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The Single Support in Hammer Throwing

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THE SINGLE SUPPORT IN HAMMER THROWING

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To achieve maximum distance in hammer throwing, one needs to release it at a high speed and under an optimum angle. For the release force to be increased substantially, the thrower would need to minimize the time taken in the turns. At the same time the thrower can 1) maintain maximum radius, or 2) maintain optimum radius *and* exert tension on the hammer above and beyond of that which results from the naturally generated centripetal force due to the system's rotation, or 3) primarily exert tension (pull) on the hammer, *ahead of the center of rotation of the hammer's path*, by using an asynchronous pattern between the thrower's center of mass and the hammer head (moment of lowest point of thrower's center of mass approximately coincides with the highest point of the hammer head and vice versa) and, secondarily cause reductions in the hammer radius, both of these actions causing increases in speed above and beyond of that which results from the naturally generated centripetal force due to the system's rotation. This third possibility seems to be the most beneficial to achieve a high hammer speed at release. The question then arises as to when the thrower can achieve those increases in the speed of the hammer head.

It is still a convention and a common assumption among practitioners that acceleration in hammer throwing occurs only during the double support phase. Along the same lines many practitioners also seem to imply that no speed increase is possible before right foot touchdown, and that no speed increase is possible after the zero-degrees azimuthal angle (when the hammer starts rising against gravity) even if the thrower is still in double-support. Many will also claim that biomechanists have demonstrated that such statements regarding the benefits of double support are true. To the contrary, none of the above assumptions is necessarily true. Speed increases and decreases are not necessarily linked causally to double support and single support, respectively. Just because two quantities coincide in time, it does not mean that one causes the other. There is also nothing to prevent speed from being gained after the low point. We do not know that any biomechanist has actually shown any such things (Dapena, 2008; 2009), and if they have attempted to, it would probably be a fairly crude biomechanics study in which the authors would have simply looked at where speed was gained, without taking into consideration what causal factors made that speed increase when it did. That is, one needs to consider that such graphs are probably "raw" hammer speed graphs, and therefore are uncorrected for gravity effects or for the →

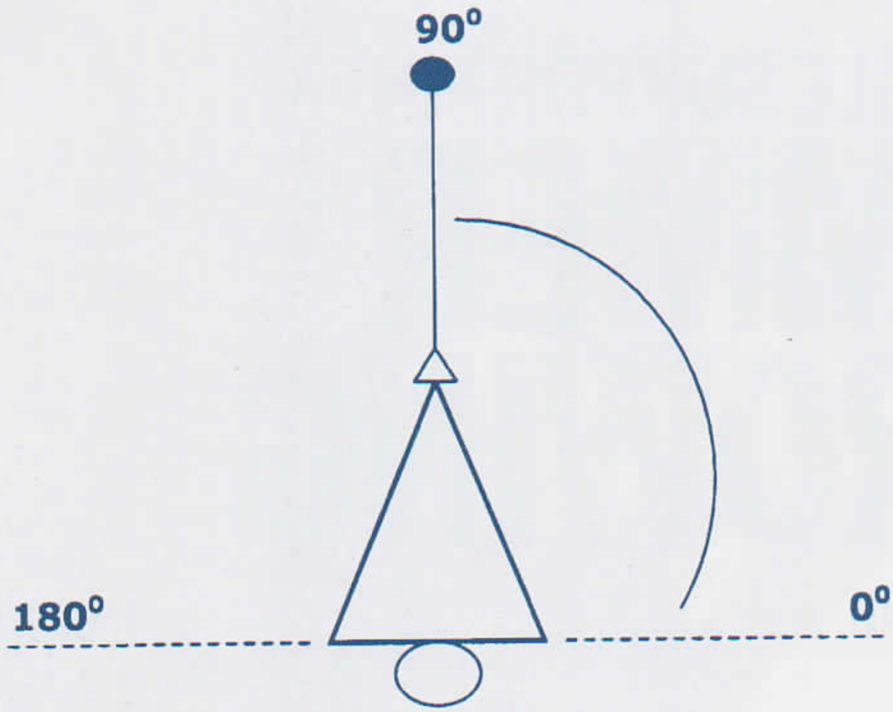

Figure 1. The angle between the shoulder axis and the hammer wire (view from top).

effect of forward travel of the system's center of mass, or other possible effects. This was a very common (and flawed) approach in early research on the hammer throw. Much of the observed fluctuation in hammer speed is not due to single-double support alteration but to other causal factors (Dapena, 1984; 1985; 1989; 1989). For example, (1) gravity is going to tend to produce a gain in hammer speed between the high point of the path (c. 180 degrees) and the low point of the path (c. 0 degrees), and (2) the forward progression of the thrower along the throwing circle tends to produce a gain in hammer speed between the 270-degree point and the 90-degree point. By not correcting for these two factors, maximum hammer speed tends to peak at roughly 45 degrees, and to have a local minimum at around 225 degrees. Both of these speed increases will occur regardless of the athlete's efforts. In addition, there will be speed increases produced by the thrower's efforts, and these efforts are the ones we need to be interested in, and study.

Dapena (1989) stated that there are virtually no increases in horizontal velocity during the turns in hammer throwing, and that any increases in speed are all in the vertical aspect of it (about a horizontal axis) while most of the horizontal speed is acquired during the winds and remains mostly the same thereafter. Similarly, Murofushi, Sakurai, Umegaki & Takamatsu (2007) found that the ground reaction force during the turns is almost entirely in the vertical. Such ground reaction force results do support Dapena's finding that a hammer throw is very different from a tug-of-war in that the hammer thrower does not push forward very much on the ground with his feet. We must note here that the study's ground reaction force results do leave open the possibility that the thrower might exert enough horizontal "pull-push forces" with the feet to produce a fair amount of horizontal speed increase for the hammer through the use of such horizontal forces during the turns. However, it does not prove that the thrower is increasing hammer speed through those horizontal forces; it just leaves open the possibility that she might be doing such a thing. Dapena (1989) has also stated that increases in vertical velocity can occur during both double and single support (for more, see Maheras, 2008). What has been observed is that the increase in the speed of the hammer ball during the turns is due mainly to the addition of vertical velocity, and in part also due to the shortening of the hammer radius. It is not due to a horizontal pull-push mechanism of the feet against the ground. That is something that stops happening with the end of the

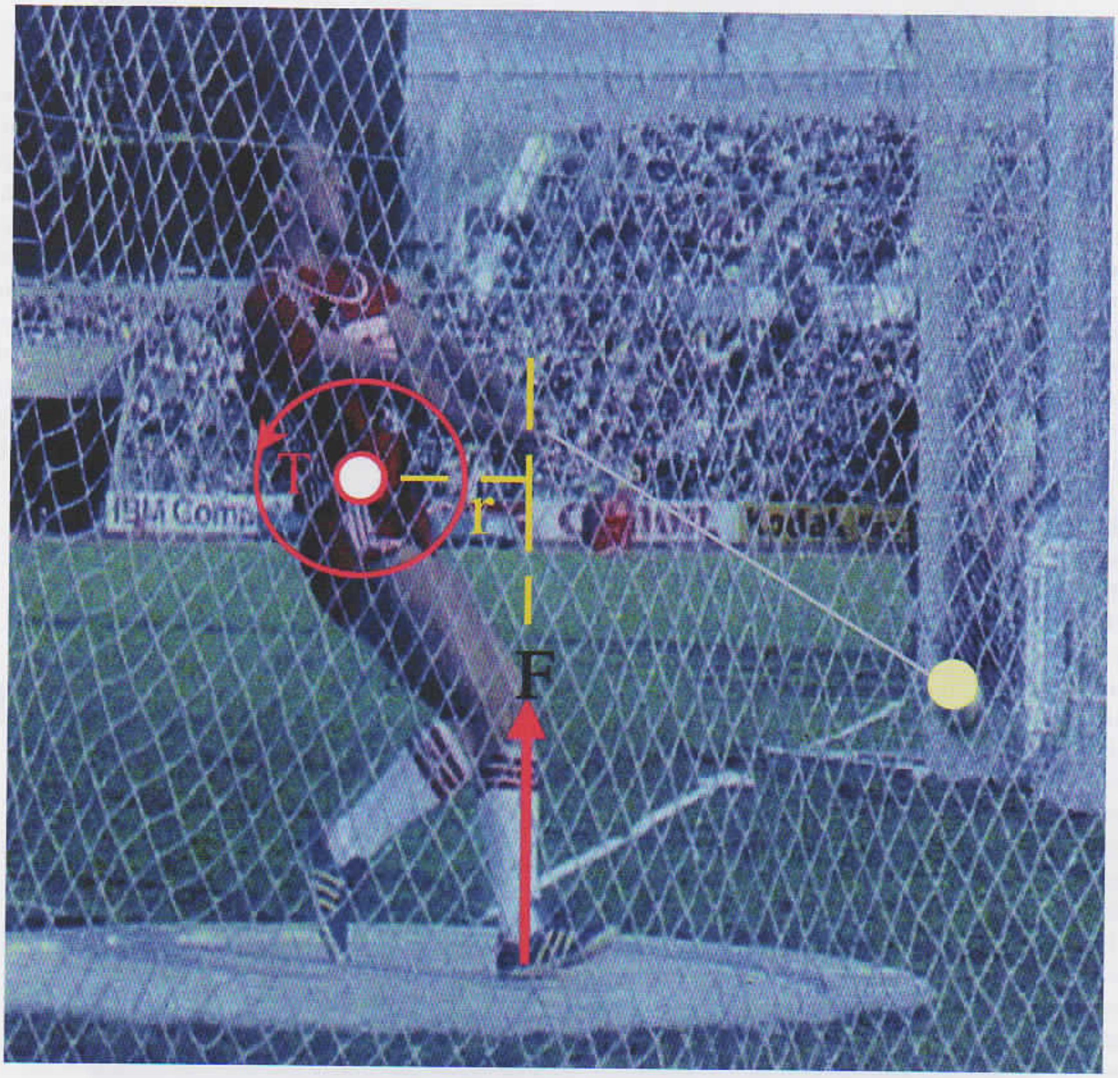

Figure 2. Vertical force (F) made by the ground, and counterclockwise torque (T) produced around the longitudinal Y-axis during single support. This axis would be perpendicular to the page and is passing through the center of mass (white dot at the right hip area). The torque about the center of mass would be the product of (r) x (F), and the torque itself would be as indicated by the curved red arrow. The torque vector would be pointing along the Y-axis, from the page toward the reader (adapted from: Dapena, 2008, reprinted by permission).

winds. Neither the increase of vertical velocity nor the shortening of the hammer ball radius are favored by being in double support. That is why, from this point of view, the achievement of a long double support during the turns may not be as important as many think. It is not needed for the kind of speed increases that occur during the turns – that is, speed increases that are based on the generation of vertical speed and, to a lesser extent, on shortening of the hammer radius.

Morriss & Bartlett (1992, 1994) suggested that longer double support phases along with a greater path traveled by the hammer during that time, might not guarantee higher speeds of release. They further argued that the pattern of the observed changes in the speed of the hammer head suggests that there are increases in the speed of the hammer during parts of the single support phases and also decreases during parts of the double support. Their main point was that acceleration of the hammer indeed occurs during single support. They actually suggested that "acceleration begins in the single support phase and continues all the way through the double support phase to the moment the right foot leaves the ground to begin the next single support phase." Their subject (a Russian thrower during a 78.82

m. throw) exhibited acceleration paths of 283, 273, 209, and 239 degrees in turns one through four respectively. If acceleration were to occur during double support only, the expected acceleration path would be approximately 160 degrees. The maintenance of an optimum radius is important as the thrower progresses from turn one to the last turn. In this respect, a progressive, moderate reduction in the hammer's radius throughout the turns has been observed in most skilled hammer throwers. It is caused by the attempt of the thrower to "counter" the hammer while at the same time there is an increase in the tension on the hammer head which eventually results in an increase of its speed. To obtain optimum radius, the thrower should maintain a "strong" triangle – that is, a shoulder-to-wire angle that is as close to 90 degrees as possible (see figure 1). In reality though, most throwers allow that angle to fluctuate more or less.

Therefore, tension is the other, more important, component contributing to the increase of the hammer's acceleration and it is this tension (or pulling) that is responsible for most of the speed increases (Dapena, 1989; Bartlett, 1983) and not the alternation of decreases and increases in the radius of the hammer path (Dapena, 1989). To maintain acceleration, the thrower should pull ahead of the position of the centroid (center of rotation) of the hammer's path, although in reality throwers do tend to also pull behind the center of rotation of the hammer's path in the course of a throw, which results in decreasing the speed of the hammer (Dapena, 1984). In that respect the direction of the pull is crucial. During double support, wire tension is achieved by the deliberate action of the thrower to "untorque" the torque that has been established during the single support phase where the hip axis is markedly ahead of the shoulder axis. In turn, proper unwinding occurs as the thrower sits back and, more or less, straightens her legs as the hammer passes through the low point at an approximately 0-degree azimuthal angle. This action starts quickly as soon as the right foot touches down. During single support the torque is produced automatically because the point of support, which is the left foot, is not directly under the thrower, and the reactionary vertical force generated by the ground on the left foot exerts a torque about a longitudinal axis passing through the center of mass (figure 2). To better picture this effect, if a person who is standing with both feet on the ground were to remove the right foot without making any other changes, he will fall toward the right. However, this is not the case during hammer throwing. This is because the torque that the thrower receives from the ground is transmitted to the hammer. This way the thrower does not fall despite the fact that his point of support (her left foot) is not directly beneath her center of mass while at the same time the hammer speeds up. We need to point here that although the existence of the torque is automatic, the size of it can be altered by the thrower, depending on how she interacts with the hammer, how she uses her leg muscles and so on.

For example, we know that most advanced throwers exhibit a progressive bending of the left knee during the single support phase (Morriss & Bartlett, 1994; Karalis, 1991). The bending of the left knee starts as soon as the right foot lifts off the ground up to the moment when the right foot touches down again to begin another double support phase. This bending of the left knee lowers the center of mass of the thrower and as a result enables the latter to exert tension on the hammer. In this fashion, acceleration of the hammer begins during the single support phase. Morriss & Bartlett (1994) also suggested that the single support phase start as early as possible which in turn means that the right foot needs to lift off as early as possible, probably at an 80-degree azimuthal angle in the first turn which could be

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reduced to as low as 50 degrees by the last turn. Karalis (1991) also proposed an early and fast-moving right leg. This early right foot lift off will eventually enable the thrower to quickly place the right foot on the ground to begin the double support phase as early as possible somewhere at the 260 degree azimuthal angle. By proposing such a right foot sequence pattern, i.e., early lift off and early touch down, Morriss & Bartlett (1992;1994) and Karalis (1991) seem to differ from the, late lift off and early touch down, right foot sequence many practitioners advocate. The latter sequence (late lift off – early placement) seems to emphasize maximization of the double support phase whereas the former (early lift off – early placement) seems to place equal importance to both single and double support.

Regarding the duration of the double versus the single support phases, Gutierrez, Soto & Rojas (2002) suggested

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that the theory of the maximization of the double support, accepted by many practitioners, did not find full support from the their collected data. Many of the throwers analyzed in their study initiated their double support later and later and there was "a tendency to reduce the distance traveled by the hammer during the double support phase in each turn." In that study many top throwers, both female and male, exhibited longer single support phases, either in all turns or particularly during turns three and four. Morriss & Bartlett (1992) found that although throwers may start and finish the double support phase late or early; in the end those differences did not seem to affect the length of the acceleration path. In their analysis the best thrower (both in distance thrown and velocity of release achieved) did not necessarily spend more time in the double support phases. In Murofushi's et al. study (2007), it seems that the best thrower of the three studied equally divided the time

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between double and single support in turns two and three. In general, some throwers may spend more time in double support than in single support throughout their throw or during part of it while similarly, others may favor single support over double support during all or part of the throw. However, it is the interconnection of several known and unknown factors in hammer throwing, including individual variations, which will determine the maximum performance for a given thrower. For example, although the thrower, who for a given angular velocity attains a greater radius, will also attain a greater tangential velocity, in Gutierrez's et al. (2002) study, the best thrower had the smallest average hammer radius. Therefore, no factor alone can be the criterion for an effective throw.

SUMMARY

In the past, many lay papers regarding the hammer throw have provided qualitative descriptions of elite throwers; however, they did not demonstrate a clear cause-and-effect relationship between an increase in hammer speed and double support. On the other hand, there is experimental evidence of the potential positive role of the single support in this event. Film analysis data have failed to add support to the "double support" theory in hammer throwing.

It used to be believed (and many apparently still believe) that the double support is the profitable part of each turn, and that the single support is the wasted time. If that were the case, it would obviously be advantageous to maximize double support, leaving as little as possible of the turn to the single support. We know, however, that pretty good stuff can be done in single support and that deceleration throughout the turns can be minimized or even excluded. Therefore, the single support phase is not the guaranteed wasteland that many think. What this means is that we cannot be sure that maximizing the double support time is the optimum. We can't be sure, but maybe maximizing double support is still the optimum. Or maybe maximizing single support is the optimum. Or maybe some intermediate breakdown between the two is the optimum. We simply don't know what is the optimum. All we know is that there is not a guarantee that maximizing double support is the *de facto* optimum and that the single support phase is not the "poor relative" in hammer throwing. As Riley (2009) speculated, a further and systematic examination of the biomechanics of the hammer throw will aid in the evolution of the event. Otherwise hammer technique will be advancing through trial and error only.

Note: *After this article was written in the summer of 2009, it has come to the author's attention that the veteran Russian coach Anatoly Bondarchuk was quoted as saying (see the 4-2009 issue of the I.A.A.F New Studies in Athletics journal, published in the summer of 2010, p.p. 85) to another coach (Klaus Bartonietz) that: "contrary to common assumption, the double support phase is not the key to greater acceleration of the hammer and longer throws. World Record holder Yuriy Sedych threw farther when total time of the throwing foot contacts was shorter, as do the best today".*

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