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Differential effects of main error correction versus secondary error correction on motor pattern of running

Stefano Corte [a], Valentina Cavedon [b], Chiara Milanese [b,*]

[a] PhD Course in Science of Physical Exercise and Human Movement, University of Verona, Italy
[b] Department of Neurological and Movement Sciences, University of Verona, Italy

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ABSTRACT

The aim of this study was to gain a better understanding of how the run pattern varies as a consequence to main error correction versus secondary error correction. Twenty-two university students were randomly assigned to one of two training-conditions: 'main error' (ME) and 'secondary error' (SE) correction. The rear-foot strike at touchdown was hypothesized as the 'main error', whereas an incorrect shoulder position (i.e., behind the base of support) as the 'secondary error'. In order to evaluate any changes in run pattern at the foot touchdown instant, the ankle, knee and hip joint angles, the height of toe and heel (with respect to the ground), and the horizontal distance from the heel to the projected center of mass on the ground were measured. After the training-intervention, the ME group showed a significant improvement in the run pattern at the foot touchdown instant in all kinematic parameters, whereas no significant changes were found in the SE group. The results support the hypothesis that the main error can have a greater influence on the movement patterns than a secondary error. Furthermore, the findings highlight that a correct diagnosis and the correction of the 'main error' are fundamental for greater run pattern improvement.

1. Introduction

In sport consistent errors in technique are very common among athletes and due to the ability of athletes to compensate, these errors are often part of the final performance. These errors over time, through months or years of training, are incorporated into the motor pattern, in a sense they are 'learned' errors and are far more difficult to remove. Learned errors, sometimes called skill-based errors, overlearned errors or recurrent errors are among the most common of all error forms in human learning (Reason, 1990). They must be identified and corrected because they cause a decrease in performance and an increase in the possibility of injury.

The correction of errors in technique in motor skills represents one of the major issues in motor control and motor learning literature (Diedrichsen, White, Newman, & Lally, 2010; Seidler, Kwak, Fling, & Bernard, 2013; Shadmehr, Smith, & Krakauer, 2010). However, these errors are not easy to identify. It is known that all motor skills present a number of constraints that are related to the skill task. These include the individual's body characteristics, their personal style and environmental constraints and understanding them is a valuable tool to increase the effectiveness of learning interventions (Williams, Irwin, Kerwin, & Newell, 2014).

* Corresponding author at: Department of Neurological and Movement Sciences, University of Verona, Strada Le Grazie, 8, 37134 Verona, Italy.
E-mail address: chiara.milanese@univr.it (C. Milanese).

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Another important effect on the precision of a movement task is variability. When an athlete is asked to perform the same skill twice, despite the same physical and environmental constraints, variation can be observed (Davids, Araújo, Glazier, & Bartlett, 2003). The variability which is a common feature of human movement is present in all motor performance and can be observed when multiple repetitions of a task are performed (Stergiou, Harbourne, & Cavanaugh, 2006). Variability, is viewed as "undesirable system noise" and even as "errors in movement pattern" by the cognitive motor control theorists. The ecological motor control theorists however, suggest a functional role to variability (Bartlett, Wheat, & Robins, 2007). The introduction of variability into the movement, they believe, is to give the athlete the possibility of adapting to any environmental constraints that may present themselves (Davids et al., 2003; Davids, Button, & Bennett, 2008). In the world of sport, it is important for biomechanists and coaches to be able to interpret inter and intra variability in technique to understand the cause of the variability. This variability may or may not be useful in adapting movements but it needs to be separated from the underlying errors within the technique which is where the skills of the coach or the data collection of the biomechanist come into play.

A critical skill for coaches is the ability to use their knowledge of a movement and their perceptual abilities to understand the details of the movement with the naked eye. Then, based on their observation, they diagnose the technical errors and limiting factors making on-the-spot decisions regarding the technique and providing feedback to their athletes.

Technique analysis in coaching is predominantly qualitative but it may is used to better understand the intricacies of the way in which skills in sports are performed. This analysis provides the groundwork for improving performance (Lees, 2002) and the information is used in the coaching process. Qualitative analysis was defined by Knudson and Morrison (2002) as the 'systematic observation and introspective judgment of the quality of human movement for the purpose of providing the most appropriate intervention to improve performance'. It is an analytic method that integrates experimental and scientific observation into a theoretical and coherent systematic process in order to focus on key elements of performance technique.

According to Pinheiro and Simon (1992), an accurate description and evaluation of the moving body segments through experience and understanding is essential to the overall analytic process. A basic understanding of mechanical terms and concepts is necessary, as well as an ability to apply this knowledge to different types of movement, for the development of an ideal model of each skill. To arrive at this model, four steps are suggested: determine the performance criteria; break the skill into parts; determine the mechanical factors affecting performance; identify the critical features (Bartlett, 2007; McPherson, 1990). Using information through the observation of the timed, sequential joint motions and other biomechanical features of the process, comparisons can be made between movement of the subject and the previously outlined ideal model. Not every aspect of the movement can be observed which is why a number of cues are used to correctly diagnose errors within the movement. The choice of cues is not arbitrary or random but is based on systematic observation of the motor skill, looking specifically for discrepancies between the current performance and the ideal model (Hoffman, 1983). Often, the experience of the coach helps when paying particular attention to certain aspects of the movement to confirm the presence or absence of 'common or probable errors'.

Once the observation and initial diagnosis has been made the second step is to decide what needs to be changed and how to stimulate the change. The numerous errors that can appear in a complex sport skill need, in some way, to be classified according to their importance on the final outcome. In the evaluation phase the coach interprets the discrepancies and identifies the errors, deciding which discrepancies affect performance, which discrepancies can be considered style variations and which discrepancies indicate modifications the athlete has made to accommodate morphological or environmental constraints. McPherson (1990) also discusses the differences in types of error when she underlines the presence of main and secondary errors and the importance of their discrimination. The main error is a repeated serious technical error within the movement pattern that most greatly affects performance outcome and increases the risk of injury and this error represents the starting point of the intervention process. Among several errors which may be present in a given movement it is this single main error that influences the dynamic balance of the body most strongly and has the greatest effect on the performance outcome. If other errors are also present (secondary errors), as in the case of novice athletes, these errors, at least in part, may be reflective of compensatory adjustments to achieve the final movement (Cesari & Milanese, 1995; McPherson, 1990). We must remember, however, that in the case of movement patterns with multiple errors present, despite there being one main error that has the greatest effect on performance outcome, the other errors may not all be a consequence of the main error but simply in coexistence. For an athlete's performance to be improved and decrease the risk of injury, the main error would need to be identified and corrected, ignoring any secondary errors if present. In the training process, after correcting the main error, any secondary errors that are a consequence of the main error will also disappear and the coach would be left with only smaller secondary errors which he may or may not feel the need to eliminate.

Once the main error has been identified by the coach or the biomechanist we need to consider how to communicate this to the athlete. This very complicated process of transforming the observed error, by the coach, into useful feedback for the athlete and then for the athlete to convert this information into modifications in the movement pattern, is an area of study which needs to be further explored. Coaching literature emphasizes error prevention or error avoidance strategies ('getting it right the first time'), (Grigalka, 1981). This is obviously the ideal situation but in reality it may be necessary to modify a skill because within the movement, technical errors are present.

Over the last decade different types of feedback to remove these errors have been proposed based on the assumption that practicing motor errors can actually strengthen motor learning. Some examples of these include: 'negative practice' (Sharp, 1988); the metacognitive learning strategy called 'Old way/New way' (Hanin, Korjus, Jouste, & Baxter, 2002); Method of Amplification of Error (Cesari & Milanese, 1995; Milanese, Facci, Cesari, & Zancanaro, 2008). These approaches deem the