The combination of high HW:BW with young age (5-8 year olds) and large angular velocity (8.29 deg/s/min) is associated with an increased risk of youth football concussions (Table 1). A high head-to-body mass ratio in less mature athletes may increase concussion susceptibility, and a lack of helmet customization for young athletes may contribute to difficulty controlling head acceleration (Table 2). Younger athletes may be more vulnerable to concussions than older athletes, and undervelopment of neck musculature may be an important factor affecting ability to resist external loads (Table 3). The purpose of this study was to identify factors that may increase susceptibility to concussion occurrence among youth football players, or that may facilitate improvements in concussion management.

RESULTS

- Peak linear acceleration (Figure 1) and peak angular velocity (Figure 2) were positively associated with increasing age.
- Arm forces, weight to body weight relationship (HW:BW) appears to affect impact force magnitudes per minute (Table 2).
- A helmet force in excess of 10% of a player's BW associated with a high linear acceleration per minute (Figure 3).
- High arterial condition per minute 10 x more likely for 5-8 year-old players with HW:BW ≥ 5%. Both factors positive: Sensitivity = 44%, Specificity = 93%, Odds Ratio = 10.11 (80% CI: 2.64 - 38.68) (Figure 4).
- High arterial angular velocity per minute 12.5 x more likely for 5-8 year-old players with HW:BW ≥ 5%. Both factors positive: Sensitivity = 39%, Specificity = 95%, Odds Ratio = 12.50 (90% CI: 2.13 - 73.41) (Figure 5).
- Lighter and smaller dimension helmets may be an important consideration for reduction of youth brain injury risk.
- Peak impacts increased with age, but HW:BW appeared to strongly influence average impact values per minute.
- The combination of high HW:BW with young age (5-8 year-olds) altered the effect of age on impact values.
- 10-12 x greater odds for elevated average impact values per minute (linear acceleration and angular velocity).

CLINICAL RELEVANCE

- Sport-related concussions have been linked to long-term degenerative effects on brain structure and function.
- Youth athletes possess elevated risk for impairment due to incomplete brain developmental processes.
- No clearly defined threshold for excessive head impact magnitude has been established for any age group.
- The results suggest that youth football players sustain comparable impacts to those sustained by older players.
- High impact values may relate to excessive nose-to-facemask distance.
- Risk for high angular velocity may increase with age, and that may facilitate improvements in concussion management.

REFERENCES