THE USE OF TRIPLE JUMP TRAINING DRILLS IN REPLICATING MOVEMENT COORDINATION PATTERNS

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The purpose of this study was to investigate how effective triple jump training drills are at replicating the lower extremity coordination patterns utilised during the triple jump. Relative motion plots and a modified version of the vector coding technique were used to quantify the coordination patterns of the lower extremities in the triple jump and four related training drills. Differences were found to exist in the coordination patterns between the triple jump and static, but not dynamic, drills and these differences were mainly in the swing (free) leg. The results of this study suggest that if the primary purpose of the training drills is to replicate the movement patterns utilised in the triple jump then dynamic drills are more effective than static drills. In addition, coaches should focus on the use of the free leg during these training drills.

KEYWORDS: joint coupling, triple jump, drills

INTRODUCTION:

The triple jump is a complex movement consisting of three separate, yet integrated phases which are carried out in an attempt to maximise the combined distance of all three phases. The demands placed on the body during the triple jump are very high with vertical forces of around 18 body weights experienced during the contact between the hop and step phases (Perttunen et al., 2000). The use of training practices have previously been utilised in the development of complex movements (Irwin and Kerwin, 2005), whereby coaches use the concept of specificity to encourage performance-related adaptations (Irwin et al., 2004). Practice specificity suggests that maximal retention of the performance of a task is facilitated by practice conditions that mimic task conditions (Henry, 1968), and according to Lauder and Payton (1995), training practices or drills should resemble the same movement patterns as the target skill. In addition to developing a complex movement, training practices may also be used to develop and improve movements when the full skill places very high loads on the body and where repetitions should be limited (Elliot, 1999). Coordination patterns can be assessed through the quantification of inter- and intra-limb coordination. Quantifying the similarity between a skill such as the triple jump and training practices or drills in terms of these coordination patterns may provide a better overall assessment of their effectiveness as a training drill (Irwin and Kerwin, 2007). The purpose of this study was, therefore, to examine the differences between full triple jump trials and four plyometric drills, that are employed in training, in terms of the coordination strategies adopted by the lower extremities during the hop-step transition phase. It was hypothesized that the coordination patterns of the drills employed in training are the same as those utilised in triple jumping performances.

METHOD:

Five competitive triple jumpers (three males and two females) were recruited as subjects for this study. All of the subjects were members of the same training group and had the same coach. Using a 12-camera Vicon^{TM} MX13 motion analysis system, three-dimensional kinematic data were collected at 100 Hz during the hop-step transition phase of the triple jump and four related training drills. The drills were selected following interviews with coaches and were all based on the replication of the hop-step transition. The drills were as follows; a static hop-step (D1), a 3-stride hop-step (D2), a static hop-step from a 30 cm platform (D3) and a 3-stride hop-step from a 30 cm platform (D4). Simultaneously, ground reaction force data were sampled at 1000 Hz using a Kistler force platform synchronised through the Vicon system. Thirty-nine retro-reflective spherical markers of 14 mm diameter were attached to specific anatomical landmarks on the subject for use with the Plug-In-Gait model (Vicon^{TM}, Oxford Metrics Ltd., Oxford, UK). Each subject performed a total of three triple jump trials and three trials of each drill. Coordinates for each of the 39 reflective markers were reconstructed using Workstation software (version 5.2.4, Oxford Metrics Ltd., Oxford, UK). Lower extremity joint angles were subsequently calculated. The frames associated with touchdown and toe-off, for the hop-step transition phase, were identified for each trial. The angle data between touchdown and toe-off were then interpolated using a cubic spline with touchdown at 0% and toe-off at 100%. Relative motion (angle-angle) profiles and a modified version of the vector coding technique were used to quantify the joint coordination patterns (Heiderscheit et al., 2002). Intra-limb couplings were created for ankle flexion–knee flexion (coupling 1) and knee flexion-hip flexion (coupling 2) of the stance leg and knee flexion–hip flexion of the swing leg (coupling 3). These couplings were chosen on the basis of the importance of knee flexion-extension of the support limb and the use of the free limb during triple jump performances. Relative motion plots were created for each coupling with the abscissa and ordinate comprising the proximal and distal segments respectively. Coupling angles were calculated using the orientation of the resultant vector to the right horizontal between two adjacent points on the relative motion plots. Following conversion from radians to degrees, the resulting range of values for the coupling angles was between 0º and 180º. For each trial the stance phase was divided into 20% intervals, in order that the movement coordination during specified phases of the trials could be investigated. The mean coupling angle over each of the five intervals was calculated for the triple jump trials and the four drills. This procedure was repeated for each intra-limb coupling. For each coupling, a two-way repeated measures ANOVA was employed (trial main effect; phase main effect; trial – phase interaction effect) to investigate any differences in movement coordination patterns between jump and drill trials. Where significant interaction effects were identified, post hoc paired t-tests were employed to examine where the significant differences existed. Significant differences were accepted when $p < 0.05$. In addition, the root mean squared difference (RMSD) between the jump and drill trials was calculated throughout the whole of the contact phase.

RESULTS:

Greater differences were found in coupling 3 (knee flex/ext – hip flex/ext of the swing leg) compared to coupling 1 (ankle flex-ext – knee flex/ext of the stance leg) and coupling 2 (knee flex/ext – hip flex/ext of the stance leg). In addition higher RMSD values were observed in the static drills (1 and 3) than in the 3-stride drills (2 and 4). Figure 1 shows the coupling angles for couplings 1, 2 and 3 for each of the four training drills and the full triple jump. No significant interaction effects between the triple jump trials and drills were found for coupling 1. For coupling 2, a significant difference was found between the jump and drill 1 ($p < 0.05$). For coupling 3 significant differences were found for between the jump and drills 1 and 3 ($p < 0.05$). Where significant interaction effects were found, post hoc paired t-tests were used to identify in which phase of the drill and jump the differences existed. For coupling 2, the difference between drill 1 and the triple jump was found in the first 20% of the stance phase (91.8º ± 7.3 for jump v 115.5º ± 8.8 for drill, $p < 0.05$). For coupling 3, the significant differences between the triple jump and both drill 1 and 3 were found to exist in the middle 20% (40%-60%) of the stance phase (39.6º ± 15.8 for jump v 10.0º ± 5.5 for drill 1, $p < 0.05$, 11.4º ± 5.8 for drill 3, $p < 0.05$). In all trials the transition point between the breaking and propulsive phases of the contact phase was found to occur between 40% and 60%.

DISCUSSION:

This aim of this study was to investigate the differences in coordination patterns of the lower extremities, between training drills and the full triple jump movement, during the hop-step transition phase. If the primary purpose of the training drills, as suggested by coaches, is to replicate the movement patterns utilised in the triple jump then the use of coordination strategies may provide a better overall assessment of their effectiveness as a training drill compared to single joint kinematics. The results of this study suggest that the dynamic drills are more similar to the triple jump than static drills. All of the significant differences between the drills and the full triple jump were found to exist for the static drills (drills 1 and 3) only.

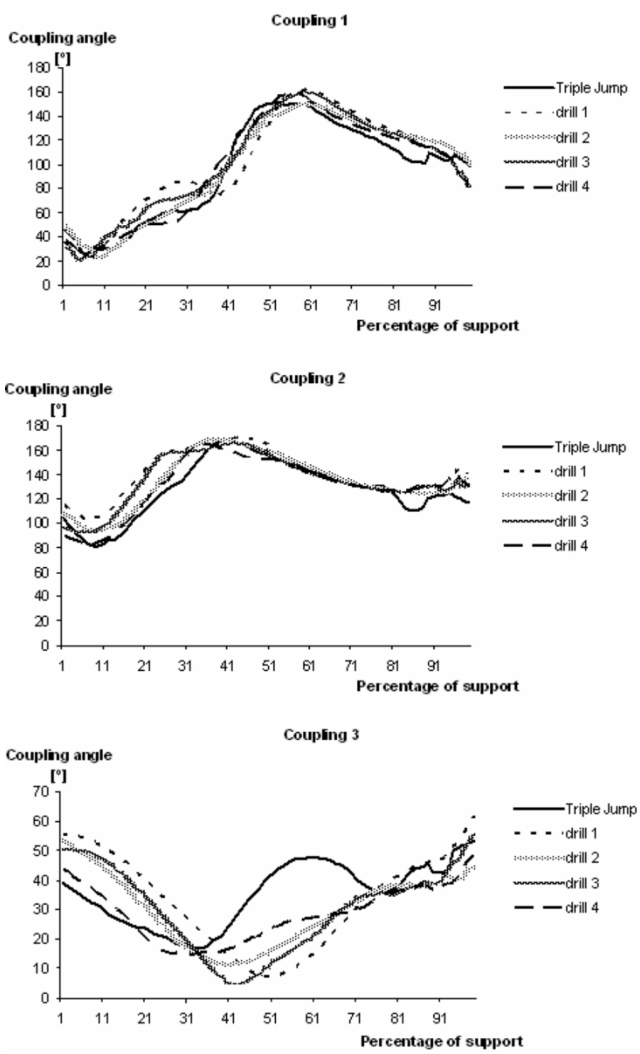

Figure 1. Coupling angles for couplings 1, 2 and 3 for the triple jump and drills

The drills with a 3-stride approach (dynamic drills) would therefore appear to be more effective in terms of replicating the full triple jump movement pattern. The largest differences in the coordination strategies of the drills and the full movement were found to exist within the free (swing) leg (coupling 3). This suggests that whilst the drills might be effective in replicating the movement patterns in the stance leg, they do not appear to be as effective in terms of the free limb. Although the stance leg is clearly an important contributor to success of the support phase (Yu and Andrews, 1998), the free limb has also been identified as important during this phase of jumping, because of its contribution to changes in velocity and angular momentum (Yu and Andrews, 1998) and its effect on the maintenance of balance (Lees and Barton, 1996; Ashby and Heegaard, 2002). The importance of free limbs in successful jumping performance highlights that for training drills to be effective, the free limb movement of the jump performance must be replicated. The majority of the significant differences between drill and jump were found to exist in the middle 20% of the contact phase, which coincides with the transition from braking to propulsion. During this transitional phase, the variation in coordination patterns between jumpers has been shown to be greater than during any of the other phases within the hop-step transition (Wilson et al., 2008). The different strategies adopted by the jumpers during this phase may therefore be crucial to the success of a performance and as such it might be expected that this is the most important phase to replicate within training drills.

CONCLUSION:

The results of this study demonstrate that the static training drills used by triple jumpers are not as effective as the 3-stride approach (dynamic) drills in replicating the coordination strategies used in triple jumping. Therefore, coaches should avoid using these static drills if their primary purpose is to replicate the movement patterns utilised during the triple jump.

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