Cumulative Exposure Risk of Concussion for Youth and High School Football Head Impacts

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Abstract

Sports-related concussion is the most common athletic head injury with football having the highest rate. Traditionally, research on the biomechanics of football-related head impacts has been focused at the collegiate level. Less research has been performed at the youth and high school level, despite undetermined rates of concussion among youth football players. The objective of this study is to develop and present a cumulative exposure risk metric and use it to analyze cumulative risk at various levels of play. Head impact exposure was measured by instrumenting the helmets of 111 youth and high school football players with helmet mounted accelerometer arrays. Age groups analyzed in this study include 6-8 years, 9-12 years, 12-14 years, and 14-18 years. The risk associated for each linear and/or rotational acceleration measured for each player was calculated based on linear, rotational, and combined probability concussion risk functions. These data were combined to define the cumulative exposure risk (CER) for the season for each player given each risk function. CERs for all players for each age group were summed to calculate the estimated number of concussions experienced for the age group. The three concussion risk functions (linear1, rotational2, combined probability (CP)3) were analyzed for each team to calculate the number of predicted concussions for each age group over the course of the season given each risk function. A non-parametric Wilcoxon test of multiple comparisons was performed to identify differences between groups for each risk function. The CERLinear was found to be significantly lower for the 6-8 age group compared to the 12-14 and 14-18 age groups ($p=0.0041$ and $p<0.0001$, respectively). Additionally, the 12-14 age group was found to have significantly greater CERLinear compared to the 9-12 age group ($p=0.005$), who was found to have significantly lower CERLinear compared to the 14-18 age group ($p<0.0001$). Similar findings were reflected in the analysis of CERRotational and CERCP. Results demonstrate age-dependent variations in CER. The predicted number of concussions was found to vary between age groups and risk functions from less than 1 to 34 concussions. The CER metric presented in this study is novel in that it accounts for the frequency and severity of each player's impacts. The results from this study contribute to the understanding of cumulative head impact exposure in football which will further our understanding of the biomechanics of head injury.