. Research across multiple disciplines that use such devices will allow the evolution of the sport environment to the point where both the benefits of athletic participation are realized and the risk of neurologic consequences is minimized. Enhanced rigor as outlined by the CHAMP best-practices manuscripts and reporting guidelines will ensure that the scientific foundation upon which those advancements are based is strong and robust. We strongly encourage their use.

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