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A Study of the Impact of Sepaktakraw Balls on the Head

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Abstract. Sepaktakraw is a traditional game played at international level in Asia. The game is played by using various parts of the body except the hands. Most notably the head is very often used. But unlike soccer, no study has been done on injuries caused by contact between the ball and the head. The balls are typically made of plastic. Recently new balls made of plastic impregnated with rubber was introduced. In this study a method has been developed to measure the Head Impact Power of Sepaktakraw balls. Using this method it was found that two different balls results in entirely two different outcomes. It was found that the balls made of plastic impregnated with rubber has 4 times more probability of causing mild brain traumatic injury when dropped from a height of 3.5m. The significance of this study is the importance of taking into consideration the safety of an athlete when designing sports equipment even as simple as a plastic ball.

Keywords: sepaktakraw, mild brain traumatic injury, head impact power, rubber impregnated plastic alls.etc.

1. Introduction

Sepaktakraw is a game between two teams which involves the use of mainly the head and legs and sometimes other parts of the body to maintain a ball in the air with less than three contacts. Exchanges of the ball occur at high speed and extreme acrobatic moves are often employed. The type of ball used may thus have an impact on a sepaktakraw athlete particularly in terms of its effect when in contact with the head, legs and to some extent the other parts of the body. However there has been no study up to date on the impact of a sepaktakraw ball on the head. In similar sports where the head is in contact with a ball such as soccer, it has been found that ball to head contact accounts for 12.6% cases of concussion [1]. Delaney et al [2] reported that more than 60% of college-level soccer players reported symptoms of concussion during a single season.

A concussion is a trauma-induced change in mental status, with or without unconsciousness caused by an impact to the head or upper body, or by non-contact severe motion, such as whiplash. It's symptoms ranges from a mild headache, nausea, dizziness, vertigo, heightened sensitivity to light or sound, amnesia to prolonged unconsciousness. It is also believed that a person who has had one concussion is four to six times as likely to have a second concussion as a nonconcussed player. The second concussion is often significantly more severe than the first, even if the second impact is seemingly minor, because the brain has not completely healed from the first concussion yet. This is often called the second impact syndrome (SIS).

A study on the probability of a concussion due to head clashes in American Football was conducted by Newman et.al [3]. It was observed that head injury severity/probability correlates to the magnitude of the rate of change of kinetic energy that the head undergoes during an impact. Based on this a Head Impact Power (HIP) equation was derived and its relation to the probability of concussion established. In this paper a methodology is developed to measure the HIP values of two types of sepaktakraw balls impacting on the head. Recently there has been a controversy on the use of a new ball made of plastic impregnated with rubber. The study seeks to demonstrate that the design of the new ball may have significant effect on the HIP values and consequently the probability of brain injury to the player.

2. Methodology

An experiment was designed in which the balls were dropped at different heights onto a force plate. The different heights will result in different velocities on impact. Dropping from a height also allows the effect of drag forces on the balls. The experiments were conducted indoors to discount the effects of air movement. A

video camera was used to capture the ball's flight (figure 1). A motion analysis software was used to measure the velocity on impact.

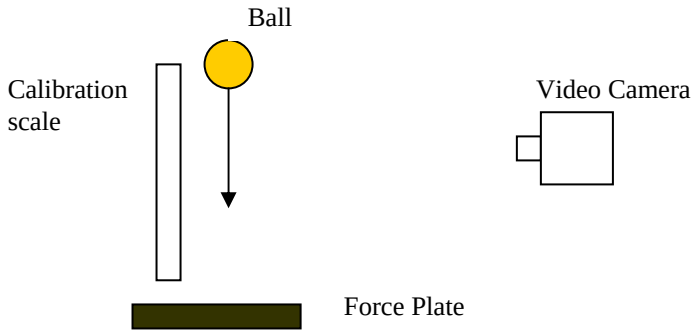

Figure 1. Experimental set-up for measuring velocity and impact force

Two different types of balls of different diameters and design were used. Ball 1 has a diameter of 133mm and made entirely of plastic (figure 1). Ball 2 has a diameter of 130mm and made of plastic with impregnated rubber (figure 2). The stiffness of each ball was also measured. This was done by loading the ball with weights and measuring the deformation.

Figure 1. Sepaktakraw ball made of plastic

Figure 2. Sepaktakraw ball made of plastic with impregnated rubber

3. Head Impact Power

The general expression for the rate of change of translational and rotational kinetic energy for any rigid object is given by

Power = Linear Force x Linear Velocity + Rotational Torque x Angular Velocity

For the experiment, only linear impact is encountered. Thus the Head Impact Power or HIP can be calculated as

HIP = Impact force x linear velocity

where the impact force is measured by the force plate and is the velocity on impact extracted from video analysis.

4. Results

The experiments were repeated 30 times at various heights for each ball. Figure 2 shows the average velocities of the ball at the point of impact dropped from different heights. It can be seen that ball 2 has a higher velocity than ball 1. The velocity of ball 2 also increases with increasing height. Figure 3 shows the average values of the impact forces of the balls dropped from different heights. The impact force of ball 2 is higher than ball 1 and also increases with increasing height. The velocities and impact forces at 3.0m and 3.5m are extrapolated. The HIP values are then calculated as shown in table 1. It can be seen that the impact power is higher for ball 2 and also increases as the height increases (figure 4). At 3.5m, the HIP of ball 2 is almost 90% of the HIP of ball 1

Figure 5 shows the deflection of the ball under load. The stiffness of ball 2 is calculated to be 19.6kN/m whilst ball 1 is only 8kN/m.

Height(m)	0.5		1.0		1.5		2.0		2.5		3.0		3.5	
Ball type	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Velocity (m/s)	1.77	3.35	2.99	4.25	3.35	4.30	4.27	6.80	4.96	8.16	5.76	9.37	6.45	10.64
Force(N)	281	282	374	392	472	491	528	547	555	592	624	669	686	739
HIP (W)	497	944	1119	1666	1583	2112	2253	3720	2754	4831	3591	6269	4425	7863

Table 1. Velocity, impact force and impact power of balls dropped from different heights

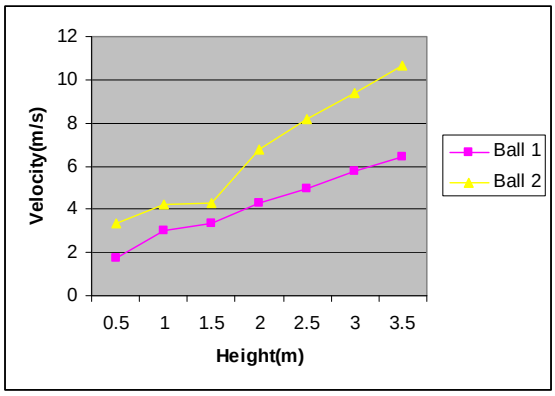

Figure 2. Velocity before impact at various heights

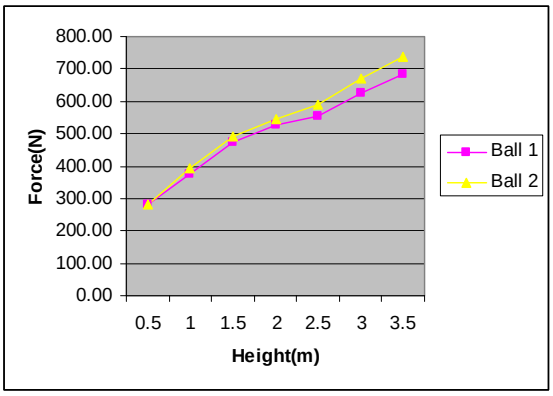

Figure 3. Force on impact at various heights

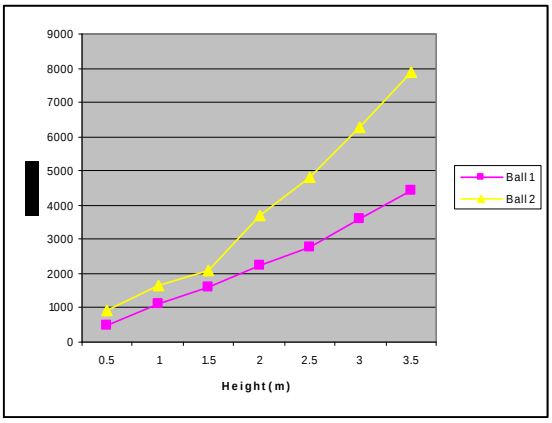

Figure 4. HIP of balls dropped from various heights

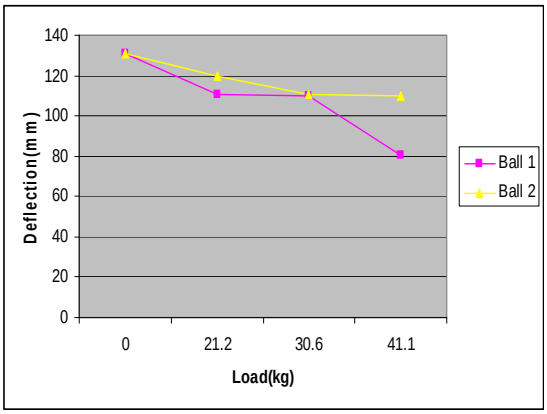

Figure 5. Deflection of balls under load

5. Discussion

To understand the implication of the HIP values, the HIP values are compared with Newman et.al [3] who had developed the probability of concussion for different HIP values. The typical values are as follows

Probability	HIP value (kW)
5%	4.700
50%	12.79
95%	20.88

Thus if we take for example the ball being dropped from a height of 3.5m, the HIP of ball 1 will give a value of 4425W or 4.425KW. This corresponds to the probability of concussion of less than 5%. For the same height, the HIP value of ball 2 is 7863N or 7.863KN. The probability of concussion is now approximately 20%. The probability of concussion has increased four times. The velocity of a sepaktakraw

ball is also known to reach speeds up to 160km/hr. Thus the probability of concussion can well exceed 50%.

6. Conclusions

A methodology has been developed to measure the Head Impact Power or HIP of a sepaktakraw ball. Two balls of different design called ball 1 and ball 2 were tested. It was found that ball 2 has a higher HIP value dropped from the same height as ball. Dropped from 3.5m height the probability of concussion when a player's head is in contact with ball 2 is increased significantly four times. Further investigation on the characteristics of ball 2 will be done namely using computational fluid dynamics to study its aerodynamic properties. In essence the result of this study emphasizes the importance of incorporating safety issues in the design of sports equipment.

7. References

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