Whiplash injury or concussion? A possible biomechanical explanation for concussion syndromes in some individuals following a rear-end collision.

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BACKGROUND

Whiplash-associated disorder and concussion are clinical presentations that share a number of common traits. Both of these diagnoses are typically based upon a history of trauma to the neck or the head, in association with presenting signs and symptoms. These conditions can plausibly occur concurrently, creating a diagnostic challenge for clinicians.

OBJECTIVE

To quantify the brain strains that may occur during rear-end motor vehicle collisions (MVCs) as compared to brain strains resulting from potentially concussive American football helmet blows, including variation with differing head kinematic parameters.

METHODS

Kinematic data from two experiments; one examining the biomechanics of head restraint impacts following rear-end MVCs, and the other examining kinematics of American football helmet rear blows, were entered into a finite element model of the human brain. This model calculated the magnitude of resulting theoretical brain strains for both kinematic conditions, including variations in parameters such as impact speed, head restraint position for rear-end MVCs and neck position for American football helmet blows.

RESULTS

Modelling indicated that magnitude of brain strain increased linearly with angular velocity change of the head for both the rear-end MVC and American football helmet rear blow conditions. Brain strains were higher in the cerebrum than the cerebellum and brain stem, and conditions with the head restraint in a lowered position led to higher brain strains than conditions with the head restraint in the raised position. Brain strains from rear-end MVCs were typically less than the low speed American football helmet rear blows (5.5 m/s); however one rear-end MVC trial with a lowered head restraint resulted in a brain strain magnitude similar to high speed (9.3 m/s) American football helmet rear blows, an impact that has previously been linked with concussion.

CONCLUSION

These findings indicate that head kinematics in a rear-end MVC have potential to generate brain strains associated with concussion. The position of the head restraint appears to be a significant factor in injury biomechanics. Clinicians managing individuals following a whiplash injury from a rear-end MVC should be mindful of concussion as a potential concurrent diagnosis.

COMMENTARY

This study presents novel data that model a relationship between head and neck kinematic factors and brain strain in rear-end MVCs, a mechanism of injury that can be associated with whiplash, and American football helmet rear blows, a mechanism of injury linked with concussion. Kinematic data were entered into a finite element mathematical model of the human brain in order to calculate brain strain, which is an estimate of the mechanical response of brain tissue to observed forces. The authors report that brain strain was employed as an outcome measure, rather than simply using peak kinematic data, as brain strain has previously been linked with neuronal injury.

Findings of this study may be extrapolated to infer a potential biomechanical link between rear-end MVCs and potential for concussion in some collisions. Such an insight is valuable for physiotherapists, medical practitioners and other healthcare professionals who assess and treat individuals following a whiplash injury, as it highlights the need to consider concussion in clinical assessment and decision-making after a rear-end MVC.

Results also suggest that position of the head restraint may be of significance in the biomechanics of a rear-end MVC, as a lowered head restraint position was associated with higher levels of brain strain, and in turn, a theoretical increased risk of concussion. This finding has direct clinical utility, as it suggests that asking about the position of the head restraint in the subjective examination of a patient following a rear-end MVC may provide important insight when assessing an individual's risk of having sustained a concussion.

It should be noted, however, that these results do not suggest that every whiplash injury is accompanied by concussion, as just a small portion of the MVC trials generated brain strains comparable to the helmet blows. Rather these findings serve to remind clinicians to utilise their clinical reasoning skills, apply a broad approach to differential diagnosis, and be wary of whiplash symptoms that can mirror concussion symptoms, such as headaches, neck pain, dizziness or anxiety. Concussion should be assessed, diagnosed and managed by a medical practitioner (Accident Compensation Corporation, 2016; Elkington & Hughes, 2016). As such, if a physiotherapist is suspicious that a patient (whiplash or otherwise) may have sustained a concussion, referral to our medical colleagues is essential for optimal patient management.

The primary limitation to be considered when interpreting these results is that this study relies on mathematical modelling of head kinematics to make inferences regarding brain strain and, in turn, assumes that this model is a valid and accurate predictor of risk of concussion. Nonetheless, this study provides physiotherapists with biomechanical evidence that may be translated to a clinical setting, suggesting that clinicians should be aware of concussion as a potential co-existing diagnosis for individuals presenting with a whiplash injury following a rear-end MVC.

Scott F Farrell, BPhty (Hons), PhD
RECOVER Injury Research Centre, Menzies Health Institute Queensland, Griffith University, Southport QLD, Australia

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