Journal of Special Topics

S1_10 Dangerous Sports: Rugby

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November 26, 2009

Abstract

This article explores the damage done to players on the rugby pitch during collisions and tackles. It is found that a dump tackle done by an average 100kg male rugby player on another player exerts a force akin to what a driver would feel in a ~30mph car crash into a solid wall. For two players running head-on the force felt is akin to a 40mph crash.

Introduction

Whilst watching a rugby game recently the author observed that several times during the game some heavy collisions occurred leaving a player on the ground for a few seconds to catch his breath. Now from the observers point of view these collisions looked like they would cause quite a lot of damage to the players involved. With this in mind, the decision was made to work out just how much damage was being done.

Investigation

In this article the 'dump tackle' and head on collisions are investigated. First, we look at the dump tackle. This is where a player runs head-on into a stationary player who stops the runner dead before driving him backwards onto the ground (as illustrated in figure 1).

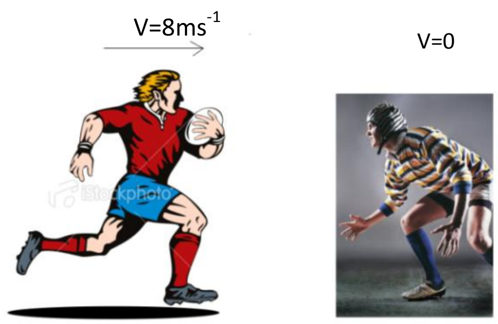

Figure 1: Diagram of a dump tackle. [1]

We approximate both masses (m) to be 100kg for a typical rugby player and the velocity (v) of the runner to be $8ms^{-1}$. The impulse of the system [2] is found using

$$I = \Delta p = mv - 0 = 800\text{kgms}^{-1} \quad (1)$$

Where Δp is the change in momentum of the system. The collision time (Δt) of the two players' impact is assumed to be 0.1secs and so the force exerted on each player during the tackle is

$$F = \frac{I}{\Delta t} = 8.0kN \quad (2)$$

The stress on both the runner (who will take the impact to his chest area) and the tackler (who impacts with his shoulder) is

$$Stress = \frac{F}{A} = 0.32MNm^{-2} \quad (3)$$

where A is the total area of impact on both players, and is approximately $0.025m^2$ (the shoulder area).

We now investigate 2 players running head on. Naturally, we would expect the force exerted on each player in this instance to be greater than that in the dump tackle. We assume that this is an inelastic collision and that both players have the same mass (100kg) and that they run at each other with the same velocity ($8ms^{-1}$). So, the force exerted is

$$F = m\frac{\Delta v}{\Delta t} = m\left[\frac{(mv + mv) - 0}{\Delta t}\right] = \frac{2mv}{\Delta t} \quad (4)$$

Substituting in the values gives a force of 16kN. Equation 3, gives the stress exerted by the impact as $0.64MNm^{-2}$.

Hence repeatable collisions like this would be a cause for concern in particular to damage to the ribs or shoulder blade of the 2 rugby players involved. If perchance a players' shoulder went into another players face with this force, it is unlikely that their nose will stay intact! In fact, the amount of force a nose can take before it breaks is 3.17kg of pressure [3] which equates to 0.048MNm^{-2} of stress. As you can see, the stress from either kind of tackle exceeds this by an order of magnitude. If the reader requires more proof that the nose will break from these impacts, experimental evidence confirming this conclusion is centrally located on the face of many rugby players.

For comparison sake we now compare the impact on the rugby players to the impact on a driver in a car crashing into a wall at different speeds. We will use the same mass for the driver and approximate the distance the driver and the car travel as the front of the car crumples to be ~1m with a constant acceleration during the crash. The force is found using equation 4 once again where the velocity v of the car is 30mph (13.4m/s). So

$$F = m\frac{\Delta v}{\Delta t} = 100x\frac{13.4}{\Delta t} = \frac{1340}{\Delta t} \qquad (5)$$

Where

$$\Delta t = \frac{\Delta x}{v_{ac}} = \frac{1}{0.5(v_i+v_f)} = 0.15. \quad [2] \qquad (6)$$

The force exerted on the driver in a 30mph car crash is thus around 9.0kN. The force on the driver for other car velocities was calculated and is shown below in figure 2 with the forces calculated for the rugby players also included.

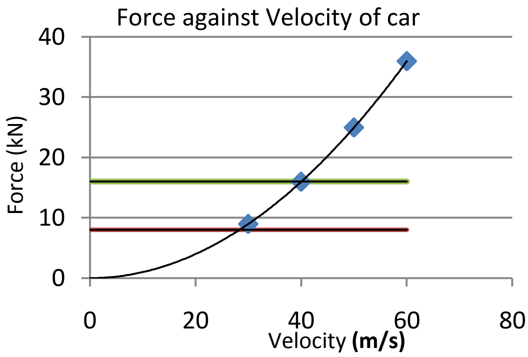

Figure 2: A graph showing the velocity of the car on the x-axis and the force of impacts on the y-axis.

The straight green line shows the force exerted on to the rugby players from a head on collision at 8ms^{-1} and the straight red line shows the force from a dump tackle. As can be seen from the points of intersection of the green and red lines with the line of best fit for the car, the force exerted on rugby player's body during the dump tackle example is comparable to a car crashing from 28mph to a stand-still with a 1m travel distance during the crash. The head-on collision is comparable to a 40mph car crash.

Conclusion

Whilst rugby is not considered one of the more dangerous sports, such as motor racing or base jumping, we have proved that injuries such as broken bones, in particular broken noses, are likely to be common because of the nature of the game and the forces exerted on players during it. A dump tackle exerts a force akin to a 28mph car crash whilst a head-on collision exerts that akin to a 40mph car crash. With the above in mind, we can see that a rugby player's body will have to withstand major stresses at least a few times during a game, explaining why players quite often sustain injuries akin to those taken by a person in a car crash.

References

[1] http://www.istockphoto.com/file_thumbview_approve/6868430/2/istockphoto_6868430-rugby-player-running-with-the-ball.jpg

[2] *Physics for Scientists and Engineers Fourth Edition* Paul A. Tipler, pages 244 and 228.

[3] http://www.ehow.com/how_2126964_break-attackers-nose.html