The development of the javelin

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ABSTRACT

The author gives a short overview on the development of the javelin from ancient Greece to the modern era. He explains the development of material, aerodynamic qualities, rule changes, describes how rule changes affected production and led to new testing procedures as illustrated by the example of the Nordic, company.

AUTHOR

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When modern athletics started up it was based on the heritage from the classical times in ancient Greece. The Olympic Games of the past were held every four years, with no interruption from 776 B.C. until 393 A.D., when the Roman emperor Theodosius the Great closed Olympia. Javelin throwing was a part of the pentathlon, which also included long jump, discus throwing, running (1 Stadium = 192,27 m) and wrestling. The pentathlon was introduced at the Olympic games in 708 B.C.

During the modern era, competitions in javelin throwing at Olympic games were held for the first time at the games in Athens in 1906, which were held to celebrate the 10th anniversary of the first Olympic Games in modern times. The women held their first Olympic javelin competition in Los Angeles in 1932.

At the beginning of modern era the javelins were made of wood; mainly birch wood. The Nordic countries were leading the development concerning both throwing and manufacturing of the javelin.

The fifties witnessed a new dimension in the construction of the javelin. Legendary Dick Held, brother of former world record thrower Bud Held, began to apply the basics of aerodynamics to the shaping of the shaft and head. Key to his design was the consideration of where the center of pressure ("centre of area") was to be situated relative to the center of gravity (COG) of the javelin. This experimental work led to the evolution and development of a "flying" javelin, which increasingly showed tendencies towards flat landings after a long flight. It also made the javelins unstable, causing them to divert from their original throwing direction to such a great extent that landings far outside the throwing sector could occur.

By the end of the seventies there was increasing concern both amongst athletic fans and within the IAAF regarding how to solve the increasing problems: flat landings, dangerous in-flight deviations and predictions that throwing distances would soon exceed field length. A shifting forward of the COG of

the javelin seemed to be a good solution. It was recognized, however, that any forward shift of the COG could be easily neutralized by making the rear part of the javelin thinner. Flat landings would, then, still be common.

At a final test in Pihtipudas, at the Finnish javelin festival in 1982, many throws were executed by top Finnish throwers. Test javelins, where the COG had been put forward by 3-4 cm, were tested. These javelins had the same rear shaft design as normal javelins of that era. According to the rules of the time, however, only a maximum - no minimum - rear shaft diameter was specified. Nordic Sport became aware of these tests and produced a couple of javelins both with the COG put forward by 4 cm and with a very slim rear part of the shaft. The estimation was that these javelins, which complied with the proposed rules, should not only land flat, but should even land tail first!

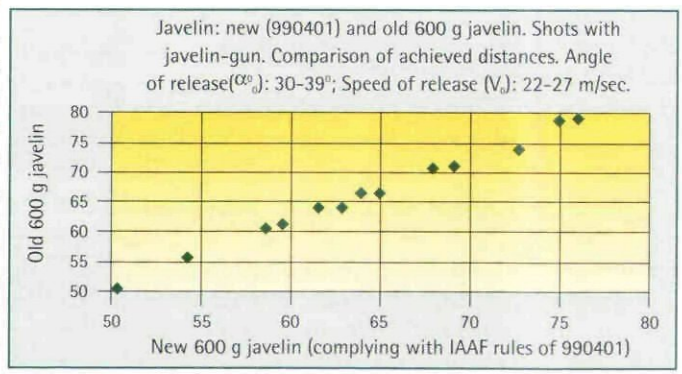
After the first part of the testing session, where javelins were landing tip first, the Nordic Sport "special model" was introduced and measured. After it was determined that the new design complied fully with the proposed rules, these javelins were then given to the throwers to be tested. The result: all of the throws landed tail first! This forced the IAAF technical committee to add a small, but necessary, alteration to the proposal, introducing a minimum diameter for the rear part of the shaft.

When Uwe Hohn threw his fabulous 104,80m on July 20, 1984, the new rules were already written and a few days later the IAAF Congress, held prior to the Olympic Games in Los Angeles, approved the new rules. At this time only specifications regarding the men's javelin were altered.

After 1986 we became used to shorter throws and no more flat landings among the men. Women's throws, however, continued to foster endless disputes among judges, coaches, throwers, spectators and media regarding whether particular landings should be ruled flat or tip first. In 1991 a small alteration of the 600 g rules came into force. The COG was not moved but minimum diameter specifications concerning the rear part of the javelin became the same - in percentage - as those pertaining to the men's javelin.

Some improvements were observed. But, while there were fewer flat landings, they were not exterminated completely.

The discussions continued until, on April 1, 1999, new rules came into force. On that date the COG was put forward by 3 cm. Together with the rule changes of 1991, where the minimum diameter of the rear part was determined, this ruling will most probably be enough to create valid landings in the women's competition. Some problems might remain in the combined events javelin competition due to shorter throwing distances, but, in general, this rule change seems to be an effective way to minimize the problems. Women's throwing distances are expected to decrease, although not to the same dramatic extent as the decreases experienced by the men after 1986. We estimate, based on tests with the javelin gun and throws made by athletes, that the differences at distances under 50 meters will be almost negligible. As throws reach world-class levels, however, it is estimated that distances will be reduced by 1-4 meters (see graph below).



The rule changes pose a new challenge for javelin manufactures. Just like the athletes, world leading javelin manufacturers such as Nordic Sport, Nemeth, OTE, Apollo and others are aiming at top performances! Possible variations in construction are now more limited than ever. It is evident that the task of

the manufacturers is to produce javelins that come as close to the (advantageous) rule limits as possible. When constructing a javelin, then, it would seem prudent to observe the following guidelines:

- the javelin should be as short as the rules permit
- the COG of the javelin should be placed as far back as the rules permit
- the weight of the javelin should be as low as the rules permit
- the area of the javelin in front of the COG should be as large as possible - which means that the front part should be as thick as the rules permit
- the area of the javelin behind the COG should be as small as possible - which means that the rear part should be as thin as the rules permit
- the head of the javelin should be as large as the rules permit
- the javelin must be made by metal or another suitable homogeneous material - the manufacturer should aim at finding a construction, within the rules, which can, as quick as possible, reduce the vibrations that occur in the javelin at release

Concerning the grip, experience indicates that it should be placed as far back on the shaft as the rules permit. Strictly from the aerodynamic point of view this advice could be questioned, since it makes the area of the rear part of the javelin a bit larger. Nevertheless, it has been noted that throwers find it much easier to throw javelins which have a grip that is significantly behind the COG.

Theoretically, the grip should be as thin as possible, too. But experience from throwers clearly shows that they want a rather thick grip in order to be able to apply the highest possible speed to the javelin during the delivery. This phase lasts just 0,10 - 0,16 sec, during which the speed of the javelin is increased from approximately 8m/sec to over 30 m/sec (men, world class)! To produce such a rapid increase in speed requires a good, firm grip! (Delivery phase: from planting the left foot till releasing the javelin – right handed).

New javelins are tested at Nordic Sport both by a javelin gun and by throwers. The javelin gun operates by air pressure. It is possible to give the javelin both a precise speed of release and a precise angle of release. Both of these parameters can, of course, be altered on a continuous scale. The speed of release is normally checked by radar gun. The force is applied through the long axis of the javelin. Thus, there is no angle of attack or 'angle of jaw' when the javelin is shot - something which is quite rare when athletes are making the throws. The gun pipe is rotating by 21,5 r/sec. This corresponds, according to biomechanical investigations, to the average rotation imparted by a thrower.

The factor which creates the greatest difficulty while undertaking a test shooting is the weather. Best conditions are reached on a completely calm day, but it is also of interest to do testing with tail- and headwinds. One experience from these test shootings is that almost no vibration occurs in the javelin, which makes this method differ from the way that athletes throw the javelin. The vibrations that a thrower brings to the javelin can diminish the throwing distance significantly. Such differences between machine and athlete make it absolutely necessary to test new javelin models using both systems of delivery. It is not enough just to shoot javelins with the gun – one must also cooperate with leading throwers to get their subjective impressions in order to find the best solutions!

When preparing for the change of the rules in 1986, Nordic Sport made several tests with both the javelin gun and throws made by ath-

letes. The average of these test gave the result that, at an average speed of release of 28,3 m/sec the javelins reached distances of 84,60 (old) and 79,58 (new) meters when launched from the javelin gun. The difference was, thus, 5,9 %. The difference was larger among the throwers, where statistical results from 1985 and 1986 world lists were used. Here the difference was 86,25 (old) and 79,30 (new), which is 8,1 %. This difference between man and machine gave a rather early hint that one common opinion among coaches and throwers could be called into question. Before the rule change many of them had suggested that: "The new javelin will demand more force and less technique".

Comparison between man and machine has also offered insights concerning speed and angle of release. For instance, the

javelin gun gives slightly longer distances compared with athletes at the same speed of release. This observation was anticipated, of course. While the javelin gun performs absolutely "clean" throws, athletes have an angle of attack, angle of jaw and a non-linear application of force against the javelin, which leads to vibrations.

Another interesting discovery was that, when launched from the javelin gun, the new javelins - and this is valid both for men's (1986) and women's (1999) javelins - continued to increase the achieved distance as the angle of release got closer to and even exceeded 40°! Experience from the field indicates that athletes are more capable of producing higher speeds of release at lower angles of release. This means that one must try to find an optimal combination of speed of release and angle of release. Among throwers the optimal angle of release - taking into consideration one's ability to produce a high speed of release - is lower compared with the best angle of the release when using the javelin gun. Nevertheless, biomechanics research has shown a gradual, slight increase in the angle of release of the men's javelin since their rule change. With the old javelin world-class throwers were close to 30° and with the new javelin they are around 34°, with individual variations (main stream: 32-36°).

It would, therefore, seem not to be too risky to advise women to increase their angle of release slightly, although this would probably not result in any dramatic improvements. Speed of release will remain, absolutely, as the main biomechanical parameter to achieve world-class performances. I can almost say that the change of angle of release should be monitored more by the feelings of the athlete than by any other thing or person: coach, biomechanical research etc.

With the ever more specified and limiting definitions in the rules it has become extremely important that javelins are most scrupulously checked before every competition. Each time a javelin lands the tip of the metal head is worn slightly, and this can easily move the COG of the javelin a couple of mm backwards - and out of the legal limits. It is much more common that a javelin becomes invalid due to wrong position of the COG than by losing weight. If the tip is worn by a couple of mm it can also lead to the problem that the maximum diameter at the midpoint between COG and the tip is exceeded - and/or that the diameter on the midpoint between the COG and the rear tip will fall below the minimum diameter. While these 'rule defying' alterations can seem to be very small they can have a significant influence on throwing distance, since they obviously give the javelin other aerodynamic characteristics!

Appropriate equipment is required for rule verification and event controls. Even for a very experienced Technical Manager it can take around 15 minutes to check a single javelin. Leading sports manufacturers could assist by providing professional measurement equipment to make these controls as smooth and correct as possible.