Why K.R.A.M.? Why measure biomechanical efficiency?

By Todd Nunan

Running performance is a common denominator of many sports; Dr. Jack Daniels (2007), observed among teenage distance runners, "…about 50% took up running either to get in shape for another sport or because they got cut from a sport they truly wanted to participate in" (p. 8). Basketball training advisor Lindsay (2007) stated, "It's estimated that a starting high school player will run a total of 3 to 5 miles in a 32-minute game". With the advent of using miniature global positioning monitors worn on the bodies of players, it is possible to break down the running component of team play which has become an object of focus in sports. "Soccer doctor", Kirkendall (2001), stated that pro soccer players will average from 5 miles (for women) to more than six miles (for men) per 90 minute competition; he specified, "The most physically intense part of the game is while in control of the ball", and yet he also pointed out that roughly 98% of the time running is spent chasing down or responding to the movement of the ball by other players. The higher intensity in basketball play, with increased possession time of the individual player, should warrant different running training strategies and yet it is accepted that most of the competitive advantages gained during play in either soccer or basketball are affected by the collective running abilities of a team's players to efficiently and repeatedly achieve offensive and defensive team positions at a minimal cost.

Figure 1. **"What is KRAM": This video can be viewed using Acrobat Reader 9.0, which can be downloaded for free at www.adobe.com , by clicking on the image (right-click to access full screen display; "Esc" button returns to normal view).**

It is not surprising that the disciplines of track and field have offered practical models for illustrating the running component of team sport strategy; the efficient execution of what former Stanford University track and field coach, Brooks Johnson (personal communication, January, 1989), called the "fluff miles" (often the first three quarters of a middle-distance or long-distance running race) is necessary in achieving position for an effective "end-race kick" or "critical zone". Formally applying Johnson's concept to team sport strategy puts the creative emphasis on defining "when" and "how" to apply the critical zone intensity and hopefully scoring as a result of the opponent's inability to respond. In a middle distance and distance running competition, a race may have multiple critical zones within a competition period (i.e. surges); team sports also would likely prepare for multiple critical zones as a strategy for distributing the timing of peak team efforts throughout a single competition.

It would be expected that the track and field community would also be the authority on assessing and teaching running mechanical efficiency; although it has offered considerable support for endurance and strength training issues for benefiting both track runners and team-sport players, there is no single template for running efficiency assessment and intervention. Instead, event-specific critical-zone skills are continually reinforced leaving the matter of efficiency up to interpretation by the athlete. Although most coaches will admit the importance of athletic efficiency, few coaches attempt to directly modify inefficient running motor behaviors.

In youth fitness assessment tests and in professional athletic coaching, the stopwatch has always been the most relied upon tool for assessing running performance and, according to Bundle, Hoyt and Weyand (2003), the stopwatch is now the primary tool used as an "…alternative to existing tests of anaerobic power and capacity" (p. 1955). Although a coach may lean on some form of taxonomy assessment of general motor abilities and specific skills for selecting a starting lineup, athletes of any age who perform well under the clock in both speed and endurance will commonly be selected simply because they can be relied upon for being in the opponent's face, most of the time. The problem with using timed running tests as the sole predictor of athletic ability is that running performance often does not serve to predict athletic performance potential in developing athletes.

Besides the use of the stopwatch, other indicants that are sometimes used by competent coaches for assessing physiological components of running ability include the heart rate monitor and, for those who can afford it, equipment for measuring *maximum oxygen uptake capacity* (VO_2max). Maughan (2000), however, warns of some important limitations of physiological assessments: "…although a high capacity for oxidative metabolism is necessary for success in distance running, it does not, in itself, distinguish the elite performer" (p. 16). Track coaches are all too aware that there will always be runners of similar performance levels who vary considerably in physiological attributes (cardio/pulmonary performance), as well as there will always be runners with similar physiological attributes who vary substantially in timed running performance. Simply, the commonly used running assessment methods fail as tools for assessing other important factors that contribute to running performance, such as motivation and biomechanical efficiency.

One of the reasons it is hard to find advice on coaching the efficiency factor of running in sports is because, "neural-level" motor analysis, which is critical to understanding kinetic and kinematic aspect of motor abilities, is commonly set apart from behavioural motor-analysis and is not regarded by many textbooks on *motor learning* as pertaining to the domain of physical education.

With major emphasis placed on behavioural motor analysis, Magill (2001) lists two theoretical supports for the science of motor learning: (a) the general "*motor program* theory" and (b) the "*dynamic pattern* theory". Many who subscribe to the program theory cite from (Schmidt, 1991) with regard to certain fundamental components of physical activities such as *running gait* as being "invariant". According to Magill (2001), Schmidt's *invariant features* theory holds that *relative time* and *relative force* of specific groups of skills or *class of actions* (e.g. the running phases) remain constant. "The term *relative* in the relative time and relative force indicates that what is invariant are the percentages, or proportions, of overall force and timing of the components of a skill" (p.48). Schmidt's theory is also in harmony with the common acceptance of the definition of *abilities*. Schmidt (1991) himself noted; "…abilities themselves do not change because abilities are by definition genetically defined and not modifiable with practice" (p. 145).

Magill (2001) described an alternative theory residing within the behavioural approach, the *dynamic pattern theory*: "The basis for this theoretical viewpoint is a multidisciplinary perspective involving physics, biology, chemistry, and mathematics" (p. 53). It proposes that motor-patterns are not all generated from programs stored in memory; instead, it allows for individual trial and error in determining "preferred" or "attractor" behaviors which best suit the individual. The dynamic pattern theory also calls on concepts, such as *nonlinear behavior* (which is shown in the transition from walking gait to running gait as a function of the increased velocity) to account for variations in "invariant" patterns such as *relative timing* patterns in an individual's running gait. Because both the motor program and the dynamic pattern theories are behaviourally interpreted by most motor-learning texts, there is little consideration for changing an individual's running form outside of changes generated from an intrinsic *interpretation of* and *response to* "environmental" factors.

How these theories have affected the last thirty years' praxis in the general teaching of running can be summed up in the comments of renowned road racer/distance runner, Bill Rodgers (1980), "You can't plug yourself into a particular coaching system. What you do is try to study and learn about different coaches, different concepts, and different ways to improve. You experiment. Try a little bit of one, a little bit of another" (p. 282). From a runner's perspective, Rodgers appeared to reflect on some appealing qualities of the sport of distance running; he was certainly reflecting (less fondly) on established coaching methodologies.

Partly due to the state of motor learning theory, coaches have been let "off-the-hook" as far as being responsible for teaching efficient running form. Among distance running coaches, high mileage training programs have become a catch-all method for addressing the development of running form, along with other various essential factors (i.e. VO_2max development, strength and stamina development) that contribute to running performance. There is always a hope that high-mileage training can be effective for promoting running efficiency if runners are afforded the opportunity to shadow runners who have already acquired efficient running mechanics; this strategy would be particularly advantageous to university sports programs that are able to draw the accomplished athletes who already display superior running behaviors.

There remains, however, impetus to directly address the issues of biomechanical efficiency in running, even among distance running programs that use high mileage training. Many debilitating injuries are directly related to overuse and poor running mechanics; this fact is pointed out by Messier, Edwards, Martin, et al. (1995) who suggest high mileage training has direct links to *iliotibial band friction syndrome*. Excessive heel-strikers, according to Laughton, Davis and Hamill (2003), often suffer overuse injuries; they recommend, "…runners, with shock related injuries such as stress fractures, might benefit from switching to an FFS (*forefoot-strike pattern*)" (p. 154).

There has been a growing community of coaches who have echoed dissonance to the idea of relying solely on "chance" as the teacher of running skill; one such voice is former Humboldt State cross country & track coach, Jim Hunt, who issued this warning to any coach who would neglect the important undertaking of directly addressing the neuromuscular development of young runners: "Beginning runners left to their own means and interpretations of the kinetics of running, almost without exception, will develop a pattern of over striding, with a slow on-and-off the running surface foot action" (Hunt, 2004, p. 1).

Two *attractor* behaviors, over striding and long ground-contact times (relative ground-contact time is regarded as an "invariant feature") were identified in Hunt's statement; he implied that if these two behaviors were not improved upon, a runner may never be able to translate inherent or acquired physical and psychological attributes, such as anaerobic power, increased VO_2max and motivation, into fast race times. This statement also implies that methodologies exist for developing a runner's performance potential through specific neural motor-behavioural intervention. This question was posed: Which specific neuromuscular activation patterns produce the kinematics and biomechanical events associated with efficient running? In simpler terms, how do the muscles of efficient runners behave? How can we run smarter?

Recent studies have linked specific motor-behaviors with kinematic and biomechanical running efficiency. With the application of electromyography (EMG) and video analysis it was discovered that the muscle timing, relative to the events common to all runners (such as foot-strike and toe-off), played a significant role in determining the physics (kinetics and kinematics) of ground-contact. Furthermore, it was determined that motor-pattern timing had a direct effect on "over striding" and "slow on-and-off the running surface foot action", spoken of in (Hunt, 2004, p. 1).

Establishing this link required the creation of a means to quantifiably measure the behaviours, *over striding* and *relative ground-contact time.* These variables, called *angle of foot-strike* (FS) and *ground-speed* (GS) would also serve as indicants of mechanical efficiency within a task analysis system, consisting of six components, called the Kinematic Running Assessment Method. This method is described in "KRAM System Components" which can be accessed at http://www.nwglory.com/Learning.html

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