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VOLUME 18, NUMBER 3
MAY 2025

Running Fast

Aerobic and anaerobic levels for endurance

PLUS

THROWING THE DISTANCE
Discus techniques and mechanics

A COACHES' ROUNDTABLE
Sprint and speed training

OFFICIAL PUBLICATION OF THE U.S. TRACK & FIELD AND CROSS COUNTRY COACHES ASSOCIATION

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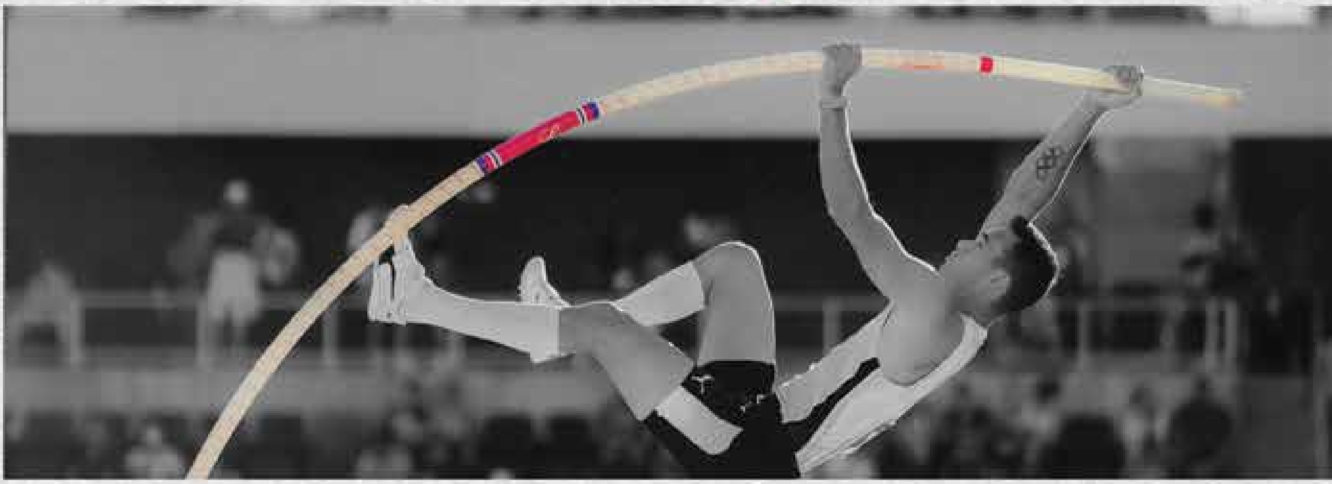
MAR 15, 2025; VIRGINIA BEACH, VA, USA; ETHAN STRAND OF NORTH CAROLINA, GEORGE COUTTIE OF VIRGINIA TECH AT THE START OF THE 3,000M DURING THE NCAA INDOOR CHAMPIONSHIPS AT VIRGINIA BEACH SPORTS CENTER.

PHOTOGRAPH BY KIRBY LEE IMAGE OF SPORT

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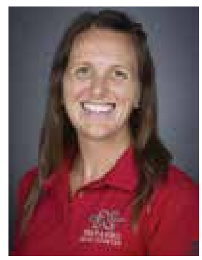

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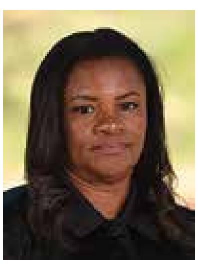

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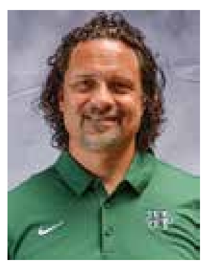

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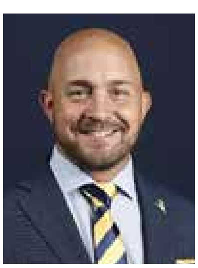

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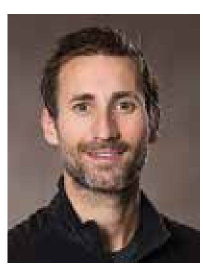

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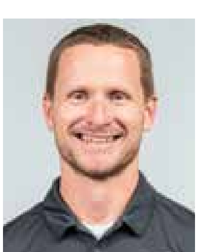

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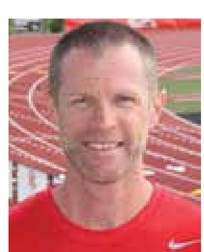

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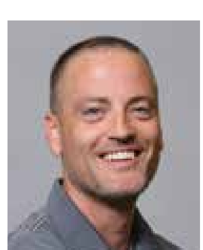

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Running Long

Aerobic and Anaerobic Contributions to Endurance Running

AEROBIC & ANAEROBIC CONTRIBUTIONS TO ENDURANCE RUNNING

- Characterization of Aerobic and Anaerobic Endurance Events
- Oxygen Deficit
- Energy Consumption
- Endurance Event Profiling
- VO 2 max Percentages Relative to Endurance Events

CHARACTERIZATION OF AEROBIC AND ANAEROBIC ENDURANCE EVENTS

ATP molecules are reduced and then regenerated constantly to facilitate skeletal muscle contractions. The amount of ATP that goes through this process is astonishing. Dr. David Costill estimated that in the running of a marathon, an athlete will reduce and then regenerate, a quantity of ATP molecules equivalent to his or her full body mass during the race. The energy used to rebuild ATP comes mainly from carbohydrate and fatty acid molecules that themselves breakdown, and the resulting energy release is captured to rebuild ATP. Unfortunately, this energy transfer process is only about 25% efficient, which means most of the energy released in nutrient catabolism is lost as heat and not ATP regeneration.

FIGURE 1. OXYGEN DEFICIT AND THE EPOC THEORY CURVE (HILL 1924).

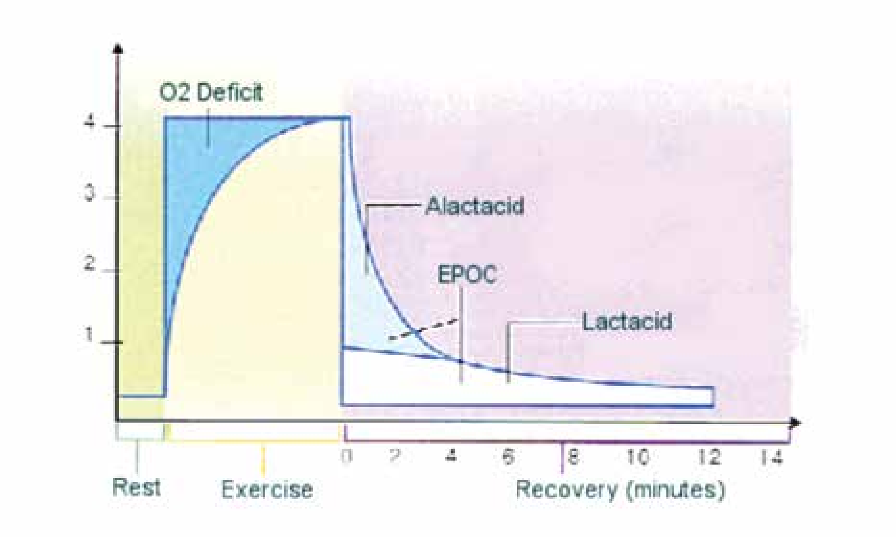

FIGURE 2. BODY STORES OF FUELS AND ENERGY
THESE ESTIMATES ARE BASED ON AN AVERAGE BODY WEIGHT OF 145 POUNDS AND 13% BODY FAT (WILMORE AND COSTILL 2004).

Carbohydrates	**Grams Stored**	**Kilocalories Stored**
Liver glycogen	110g	451 KCAL
Muscle glycogen	500g	2050 KCAL
Glucose in body fluids	15 g	62 KCAL
Total	625 g	2563 KCAL
Fat	**Grams stored**	**Kilocalories stored**
Subcutaneous and visceral	7800g	73320 KCAL
Intramuscular	161g	1513 KCAL
Total	7961g	74833 KCAL

Endurance events in track and field are characterized by having both an aerobic and anaerobic energy system contribution to the regeneration of ATP molecules during maximum effort. The contribution of each system is chiefly dictated by the duration of the race. Longer endurance races have a greater aerobic energy system contribution than shorter races do.

Each endurance event will demand a certain level of aerobic energy contribution; i.e., the oxygen demands of the event that can be met by the cardio-respiratory and the muscular system aerobically, in order to be successful. The energy demand that cannot be met by the aerobic system must be met with the anaerobic energy system. This level of intensity will be faster than the lactate threshold and will accumulate varying levels of disassociated lactic acid, thus increasing the acidity of active muscle tissue.

OXYGEN DEFICIT

The levels of increased acidity caused by exceeding the lactate threshold may be referred to as oxygen deficit (debt). This physiological concept, well known to endurance coaches, can be defined as: The amount of additional oxygen required by muscle tissue to oxidize disassociated lactic acid, while regenerating both depleted ATP and PCr (creatine phosphate) molecules following vigorous exercise.

Physiologist A.V. Hill, working at Kings College in London in the 1920's, developed the concept of oxygen supply being the limiting factor in human exercise. Because oxygen needs and oxygen supply differ during the transition from rest to exercise, the body incurs an oxygen deficit as shown in Figure 1, even with low levels of exercise. The oxygen deficit is calculated simply as the difference between the oxygen required for a given rate of work (steady state) and the oxygen actually consumed. Despite insufficient oxygen, skeletal muscles still generate the needed ATP through anaerobic pathways (Wilmore and Costill 2004).

During the initial minutes of recovery, even though the muscles are no longer actively working, oxygen demand does not immediately decrease Instead, oxygen consumption remains elevated temporarily (Figure 1.). This consumption, which exceeds that usually required when at rest, is now known more commonly as: excess postexercise oxygen consumption (EPOC).

The EPOC curve has been described as having two distinct components, an initial fast component (alactacid) and a secondary slow component (lactacid) (Astrand 2003). According to classical theory, the fast component of the deficit curve represents the oxygen required to regenerate ATP and PCr used during exercise. The slow component of the curve is thought to result from the removal of accumulated lactate from the tissues. Later studies have shown this to be true, but too simplistic. Essentially, the EPOC theory does not account for oxygen borrowed from myoglobin and hemoglobin and high body temperatures which utilize more oxygen to maintain (Wilmore and Costill 2004).

The oxygen deficit levels will be specific to each individual's physiology (genome and fitness), coupled with the demands of the race distance. Low demand aerobic activities have a short oxygen deficit recovery of less than 20 minutes; while some very high demand anaerobic activities may need a 24 hour recover.

ENERGY CONSUMPTION

ATP molecules are regenerated using energy from catabolizing consumed nutrients available to the contracting muscle cells.

FIGURE 3. AEROBIC AND ANAEROBIC CONTRIBUTION IN ENDURANCE EVENTS AT MAXIMUM EFFORT (ASTRAND 2003, NOAKES 2004, CHAPMAN 2004)

Event	Duration	Aerobic	KCAL used	Anaerobic Glycolytic	KCAL used	Anaerobic Alactic	KCAL used	Total KCAL
800 Meters	2 min	**50%**	45	**44%**	40	**6%**	5	90
1600 Meters	4 min	**70%**	100	**28%**	42	**2%**	3	145
3200 Meters	10 min	**87%**	249	**13%**	36	**<1%**	1	286
5000 Meters	15 min	**92%**	372	**8%**	32	**<1%**	1	405
10,000 Meters	30 min	**95%**	700	**5%**	30	**<1%**	1	730

FIGURE 4. FRACTIONAL PERCENTAGE OF VO2 MAX NEEDED FOR MAXIMUM EFFORT IN EACH EVENT

Event	% VO2 Max
800 Meters	120-136%
1500 Meters	110-112%
3000 Meters	100-102%
5000 Meters	97-100%
10,000 Meters	92%

The energy potential in these nutrients is measured in kilocalories (KCAL). There are three nutrients that are consumed for fuel by humans: carbohydrates, fats and proteins. Of the three, fats have the greatest energy potential per gram at approximately 9 KCAL/gram. Carbohydrates and proteins are considerably less energy-rich at approximately 4 KCAL/gram respectively. Because of the ring design of the carbohydrate molecule, and because it has the same hydrogen to oxygen ratio as water, it is the quickest to-action of the three nutrients. Fats and proteins must proceed through multiple steps in the utilization process. Thus, using either nutrient is a slower to-action potential because of the extra steps, along with additional enzymes to make it happen.

Any activity will have an energy requirement, thus nutrients will be needed to supply energy. Physiologists have calculated the energy requirements to perform all of the track and field events at maximum effort. Carbohydrate, fat, and protein catabolism all contribute to the energy supply needed in the endurance events through various steps and pathways. The body uses protein for cells and other structures that are necessary for life and only under very serious conditions will protein be used as a fuel. Protein monomers are the 20 amino acids a human body requires and there is little mechanism for storing these amino acids.

The human body is able to store quantities of both carbohydrates and fat to be used as metabolic fuel. As expected there is a greater amount of fat stored in the body than carbohydrate (Figure 2) which reflects our evolutionary lifestyle.

ENDURANCE EVENT PROFILING

In the right-side column of Figure 3 are the total KCAL needed to perform the listed endurance event for a 150 pound person and the listed duration of the activity. Physiologists have conducted experiments to determine what the amount of KCAL that are metabolized through the aerobic pathways, and which are metabolized through anaerobic pathways (Astrand 2003). For all endurance events, the aerobically metabolized KCAL dwarf the amount metabolized anaerobically, but both are needed to perform at maximum effort. Physiologists then have calculated the percentage metabolized by both pathways to the total energy demand. The event percentage differences make an interesting comparison for the coach to study when setting up training plans. The higher demand activities will require more developed anaerobic pathways thus training stimuli will need to be presented to address this metabolic need.

The specific physiology (genome and fitness) of the individual athlete will determine the success in a certain event or range of events. Each of the unique endurance events will demand different training combinations to achieve the specific aerobic and anaerobic contributions necessary for success. More specifically, each component must be developed fully in order to cope with the acidity levels that the athlete must handle during the duration of the event.

David Costill Ph D, working in the famed Ball State University Human Performance Laboratory in the 1970's and 1980's, pioneered the first charts that measured and compared aerobic and anaerobic contributions in endurance track events. The percentages his lab published showed a higher anaerobic contribution in each event then we accept today. Laboratory work in the 1990's by Per-Olaf Astrand Ph D (Sweden), Timothy Noakes Ph D (South Africa), and Robert Chapman Ph D (USA), who were all working independently, contributed to the modern percentages seen in Figure 3. The modern comparison chart resulted from improved technique in oxygen and lactate measurement, and an increased understanding of oxygen deficit.

VO2 MAX PERCENTAGES RELATIVE TO ENDURANCE EVENTS

While examining energy consumption and oxygen limitations it may also be helpful to look at the relationship to each of the endurance events in track and field as they relate to the fractional percentage of VO2 max needed for each event to reach maximum effort (Figure 4).

As a coach in the field, it is helpful to know that whatever time effort an athlete can successfully sustain for 3200 meters in the form of a test (Astrand test), or in a comparable race, is generally accepted to be the pace of VO2 max at any given time. With an understanding of Figure 3, training can be formulated to accommodate different levels of aerobic/anaerobic efforts as it relates to the endurance events.

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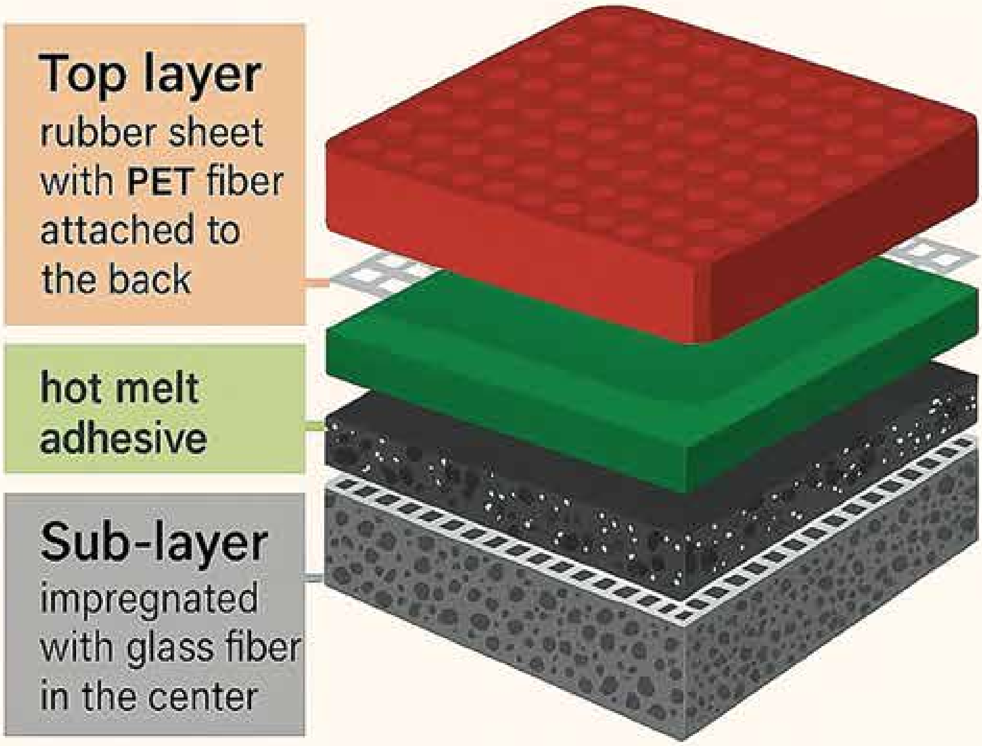

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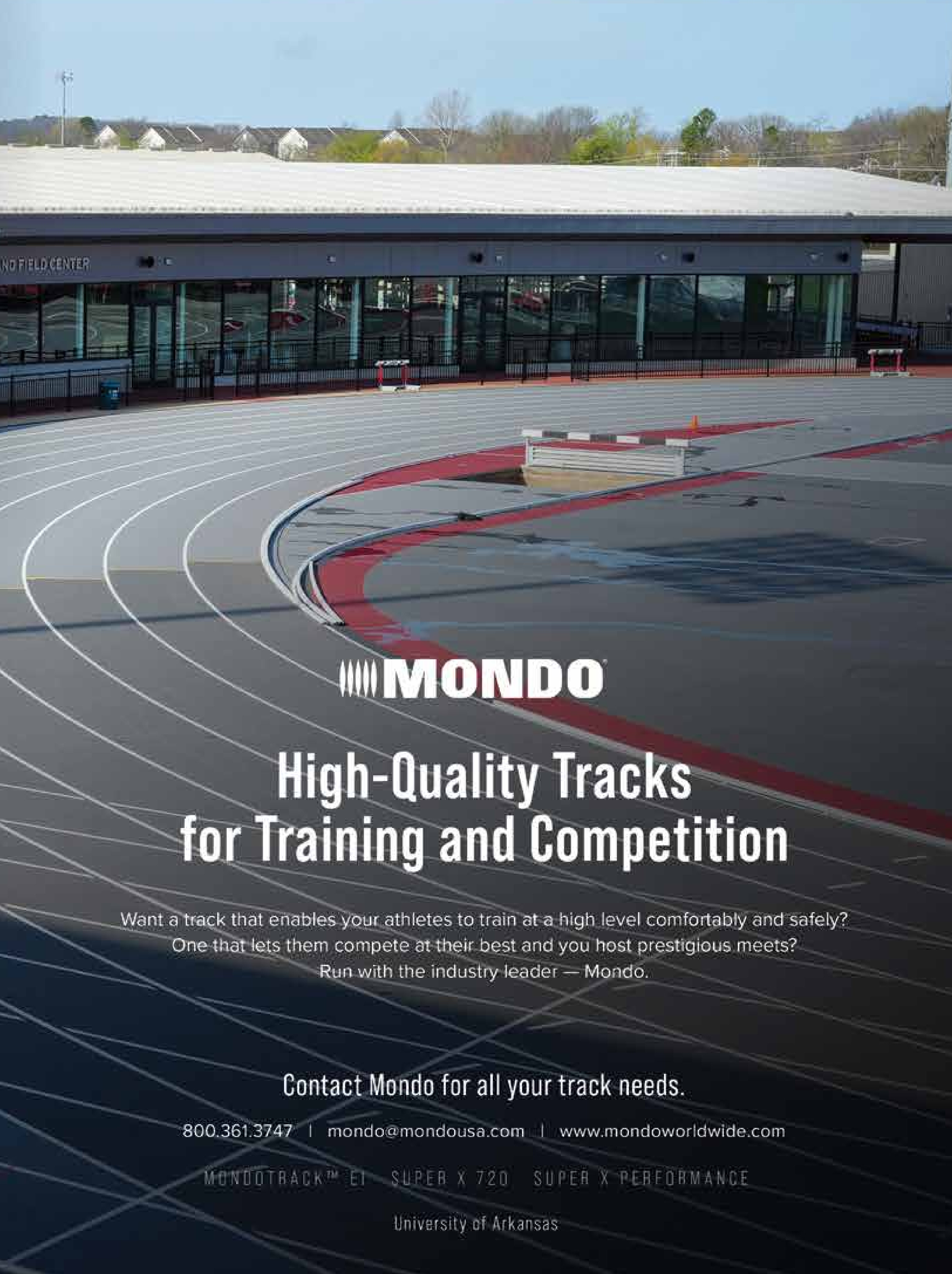


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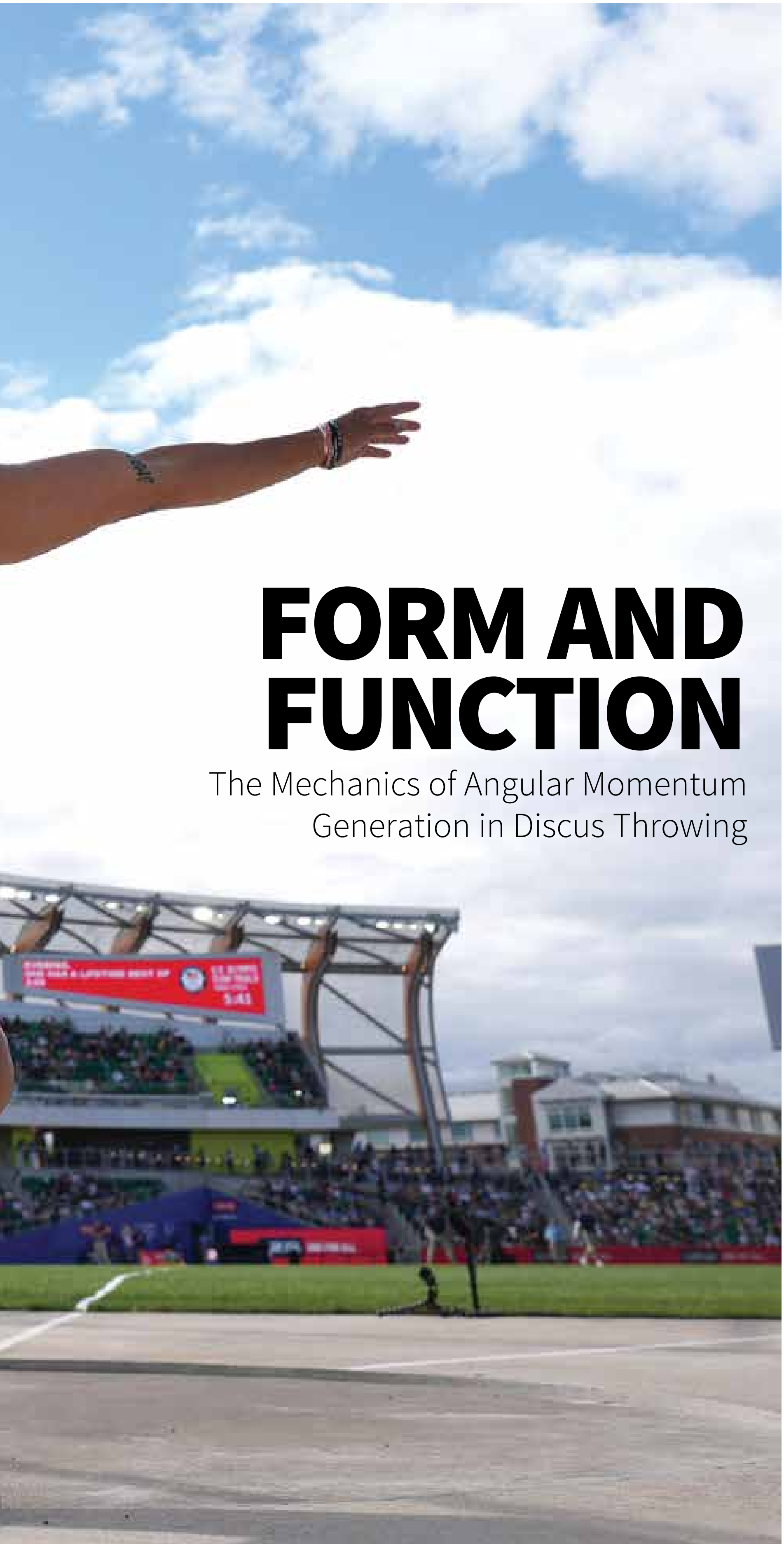

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FORM AND FUNCTION

The Mechanics of Angular Momentum Generation in Discus Throwing

In discus throwing, the one and paramount concern from a mechanical point of view, is to generate the maximum amount of angular momentum possible. Angular momentum is the mechanical element, observed in rotational movements, which contributes by far, the most in the generation of both horizontal and vertical velocities, and eventually the velocity of release, the latter being the most important factor determining the distance thrown. Angular momentum is generated almost entirely in the back of the ring (Dapena & Anderst, 1997) during the first double support and the first single support. The criterion then for a good technique in that particular phase of a discus throw, is whether the thrower's actions indeed allow for the generation of the maximum amount of angular momentum possible. The nature of those actions, from a mechanical point of view, are presented here.

THE ELEMENTS OF TORQUE AND TIME, DURING THE FIRST DOUBLE & FIRST SINGLE SUPPORT (ALSO MAHERAS, 2022).

TERMINOLOGY:
CCW (Counterclockwise)= Towards the thrower's own left.
CW (Clockwise)= Towards the thrower's own right.

CCW Torque= Torque that results in a rotation towards the thrower's own left.

CW Torque = Torque that results in a rotation towards the thrower's own right.

CCW Angular momentum= Angular momentum generated due to rotation towards the thrower's own left.

CW Angular momentum= Angular momentum generated due to rotation towards the thrower's own right.

c.m. = Center of mass.

Angular momentum is generated by the torques (rotational forces) exerted on the body+discus system, about the vertical axis. The increase in angular momentum is equal to the amount of torque received from the ground, multiplied by the time during which this torque is exerted. That is, angular momentum = T (torque) x t (time), and that relationship says that, for any given amount of time, the bigger the torque, the bigger the angular momentum that the thrower will have in the end. So the thrower wants a maximum value for the product of torque and time. However, the counterclockwise (CCW)

torques exerted by the ground on the thrower make the thrower rotate faster and faster CCW, and as the thrower rotates faster and faster CCW, it becomes harder and harder to make those large muscle forces, because the muscles go from isometric conditions (at the time of the most clockwise position of the discus) to slow concentric conditions, and later to fast concentric conditions. This will result in the leg muscles losing tension, i.e., their ability to exert maximum torque. From a physiology point of view, the faster the concentric conditions of a muscle, the smaller the force that it can exert.

Therefore, central to the actions the thrower is undertaking to increase angular momentum, is the fact that the leg muscles need to be kept at all times at whatever is the maximum tension that they can exert. Although that tension will tend to make the body rotate fast, and thus reduce the muscle forces, to a great extent, this is unavoidable. However the thrower can mitigate the loss of muscle tension, by keeping this in mind: The slower the CCW rotation of the lower body/hips, the larger the CCW torque that the leg or legs can get from the ground. And this torque affects the angular momentum of the whole body, a huge goal in discus throwing.

RUDIMENTAL MECHANICAL CONCEPTS

We assume an upright person who is static, (i.e, has zero tendency to turn, or has zero angular momentum) and is balancing in single support on the toes of one foot, say the left. From this position, if she lifts the left arm horizontally and then "throws" that arm rapidly counterclockwise (CCW), towards the person's own left, the lower body with the action of the oblique muscles, will necessarily turn clockwise (CW), towards the thrower's own right (figure 1). Essentially here, the upper body, with the "throwing" of the left arm (shoulder axis) to the left, attempts to gain angular momentum and also acts to pass angular momentum to the lower body towards the same direction. However, the lower body (hips) reacts, and that reaction force makes the hips turn to the right. In this case, the total angular momentum about the vertical axis would stay unchanged. The upper body would gain angular momentum, and the lower body would lose angular momentum, but the total angular momentum would remain constant, which in this case is zero.

On the other hand, if the left foot is placed farther to the left (figure 2), and the whole body is already rotating CCW, i.e., towards the thrower's own left, as it happens in the middle of the double-support phase in the back of the circle, and also in the first single-support (over the left leg), then the athlete can use the leg muscles to push on the ground. This force made on the ground is shown in the left of figure 2 as a black arrow pointing away from the circle. This force will evoke an equal and opposite reaction force from the ground, shown as a black arrow to the right of figure 2, pointing towards the center of the ring. This reaction force, when seen from overhead, exerts a CCW torque about the center of mass (c.m), and therefore increases the body's CCW angular momentum about the vertical axis that passes through the c.m. The reaction torque in this case would not necessarily produce a CW rotation of the lower trunk and pelvis as in figure 1, but instead a slowing down of the CCW speed of rotation of the lower trunk and pelvis (Dapena, 2024).

By using the oblique muscles of the trunk to slow down the CCW rotation of the lower trunk and pelvis, the thrower will allow the foot to make a larger force on the ground, because of the slower concentric conditions for the leg muscles. This will evoke a larger ground reaction force, therefore a larger CCW torque about the c.m., and ultimately a larger rate of increase of the CCW angular momentum of the whole body. Theoretically, if there is enough torque made by the oblique muscles, the lower body could actually reverse the direction of its rotation, and end up rotating CW. But in practice, this will not happen, because in an actual discus throw the torque will never be big enough to achieve that.

CASE EXAMPLES

Case 1. (Note: Numerical values in all cases are, made up, for descriptive purposes).

This hypothetical case introduces the concepts of lower and upper body angular momentum, the interaction between them, and also total body angular momentum. It also assumes that the ground forces do not make any torque on the body.

We consider that at some point in time within the period of single-support on the left foot (figure 3), the athlete (the combined athlete+discus system) has a CCW angular momentum of 70 about the vertical axis. At the instant being considered, 35 units of that angular momentum are stored in the upper body (upper trunk + head + arms + discus) and the remaining 35 are stored in the lower body (lower trunk + pelvis + legs). We further assume that the lower body, through the action of the oblique muscles, exerts on the upper body a CCW torque of 40 units over a period of time of 0.10 seconds. The torque exerted on any object determines the rate of change in the angular momentum of that object. So if the torque is 40, that means that the angular momentum of the upper body will change at a rate of 40 units per second. But the torque will not be exerted for a whole second, but for 0.10 seconds. The change in the angular momentum of the upper body then will be (40 x 0.10=) 4 units. So, at the end of the 0.10-second period, the angular momentum of the upper body will be 35+4= 39 units.

If the lower body makes a CCW torque

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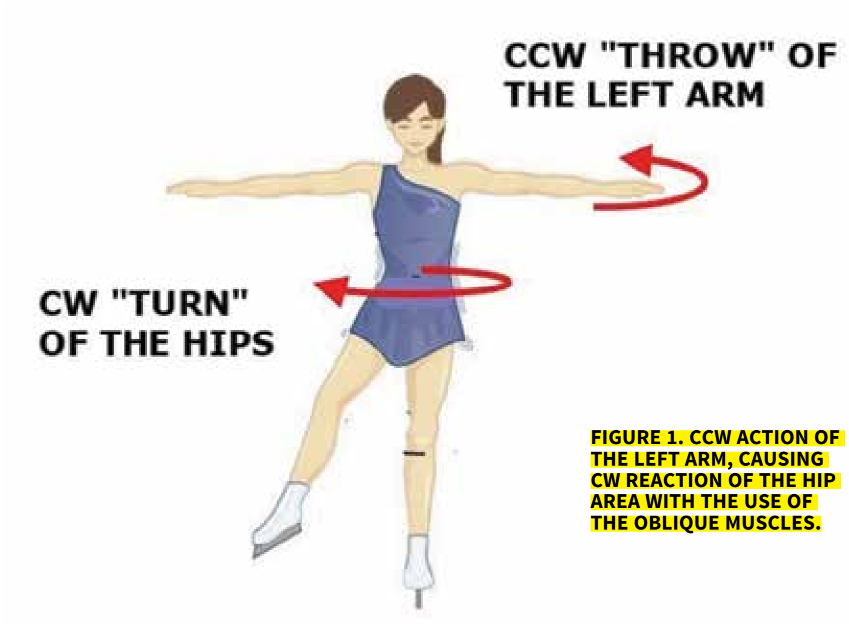

FIGURE 1. CCW ACTION OF THE LEFT ARM, CAUSING CW REACTION OF THE HIP AREA WITH THE USE OF THE OBLIQUE MUSCLES.

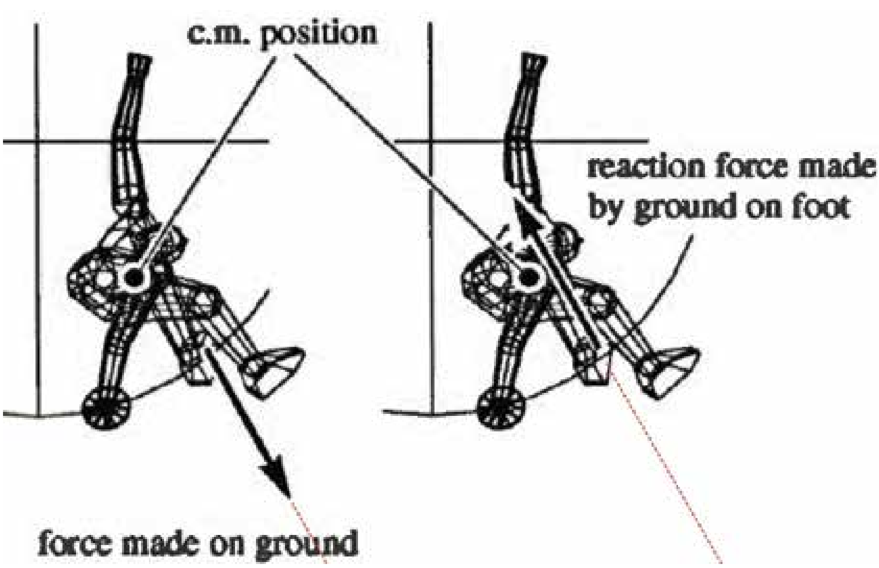

FIGURE 2. THE GROUND REACTION FORCE (BLACK ARROW, RIGHT). VIEW FROM TOP ROTATING CCW.

of 40 units on the upper body, by reaction the upper body will make a CW torque of 40 units on the lower body. Since we have assigned positive values to CCW, we have to assign negative values to CW. So this torque exerted by the upper body on the lower body will actually be (-40). Exerted over a period of time of 0.10 s, this will change the angular momentum by an amount of (-40 x 0.10=) -4 units. So at the end of the 0.10-second period the lower body will have an angular momentum of 35 + (-4) = 31 units.

Summarily, at the end of the 0.10-second period the upper body will have an angular momentum of 39, and the lower body an angular momentum of 31. The upper body will be rotating CCW faster than before, and the lower body will also be rotating CCW, but slower than before. The total angular momentum of the whole body will be 39+31= 70, exactly the same amount as it had at the start of the 0.10-second period. From the thrower's point of view, that is not good at all, because after the interaction between the lower and the upper body, the total angular momentum of the body is still 70 units, and the thrower would have liked that amount to increase.

Again, in case 1, although the lower and the upper body were acting and reacting against each other, the TOTAL body angular momentum remained the same. As the throw progresses, the total angular momentum increases, and this is a very good thing. The thrower needs that, it is the "super-goal." But as the thrower increases her angular momentum, her ability to further increase that angular momentum progressively becomes less and less, because her leg muscles go into faster and faster concentric conditions. So we want to keep the leg muscles in the slowest possible concentric conditions while the angular momentum of the whole body increases as much as possible. How can this be achieved? If one looks at it superficially, it seems like an impossible task. But it is not.

What we want to do is to increase the total angular momentum of the body as much as possible, while at the same time limit the increase of the part of that angular momentum that makes the leg muscles go into faster and faster concentric conditions. And that part is the angular momentum of the lower body. So the thrower wants to minimize the increase in the angular momentum of the lower body while she increases the total angular momentum as much as possible. To understand how this can be done, we can examine another hypothetical case which is closer to what happens in a more realistic situation.

Case 2. It starts like case 1, i.e., total angular momentum = 70; upper body = 35; lower body = 35. However, here, the athlete will make on the ground a horizontal force with the supporting foot (blue arrow in figure 4), with a value of say, 30, and because of that, the athlete will receive the corresponding CCW initial torque from the ground. In addition, we will stipulate that the lower body will make a CCW torque of 30 on the upper body through the oblique muscles. In this case, the angular momentum values at the end of the 0.10-second period will be:

a) the angular momentum of the upper body, after receiving those 30 units of torque from the lower body, would have an increase of 30 x 0.10 = 3. So its final angular momentum would be 35 + 3 = 38.

b) the lower body in this case, however, would be subjected to TWO torques. One of them would be the one exerted on it by the ground, it would tend to rotate the hips CCW, and it would have a value of 30. The other torque would be exerted on the lower body by the upper body, it would tend to rotate the hips CW, and it would be the reaction to the torque exerted by the lower body on the upper body, and it would have a value

of -30. The total of these two torques would add up to zero.

Therefore, the hips will tend to rotate neither CCW nor CW, and the angular momentum of the lower body would stay constant at 35 throughout the entire 0.10-second period. Because of that, the leg muscles would stay in exactly the same concentric conditions throughout the entire 0.10-second period. Therefore, the torque received from the ground during the 0.10-second period would stay at the value of 30 units throughout the entire 0.10-second period, and in the end the total angular momentum of the whole body would really be 73. There would be 38 units of angular momentum in the upper body and 35 units in the lower body. Our goal was to maximize the total angular momentum, and indeed that value went from 70 in case 1, to 73 in case 2. This was achieved by adding angular momentum to the upper body (from 35 to 38) and not to the lower body where it remained the same.

What would happen if the lower body passed even more angular momentum to the upper body than in case 2? In such a case, the lower body would be rotating slower than in case 2. So the torque obtained from the ground (and the final whole-body angular momentum) would be larger than in case 2, a good thing.

RELATIONSHIP BETWEEN THE TWO TORQUES

There is a positive influence of (1) the CCW torque exerted by the lower body on the upper body on (2) the CCW torque exerted by the ground on the feet. So as one goes up, the other also tends to go up.

And vice versa, there is a positive influence of (1) the CCW torque exerted by the ground on the feet on (2) the CCW torque exerted by the lower body on the upper body.

Similarly, we can say that the oblique muscles of the trunk and the leg muscles actively support each other as follows:

As the thrower uses the oblique muscles to increase the CCW angular momentum of the upper body, these muscles also decrease the CCW angular momentum of the lower body. This puts the leg muscles in slower concentric conditions, which allows the leg muscles to make larger forces.

And here is the vice versa: As the thrower uses the leg muscles to make a larger CW torque with the feet on the ground, the increased CCW reaction torque made by the ground on the feet tends to increase the CCW angular momentum of the lower body, which in turn tends to reduce the differences in CCW angular velocity between the lower body and the upper body, which in turn puts the oblique muscles in slower concentric conditions, which allows these muscles to make larger forces.

We can say then, that the oblique muscles and the leg muscles help each other by making the conditions of the other group of muscles be slower concentric, and thus stronger.

THREE MAIN TECHNIQUE POINTS IN THE BACK OF THE RING

Generally, the three main suggested technique points when the thrower is in the back of the ring in her effort to generate as much angular momentum as possible are (figure 5)

1) While in double support and before rotating CCW, the thrower needs to start the throw from a very CW position, as much to the right as possible. Following, the lower body already exerts CCW torque on the

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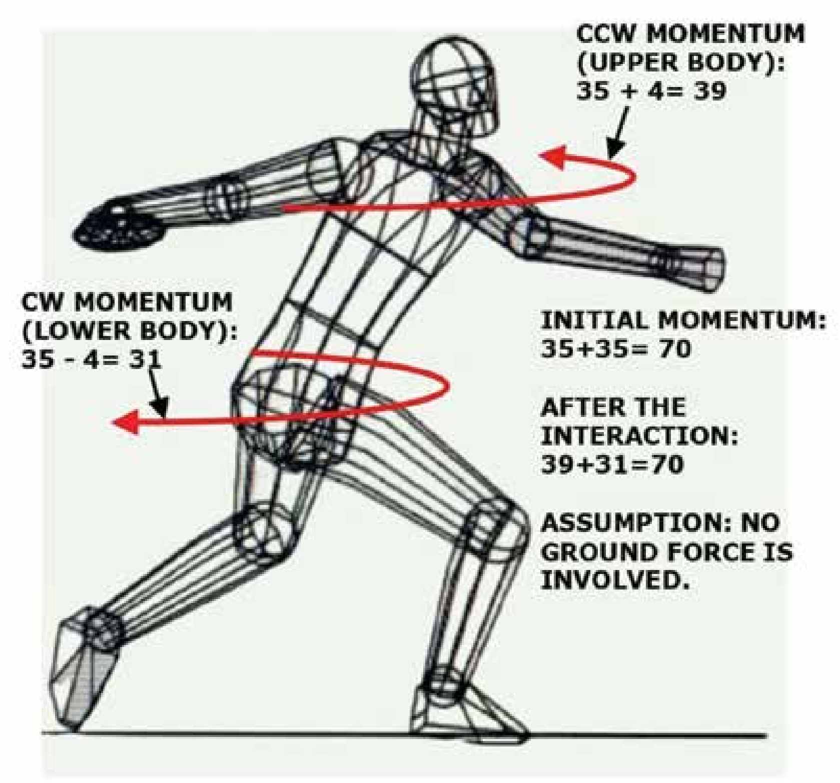

FIGURE 3. DYNAMIC ELEMENTS OF CASE #1. VIEW FROM THE FRONT, FIRST SINGLE SUPPORT, ROTATING CCW, NO GROUND REACTION FORCE.

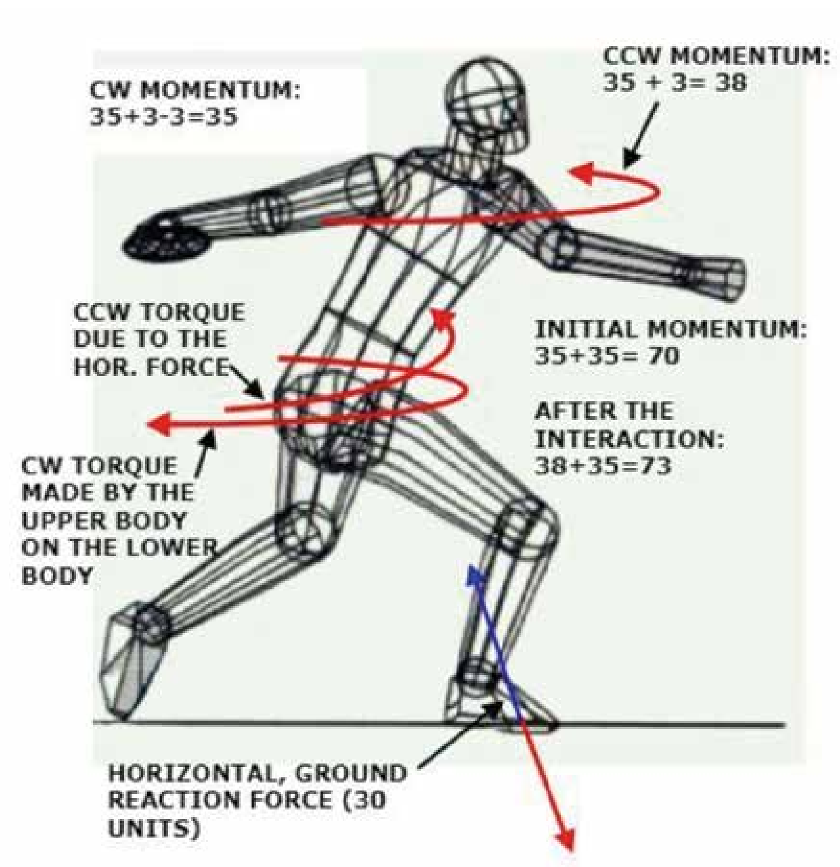

FIGURE 4. DYNAMIC ELEMENTS OF CASE #2. VIEW FROM THE FRONT, FIRST SINGLE SUPPORT, ROTATING CCW, WITH A HORIZONTAL GROUND REACTION FORCE PRESENT.

upper body, and the thrower should keep the arms spread and away from the middle of the body, so the inertia is kept high, which essentially means that for the maximum angular momentum the athlete is getting, she is also getting minimum lower body velocity. This will have the effect of slowing down the CCW rotation of the lower body and eventually increase both the time over which the feet exert force, and also the size of the force produced by both the right and the left feet.

2) While in single support over the left foot, the thrower should continue keeping the arms spread out but also actively drive the right leg wide around the left leg as she pivots CCW over the left toes. Generally speaking, this will increase the inertia of the rotating system and will slow it down, something that is good because the feet can now exert more force against the ground. Specifically, during this single support phase, the lower body, through the right leg, exerts a good amount of CCW torque on the upper body, something that was already happening during the initial double-support phase. This right leg action during the single-support on the left foot helps to reduce the CCW angular momentum of the lower body. The CCW torque that the lower body makes on the right leg, plays exactly the same role as the CCW torque that the lower body makes on the upper body: The reactions to both of these torques are CW torques exerted on the lower body, which decrease the CCW angular momentum of the lower body, and thus help the left leg make a larger force on the ground, and therefore to receive a larger CCW torque from the ground.

3) In addition, during this single support, the thrower should throw the left arm, (and to some extend the right arm) and the shoulders CCW, i.e., to the left. This action on the part of the upper body will also produce an additional reaction that will slow down the lower body even more, and as above, it will help the left foot make a larger force on the ground, and therefore to receive a larger CCW torque from the ground.

Again, the key here is for the thrower to make everything in the body EXCEPT the hips, to rotate CCW as fast as the thrower can make it. This way the thrower makes a deliberate effort/choice to put more angular momentum in the upper body and leave less for the lower body which means that the lower body (hips) will rotate CCW more slowly. Essentially, the angular momentum is obtained from the ground, but only a small part stays in the lower body. Most of it is transmitted to the upper body and to the right leg. The small size of the CCW angular momentum that stays in the lower body is a good thing because it allows the legs to keep getting more angular momen-

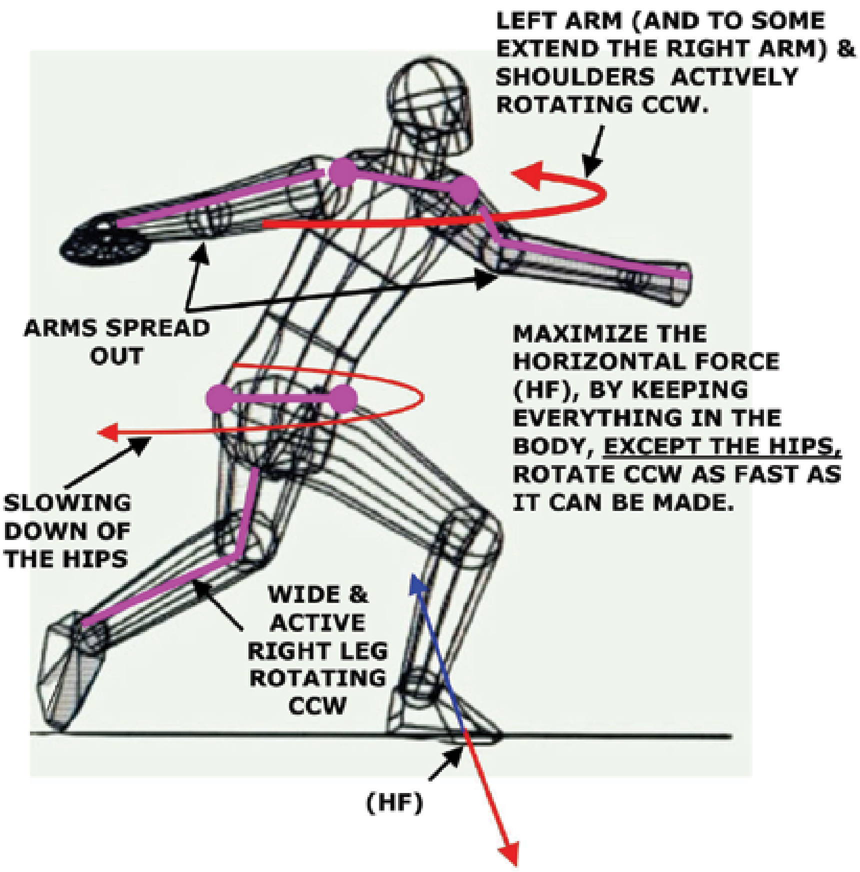

FIGURE 5. SUGGESTED ACTIONS TO BE TAKEN IN THE BACK OF THE RING TO MAXIMIZE THE GROUND REACTION FORCE AND THEREFORE, THE TOTAL ANGULAR MOMENTUM.

tum from the ground. Not much CCW angular momentum is allowed to stay in the lower trunk, because that would reduce the ability of the thrower to get additional angular momentum from the ground, due to faster concentric conditions of the leg muscles.

THE DYNAMIC ACTION OF THE LEFT ARM AND SHOULDERS

There are practitioners who strictly advice the throwers to actually try to prevent the left arm and the shoulders from being thrown to the left and rotate CCW during the first single support. Some even suggest to actually hold back the shoulders during that phase, as if they want to create an early separation between the shoulder axis and the hip axis, similar to what a thrower tries to do in the middle of the ring in the power position before the start of the pulling of the discus. From a strictly mechanical point of view, there is no merit to either of those two suggestions. Those throwers who can successfully and dynamically engage the left arm (and to some extend even the right arm) and the shoulders, and «throw» them CCW, should by all means do it. It is the mechanically right thing to do. Those practitioners who strictly advise to keep the shoulders neutral or, even worse, actively hold them back (CW relative to the hips) in the initial double support and single-support on the left foot, may be concerned that, if the shoulder axis rotates CCW relative to the hips in those two early stages of the throw, the thrower may not be able to “re-wrap” in time for the start of the final delivery phase. Although this may be a justified concern for some throwers, it is something that the coach needs to evaluate on a case-by-case basis. In the back of the circle the athletes need to throw the shoulders, the left arm and the right leg CCW. But then, indeed, they need to “re-wrap” during the airborne and single-support on the right leg. If they do not manage to re-wrap fully, they need to work on that re-wrapping ability.

What if the athletes are never able to re-wrap enough, no matter how much they train for it? In other words, what is better, (1) to “live” with that incomplete re-wrapping, or (2) to not unwrap quite so much, and therefore allow for a full re-wrap? Hard to tell!! But first, the athletes need to try to enhance their ability to re-wrap. If they succeed in this, then they will not have to make a choice! However, in all those cases where the left arm and shoulders are not actively employed (for whatever reason), the generation of angular momentum will certainly be compromised.

CONCLUSIONS

Angular momentum development in the back of the ring, during the first double and first single support, is of paramount importance in discus throwing because this is where almost all the angular momentum the thrower can generate will be generated. From a purely mechanical point of view, to achieve that, the thrower should keep her arms spread apart, and also actively throw both the right leg and the left arm and shoulders CCW. Those three actions will collectively contribute in slowing down the lower body, as the thrower actively chooses to pass as much angular momentum to the upper body at the expense of the lower body which slows down, while the overall angular momentum increases as shown earlier in case 2. The slowing down effect of the lower body/hip area, is an event which will allow the leg muscles to be in high tension as long as possible, and exert higher forces against the ground. Higher forces over time translate into higher overall angular momentum which is exactly what the thrower wants.

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A Coaches Roundtable

Sprint Training /Speed Development Coaches Forum, Part Two

The retired four-time national coach of the year coordinates a panel of leading coaches examining various speed development and sprint topics in part two of a coaches' roundtable discussion

Tim Minchin certainly had it right when he talked about sharing knowledge. "Even if you are not a teacher, be a teacher. Share your ideas. Don't take for granted your education. Rejoice in what you learn and spray it," said the Australian actor and musician. That sums up our objective very well as we continue down the information highway in part two of our coaches' roundtable discussion concerning sprint training and speed development topics.

I have stated many times that the sharing of information amongst coaches is essential. Especially if coaches wish to expand and develop their abilities. I have also stated that one of the best methods to achieve this is coaches' roundtable forums where coaches can examine the powerful perspectives and ideas of their peers.

Our objective for this article, for part two in the series, is the same as it was for part one: To provide information and perspectives from our survey of sprint coaches. A number of questions were presented to the panel of coaches. Again, like in the previous presentation, some of the questions were my own, and others were suggested by coaches and athletes. The coaches involved in the project were the same as part one, with the exception that Reece Vega from North Dakota State University was added to our conclave. It was very apparent that the coaches put a lot of time and effort into answering the questions. That was refreshing. Especially since we live in a world where people want answers "right now" and often very little thought is put into the responses. That method, however, doesn't always produce the most fruitful answers. Before we move into the questions, a quick bio of each participating coach.

Curtis Taylor, University of Oregon Coach Taylor is in his ninth season with the Ducks and sixth as associate head coach. He is in charge of both sprinters and hurdlers. Taylor is an 8 -time West region assistant coach of the year and three- time national assistant coach of the year. Taylor was a highly successful high school and junior college coach prior to arriving at Oregon in 2014 from Laney College in Oakland where he was the woman's head coach. Taylor has an impressive list of standout athletes he has tutored, including Micah Williams, Kemba Nelson, Cravon Gillespie and 2015 Bowerman winner Jenna Prandini. Coach Taylor has been a part of 10 national championship teams at Oregon.

Cale Korbelik, University of Mary (ND)
Coach Korbelik, who took over the head coaching position at Mary in 2022, has continued the storied success that the Marauders have grown accustomed to throughout the years. Korbelik, a graduate of Northwest Missouri State, came to the University of Mary as an assistant coach in 2020. He assumed the interim head coaching position in 2021. He had prior coaching stops at Whitworth (WA) and Buena Vista (IA) before coming to Mary. Korbelik, a football and track standout at Northwest Missouri, specializes in the sprints, hurdles, and relays. He is also the recruiting coordinator.

Kyle Grossarth, BYU The men's and women's sprint/ hurdle coach at BYU, Grossarth was the 2021 Mountain region assistant coach of the year. During his time at BYU he has had a great deal of success, developing 16 first team All Americans. His athletes have set numerous school and conference records. Grossarth, a conference champion 400 meter hurdler for BYU, competed in the 2000 Olympic trials as an intermediate hurdler. Grossarth was a volunteer assistant at BYU from 2000-2007.

Andrea Blackett, Azusa Pacific (CA)
Blackett is the sprints/hurdle coach for the Cougars. She arrived at Azusa in 2017 from UCLA. A 1997 graduate of Rice, Blackett was a two-time Olympian for Barbados. She coached at her alma mater, Rice, for 10 years, the first five years serving as a volunteer coach. Blackett, the 2021 national assistant coach of the year, had an 11-year professional career. She coached her native Barbados in the 2008 Beijing Olympic Games.

Armando Payan, University of Wisconsin-Platteville (WI) A successful track and field and football athlete from Graceland University in Iowa, Payan is an assistant coach specializing in the men's and women's short sprints. He is in his third year of coaching the Pioneers after a two-year coaching gig at the University of Mary where he was both a sprints and hurdles coach. His athletes have rewritten the record books at Platteville since his arrival in 2022.

LaRon Bennett, University of Virgina A three time all American in the 400 meter hurdles at Georgia, Bennett joined the University of Virginia in 2021. Bennett was the director of track and field and cross country at Belhaven in Jackson MS from 2019 to 2021. He spent 2012 to 2017 at Drake University in Des Moines, serving as co-head coach during his last season. Bennett coaches the sprints, hurdles, and relays for the Cavaliers, with his athletes obtaining considerable success at the conference, regional and national levels. Bennett competed in four Olympic trials and was the bronze medalist in the 2007 Pan American Games in the 400 meter hurdles.

Kebba Tolbert, Harvard The associate head coach at Harvard is nationally recognized as a sprint, hurdles and jumps coach. He has been at Harvard for 14 seasons, spending 13 as the associate head coach. A Colby College (ME) graduate, he is a many times Northeast Region assistant coach of the year. He has had many top athletes and has the distinction of coaching Gabby Thomas at Harvard. Thomas was the Paris Olympic Games champion in the 200 meters. His coaching career began at Iowa Wesleyan, and he has had coaching stints at McKendree (IL), Syracuse, Portland State and UTEP. He is a widely sought after clinician and has been involved in coaching education for many years.

Tommy Badon, University of Louisiana
Badon, a widely known and extremely popular coach, took over the head coaching duties at his alma mater in 2024. He served as the interim coach in 2023. The 1981 graduate of Louisiana had been an assistant for the Ragin Cajuns since 2018 before accepting the interim tag. He also was an assistant coach at Louisiana from 1989 to 1997. Badon is well known for coaching Hollis Conway, one of the top high jumpers of the 90's and the American indoor record holder in the high jump at 7-10 1/2. Badon has been an active clinician and a level 1 and 2 instructor for 20 years.

Chris Parno, Mankato State University (MN) Parno has led the Mavericks to unprecedented success in the sprints and hurdles in his 12-year career at Mankato State. The associate head coach is a five-time national assistant coach of the year and a many- times regional coach of the year. He has created a powerhouse in Division 2 sprints and hurdles, with hurdlers Denisha Cartwright (a Bahamian Olympian) and Myles Hunter holding Division 2 national hurdle records. A graduate of Minnesota Duluth in 2010, Parno was at Augustana (SD) for two years, 2010 to 2012, prior to arriving at Mankato. Parno serves as a USATF lead instructor for the level 1 coaching certification programs and is an instructor in the level 2 and 3 certification courses. The Mavericks have won 36 conference championships and one national championship during his tenure.

Reece Vega, North Dakota State University
Vega is currently a fourth-year sprints/hurdles coach at North Dakota State University in Fargo, ND--where he was an All American sprinter. He has been remarkably successful at his alma mater, having guided athletes to numerous all-conference honors and adding many performers to the all-time Bison top ten list. Vega, who has coached 35 All Americans, came to NDSU from the University of Mary in Bismarck, ND, where

he was ultra-successful. Now in his 20th year of collegiate coaching, Vega was named the NSIC Indoor Assistant Coach of the Year in 2019 and 2020, and the Central Region COY in 2018. Vega is a former head coach at College of Saint Rose in Albany, NY, and at Graceland University in Lamoni, Iowa.

Let's delve into the questions and answers from the 10-member panel. Not all coaches answered all questions, and some responses have been edited for brevity, clarity, and grammatical correctness.

QUESTION 1
DO YOU OR YOUR TRAINING STAFF ACTIVELY ENGAGE IN A PREVENTIVE HAMSTRING INJURY PROGRAM? WHAT HAVE YOU FOUND TO BE THE BEST FORM OF HAMSTRING INJURY REHABILITATION?

Bennett: Yes, most hamstring injuries can be prevented with elite care in the areas of sound sprint mechanics, good hydration, proper sleep recovery, and overall strength/mobility of the muscles. But most importantly, coaches need to know when to adjust and modify reps and workouts.

Grossarth: As part of our strength and conditioning program we are always working the posterior chain. Our strength coach has done a great job in developing a nice Nordic progression for the sprinters. The consistency of this exercise has seemed to decrease the number of hamstring issues we have had. If someone does sustain a hamstring injury, I have a rehab protocol that I have used for a number of years that works pretty well. One component that I feel is very critical to the success of the protocol is getting the athletes to start running/sprinting within two to three days of injury, and to do it consistently throughout the recovery.

Korbelik: This is something we are always working on and modifying to improve. We have several preventative programs and a return to max speed rehab. We like to be doing more prehab than rehab work. Prehab is preparing for those demands and if someone has past hamstring issues, we try to get down to the root of the issue. I have found that most times it is the hips/glutes/hip flexors that are the reason for the injury. I would say that it is our main focus and most effective rehab.

Taylor: We do actively engage in a hamstring strengthening program that calls for a prehab program before practice, a lumbopelvic strength/stabilization program as well as a NordBord (device that measures hamstring strength and imbalances) program. What works best to prevent injuries, though, is good and effective sprint mechanics, proper hydration, adequate sleep and recovery.

Parno: Yes, it is always a focus and a concern with sprint coaching. We work to do as much preventative work as possible. There are TWO main ways I feel we are preventing hamstring injuries. 1. We sprint often. We expose the body to higher intensities early and often in purposeful progressions. 2. We put a BIG emphasis on biomechanics and technical training towards research-backed models. Reigning in wild technique and putting the body in the correct planes will greatly decrease exposure to situations where you may see a hamstring injury occur. Specifically, eccentric loading has been a good tactic, especially a series of Nordic hamstring and quad exercises.

Payan: I learned from Vince Anderson that sprinting does not cause injuries.(Coach Payan is referring to Vince Anderson, a legendary, retired coach from Texas A & M) Many other factors contribute to injuries. We address it when it happens, we evaluate the situation, and we begin the recovery process

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right way. We do the same things we did before the injury happened, but at a much lower intensity. If we start at 1%, we will progress from there until they are healthy enough to get back into slow sprinting. We focus a lot on general strength, glute/hip strength, core, and multi-throws. We are always adjusting and modifying based on the athlete's limitations. Also, our trainers have done a fantastic job in preventing and taking care of hamstring injuries. They have implemented strength circuits, recovery exercises, and rehabilitation techniques to keep our athletes healthy and competing on a weekly basis.

Badon: We utilize Boo's hamstring return to play protocol (Coach Badon is referring to Boo Schexnayder's "A Guide to Handling Hamstring Injuries for the Coach." Coach Schexnayder is an internationally known former track and field coach who is an authority on training design) and we work in conjunction with the training staff. As far as prevention, research indicates that the two leading causes of hamstring issues are hydration and mechanics, so we attack those two factors from day one.

Tolbert: No. Good training design and good mechanics tend to address these. A lot of the stuff I see (Nordics, mobilizations, band stretching and things like that) don't really address the true hamstring issues. Fascial restrictions, pelvic restrictions, poor foot, ankle, and lower leg mobility are all keys to understanding and evaluating hamstring issues. So, when we see compromises in any of these areas, it's important to understand how to treat the root causes. In terms of rehab, of course, it depends on the severity of the injury. But much too often I don't see the above issues properly considered or addressed. I also tend to see a lack of intensity and progression in hamstring rehab. I also don't see enough consideration of eccentric forces, fascial planes, and associated areas (psoas, low back and spine, and the foot).

Vega: Between the track coach/athletic trainers/strength staff, we all have a role in hamstring injury prevention and rehab. Working together with all three has had big benefits in keeping our hamstrings healthy.

QUESTION 2
WHAT ARE YOU DOING IN THE RECOVERY PROCESS THAT LEADS TO SUCCESS IN YOUR SPEED DEVELOPMENT PROCESS? EXPLAIN THE MODALITIES THAT YOU USE.

Bennett: You must grade out at least 90% in these areas of training: mobility, flexibility, nutrition-hydration, sleep, ice bath and massage/chiropractor work.

Grossarth: We don't do anything super fancy for recovery. I am really deliberate about making sure that there is a true recovery day in the middle of the week, especially as we get into the season and the intensity ramps up. It's typically on a Wednesday and is a low impact/intensity day that is 30-45 minutes in length. I like to change what we do on those days to keep away from the monotony and will even throw in some different games from time to time. I throw in games because I feel like mental recovery is just as important as physical recovery. My athletes usually hit the training room daily, and some will sauna or occasionally use the cold plunge. We are fortunate to have massage therapists that come in weekly that they can sign up for as well. We try and help them understand all the modalities and resources they have at their disposal but then let them decide what will work best for them.

Korbelik: We give 72 hours between all speed development days. We always do an active recovery day before speed development days. Other modalities I like are the Normatec for the compression (Coach Korbelik is referring to the Normatec leg compression pants). Mobility training is a huge factor for recovery and daily blood flow helps with that. I'm not a big believer in ice baths. I find the athletes do it too often, too cold, and too long. I would much rather have them soak in a cold tub three hours after a training session or in the mornings well before their training session. The cold temperatures should be manageable, and the athletes should soak for 10-15 minutes. I find massage and compression to be the most beneficial forms of recovery outside of the big three (sleep, nutrition, and hydration). There is no point in doing a quality speed development session if we aren't recovered.

Taylor: Our recovery begins with skeletal realignment if necessary, manual therapy if needed, movement therapy, contrast baths/showers, rolling out/self-massage, yoga, and/or complete rest.

Parno: Purposeful planning of deload weeks within the plan, and recovery days within the weeks where we employ general strength and circuit work. We train five days a week, with the weekends being off/optional general strength work.

Blackett: Everyone spends 8-10 minutes stretching with foam rollers and massage guns after every session. Ice baths are recommended once or twice a week.

Payan: Too many rest days becomes a rest year. We are careful about how much we give our athletes. We don't want them to lose what they have already built, so we base our training on how they are feeling for that week. If we see that they are still tired from the meet or last week's training, we adjust accordingly for each athlete. Not all of them are going to feel the same. Some might feel great. Others may not. There is no reason to risk an injury when an athlete is not feeling their best. We do one to two days of rest per week, sometimes even more, depending on where we are in the season. Some weeks we feel like we can hammer them a little more, but others we will tone it down depending on if it's an important competition. Once it starts getting close to conference or nationals, we taper down to where we are having two hard training sessions per week. We are not trying to play catch up when it comes to training. We are not going to make up a training unit during the season because I would rather have them perform well at the meet and use that as a great "speed" session.

Badon: I am a big believer in circuits/bodybuilding weight training to enhance recovery and also hydro-therapy (hot and cold,) along with rollouts and other physiotherapy activities. The body does like routine, and it does like to work, so active work with low intensities, including tempo running with short recoveries, can enhance the recovery process when structured within the workout cycle.

Vega: We do a lot of circuits on the track to help the body recover as well as other lighter auxiliary drills. Off the track, it's up to them to ice/contrast bath, meet with the athletic trainers, chiropractors, eat, sleep, nutrition, etc.

Tolbert: We make sure we have a steady diet of recovery work. We are always employing training means to recover from intense training and rebuild the body – and we're using training means to prepare for the next big intense effort. All of our general work, in a sense, becomes more important (i.e., med ball, general strength, intermittent use of auxiliary and bodybuilding lifts, and other balancing, prehab, restorative work). The stimulatory work we do here, as well as between competitions and big training sessions, is essential.

QUESTION 3
WHAT ARE YOUR IMPORTANT TRAINING

EXPECTATIONS FOR THE OFF-SEASON, ESPECIALLY THE SUMMER MONTHS?

Payan: Rest and recovery is our priority over the summer. We take two to three weeks off after the last meet and this allows the body to recover. They can take longer if they are dealing with injury. It is an expectation for the athlete to train three times a week (including lifting) during the summer. This will make transitioning easier when they arrive on campus and not prone to injuries. The goal is to work on strength, endurance, technical skills, acceleration, and overall fitness. We also want to address weaknesses and improve strength. It is not going to be overly complicated training. We want workouts that will get them in shape holistically.

Parno: We usually have 36-38 weeks in a given season. After outdoor nationals, the athletes will get a three to four week break from any sort of optional off season training. The focus in the off season is to recover from the season and to start building capacities again. An athlete can always get better technically through accel/max velocity workouts, build general aerobic capacities (event dependent), and dedicate time to the weight room. The whole goal of the off-season training is to be prepared for the next season with strength/speed levels that are higher than the previous year.

Grossarth: The number one thing that I want my athletes to do during the summer is to take some time off. I will usually give them two weeks off from everything and then give them another 1 to 1 ½ months off from running. I encourage them to stay active during this time. I feel the most important thing for my athletes to do over the summer months is to be consistent in the weight room. Athletes that are consistent in the weight room during the summer months come back to fall training better prepared and at a better starting point than the previous year.

Blackett: I am really hoping that during the summer my athletes first and foremost address any aches, pains and injuries that they may have carried during the previous season. Next, I want them to work on any deficiencies that were highlighted during the previous season. For example, maybe weak hamstrings, weak hip flexors or even just a lack of fitness. Summer is a time to work on overall general fitness. Nothing too specific should be done over the summer. I like to think of summer training as general preparation for any sport. At the end of the summer, a well -prepared athlete should be fit enough to begin specific training in almost any sport if they did a good job.

Korbelik: Consistency is king. We ask for three days a week of running, and three days a week of weight training. If they can't do something this simple and work independently without the coach and training group, it really shows how much they want to be successful in this sport.

Badon: After a long collegiate season, summer training can be tricky. Obviously, no one wants to go backward and lose the gains made during the season. But at the same time, athletes need a break both mentally and physically, so summer training is a balance of maintaining fitness levels and renewing mental and physical abilities moving into the fall. We generally accelerate summer training as the months pass, starting slowly and gradually progressing through August. In the fall we focus on mechanical changes with a long-term focus for development of both neural and energy system gains.

Bennett: In the summer months, we focus on the building blocks of core, flexibility, mobility, and easy mileage. These areas serve as the foundation for a successful and long season.

Taylor: I feel that the most important thing is to maintain some level of fitness, whether that be through yoga, Pilates, spin classes, body sculpting, etc. We don't want to "get in shape to get in shape" in the fall.

Vega: Weightlifting, staying active, and keeping strength and speed at a relatively good level throughout the summer are important.

Tolbert: I keep my offseason expectations fairly limited. Whenever we finish our season, I give them four weeks off with absolutely no directions or suggestions other than to be as active as much as they desire, and to do anything but track. Some in my training group will end their season at the conference weekend, others at NCAA prelims, others at the NCAA Championships, some at the US Champs, other national champs, or U20 Worlds, Diamond League finals, or even world champs, so the range is quite large. In any case, after a long season, rest is needed – so we rest. After four weeks, they can ask for off-season training cycles. These start out fairly easy with three to four days of prescribed training and few more suggested active days. Then, after a few weeks, they can ask for the next cycle… This cycle is normally five days of training. And after that is done a few times, they can ask for the next one. In between each of these summer cycles there are short rest weeks with reduced training. As you can see, when they're ready to progress or ramp up, they let me know. In this way, the onus is on them to complete the training and to indicate readiness. So, it's mostly self-selected. Additionally, the summer training is not nearly as dense or intense as the in-season training. It's meant to give them a mental break while also allowing them to come back to campus refreshed and eager to resume regular training with the team. We have the luxury of starting in the fall and have a fairly long on-ramp before any important competitions, so I don't see the need for a super specific, very intense off-season programs.

QUESTION 4
HOW IMPORTANT AND WHAT ROLE DO ARM MECHANICS PLAY IN THE SPRINT PROCESS? EXPLAIN.

Payan: My mentors always told me that you are only as good as your technique allows you to be. Arms play a big role; the arms guide the legs. They act to maintain balance, build momentum, and aid in overall rhythm. Sprinting is a skill. We need to address it day one, because it reduces the risk of injury and improves overall performance.

Parno: The arms balance the legs. They clearly work in opposition to what the legs are doing. If you want big amplitudes in the lower legs during acceleration or upright max velocity sprinting, the arms must match said amplitudes to provide balance and counter any unwanted rotation. I don't do any isolated arm drills and more so focus on how the arms are incorporated into the full gambit of sprint drills we do.

Grossarth: I start addressing arm mechanics right from the start of training in the fall. I feel that your arms are critical throughout the run but can be extra beneficial during the acceleration phase of a sprint where we want to see large, aggressive movements with the arms. I like to cue large splits in the arms while driving the elbows down and back. The arms can also be very crucial at the end of the run as fatigue sets in. We really focus on keeping the arms moving with good frequency and keeping the shoulders relaxed as they fatigue.

Blackett: Arms are extremely important

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in the sprint process. The arms work in direct conjunction with the legs. If the arms cease to move in an efficient manner, then the legs will do the same. Arm motion and strength are an important part of our training process in the fall. Sometimes, the arms don't work correctly because they don't have the strength and endurance to keep up with the legs that have been trained specifically to do what they need to do. Therefore, the arms should also be trained accordingly.

Korbelik: I think the arms drive the legs. When it comes to the sprint process, the hips play a huge role as well. I believe if you can't control your arms or hips, then you are missing a huge part of the sprinting process. There are arm mechanics for each progression of the run. The start has a bigger arm swing and transitions as you come upright. I also teach arm mechanics at certain speeds. Many people drastically improve by improving arm mechanics. The arms at 90 degrees are helpful. They open on the back end and close on the front end. We also focus a lot on limiting wide arms and torso rotation, this being a huge issue for some people.

Badon: Biomechanically, arm action is a reaction to lower body function. Since sprinting is a push kinetic and has a big vertical component, the arm action mirrors that mechanic. As the foot moves vertically down, the arm moves vertically down toward the back "pocket." Sprinting is an elastic exercise, so the arms mirror the elastic nature of the lower body. A "down" emphasis is essential to proper arm mechanics.

Bennett: Arm mechanics are important, as they are linked to stride length, frequency, and range of motion. Uniquely though, an athlete is able adjust and compensate for what one would consider "inefficient arm mechanics," and still produce fast times. As a coach, I try to find what mechanics are efficient and optimal for the athlete so they can still run 'natural' vs 'robotic.'

Taylor: The late, great Dr. Ralph Mann said, "we should just cut the arms off," meaning that we pay too much attention to them. (Coach Taylor is referring to the former great 400-meter hurdler who was a pioneer in sport research and who died in January) Basically, they help to steer the ship, like a rudder. But they are not the main engine. My major emphasis is that the action should be down and back, using the stretch reflex at the shoulder as their main driver.

Vega: Arm mechanics are vital, but there are so many different ways an athlete can move. We don't utilize a "one style fits all" approach. We do, however, teach certain movements that have shown to help increase sprint mechanics.

Tolbert: They are very important. Arm movement dysfunction can really create problems. However, you see a lot of top-flight sprinters with just average arm movement function and awareness. But I think they give clues to balance and harmony throughout the body. When we see issues with arm movement in sprinting it can be diagnostic. Sometimes the issue is simply a lack of awareness of what they should be doing. There's a lot of bad "arm science" out there on the internet and social media. The arms angles should change – that is they should open and close and be in harmony and in congruence with the legs. So, in sprinting, upstairs and downstairs (lower body) should match on opposite sides. There's an interplay between hips, knees, ankles, and shoulders, elbows, and wrists. When this movement harmony is interrupted, we see technical issues that either affect sport health, power expression, efficiency, or some combination of the three. The fix can be multifaceted – if the hips, low back, or mid back have tightness, fascial restrictions, or other issues, you're going to then see associated issues with the arms as they pick up or restrict movement in reaction to what is happening elsewhere. When you see arm issues, it's important to have a "what else, where else philosophy" (as Dan Pfaff would say) in your diagnosis of the issue. (Coach Tolbert is referring to Dan Pfaff, a legendary, retired Hall of Fame coach).

QUESTION 5
DO HIGH SPEED TREADMILLS PLAY A PART IN YOUR TRAINING AND WHAT DO YOU CONSIDER THE PROS AND CONS OF TRAINING ON TREADMILLS, ESPECIALLY THE CURVED AND HIGH SPEED TREADMILLS?

Payan: Curve treadmills have been a good part of our training. We have athletes that have the tendency to reach as they are sprinting and are unable to feel how to strike the ground correctly (underneath the hip), and the curve treadmill forces them to do so. We do other things like wickets, stick drills, and max velocity drills to engrave this movement pattern. But, using the curve treadmill and doing reps at slightly lower intensities and gradually increasing it, has allowed form and technique to change very positively. I do not do much overspeed with bungees since most of my athletes are not elite athletes. Consequently, the curve treadmill has allowed me to work on overspeed reps even if it is for only a few seconds.

Parno: I have utilized treadmills only in return to run protocols, or if weather necessitates the use. High speed treadmills, although taxing, produce speed for you. Treadmills could be thought of as more, "catching" yourself with each stride, vs. producing the force when sprinting maximally without a treadmill. I would utilize the curve treadmills if we had access to help reinforce more frontside mechanics, as the curve almost forces it, but there are some other pieces of equipment I would probably purchase first.

Grossarth: We do not use high speed treadmills. We have other overspeed modalities that we utilize. I just feel like we are racing on the ground, so I am going to do everything on the ground and not on the treadmill.

Blackett: Coaching in California I really don't have much need for a high speed treadmill. If I did though, I would be careful to watch the athlete's mechanics while running and make sure they aren't changing their natural running gait too much because that can cause huge problems when running at a very high speed. I have seen some crazy treadmill videos on social media recently and am somewhat concerned about hamstring and labrum issues resulting from incorrect treadmill use. Just because an athlete CAN turn over that quickly on a treadmill, it doesn't mean they should be doing it excessively.

Korbelik: I've never used high speed treadmills for training. I'm sure there are some benefits. I wish I had two curved treadmills. I would use it for a lot of tempo running work for athletes who struggle running indoor workouts on 200 meter tracks. They have a great way of building strength, focusing on form, and being low impact.

Badon: We do not use treadmills.

Bennett: We use treadmills when the weather isn't conducive for the athletes to run outside. The pro to high-speed treadmills is it allows the athletes to run and feel the speed at which they need to run. The cons are that it can give a false sense of


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speed because the treadmill is moving the athlete, vs them applying true forces to the ground to move themselves. Also, the speed at which the treadmill keeps the athlete can be unsafe when fatigued. There is no slowing down when you are in mid sprint on a treadmill.

Taylor: No to high speed treadmills of any sort. Because the ground moves underneath you, an athlete can never generate ground forces similar to what is needed to achieve maximum velocity. I only see them as a recovery tool or for longer, slower runs.

Vega: We do have treadmills and higher performance treadmills, but we don't utilize them often.

Tolbert: We don't use them.

QUESTION 6
DO YOU HAVE A PROTOCOL FOR YOUR SPRINTERS IN TERMS OF A BREATHING MODEL FOR THE 100 AND 200 METERS?

Payan: I use a lot of imagery in my training. My favorite thing to say is imagine yourself as a tea kettle. As you are in the blocks, build pressure by pushing against the blocks and hold your breath as you are coming up to a set position. Keep building it until the gun goes off and you perform the release. My athletes think it's silly, but they have no idea they are performing the Valsalva maneuver at the start. This helps them generate more power during the initial push and be a little more aggressive against the blocks. As the athlete is running, we keep it a little simpler. We use the 2:2 pattern, breathing in for two steps, and exhaling for two steps.

Parno: Most of the time I am focused more on executing proper block clearance, accel mechanics, and building a sound race model. Breathing would usually be the last part of the equation, as I feel like the potential benefits are irrelevant if you aren't putting maximal efforts in to block clearance, accel mechanics, and building a race model. A deep breath in could help make the torso more rigid, assisting in getting a longer line/posted position in acceleration, but again, I think it can be addressed if it becomes an issue down the road.

Grossarth: I do not.

Korbelik: I don't have a protocol. It wouldn't be a bad idea. I say to the athletes that they should be using long breaths, not short bursts. I learned this from Charlie Francis, (Coach Korbelik is referring to the late, great Canadian sprint coach) If you want to run fast, its exhaling. When you inhale you slow down slightly. So, being intentional on when you breath is key. You do not want to be in hyperventilation. Quick breaths never work out well and you never get the oxygen needed for the body. My protocols: 60m – 2-3 big breaths; 100m: 4-5; 200m 10-12.

Badon: Breathing mechanics are an extremely complicated element of sprinting...generally speaking, no more than three to four breaths for the 100 are necessary.

Bennett: Not necessarily. We emphasize controlling your breathing and not holding your breath. When you hold your breath, you cut off the oxygen supply to the firing muscles, which can cause them to fatigue faster.

Taylor: There is a breathing model for both races, but there are too many other things to concentrate on to have them focus on breathing patterns as well. I feel it's better to teach that after the correct technical and race modeling patterns have been mastered.

Vega: We have a breathing model for when an athlete is in the blocks, but really not a lot for during the race.

Tolbert: I don't – at least not one that I apply with every sprinter. I do understand Val Salva maneuvers and how employing them in sprinting can be helpful. However, for most sprinters I work with, the problems we're trying to fix are way bigger than breathing patterns. Also, most sprinters don't need more things to think about. When I've had truly world-class sprinters, we've talked more deeply about breathing patterns, but to me, it's a Ph.D. type of approach, so you've got to graduate before moving into a deep discussion of breathing patterns.

QUESTION 7
WHAT DO YOU FEEL ARE SOME OF YOUR BEST ACCELERATION DRILLS? BRIEFLY EXPLAIN.

Parno: The best drill could potentially just be accelerating and working on feeling projection! There are some wall drills to simulate the acceleration positions. Various bounds (standing long jump, three bounds, five bounds) can help force longer pushing and projecting through each step. I like drop in starts and repping a lot of 3-point starts before introducing the blocks.

Grossarth: Any drill that helps the athlete get into the right position and master the technique is the best drill. Sometimes the drills may be different depending on what the specific needs of the athlete are. I will do a lot of things using heavy Prowler sleds. I also like using shoulder harnesses that have a partner holding the person doing the drill. This allows the person doing the drill to be in the correct position and have the freedom to move their arms.

Blackett: I really like pushing and pulling sleds, and playing with different weights on the sleds. It really helps me to see if athletes are hitting the correct angles. I also use acceleration ladders that give the athlete a visual on where their foot placement should be, as they push out for the first 6-8 steps. It also helps me to see any steps that are cut short or overreaching in the acceleration process.

Korbelik: 1: Sled pulls (variations of 20-40m) with less weight the longer the rep. 2: Hills 3: Varied starts (makes them accelerate in various ways and really teaches them how to challenge themselves to move properly) 4: Wall drills. The best drills are the act of doing the desired movement the right way. Too many athletes want the secret drill and there is no secret drill. You must be able to do it and take ownership of your body control.

Badon: I am strong believer in sled pulls up to 40-50 meters, weighted runs to 40 meters, and we have a 45% tunnel we use up to 30 meters. Of course, 2-point, 3-point and 4-point starts from 10-20-30-40 meters, and block starts both on the straight and on the curve.

Bennett: Tape drill: Tape is placed at progressive distances on the track. Bungees: They assist with allowing the athlete to get up to speed faster.

Taylor: I don't think the drills make a difference if the initial tenets of acceleration aren't applied. Dorsiflexion, low heel recovery and severe shin angle concepts should be taught first, and then progressed with drills and/or equipment as available.

Vega: Falling Starts, crouch starts, 3-point starts and med ball starts are all progression drills we use. We have also utilized sled pulls and sled pulls from blocks. Teaching the athlete how the body should be positioned, where the feet should land, and producing the force needed have been the biggest factors in teaching acceleration.

Tolbert: I'm not sure… As I said in the first roundtable, I don't believe drills by themselves teach anything. For acceleration, we do resisted work with sleds, tires, and other devices such as Exer-Genies and power cords. We will do work that emphasizes projection, like some of the resisted short step blasts that Stu McMillan is using

at Altis.(McMillian is the CEO, coach, and leader at Altis, an educational resource coaching group). I'll use stick drills at times to help athletes get a sense for stride length progression. We'll use bullet belts to help get a better sense for the initial pushes in acceleration. But through all these types of drills, you have to coach, teach, and demand change and focus. As Boo Schexnayder is famous for saying, "the drill simply gives you an opportunity to teach."

QUESTION 8
DO YOU AGREE THAT COMPETITION IS THE BEST FORM OF TRAINING, THAT IT IS THE ONLY WAY TO MAXIMALLY DEVELOP ALL THE LIMITING FACTORS IN SPRINTING, AS MANY COACHES HAVE SUGGESTED? EXPLAIN.

Payan: Absolutely! Competition serves as the ultimate training for any athlete, bringing a rush of adrenaline, excitement, and anticipation. Colorado Head Football Coach Deion Sanders aptly said, "Practice like you play; that way, when you're playing, it feels like practice." This philosophy is equally relevant in track and field, where healthy competition during practice helps athletes translate their speed, acceleration, and maximum velocity into meets. By simulating race scenarios, athletes learn how it feels to compete against others, achieve their desired speeds, and refine their racing strategies.

Parno: It's certainly the most specific! Intense efforts over race distances check many of the boxes, but if you are racing with poor mechanics or rushing through race models/plans, then some sort of parting out to feel proper pathways would be helpful. For example, working wickets to feel/enhance front side mechanics if you are dealing with someone that has trouble letting the limbs recover more on the backside.

Grossarth: As much as we try to replicate competition in training, there are just too many factors involved that make competition the most beneficial type of training. Competition days provide an environment where athletes can achieve higher intensities and speeds vs. training days. It also creates an environment that truly tests their mental training. The most growth and progress can be achieved by competing on a regular basis.

Blackett: Absolutely! I had a head coach that would often tell us assistants that the competition day should be the hardest training day of the week. In practice it is often very difficult to create an environment where athletes are truly at maximal effort. I wouldn't say it is the only way to develop all the limiting factors, but it is the best way. Taking advantage of early season competitions to develop the athletes is very important. The mental and physical benefits of competition should greatly pay off by the end of the season.

Korbelik: Competition is great. But I find for a lot of people who aren't the best, it creates a lot of bad habits when they try to keep up. I know of a coach who does most sprinting at 90% and there isn't racing in practice. I think racing in practice too often can burn people out regarding longer reps. Then they get to meet day, and the CNS/body is fried. I like it when athletes compete in starts from 10-50m. Anything more than that too often creates issues for the athletes who aren't the fastest. Competing is great for the #1 person. I will have my top women run with the men because they need the push. But they are smart enough not to throw their technique out the window and strain the whole rep. Men, on the other hand, don't have control of their emotions because of inflated egos. I love competitions and racing. It does create the most change for training stimulus.

KIRBY LEE IMAGE OF SPORT

But it needs a lot of recovery with it as well. Sometimes training is more important than competing at various times of the year.

Badon: Competition is the ultimate judge of how training is going. On a scale of one to five for intensity, it is always a five. So, using competition as a tool to determine how your race planning is going, how athletes are adapting to your protocols, how they handle competition stress, how they deal with travel, school work while on the road, and sleeping away from home, etc. can only be determined by using competition to access where an athlete may be at any given point.

Bennett: I don't think it's the singular best form of training, but it has its benefits to access where the athlete is at in their training. Executing paces and reps efficiently are beneficial to training as well. Mental processing is one of the best indicators for effective training. For example, some athletes raise their level of play when competition is introduced, but will only give 90% when not in a competitive environment. Another athlete may be a practice champ and thrive in that setting, but will not perform at the same intensity in competition. So, it's more important to create environments that will help the athlete achieve the desired results and times.

Taylor: I do not feel that competition is the best form of training. I do, however, feel that it's the best way to achieve maximal velocity without assistance. The issue here is that because it is a competition, technical competence often goes out the window in an attempt to win and often detracts from actual speed development. It's an effective tool, but those limiting factors need to be addressed in practice until they become an autonomic response process which can be applied in a competition. Once that is achieved at some level, then competition becomes the best training factor for maximum speed. The combination of the two allows for the best outcome.

Vega: Yes, I believe you can't get anything better than competition. Especially in sprinting and getting an athlete's body to sprint at 100% top speed. It's almost impossible to get that output in practice.

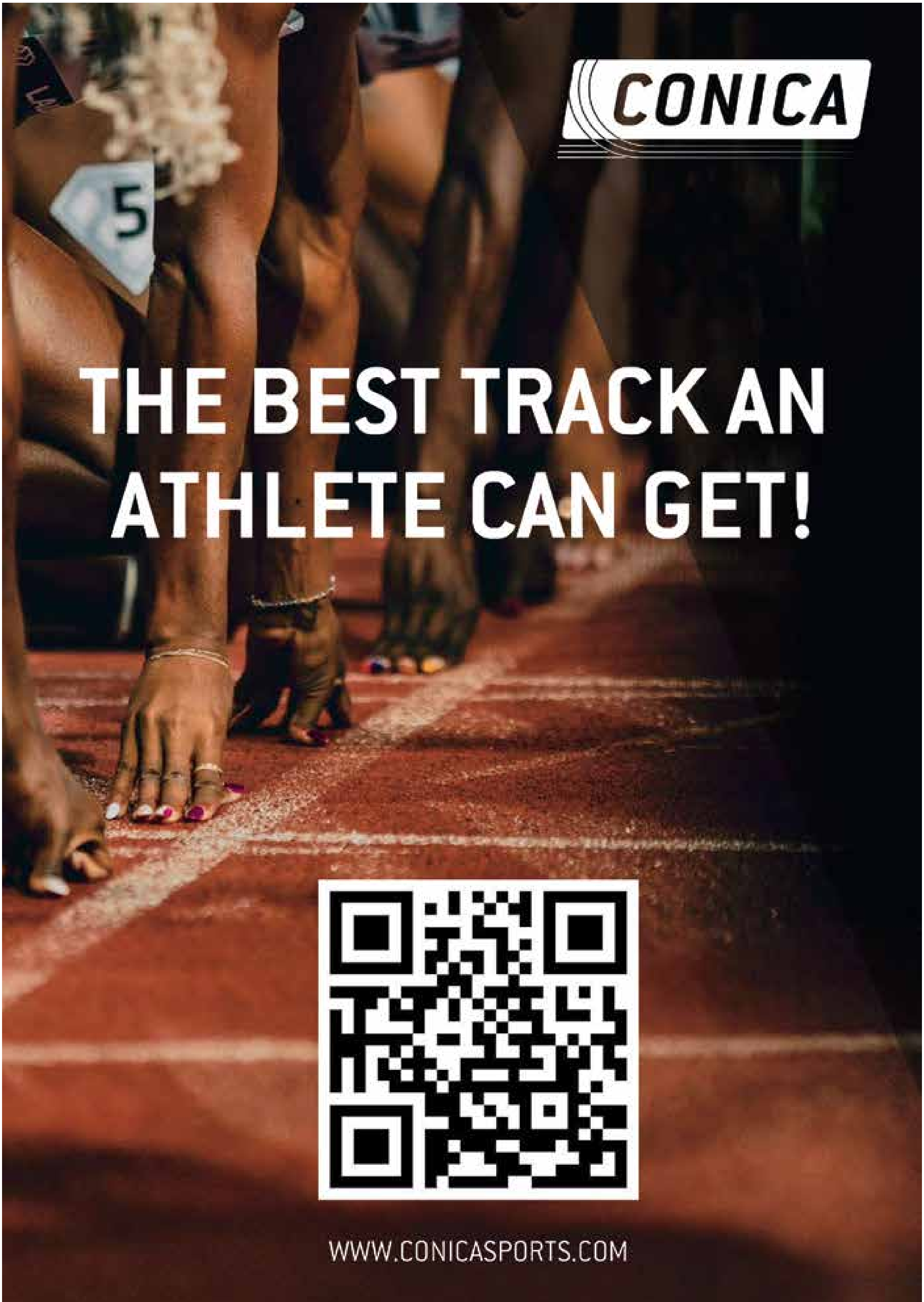
Tolbert: Not really. Competition at the right time is very important. But so is training. Competition is a stressor that allows us to see how things hold up or fall apart under pressure. But training is critical because you get multiple reps to teach skills, to give feedback, to talk with and question the athlete, and to stabilize patterns. It is in training where so much of the learning takes place. It sets the foundation for competitive excellence.

SUMMARY

As in part one of this series, it was very apparent that there were both a lot of commonalties and a lot of differences among the coaches in how they approached the different sprint topics. Both presentations clearly demonstrated that there are many different ways to obtain success in the training of sprinters and in speed development. The project also revealed that many coaches need to be open to new concepts and the idea that there may be different ways to improve and obtain success. It has been our experience that many coaches struggle with change and the fact that there may be better ways to do something. I was one of them. Many times, as a younger coach, and unfortunately, too, as an older coach at times, I allowed my stubbornness and bullheadedness to hinder my coaching. Change is a constant in life and in athletics and like many people, coaches aren't immune. A great quote by George Bernard Shaw regarding change says it well: "Progress is impossible without change and those who cannot change their minds cannot change anything," said the Irish playwright and critic, and the 1925 recipient of the Nobel prize for literature. It was our hope that this presentation provided coaches with insights and ideas and food for thought. With any kind of information, however, it is always the individual coach who must digest and pick and choose what they employ and what can assist and improve their program and training. I always caution coaches and athletes alike that they shouldn't assume that everything out there is true and should be used. Quite often it is not. Often it is incorrect information that has not been tested or proven that some coach has tossed out in a tweet or blog. So-called facts tainted by opinion have never interested me. World renowned strength and conditioning coach Mike Boyle summed this up very well: "Remember you can't believe everything you read, and you shouldn't read only what you believe," said the coach who died in 2021. Vern Gambetta, the founding father of functional sports training and a former track and field coach, says coaches need to be "creative artists," and our hope is coaches are inspired and motivated from the coaches' roundtable articles and other educational tools to start "painting," so to speak. Our expectation is that all coaches feel the need and want to grow and improve. A great quote by the renowned biomechanist, the late Dr. Ralph Mann, summarizes exceedingly well what coaching education attempts to do: "There is no right or wrong way to coach any aspect of the sprints or hurdles," said the former five-time national champion who was elected to the USA Track and Field Hall of Fame in 2015. "Only a better way." I have always been a goal-oriented person, both personally and professionally. One of my goals since my retirement has been to assist and help educate coaches to be "better" coaches. Better coaches equal better athletes, which equals better performances. If the roundtable forums can help coaches be better, I will consider the goal achieved.

A very special thank you to Ann Thorson and Amelia Sherman for editing and technical assistance

MIKE THORSON, FORMER DIRECTOR OF TRACK AND FIELD/CROSS COUNTRY AT THE UNIVERSITY OF MARY (BISMARCK ND)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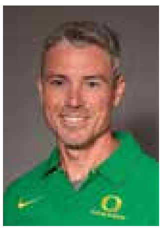

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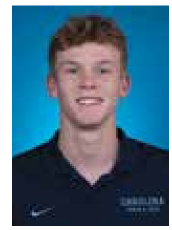

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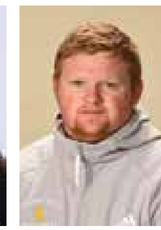

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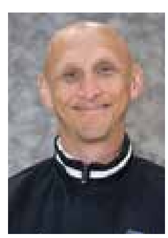

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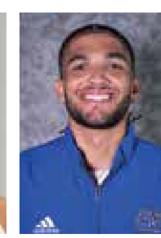

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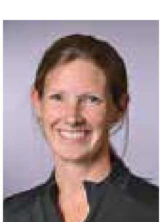

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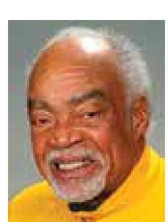

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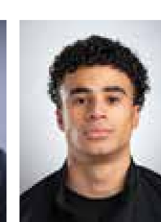

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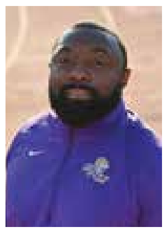
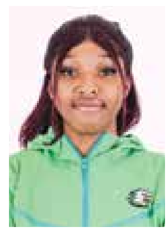
Women's COY

Katie Wise
Marian (Ind.)
Men's COY

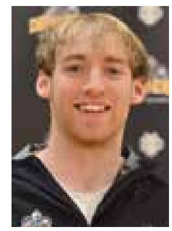


Zontavius Johnson
Olivet Nazarene (Ill.)
Women's Assistant COY

Mychal Vinson
Marian (Ind.)
Men's Assistant COY



Briana Campbell
Life (Ga.)
Women's Track AOY



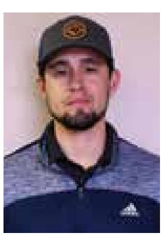
Payton Mauldin
Dordt (Iowa)
Men's Track AOY

Sydney Duncan
IU Kokomo (Ind.)
Women's Field AOY

Robert Atwater
Midland (Neb.)
Men's Field AOY

NJCAA

David Burnett
Iowa Western CC
Women's COY



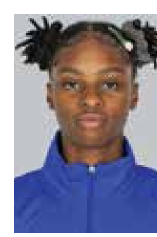
Wes Miller
South Plains (Texas) CC
Men's COY

Marc Bierbaum
Iowa Western CC
Women's Assistant COY

Jim VanHootegem
South Plains (Texas)
Men's Assistant COY

Maimuna Jallow
Cloud County (Kan.) CC
Women's Track AOY

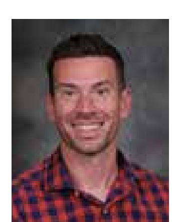
Bovel McPherson
New Mexico JC
Men's Track AOY



Celine Riddle
Barton (Kan.) CC
Women's Field AOY

Trevon Hamer
Barton (Kan.) CC
Men's Field AOY

2025 NATIONAL HIGH SCHOOL CROSS COUNTRY COACHES OF THE YEAR



Jonathan Dalby
Mountain Vista (Colo.)
Girl's COY

Eric Selle
Mountain Vista (Colo.)
Girl's COY

Francisco "Frankie" Ruiz
Belen Jesuit (Fla.) Preparatory
Boy's COY

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