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Effect of different knee starting angles on intersegmental coordination and performance in vertical jumps

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ABSTRACT

This study aimed to analyze the effect of different knee starting angles on jump performance, kinetic parameters, and intersegmental coupling coordination during a squat jump (SJ) and a countermovement jump (CMJ). Twenty male volleyball and basketball players volunteered to participate in this study. The CMJ was performed with knee flexion at the end of the countermovement phase smaller than 90° ($CMJ_{<90}$), greater than 90° ($CMJ_{>90}$), and in a preferred position (CMJ_{PREF}), while the SJ was performed from a knee angle of 70° (SJ_{70}), 90° (SJ_{90}), 110° (SJ_{110}), and in a preferred position (SJ_{PREF}). The best jump performance was observed in jumps that started from a higher squat depth ($CMJ_{<90}$–SJ_{70}) and in the preferred positions (CMJ and SJ), while peak power was observed in the SJ_{110} and $CMJ_{>90}$. Analysis of continuous relative phase showed that thigh–trunk coupling was more in-phase in the jumps (CMJ and SJ) performed with a higher squat depth, while the leg–thigh coupling was more in-phase in the $CMJ_{>90}$ and SJ_{PREF}. Jumping from a position with knees more flexed seems to be the best strategy to achieve the best performance. Intersegmental coordination and jump performance (CMJ and SJ) were affected by different knee starting angles.

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1. Introduction

In order to reach maximum jump height, humans often select different initial squat-depth positions. According to Bobbert, Casius, Sijpkens, and Jaspers (2008), when different postures are assumed, the muscle-tendon units of the lower limb are at different lengths, so they will produce different forces and joint moments at a given level of stimulation. The modulation of squat depth may affect some variables related to vertical-jump performance, such as peak power output and impulse (Dowling & Vamos, 1993; Harman, Rosenstein, Frykman, & Rosenstein, 1990), and consequently, the jump height (Moran & Wallace, 2007).

Some authors have found that in squat (SJ) and countermovement jumps (CMJs) performed with a higher squat depth, it is possible to reach higher height, net impulse and take-off velocity; however, power output and force decrease in this situation (Domire & Challis, 2007; Kirby, McBride, Haines, & Dayne, 2011; McBride, Kirby, Haines, & Skinner, 2010). On the other hand, Moran and Wallace (2007) state that a smaller range of knee motion combined with an increasing negative phase resulted in a significantly greater countermovement jump height. Therefore, researches have shown inconsistencies in how performance and biomechanical variables are modulated in different initial squat positions or ranges of knee motion during the SJ and CMJ.

Additionally, little attention has been given to analysing whether there are changes in movement coordination during jumps performed from different ranges of motion and what the effect of such differences on jump performance might be. Domire and Challis (2007) reported that the SJ performed from a deeper squat depth did not result in larger jump heights, and they suggested that the results were due to non-optimal coordination during the jumps. Movement coordination was previously analyzed by Van Soest and Bobbert (1993), who suggest that when different initial postures are assumed during the jump, irrespective of the force production, different accelerations are generated; hence, the dynamics, and possibly the coordination of movement, could be affected. On the other hand, it has been postulated that subjects may perform movements from a range of initial postures using the same pattern stimulation (Van Soest, Bobbert, & Van Ingen Schenau, 1994), so the dynamic or coordination would not change during jumps performed from different squat depths.

Joint coordination has been evaluated by using different methods such as electromyography (Bobbert & Van Ingen Schenau, 1988; Rodacki, Fowler, & Bennett, 2002), timing and sequencing of segmental movements (Rodacki, Fowler, & Bennett, 2001), and continuous relative phase (CRP) (Hamill, Van Emmerik, Heiderscheit, & Li, 1999; Quinzi, Sbriccoli, Alderson, Di Mario, & Camomilla, 2014; Seifert, Leblanc, Chollet, & Delignières, 2010; Van Emmerik & Wagenaar, 1996). The last method is based on a dynamic system approach (Kelso, 1984), providing information on the stability of the coordination patterns by time–angle relationships inter-/intralimbs during an entire cycle of movement (Hamill et al., 1999; Kelso, 1984). The CRP was recently used for analysing the effects of fatigue on coordination during continuous jumps (Dal Pupo, Dias, Gheller, Detanico, & Santos, 2013). This method could also be an interesting tool for investigating the effect of different ranges of knee motion on vertical-jump coordination. To our knowledge, no previous studies have analyzed the coordination of CMJ and SJ with this approach considering different knee-angle positions. The main hypothesis is that the CRP changes according to the level of squat depth. Therefore, this study aimed to analyze the effect of different knee starting angles on jump performance (jump height), kinetic parameters, and intersegmental coupling coordination during SJ and CMJ.

2. Methods

2.1. Participants

Twenty male volleyball and basketball players (23.5 ± 3.58 years; 82.38 ± 9.83 kg; 185 ± 6.31 cm; 13.79 ± 3.31% body fat) volunteered to participate in this study. Participants trained on a regular basis