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Exploring the kinaesthetic sensitivity of skilled performers for implementing movement instructions

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ABSTRACT

The capability to effectively control or adapt a movement pattern based on instructional feedback is essential for effective motor skill learning in high-level sport, as it is in other domains such as rehabilitation or music. Despite this, little is known about the capabilities of skilled athletes to use kinematic feedback to purposefully modify complex movements. This study examined the accuracy with which skilled junior tennis players could translate specific kinematic feedback into appropriate modifications of their service actions. Participants were required to either increase or decrease maximum knee flexion or shift impact position laterally by incremental amounts. Further, participants were required to execute their serve with the smallest increase and decrease in these kinematic components as they could consciously produce. Inherent variability within the desired target parameters was calculated to add context to the athlete's accuracy. Results demonstrated that while participants had considerable control over their movements, only some instructions were executed with accuracy greater the variability normally present within their movement. As the required change in knee flexion and impact position increased, absolute accuracy of implementation decreased. These findings are discussed with reference to the

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smallest controllable changes produced by the athletes and the variability within their actions.

1. Introduction

Proprioceptive acuity is "the ability to sense joint positions, movement and force of muscle contraction and to discriminate movements of limb segments individually and relative to each other" (Muaidi, Nicholson, & Refshauge, 2008, p. 371). Proprioceptive acuity represents a critical feature within movement learning domains such as physiotherapy, dance or sports coaching, where the performer must integrate the guidance of an instructor into the conscious control of their movement pattern(s). A movement pattern refers to the behavioral characteristics (spatial, temporal and spatio-temporal characteristics) of a specific limb or combination of limbs that from a component of an action (e.g., walking) or a skill (e.g., striking a ball) (Magill, 2007). The capacity of the performer to directly integrate specific instructions and error-correction feedback is not well understood, with the available research limited to a relatively small number of studies conducted within clinical settings (Rosker & Sarabon, 2010). Work in these settings has typically focused upon relatively untrained groups of individuals, usually in rehabilitation, seeking to recover proprioceptive acuity after injury or surgery, (Cooper, Taylor, & Feller, 2005; Fischer-Rasmussen & Jensen, 2000; Fridén, Roberts, Zätterström, Lindstrand, & Moritz, 1996). Perhaps surprisingly, there has been very little research work to date that has considered the capacity of people with highly developed movement skills, such as elite athletes, to implement fine-grained proprioceptive changes based on instruction and feedback from their coach. Consequently work of this type offers potential as a valuable addition to our understanding of the skill learning process.

Proprioception is typically measured using one of several psychophysical methods such as the measurement of joint position sense, the absolute judgment method or via determination of the threshold to detect passive motion (Fischer-Rasmussen & Jensen, 2000; Muaidi et al., 2008; Roberts, Friden, Stomberg, Lindstrand, & Moritz, 2000). Research using such methods has shown that proprioceptive acuity for the knee to be relatively small for both rotational and flexion/extension movements (0.5°–6.5°) (Fischer-Rasmussen & Jensen, 2000; Fridén et al., 1996; Pap, Machner, Nebelung, & Awiszus, 1999; Roberts et al., 2000). In a rare study of athletes, Muaidi, Nicholson, and Refshauge (2009) found skilled soccer players exhibited significantly greater proprioceptive acuity for knee rotation compared to non-athletes. While clinical research has shown sensitivity to changes in kinematics that are often quite small, these sensitivities are typically measured in quite static postures rather than within dynamic movements and hence it is relatively unknown whether these sensitivities measured in isolation are maintained, enhanced or diminished when the joints concerned are involved in performance of more dynamic and complex movements of the type typical in sport.

In contrast to the case of sensitivity for movement correction/adjustment, the role of instruction and feedback has received a great deal of attention in the domain of movement science (Hodges & Franks, 2002; Phillips, Farrow, Ball, & Helmer, 2013; Shea & Wulf, 1999). The bulk of this research surrounds the type, content, and timing of the feedback provided (Wulf & Shea, 2004), with less focus on the specificity of the information provided (Abernethy, Masters, & Zachry, 2008). Instruction has been provided both before skill execution, to shape the performer's practice attempt, and after skill execution, so that comparison to the desired movement pattern can be considered and adaptations sought. Instructions have been shown to be able to be successfully used to alter the kinematic parameters of specific skills. For example, McNair, Prapavessis, and Callender (2000) examined the effect of technical instructions on lowering ground reaction forces during a vertical jump. Results demonstrated that technical instructions such as "bend your knees until well after landing" and "position yourself on the balls of your feet" significantly reduced ground reaction forces. The efficacy of such instructions is particularly important when the resultant kinematic changes are associated with injury prevention.