Reducing the dead zone in the hammer landing sector

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ABSTRACT

Over the last 60 years, the IAAF has reduced the angle of the hammer throw landing sector and altered the requirements for the design of the safety cage. The main aim has been to increase the safety of athletes and officials by reducing the danger zone in which misthrown hammers could possibly land. However, recent changes have lead to a number of problems, the most important being an effective reduction of the landing area, which has negatively impacted both the technique of top throwers and the development of the event. After studying the trajectory of the hammer head after release by a right handed thrower for selected cases with different safety cage designs, the authors, including Olympic Champion Koji Murofushi, are able prove the existence of a dead zone of approximately 6° inside the landing sector. They explain the calculations they used on data obtained from biomechanical research projects carried out at the IAAF World Championships in Athletics in Tokyo in 1991 and Osaka in 2007. They conclude with proposals for eliminating the dead zone without expanding the current danger zone. They hope their ideas will lead to a dialogue that attracts the viewpoints and opinions of athletes, coaches and others.

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Introduction

Over the last 60 years, the angle of the hammer throw landing sector has become narrower as the distance of the men's world record has progressed. The sector was altered from 90° to 60° in 1958, from 60° to 45° in 1965, from 45° to 40° in 1970, and from 40° to 34.92° in 2002[1]. In each case, it seemed appropriate to decrease the sector angle in an attempt to ensure that as the world's top athletes increased their throwing distance, the implement would not go out on to the track in the case of a foul throw and thereby endanger other athletes, competition officials and spectators.

The design of the safety cage has also been gradually improved, up to the latest IAAF design regulations in 2004, with the same aim in mind. The previous year, a state of the art cage configuration had been introduced following a design proposal submitted by a group of elite Hungarian hammer throwers based their experience with the cage at the IAAF Accredited Training Centre in Szombathely, Hungary. This design kept the 6m width of the cage opening in use up to that point but moved the gate further away, to 7m from the centre of the circle, and inserted two 2.8m long side panels. The various changes have drastically decreased the danger zone from 85° to 53° and the latest design has decreased the chance of a mis-thrown hammer bouncing back towards the thrower.[2]

However, Olympic gold medallist Koji Murofushi (JPN), one of the authors of this article, has suggested that there are a number of problems created by the Szombathely design, the most important being the creation of a dead zone inside the 34.92° landing area sector where it is impossible for the hammer to land, effectively reducing the size of the sector more than the intention of IAAF Rule 192 and thereby impacting the technique of throwers and possibly the development of the event.

In this article, we prove the existence of a dead zone of approximately 6° in the landing sector when the Szombathely design cage is used and then put forth proposals for an alternative cage configuration to eliminate it without expanding the current danger zone. In the spirit of section 4 note vi of Rule 192 (Innovative designs that provide the same degree of protection and do not increase the danger zone compared with conventional designs may be IAAF Certified), we hope this will be a starting point for a dialogue that will attract the viewpoints and opinions of athletes, coaches and others.

Theoretical Comparison

The distance of a hammer throw is largely determined at the instant of release. The factors involved include release angle relative to the horizontal plane, release direction on the horizontal plane, release position and release velocity of the hammer head, but the most important factor is the release velocity. Air resistance can alter the distance by 4.30 ± 2.64m.[3]

For the purpose of this project we studied the trajectory of the hammer head after release by a right handed thrower for seven selected cases from the pre-2002 and Szombathely cage designs. Disregarding air resistance, we looked at the path the head would travel relative to the cage when it landed on the right and left sector lines as well as for throws passing close to the panel and gate of the cage.

The sequence of calculating the path of the hammer head in each case were to 1) assume the release velocity, release angle and release point in order to explain the vertical parabolic displacement, 2) calculate the airborne time, 3) assume the landing direction, 4) calculate the release velocity components Vx and Vy by solving the quadratic equations, 5) calculate release direction and 6) calculate the X and Z components passing through some Y components assuming linear movement with constant velocity on the horizontal plane and parabolic movement with gravitational acceleration on the vertical plane (see Figure 1). The release point and release angle were assumed with reference to a study made at the 2007 IAAF World Championships in Athletics in Osaka[4] and the release velocity was assumed to be 30m/s, which would probably be enough to reach the current world record.

When the angle of the landing area sector was 40° and the cage opening was 6m with the pre-2002 cage design, there was hardly any dead zone (see Figure 2). In reality, there were times when the hammer head exited the cage opening but the handle would hit the panel, therefore to be correct we must say that there was a small dead zone.

However, with the angle of the landing area sector at 34.92° and the cage opening at 6m with the Szombathely cage design, the ham-

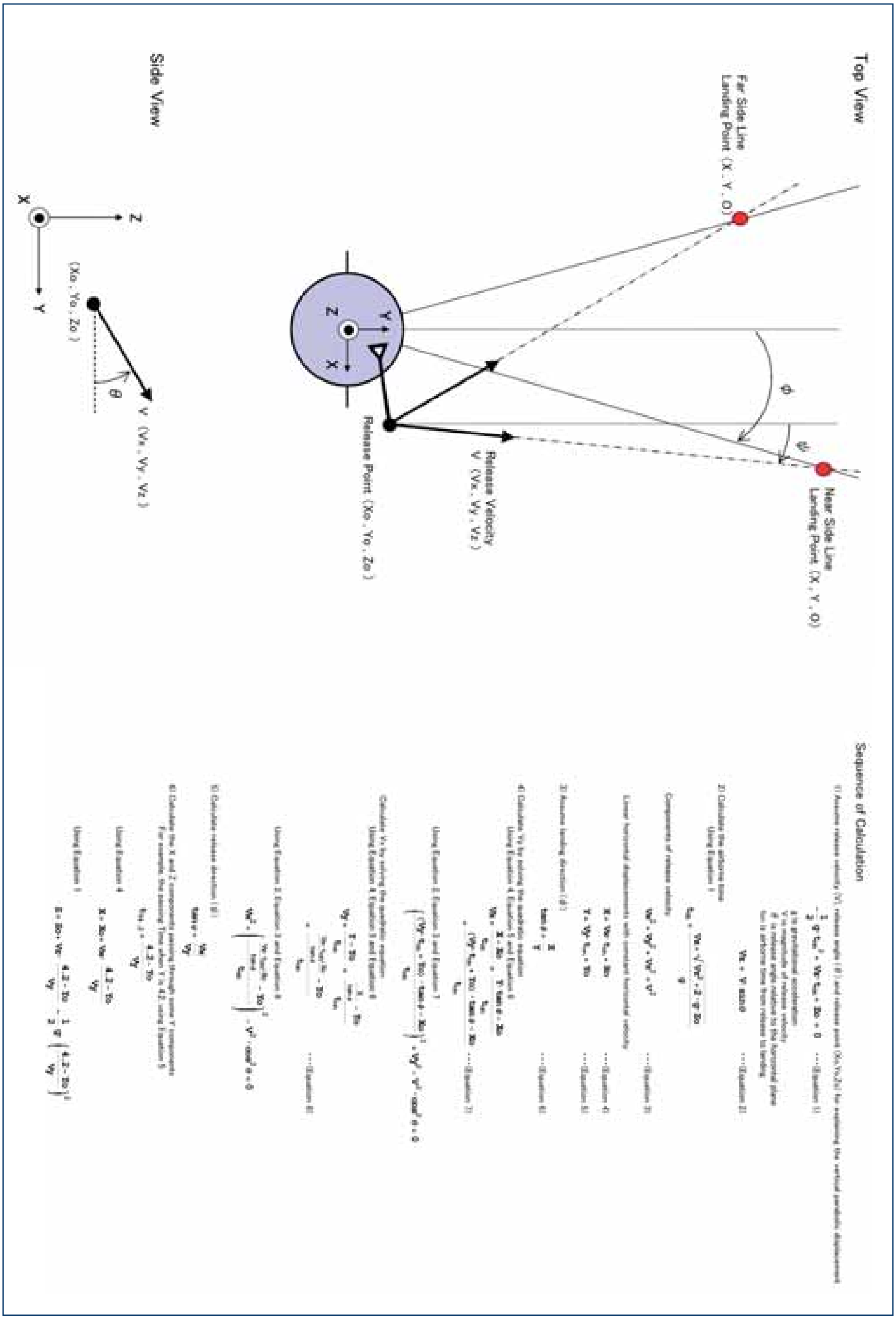


Figure 1: Using the hammer release conditions and expected landing point to calculate the hammer head path near the cage opening

mer cannot land on the right sector line, because travelling on the necessary path it would hit the right panel of the cage first. When the hammer head passes the right panel as close as possible without hitting, it will land approximately 5.2° inside the right sector line. This dead zone is approximately 15% of the 34.92° landing area sector, making the actual valid throwing angle less than 30°. Moreover, because the athletes will consciously release so that the handle does not hit the panel, the dead zone on the right is effectively even greater.

Practical Comparison

We compared data from the men's hammer throw obtained at the 1991 IAAF World Championships in Athletics in Tokyo[5], when the pre-2002 cage design was used with the 40° landing area sector, to the corresponding data from the 2007 IAAF World Championships in Athletics in Osaka, when the current cage configuration and a sector angle of 34.92° were used. At the 1991 championships, the average release direction angle by the throwers studied was -8.7°. Under the rules in force in 2007, the average release direction angle by the throwers studied was -0.7° (see Table 1).

Despite the fact that there is a dead zone on the right side, and maybe because the left side danger zone has been narrowed down, the throwers threw more to the right side in Osaka than in Tokyo. However, even with the current cage configuration, there is plenty of possibility for the release direction to be more on the left side depending on the facility. But if there is a dead zone on the right side, the results show an inconsistency between the cage and the sector angle, and it may be that this is restraining the performance of the athletes.

Diminishing the Dead Zone on the Near Side of the Sector

Maintaining the cage opening width at 6m and moving the cage opening forward to 7m from the centre of the circle reduced the danger zone and eased the threat of the hammer bouncing back to the thrower, but it created the problem of a dead zone on the right side of the sector as well as problems related to the need to build the front side panels and gates very high while ensuring they are mobile and can stand up to the wind. From the athlete's point of view there are two problems: it is equally important to resolve the dead zone (near side problem) and the coerced feeling caused by the gate (far side problem).

In order to diminish the dead zone we make the following proposals (see Figure 3):

1) Widen the cage opening of the Szombathely design;
2) Widen the cage opening and bring the cage opening back closer to the circle than the Szombathely design;
3) Bring the cage opening back closer to the circle and lengthen the gate opening distance longer than the distance of the pre-2004 design.

For proposal 1) we would need to widen the cage opening to 7.45m. For 2) we would need to widen the cage opening to 7.45m and bring back the cage opening so that it is 6m from the centre of the circle. For 3) we would need to bring back the cage opening to 4.2m from the centre of the circle, as in the pre-2004 design, and lengthen the gate opening distance to 7m from the centre of the circle.

According to the sequence of calculation we used in Figure 1, with 1) the landing direction of the far side would be -22.3° and the danger zone would be about 45°; for 2) the danger zone would be 52°; for 3) it would be 50°.

Although the sequence of calculation for the danger zone with the current cage design is not known, we believe that none of the proposals we have made would actually increase the danger zone. The increase in danger from the bounce back of the hammer should be minimal but, importantly, the coerced feeling currently experienced by the athletes would be reduced.

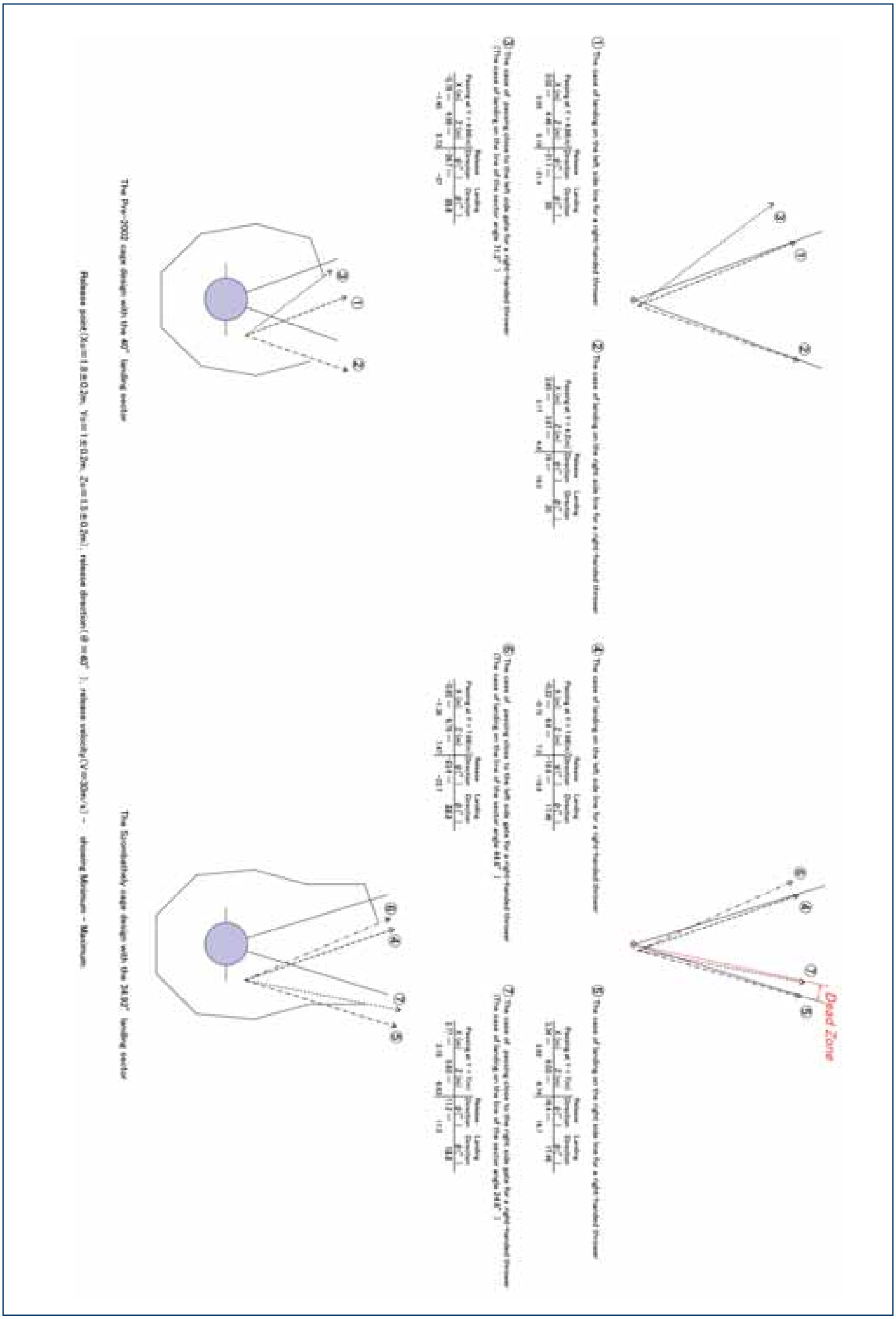
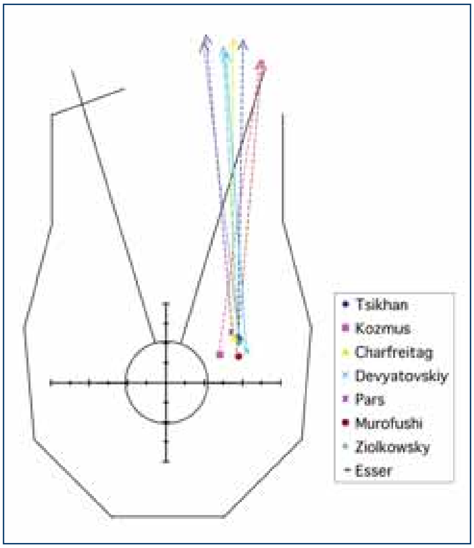


Figure 2: Release direction and hammer head path in the pre-2002 and Szombathely cage designs

Table 1: Release conditions for the best throws in the Men's Hammer at the IAAF World Championship in Athletics in 1991 (Tokyo) and 2007 (Osaka)

Tokyo in 1991	Country	Result	Release Direction ϕ	Release Angle θ	Release Height Zo
Sedykh	URS	81.70m	-10.5°	38.9°	1.69m
Astapkovich	URS	80.94m	-8.0°	42.8°	1.65m
Weis	GER	80.44m	0.8°	45.2°	1.31m
Gecsek	HUN	78.98m	-1.9°	42.8°	1.55m
Abduvaliev	URS	78.30m	-15.8°	41.4°	1.93m
Ciofani	FRA	76.48m	-16.6°	40.7°	1.66m
Mean		79.47m	-8.7°	42.0°	1.63m
SD		1.76	6.5	2.0	0.20

Osaka in 2007	Country	Result	Release Direction ϕ	Release Angle θ	Release Height Zo	Release Point Xo	Release Point Yo
Tsikhan	BLR	83.63m	1.0°	36.0°	1.54m	1.88m	1.15m
Kozmus	SLO	82.29m	7.4°	42.5°	1.56m	1.41m	0.71m
Charfreitag	SVK	81.60m	-0.2°	40.4°	1.74m	1.80m	1.14m
Devyatovskiy	BLR	81.57m	-3.6°	39.1°	1.73m	2.12m	0.80m
Pars	HUN	80.93m	-4.5°	40.8°	1.29m	1.72m	1.27m
Murofushi	JPN	80.46m	4.8°	40.2°	1.29m	1.90m	0.66m
Ziolkowsky	POL	80.09m	-2.9°	41.1°	1.39m	1.92m	0.99m
Esser	GER	79.66m	-7.2°	41.4°	1.36m	1.88m	1.08m
Mean		81.28m	-0.7°	40.2°	1.49m	1.83m	0.98m
SD		1.29	4.9	2.0	0.19	0.20	0.22



Whichever the case, the width should be increased – for proposal 1) and 2) to 2.7m, for 3) to 3.4m - and that will bring up discussions such as strength against wind etc. However, if we do not resolve these problems, we cannot expect the development of technique or further increases in record for the men's hammer throw.

Conclusion

Maintaining the safety of the spectators, officials and athletes is, of course, the primary concern in the hammer throw. However, the current safety cage configuration for the hammer throw is inconsistent with the landing sector angle and creates a dead zone, which has a negative impact on elite throwers. It is

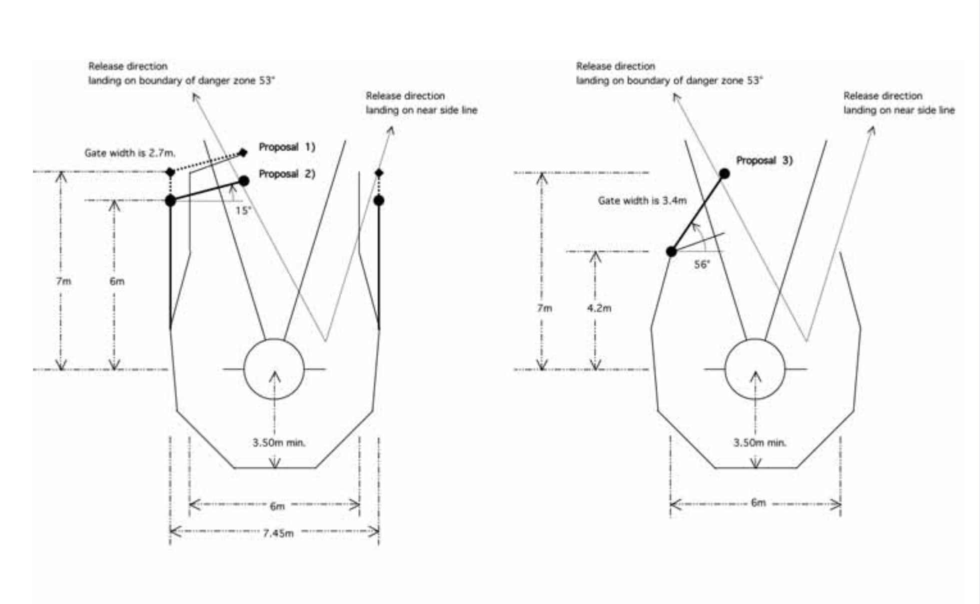


Figure 3: Proposals for modifying the Szombathely cage design and the pre-2004 cage design

possible to make changes that would help the throwers without compromising safety. In order to diminish the dead zone we need to widen the cage opening and/or move it back towards the circle. Realistically there would be many obstacles to overcome, including maintaining the strength and mobility of the cage, hammer bounce back safety and construction costs. With this article we have opened a discussion on three approaches to solving the problem. We should now gather opinions of the athletes (hammer throwers as well as other track and field athletes who share the field), coaches and others and then start to develop a new cage with the manufacturer(s).

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