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Relative Speed Fluctuations in Discus Throwing

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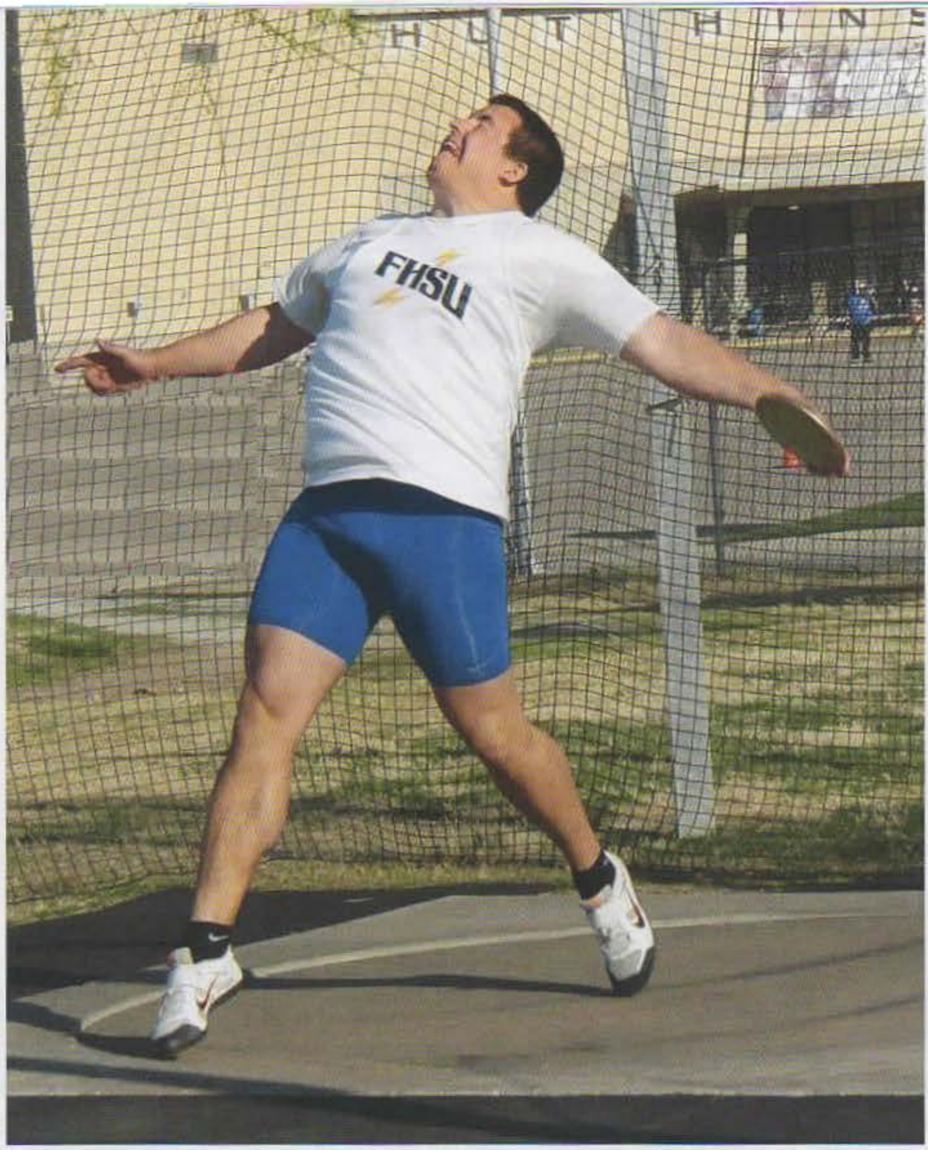

ANDREAS MAHERAS PHOTO

Relative Speed Fluctuations

IN DISCUS THROWING

BY ANDREAS V. MAHERAS, PH.D.

In the course of a discus throw, the center of mass of the (thrower + discus) system translates forward across the circle. This way the speed of the center of mass contributes to the speed of the discus. An analogy that can be used to explain how the speed of the center of mass contributes to the speed of the discus is as follows. That is, one can compare the discus thrower with a ship, firing a cannon. If the ship, firing the cannon, is traveling forward as the cannon is fired, the forward speed of the ship is added to the forward speed of the projectile. This results in a larger total horizontal speed of the projectile as compared to a condition where the ship would be stationary when it fired the cannon. The forward (linear) motion of the thrower+discus system contributes to the speed of the discus at release and the thrower, indeed, needs to take advantage of this forward motion as much as possible albeit its limited contribution (linear vs. rotational) to the overall speed of the discus at release (Maheras, 2011).

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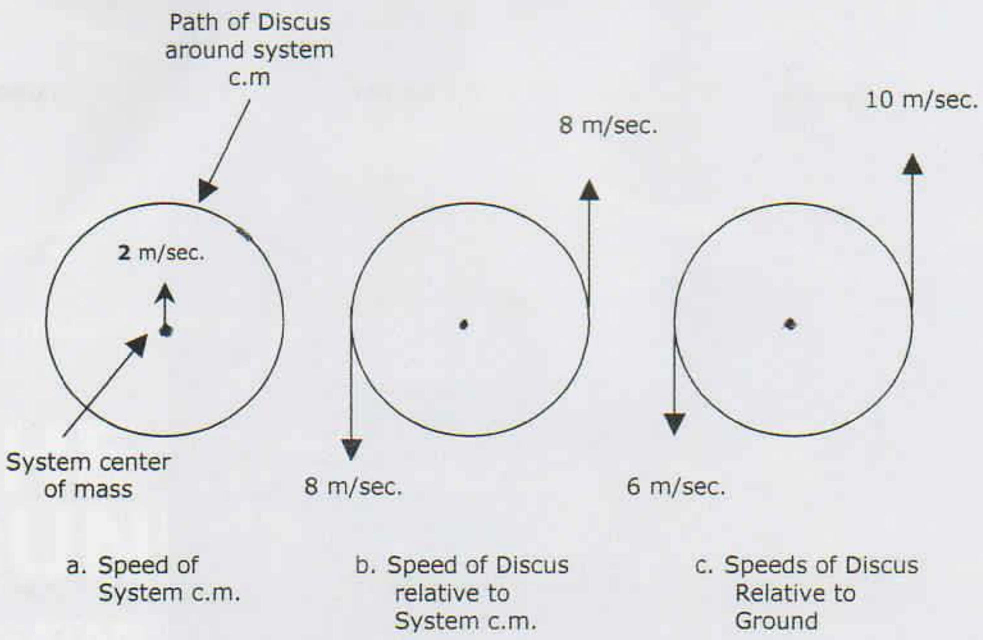

Figure 1. Relative discus speed fluctuations, during a hypothetical movement of the thrower+discus system across the circle.

However, as the system translates forward, the discus also rotates counterclockwise around it. This combination of the horizontal translation of the system's center of mass and the rotation of the discus results in a fluctuation in the speed of the discus in relation to the ground. To clarify this phenomenon, one should consider a discus thrower who, with her discus, moves across the circle at a hypothetical constant speed of 2 meters/second (figure 1). It can also be hypothesized that the counterclockwise rotation of the discus around the system's center of mass imparts a constant speed of 8 m/s to the discus relative to the system's center of mass. At the moment the discus is on the right side of the system's center of mass, the discus is moving in the same direction as the system's center of mass. Their speeds can then be added up to produce a speed of 10 m/sec., (8+2), relative to the ground. Similarly, when the discus is on the left side, the discus and the system's center of mass are moving in opposite directions. This way their speeds are subtracted from each other to produce a discus speed of 6 m/sec., (8-2), relative to the ground. This combination of the forward translation of the system's center of mass and of the counterclockwise rotation of the discus around it, results in fluctuations in the speed of the discus relative to the ground. As shown, there is a local maximum speed when the discus is at the right side and, local minimum speed when the discus is at the left side. At the instant of release, the discus is at the right side and this way the speed of the system's center of mass contributes to increase the speed of the discus relative to the ground.

At this point, the main concern is the confusion that the fluctuations in the speed of the discus relative to the ground can cause in interpreting the dynamics of the throw. It needs to be made clear that the effort that the thrower exerts to increase the speed of the discus is related to the changes in the speed relative to the system's center of mass and not to the changes that may result to the speed of the discus relative to the ground. This implies that to produce the hypothetical movement shown in figure 1, the thrower does not apply any forces on the discus to speed it up or slow it down. The thrower merely hangs on to the discus to keep it in a circular path around the system's center of mass. No effort is necessary to speed it up or slow it down, even though the discus is indeed speeding up or slowing down in relation to the ground. However, the thrower is doing nothing to increase or decrease the speed of the discus. That increase or decrease in the speed of the discus is occurring automatically just because the system's center of mass is moving forward and the discus is rotating around it, a motion that requires no effort from the thrower.

The dark line (squares) shown in figure 2 shows the absolute speed of the discus in relation to the ground in an average throw. Here, there is a maximum value at around the time the left foot loses contact with the ground in the back of the circle (LTO) which is followed by a series of smaller values before they eventually increase dramatically between the instant of landing of the left foot (LTD) and the release of the discus. Here, it would be an error for one to theorize that this speed pattern means that the thrower makes a forward force on the discus to increase its speed prior to the take off of the left foot, and that then makes a backward force to slow it down and then waits until the start of the double support delivery phase to make a another forward force to produce the final speed increase for the release of the discus. The top speed that occurred at left foot take off was the result of the discus being at the right side, as viewed from the back, during that instant and consequently the speed of the system's center of mass helped to increase the speed of the discus relative to the ground. Those increases and decreases in the speed of the discus relative to the ground are the result of the forward movement of the system's center of mass and not the result of any propulsive (or braking) forces applied by the →

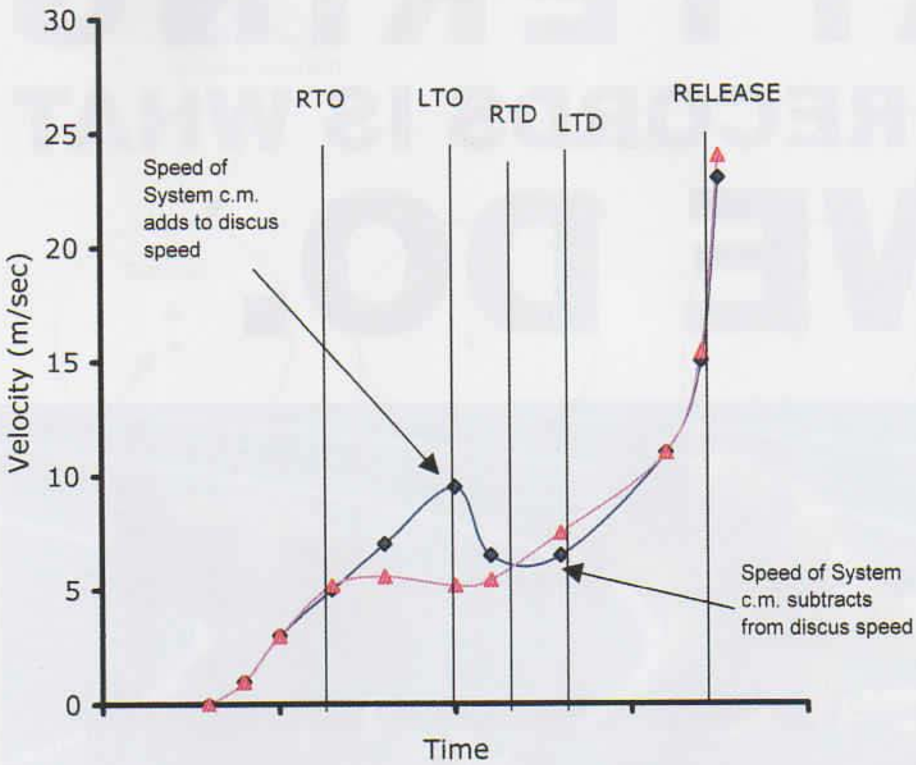

Figure 2. Approximate patterns of: a) the speed of the discus relative to the ground (dark line-squares) and, b) the speed of the discus relative to the system's center of mass (red line–triangles). Adapted from Dapena & Anderst (1997).

thrower on the discus.

If the motion of the system's center of mass is subtracted from the motion of the discus, then the relative motion of the discus with respect to the system's center of mass can be revealed and it will look approximately as in the red line (triangles) in figure 2. This line shows the true action of the thrower upon the discus. It reveals an initial speed increase between the moment of the most backwards point in the discus path and the moment at which the right foot takes off (RTO). This is followed by small increases and decreases in speed and then a final increase is observed, which commences approximately when the right foot lands on the ground (RTD). This pattern is common in most advanced throwers and it reveals that throwers clearly start their final "pull" of the discus before the landing of the left foot in the front of the circle. This event may remain unnoticed to someone examining the absolute discus speed relative to the ground only, and the reason is that the discus is in the left side and is moving towards the back of the circle at the moment of the planting of the left foot in the front of the circle, while at the same time the system's center of mass is moving towards the direction of the throw. Thus the discus and the center of mass of the system move in opposite directions. This reduces the absolute speed of the discus relative to the ground at that moment and in this fashion it disguises the fact that the thrower has already started the final "pull" of the discus some time before that (i.e., before the planting of the left foot in the front of the circle), as the observation of the pattern of the speed of the discus relative to the system's center of mass demonstrates, in figure 2.

CONCLUSIONS, PRACTICAL APPLICATION

The observation of the pattern of the discus speed relative to the system's center of mass is a much better indicator of the propulsive or braking forces that the discus thrower is making on the discus than the observation of the absolute speed relative to the ground.

Many practitioners believe that the main propulsive action of the discus should not commence until the left foot is planted in the ground in the front of the circle. In fact, practically all advanced throwers start the propulsive, "pulling" action much earlier than that. The danger here is that if throwers take such instruction literally and indeed wait until the left foot has landed in the front of the circle to start their final action, then the discus may advance forward enough along its path towards the front, without any force applied to it, and this could lead to a shortening of the effective final acceleration path of the discus. Such reduction will result in the reduction of the speed of the discus at release and eventually, the distance thrown.

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BIO

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