Exploratory Analysis of Factors Relating to Youth Football Concussion Risk

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MomsTEAM® Youth Sports Safety Institute
SmartTeams™ Pilot Program Initiative
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BACKGROUND AND PURPOSE

- Approximately 300,000 sport-related concussions occur annually in the United States[1]
  - The highest number of sport-related concussions has been recorded in American football[2]
  - 5.6% of high school football players sustain a concussion in a given season[2]
- The primary mechanism of concussion occurrence involves acceleration or deceleration of the head[3]
  - Imposition of compressive, tensile, and/or shearing forces on the brain
- Linear acceleration ≥ 80g believed to represent high-magnitude impact presenting potential for concussion[4]
- Angular velocity ≥ 1000 degrees/second believed to represent high-velocity displacement[4]
- Existing football helmets weigh from 3 to 5 pounds[5]
- Younger athletes may be more vulnerable to concussions than older athletes[2]
  - Greater head-to-body mass ratio in less mature athletes may increase concussion susceptibility[6]
  - Lack of helmet customization for young athletes may contribute to difficulty controlling head acceleration[7]
  - Underdeveloped neck musculature may be an important factor affecting ability to resist external loads[8]
- 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

Table 1

Age Group	N	Body Weight (kg)	Height (cm)	Helmet Weight (kg)	Helmet Wt:Body Wt	Avg Time (min)
5-7	10	28.50 ±10.55	124.40 ±6.62	1.64 ±0.17	0.061 ±0.013	99.70 ±52.99
8	10	33.10 ±5.60	138.50 ±8.20	1.70 ±0.16	0.053 ±0.009	116.90 ±93.317
9	23	42.03 ±12.71	144.30 ±7.20	1.73 ±0.15	0.044±0.013	153.35 ±64.24
10-11	17	45.08 ±14.64	147.20 ±5.96	1.64 ±0.15	0.039 ±0.010	160.65 ±102.95

Figure 1

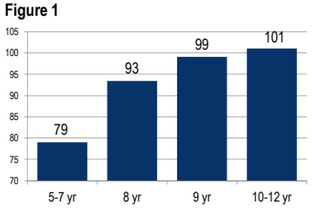
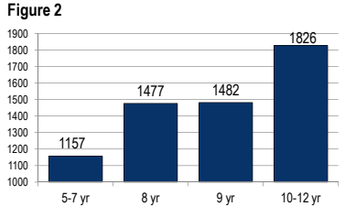


Figure 2



METHODS

- A force accelerometer was installed in each youth football player's helmet (gForce Tracker, Markham, ON)
  - Linear acceleration (g) and angular velocity (degrees/second) recorded during a total of 16 games
- 60 youth football players from 6 teams participated (all male), ranging from 5 to 11 years of age
  - Anthropometric characteristics, helmet weight, and impact recording time presented for age groups (Table 1)
- All available data extracted from helmet sensors, providing variable amounts of data for individual players
  - Threshold for recording of impacts (hits) set at ≥ 10g, which were averaged for each player-minute of monitoring
  - Exploratory analyses performed to identify any meaningful relationships within the dataset
- Receiver operating characteristic analyses performed to identify optimal cut-points for categorizations
  - 2 x 2 cross-tabulation analyses performed and odds ratios calculated

RESULTS

- Peak linear acceleration (Figure 1) and peak angular velocity (Figure 2) were positively associated with increasing age
- Helmet weight to body weight relationship (HW:BW) appears to affect average impact magnitudes per minute (Table 2)
  - A helmet weight ≥ 5% of a player's BW associated with high average linear acceleration per minute
    - 0.173 g/min: Sensitivity = 73%, Specificity = 67%, Odds Ratio = 5.5 (Figure 3)
  - A helmet weight ≥ 5% of a player's BW associated with high average angular velocity per minute
    - 2.65 deg/s/min: Sensitivity = 87%, Specificity = 57%, Odds Ratio = 8.5 (Figure 4)
- Both age and HW:BW strongly associated with high values for average impact magnitudes per minute (Table 3)
  - High average linear acceleration 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 (90% CI: 2.64 – 38.68)
  - High average 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)

Table 2

Age Group	Avg Linear Acc (g) per hit	Avg Angular Vel (deg/s) per hit	Avg Linear Acc (g) per min	Avg Angular Vel (deg/s) per min	Avg Hits/Min	Peak Linear Acc (g)	Peak Angular Vel (deg/s)
5-7	22.30 ±3.32	360.92 ±51.82	0.39 ±0.44	6.20 ±6.36	0.508 ±0.220	79.00 ±51.69	1157.00 ±688.14
8	26.48 ±7.76	469.57 ±157.65	0.81 ±1.54	12.71 ±23.24	0.705 ±0.298	93.43 ±34.81	1476.80 ±766.45
9	23.50 ±3.91	409.80 ±108.24	0.21 ±0.17	3.55 ±2.91	0.625 ±0.334	99.10 ±41.53	1481.96 ±534.11
10-11	22.92 ±4.01	467.42 ±182.36	0.21 ±0.15	5.01 ±5.60	0.795 ±0.402	101.08 ±39.40	1826.35 ±708.82

Figure 3

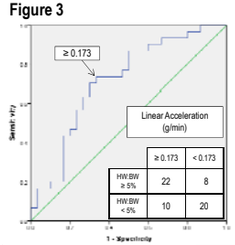


Figure 4

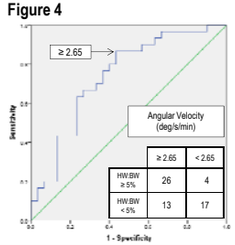


Table 3

Age Group	Players with HW:BW ≥ 5%	Among Players with HW:BW ≥ 5%: High Linear Acceleration ≥ 0.173 g/min	Among Players with HW:BW ≥ 5%: High Angular Velocity ≥ 2.65 deg/s/min
5-7	90% (9/10)	100%	100%
8	70% (7/10)	88%	88%
9	39% (9/23)	67%	62%
10-11	29% (5/17)	25%	30%

CLINICAL RELEVANCE

- Sport-related concussions have been linked to long-term degenerative effects on brain structure and function
  - Youth athletes may 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
  - Our results suggest that youth football players sustain comparable impacts to those sustained by older players
- Peak impact values 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)
- Lighter and smaller dimension helmets may be an important consideration for reduction of youth brain injury risk
  - HW:BW may adversely affect ability to control head movements, which may increase risk for high impact values
  - Risk for high angular velocity may relate to excessive nose-to-facemask distance

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