Track and Cross Country Journal, 2016, Vol. 2, No. 4
Published Online April 21, 2016 http://www.tccjournal.org

Video Analysis Tools for the Assessment of Running Efficiency

Marshall Milbrath[1], Peter Stoepker[2], and Jennifer M. Krause[3]

[1]Marshall Milbrath is a doctoral student in sport pedagogy/coaching education in the School of Sport and Exercise Science and assistant track and field coach at the University of Northern Colorado and Coaching Education Instructor for USA Track and Field.

[2]Peter Stoepker is a doctoral student in sport pedagogy in the School of Sport and Exercise Science at the University of Northern Colorado and an avid marathoner and triathlete.

[3]Jennifer Krause is an assistant professor of sport pedagogy in the School of Sport and Exercise Science at the University of Northern Colorado and former middle school track and field coach.

Abstract

Technology-based assessment in sport has become increasingly popular. This is in part due to increasing accessibility to programs and mobile applications that can be used with minimal training. Coaching endurance runners is no different in its interest in movement analysis of athletes. Many mobile applications have been used by endurance running coaches to augment assessment practices in coaching. Three such apps are Coaches' Eye, Hudl (formerly Ubersense) and SloPro. This paper will highlight the advantages and limitations of these mobile apps with an emphasis on capability and comparisons among them. Furthermore, this article will explore how these apps can guide coaches to help improve coaching practice with endurance runners.

Keywords

Assessment, Apps, Applications, Video Analysis, Running

Introduction

A common and traditional way to assess athlete performance is based on the observation of and augmented feedback from an expert person, such as a coach (Ahmadi, Rowlands, & James, 2009). Augmented feedback, which can be essential for skill acquisition, provides athletes with knowledge or results and performance that they would not otherwise receive on their own and facilitates achievement of the action goals and motivates the athlete to continue striving toward the goals and is often used to enhance other types of feedback (Magill, 2011). However,

using coach observation and basic augmented feedback in assessing athletes limits the potential to assess an athlete objectively. Coach observation is a subjective method, based upon coach experience, which is complicated by speed of a skill which cannot always be detected by human eyes (Ahmadi et al., 2009). Technology-based assessment in sport, such as video analysis software has become increasingly popular and important as a more reliable and objective form of augmented feedback. This, in turn may result in enhancing athletic performance (Sprigings, Marshall, Elliott, & Jennings, 1994). Increasing popularity of video analysis software has been met with increasingly user-friendly and inexpensive options for video analysis, including mobile applications, or apps. The portability of mobile devices (e.g., smartphones and tablets) in conjunction with movement analysis applications now allows coaches to easily and objectively assess movement (Trout, 2013). Digital movement analysis is an effective tool that can be used by a wide variety of coaches. It is often used for individual qualitative motor skill analysis, such as a soccer player's kick or a baseball player's swing. In addition, it has been used for tactical analysis of team and dual sports to evaluate offensive and defensive strategies. It is also becoming an essential tool for assessing and developing runners' efficiency.

Coaches assessing runners now have a systematic approach to analyzing running by using video analysis (Fleming, Young, Dixon, & Carré, 2010). Video analysis can provide relatively detailed gait information and other characteristics (Fleming et al., 2010). Video analysis can be used to detect errors in form, which can in turn inform decisions that may help prevent injury (De Cock, De Clercq, Willems, & Witvrouw, 2005). With these things in mind, it is plausible to suggest that abstaining from use of video analysis in the assessment of runners could result in the optimal rate of development never being reached. Therefore, the purpose of this article is to identify running efficiency parameters of interest while highlighting tools that can be used to assess these parameters using low-cost video analysis with mobile applications that can be used by coaches at any level.

Parameters of Interest in Assessing Running Efficiency

When coaching endurance runners, running economy is a major factor of interest as it can account for variations in race performance (Conley & Krahenbuhl, 1980). Biomechanical parameters indicative of running efficiency contribute to running economy. Among these parameters are stride characteristics, such as stride rate and vertical oscillation, as well as foot strike characteristics, including ground contact placement and ground contact time (Magness, 2014).

Importance of Stride Characteristics

Stride characteristics include stride frequency and vertical oscillation. A stride is defined as two steps, or a locomotive action beginning with one foot and ending with the same foot, with stride frequency being measured in strides per minute. Research has shown that runners tend to self-select stride frequencies that optimize running efficiency (Cavanagh & Williams, 1982), with evidence also indicating that changes in stride frequencies can result in increased efficiency (Morgan et al., 1994). While this article does not provide methods for measuring running economy as a result of variations in stride frequency, the assessment of stride frequency, in itself, may be of interest to a coach.

Vertical oscillation is the amplitude by which the hips rise and fall vertically during each stride. Vertical oscillation in itself is not detrimental to running efficiency. However, exaggerated oscillation has been related to a loss in running efficiency (Magness, 2014). When assessing a runner, it has been stated that a coach should not focus on simply minimizing vertical oscillation, but rather finding the optimal vertical oscillation of the individual (Magness, 2014). These implications of vertical oscillation may be of interest to the running coach, and as such require and effective means of assessment.

Importance of Foot Strike Characteristics

Ground contact placement and ground contact time are both implicated in the assessment of foot strike. Ground contact placement techniques have been often debated with deliberations centering on arguments for why or why not heel striking (contacting the ground heel first when taking a step forward) versus midfoot/forefoot striking (contacting the ground first with the forefront of the foot when taking a step forward) is more advantageous in

increasing running efficiency (Magness, 2014). Various studies have reported that both of these ground contact placements can promote optimal running efficiency (Arogo, Lafortuna, Minetti, Mognoni, & Saibene, 1995; Cavanagh & Williams, 1982). It is likely that individual differences exist in optimal striking technique and that these differences may be further differentiated at different running speeds (Kyrolainen, Belli, & Komi, 2001).

Ground contact time is the length of time that a foot remains on the ground during a step. Ground contact time is related to ground contact placement and it is generally accepted that minimizing ground contact time is encouraged when coaching runners (Magness, 2014). Taken together both ground contact placement and ground contact time can be assessed by the coach in regards to how each affects the other as well as performance. As with the other running efficiency parameters, this article does not aim to provide gold standards for these parameters, but instead identifies the implications of these two components in running efficiency indicating the importance in assessing these characteristics. For a more comprehensive review of all running efficiency parameters, including ranges in optimal demonstration, see Magness (2014).

Assessing Running Efficiency Parameters using Video Analysis Mobile Applications

Movement analysis software has become increasingly mainstreamed. Dartfish is well known software but is expensive and potentially more sophisticated than some coaches may want to use (Trout, 2013). Many movement analysis apps exist and are available on Android and iOS operating systems. This article addresses three of these apps: SloPro, Hudl (formerly Ubersense), and Coach's Eye. Each of these apps features tools that can aid a running coach in the assessment of an athlete with small differences between them pertaining to cost and functionality.

SloPro (Sand Mountain Studios, Provo, UT; Free) is the simplest of these three apps. With SloPro, a video can be taken using the app or with the camera of a mobile device and can be uploaded post-recording. SloPro then enables the user to adjust the speed of the video for assessment of the demonstrated skill. Selections can be made of the video and play speeds can be designated for the selected sections. This app allows a coach to subjectively review the biomechanics of the skill at a slower speed allowing the coach to detect movements that may have been missed at full speed. Practical application of this would be recording an individual running on a treadmill and then observing foot contact placement (e.g., heel strike vs. midfoot/forefoot strike) (Figure 1). Advantages of this app include a simple, user-friendly way to review movement with a free app. It is, however, limited by its lack of functionality to analyze movement in a quantified way.

Hudl (Ubersense Inc., Lincoln, NE; Free) possesses the same variable speed playback capabilities as SloPro, but additionally includes enhanced capabilities and tools that can be used to assess movement in a quantified way. Like SloPro, video can be taken with the app or uploaded from an existing file, which can then be tagged with the name of the athlete and the exhibited technique. This allows for libraries to be created allowing for easy future access. When analyzing, the user can either play back the video at variable speeds or gradually scroll through the video using a scroll bar at the bottom of the screen. Additionally, the user can play videos side-by-side simultaneously in order to compare individuals or different efforts of the same person. When the user has found a screenshot of interest, tools such as lines, arrows, polygons, or a protractor can be used to highlight body positions and posture of interest. Comments can also be left by the coach, and the video can then be shared with others directly from the app. While the app itself lacks a way to capture the remarks on the still image, taking a screenshot with the mobile device is a way to save the image.

Practical applications of these capabilities would include using the on-screen tools to assess vertical oscillation. A line could be inserted on the picture over the hip of the runner at the highest point of the oscillation (Figure 2). A second line could then be inserted at the lowest point. While this does not allow for a quantified measurement of the vertical oscillation, if care is given to video the athlete from a consistent distance, then the coach can compare between various sessions. Another example with Hudl would be measuring the stride rate of a runner (Figure 3). To do this, the video is paused at the moment a foot touches down. It should also be noted that this is the moment when ground contact position can be assessed. The user then takes note of the timestamp at the bottom of the screen. The video is then played and the paused at the next time the same foot touches down, again taking note of the time stamp. The difference between the times indicates the time of one stride. The stride rate (strides per minute) can then be calculated with the following equation:

Stride Rate = 60/ time of 1 stride

Advantages of this app include a cache of tools with which the coach can use to assess the athlete in a quantified way, while it is limited by its inability to capture on-screen comments through either video or still shot.

Coach's Eye (TechSmith Corp., Okemos, MI; $4.99) possesses the same assessment capabilities as Hudl in addition to others. Like Hudl and SloPro, video can be taken with the app or uploaded from an existing file, which can then be tagged with the name of the athlete and the exhibited technique. It can also play back video at variable speeds but can also do so with an overlaid stopwatch tool that allows the user to see time differences between points of interest in the video. Like Hudl, the user can scroll through side-by-side or solitary video to look for positions of interest using tools to quantitatively assess the athlete. Figure 4 shows the ability to evaluate ground contact time as well as stride frequency using the on-screen stopwatch. To use this, the video is paused at a point of interest; in this case it is when the foot touches the ground (Figure 4-A). The stopwatch can then be placed on the screen which then measures time relative to that point in the video. Figure 4-B shows the moment the foot leaves the ground with the time on the stopwatch providing the ground contact time. Lastly, Figure 4-C shows the stride time without the need for calculation, which can then be converted to stride rate by the above equation.

An additional capability of Coach's Eye is that the user can record the screen while using the assessment tools in order to share the annotated video. However, some of the most distinguishing features of Coach's Eye are the network of videos to which the user has access. A user can then use Coach's Eye to browse videos posted by other users, which can then be imported for further analysis. Additionally, packages featuring elite athletes are available for in-app purchase, which can then be used for side-by-side comparisons or simply to assess the techniques of elite athletes to be used for future reference. While these distinct features of Coach's Eye certainly have advantages, many of the features, including some assessment tools, come at an additional cost beyond the price of the app.

Benefits of Video Analysis Apps

The apps discussed in this paper, as well as many others on the market provide coaches with an easy to use and easily accessible tool to evaluate their runners' efficiency. Many elite athletic programs have access to advanced software, such as Dartfish, which can cost thousands of dollars. A majority of running coaches do not have access to or funds for such advanced software. Most basic video analysis apps, however, are very low cost or free and do not require additional equipment or software above a simple smartphone or tablet. These features make these apps more attractive and accessible to coaches of all levels. Youth running club, high school varsity, and college level cross country/track coaches can all use these simple and affordable apps to improve the efficiency of their runners.

Conclusion

Solely using coach observation as a technique limits assessment of athletes and the ability for athletes to be provided with objective augmented feedback on their skills. When coaching running characteristics related to running efficiency are of interest in order to improve performance. Using mobile applications like, SloPro, Coach's Eye, and Hudl provide a low cost tool by which coaches can assess athletes objectively. Use of mobile applications like these and others eases the assessment process allowing the coach to augment the way in which training is implemented and assessed within the parameters of the existing program.

References

Ahmadi, A., Rowlands, D., & James, D. A. (2009). Towards a wearable device for skill assessment and skill acquisition of a tennis player during the first serve. *Sports Technology*, *2*(3-4), 129–136. http://doi.org/10.1080/19346182.2009.9648510

Arogo, L. P., Lafortuna, C., Minetti, A. E., Mognoni, P., & Saibene, F. (1995). Metabolic and mechanical aspects of foot landing type, forefoot and rearfoot strike, in human running. *ACTA Physiologica Scandinavica*, *155*(1), 17 – 22. http://doi.org/10.1111/j.1748-1716.1995.tb09943.x

Cavanagh, P. R., & Williams, K. R. (1982). The effect of stride length variation on oxygen uptake during distance running. *Medicine and Science in Sports and Exercise*, *14*(1), 30 – 35. http://doi.org/10.1249/00005768-198201000-00006

Conley, D. L., & Krahenbuhl, G. S. (1980). Running economy and distance running performance of highly trained athletes. *Medicine and Science in Sports and Exercise*, *12*(5), 357 – 360. http://doi.org/10.1249/00005768-198012050-00010

De Cock, A., De Clercq, D., Willems, T., & Witvrouw, E. (2005). Temporal characteristics of foot roll-over during barefoot jogging: Reference data for young adults. *Gait & Posture*, *21*(4), 432–439. http://doi.org/10.1016/j.gaitpost.2004.05.004

Fleming, P., Young, C., Dixon, S., & Carré, M. (2010). Athlete and coach perceptions of technology needs for evaluating running performance. *Sports Engineering*, *13*(1), 1–18. http://doi.org/10.1007/s12283-010-0049-9

Kyrolainen, H., Belli, A., & Komi, P. V. (2001). Biomechanical factors affecting running economy. *Medicine & Science in Sports & Exercise*, *33*(8), 1330–1337.

Magill, R.A. (2011). *Motor Learning and Control (9th ed*). New York: McGraw-Hill.

Magness, S. (2014). The Science of Running (pp. 81–98). Origin Press.

Morgan, D., Martin, P., Craib, M., Caruso, C., Clifton, R., & Hopewell, R. (1994). Effect of step length optimization on the aerobic demand of running. *Journal of Applied Physiology*, *77*(1), 245 – 251.

Sprigings, E., Marshall, R., Elliott, B., & Jennings, L. (1994). A three-dimensional kinematic method for determining the effectiveness of arm segment rotations in producing racquet-head speed. *Journal of Biomechanics*, *27*(3), 245–254. http://doi.org/10.1016/0021-9290(94)90001-9

Trout, J. (2013). Digital movement analysis in physical education. *Journal of Physical Education, Recreation & Dance*, *84*(7), 47–50.