Mind the Gap: Load Management in Contact & Combat Sports

Introduction

Current practices often fail to address critical aspects of athlete health & performance – specifically the load associated with impacts to the head in contact and combat sport. Improvements in Sports Science have focused on the concepts of 'Internal Load' (psycho-physiological responses, heart rate, perceived exertion) and 'External Load' (athlete accelerations, forces, speeds). In this paper we investigate if it is possible to address this gap and propose concurrently quantifying inputs of Internal, External, and Head Impact Load through a novel smart mouthguard and mobile application.

Methods

This study adopted a mixed method research design, combining laboratory testing, field-based data collection and case studies with professional athletes. To validate the concept of Head Impact Load (HIL) we compared smart mouthguard (ORB Sport, US) data to laboratory grade tri-axial accelerometer during simulated impacts on an anthropometric test device and pendulum impactor. In the field the preparation of a professional boxer during sparring in training camp was recorded and compared the Head Impact data to two official fights. Internal Load (IL) was calculated based on heart rate data from the smart mouthguard was evaluated in laboratory and field-based analyses with Mixed Martial Arts athletes and compared to reference ECG. Finally External Load (EL) was estimated by the smart mouthguard (inertial sensor) and compared to a force plate instrumented treadmill for resultant ground reaction forces, acceleration and distance.

The validity of the smart mouth guard data was evaluated using intraclass correlation coefficients, mean absolute percentage error (MAPE) and root mean squared error (RMSE) compared to the criterion reference.

Results

The relationship between the smart mouthguard and the laboratory reference sensors was found to be linear and demonstrated good agreement, see Figure 1 demonstrating ICC = 0.944 and MAPE = 11%. The current measurement of Head Impact Load then showed that a professional boxer was often exposed to much higher Head Impact Loads during sparring compared to official competitive fights, see Figure 2. During MMA sparring we observed that the lower ranked athletes were exposed to greater Head Impact Load.

The validity of heart rate estimates provided by the mouthguard was evaluated in participants (n=42) during high-intensity treadmill running. Compared to the ECG reference, the mouthguard showed very strong agreement, with an intraclass correlation coefficient (ICC) of 0.94 and a root mean squared error (RMSE) of 10.7 bpm. During field

testing with MMA athletes sparring only small differences were observed between the smart mouthguard and ECG reference device (MAPE = 4.4%). For External Load the smart mouthguard could estimate forces, acceleration and distance with moderate strength (r=0.6) and MAPE ranges of 18.3 to 4.6%.

Conclusion

This study shows that the concurrent measurement of Internal, External and Head Impact Load is now possible in contact and combat sports and highlights the importance of quantifying Head Impact Load for better management of athlete health & performance.

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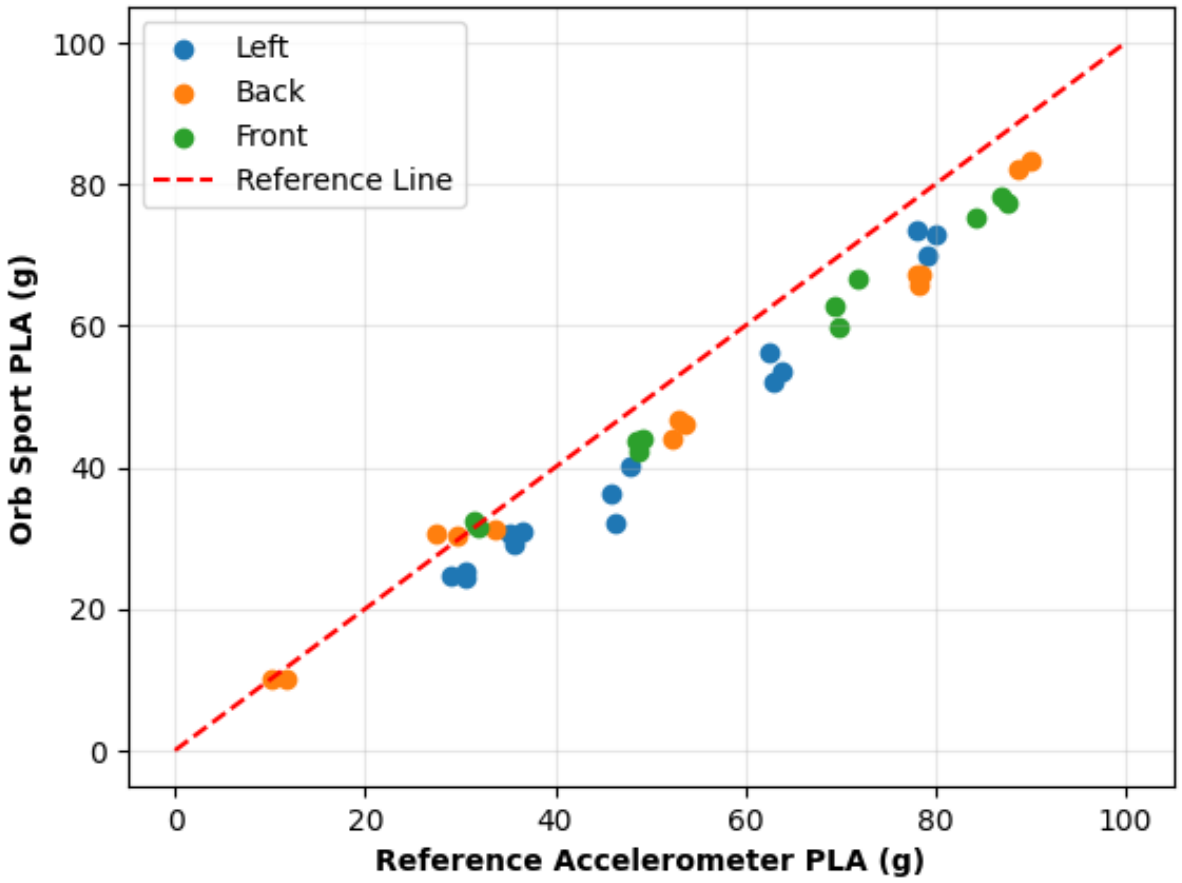

Figure 1. Comparison of Smart Mouthguard (ORB Sport) versus Laboratory Reference for Peak Linear Acceleration (ICC =0.944, MAPE = 11%).

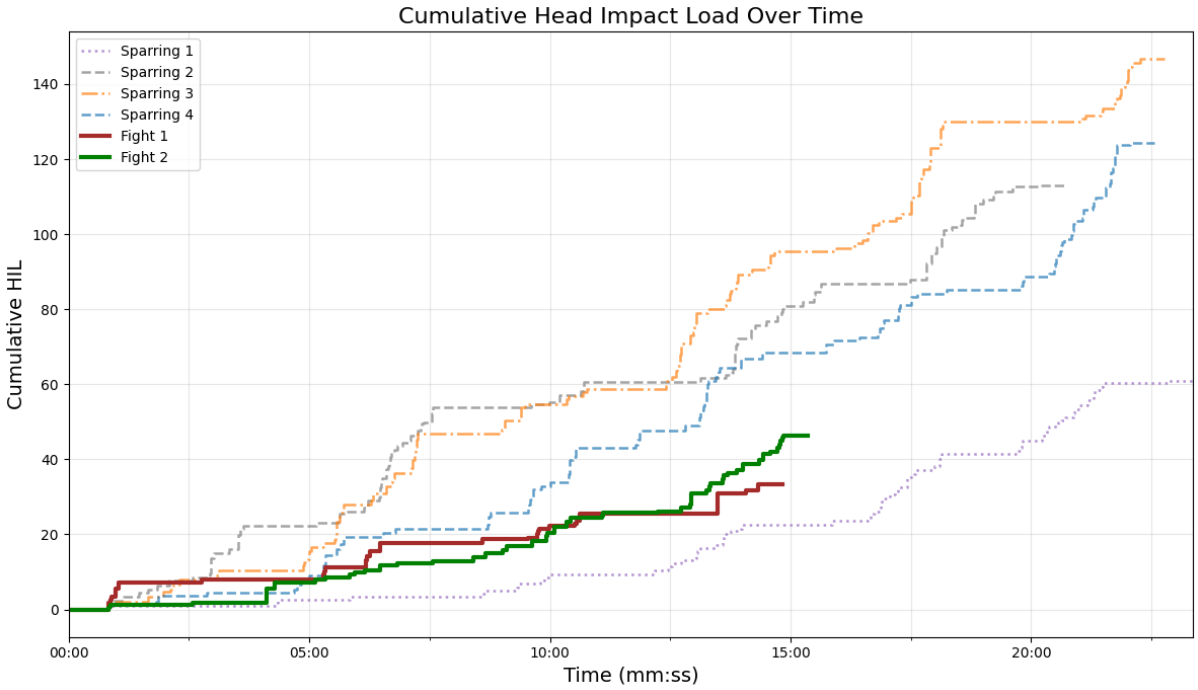

Figure 2. Comparison of Head Impact Load between official pro Boxing fights and sparring completed during preparation.