Fatiguing Effects on Lower Extremity Kinetics and Kinematics in a Countermovement Jump Performed by College-age Females

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Purpose: Examine the effects of leg fatigue on the kinetics and kinematics of jumping at the hip, knee, and ankle as well as its role in the successful completion of a movement. Methods: Eight unskilled college-age females performed two maximal countermovement jumps without fatigue and two maximal countermovement jumps with fatigue from the surface of two Kistler force plates. Subjects were fatigued using a Monark ergometer testing bike, riding with a force of 10% of their body weight for 30 seconds at 100 bpm. Motion analysis was done using reflective markers on the right foot, leg, and arm to determine joint angles using the Expert Vision Analysis, sampling at 120 Hz. Results: Significant differences between normal and fatigued jumps were only found in maximum extension resultant joint torque and range of motion at the hip joint. No significant differences were observed at the knee and ankle joints for these components. There was no significant difference between fatigue and normal jumps in the time, however there was a significant difference in the velocity at takeoff. Conclusions: The reduced resultant joint torque and range of motion at the hip may be an indication of redistribution of the demands of a jump or a fault in the fatiguing method which did not allow for equal exhaustion of lower extremity joints. The former implies that training muscle groups that take more of the demand of a jump could aide in the successful completion of a movement.

Jennifer Garrett & Kaitlyn Warner

Purpose: It is well documented that arm swing increases vertical velocity at takeoff and jump height. The purpose of this study was to examine the effects of arm swing on kinetic and kinematic variables of the lower extremities which increase jump height in a broad participant pool, spanning a wide range of skill levels and sport specialties. Methods: Countermovement and arm-swing characterize most jumping. To determine their effects and interactions, coordinate data of seventeen college-aged (18-22) females performing countermovement vertical jumps with and without an arm swing was collected. Average kinematic data, resultant joint force, and torque at the trunk, hip, knee, and ankle for two trials per condition were measured, computed, and normalized using two Kistler Force plates and the EVA motional analysis system. Results: Larger values for the vertical velocity of the center of mass at take-off were recorded in countermovement vertical jumps with arm swing (mean 1.59 m/s) versus without an arm swing (mean 1.55 m/s). Countermovement vertical jumps without an arm swing showed greater flexion angles in the trunk, hip, knee, and ankle. The no arm swing jumpers maximized joint flexion in order to increase the range of motion in which joint torques could be applied. Conclusions: The use of the arm swing in a countermovement jump optimizes the lower extremity musculature's capacity to produce extensor torques via the force-velocity relationship.

Kevin Howard, Brandon Lee, Anne McKinley

The effects of verbal encouragement on countermovement vertical jumps: a biomechanical analysis

Vertical jumping is a central skill in many sports such as basketball, volleyball, football, and soccer. It is suggested that vertical jump performance can be affected by different forms of motivation by increasing self-efficacy, but little research has been done on the effects of motivation via verbal encouragement. **Purpose** This study examined the effects of verbal encouragement on vertical jump performance and kinematics in 19 college-age female subjects. **Methods** Each subject first performed two countermovement jumps without verbal encouragement, and then received a general verbal message expressing confidence in the subject's ability to improve her performance before completing the two motivated jump trials. **Results** Subjects in the motivated condition displayed significant changes in time from takeoff (TO) to low point (LP), vertical velocity of the center of mass (COM) at TO, vertical displacement of COM at LP, hip flexion angle at LP, maximum trunk extension angular velocity, and maximum hip, knee and trunk flexion angles. **Discussion** Evaluation of effect size using Cohen's *d* assigned small or negligible magnitudes to each of these significant measures. The production of a significant improvement, however, encourages further research in the area, with special attention to confirming increase self-efficacy.

Lauren Denman, Shenae De Weese & Emily Wynne

Surface compliance is a variable that has a large effect on the kinetic and kinematic biomechanics of movement. Purpose: The purpose of this study was to determine the difference in kinetic and kinematic measures, as well as, to make observations about the stiffness of the legs during vertical jumps performed on sand versus a rigid surface. Methods: Nineteen female university students, performed a countermovement jump (CMJ) off two surfaces: a rigid (RS) and sand surface (SS). Two trials per subject per condition were analyzed using 2 Kistler force plates, EVA 7.0 and Kintrak software. Results: A two tailed, paired samples T-test was applied to the data in order to identify the differences in the examined CMJ force and kinematic parameters between RS and SS jumps. Statistical significance was determined at $p<.05$. Max plantarflexion (PF) resultant joint torque (RTJ) at the ankle was significantly greater on SS (while max EXT RJT at hip was greater in RS. Max EXT RTJ for the knee did not differ significantly. Significant was found in all of the following joint angles (in the RS jumpers): ankle PF angle at TO, the maximum flexion angles at the knee and hip, hip EXT/FLEX angle at LP, trunk EXT/FLEX angle at LP was greater in the SS and the angle at TO was greater in the RS. Conclusions: Individuals, when jumping on a RS, had significantly greater joint range of motion and RJT in the hip; they were less stiff on a RS than a SS. Gaining an awareness of biomechanical adjustments made can aide coaches and athletes in determining execution of technique on different compliant surfaces.

Andrew Morrison
Jonathan Lee
Karra Imoto

It is known that the use of arm swing in countermovement vertical jumps increases jump height through a number of mechanisms; however, what hasn't been thoroughly studied is how skilled jumpers utilize an arm swing more effectively than unskilled jumpers. Purpose: To examine the effect that arm swing has on vertical jumping and how skilled jumpers utilize the arm swing to increase their vertical height when compared with unskilled jumpers. Methods: Nineteen college-aged females were separated into "skilled" and "unskilled" groups. Each participant performed two trials of each; a neutral trial, a countermovement jump without an arm swing, and a countermovement jump with an arm swing. During each of the movement trials average vertical ground reaction forces (VGRF) were determined by two force plates while 3D motion of the body, collected by the Peppermint Motion Analysis System, provided joint angles, joint velocities and resultant joint torques (RJTs) of all the relevant points on the body. Three 2x2 repeated measures ANOVAs were used to analyze the dependent variables. Results: The use of an arm swing increased jump height ($p<0.05$) and skilled participants jumped higher than unskilled ($p=0.055$). Skilled jumpers produced RJTs at the ankle ($p<0.055$) than unskilled. There was no significant difference found between the two groups in velocity at the elbow and RJT at the hip or knee. Conclusions: The use of an arm swing has a positive effect on the vertical jumps of both groups. Skilled jumpers utilize the arm swing more efficiently than unskilled jumpers by using the arm swing to increase their RJTs at the knee and ankle closer to take-off, creating higher VGRFs resulting in higher vertical jumps.

Chris Upchurch, Kobylanski, Kealiiokalani & Chi-Chieh Weng

The impact of different jump types is something unique to a variety of sports and activities. The two most applicable jump types are a countermovement (CMJA) and drop-step jump (DSJA). Purpose: The purpose was to examine the differences exhibited at the ankle, hip, and shoulder between the DSJA and the CMJA. In addition, it is intended to illustrate how those differences would yield an increase vertical velocity at take off. Methods: 17 undergraduate, female students from Pepperdine University performed a total of 4 trials of jumps. (2 trials of countermovement w/ arm swing and 2 trials of drop-step jump w/ arm swing). The trials were done consecutively over the plane of two Kistler force plates. The Vertical Velocity (VV), Horizontal Velocity (HV), Angular Velocities of the ankle, hip, and shoulder, and Peak Vertical Ground Force (VGRF) of the right and left feet were determined for each trial. T-tests, correlations, mean and standard deviation between jumps and their measures were done to evaluate the data. Results: The VV had no significant difference between the two jumps ($p=0.410$), but did have a positive correlation ($r=0.931$). The plantar flexion angular velocity of the ankle had a positive correlation ($r=.779$), but showed no significant difference between the two jumps ($p=0.391$). The hip extension angular velocity both showed a significant difference ($p=0.024$) and a positive correlation ($r=0.627$). The angular velocity of the shoulder flexion had a positive correlation between the jumps, but no significant difference. Conclusion: This study cannot be used to define the relationship of the two jumps because of several limitations. The data analyzed showed no difference between the jumps not allowing for major findings to be discovered.

Kathryn Hosey
Braden Mogler
Daniel Timko

Simple observation shows high skill (HS) and low skill (LS) jumpers utilize their bodies in different ways allowing HS individuals better jump height, but how specifically do HS jumpers optimize performance? Purpose: To analyze how joints and musculature of the hips, knees, and ankles contribute to vertical jump height performance in a countermovement jump (CMJ) in HS and LS individuals. Methods: Nineteen college-aged females inferentially separated into HS and LS groups performed two verbally motivated CMJs with an arm swing from the surface of two Kistler force plates. High-speed cameras and motion analysis software collected and calculated various angles, torques, velocities, and impulses and the time at which they occurred. Correlation and regression analysis were used to analyze the data. Results: There was no difference in mean vertical velocity of the center of mass (VVCM) at takeoff (TO) for HS (1.618 m/s) and LS (1.611 m/s), showing the inferential classification to be without basis. Therefore, numerous variables were analyzed for correlation with VVCM at TO. Maximum extension resultant joint torque (RJT) at the knee ($R=0.659$, $p=0.003$), net vertical ground reaction force (VGRF) impulse ($R=0.579$, $p=0.012$), time of maximal knee flexion angular velocity ($R=-0.504$, $p=0.033$), time of maximal elbow flexion ($R=-0.523$, $p=0.026$), and maximum extension RJT at the hip ($R=-0.482$, $p=0.043$) were significantly correlated. Non-significant correlates ($R>0.36$, $p>0.05$) were maximum plantarflexion RJT at the ankle ($R=-0.458$), time of maximal hip extension angular velocity ($R=0.379$), and time of maximum plantarflexion RJT at the ankle ($R=0.363$). Conclusions: RJT at the knee, hip, and ankle are strong contributors to maximum jump height (in order of amount of contribution). Higher jumps were also achieved through better overall technique and coordination of the upper and lower body.

Becca Fung-A-Fat, Heather Hirata & Paige Taylor

Physical fatigue is often cited as the cause of diminished performance in sport skills; however, the exact causes and changes in biomechanics that occur with fatigue are relatively unknown. PURPOSE: The purpose was to investigate any significant differences in resultant joint torques (RJT), joint angles (θ) at hip, knee and ankle (HKA) and vertical velocity at take off (TO) when performing a maximal vertical counter-movement jump (CMJ) pre and post fatigue inducing protocol. METHODS: Eighteen college-aged females performed separate trials of two maximum CMJ's on Kistler force plates before and after fatigue inducing exercise using a maximal cycle ergometer Wingate Test. Reflective markers were placed at strategic anatomical landmarks for motion analysis cameras to capture 3-D kinematic and kinetic data. RJT and joint angles at HKA and vertical velocity at TO data were collected from force plates and cameras, then analyzed using the Kistler Bioware Software and Motion Analysis systems. One way t-tests were run to determine significance of findings. RESULTS: One way t-tests showed no significant difference between the fatigued and un-fatigued vertical velocity at TO ($p=0.18$), RJT's at HKA ($p=0.07, 0.25, 0.24$) respectively, or for joint angles at HKA ($p=0.09, 0.16, 0.44$) respectively. The one factor that showed a statistically significant difference was the maximum knee extension (angular velocity or ω) ($F=1.88$, $p<0.01$). CONCLUSIONS: There were no statistically significant differences in vertical velocity or RJT and angles at all joints, however, maximal knee extension/angular velocity (degrees/s) was found to have significantly decreased with fatigue.