METHODS: Ten collegiate swimmers (1.77±0.07 m, 72.4±7.6 kg, 19.8±1.0 yrs) experienced with dolphin and flutter kicking completed eight 10 m maximal effort underwater kicking trials. Body position and kicking style were randomly varied between trials such that half of all trials were performed using each kicking style and each body position. A calibrated underwater camera was used to record each trial at 60 Hz. Six body landmarks were digitized for three complete kicking cycles to determine linear and angular kinematic measurements. Whole body speed was defined as horizontal hip velocity. Kicking amplitude and frequency were determined using vertical toe movements. The Strouhal number, a dimensionless index related to the efficiency of underwater undulatory movement, was computed using the kicking amplitude, frequency and velocity. Kinematic data were filtered using a fourth order Butterworth low-pass digital filter with cutoff frequencies individually determined for each coordinate. Linear velocities were computed using the first central difference method. Kinematic measures were compared between kicking style and body positions using a 2x2 (kick x position) repeated measures ANOVA.
RESULTS: Dolphin kicking velocity (1.22±0.18 m/s) was faster ($p<0.001$, $\eta^2=0.88$) than flutter kicking velocity (0.99±0.12 m/s). Dolphin kicking amplitude (0.58±0.10 m) was larger ($p<0.001$, $\eta^2=0.93$) than flutter kicking amplitude (0.48±0.08 m). Dolphin kicking frequency (1.85±0.34 Hz) was lower ($p=0.002$, $\eta^2=0.68$) than flutter kicking frequency (2.33±0.33 Hz). Dolphin kicking (0.88±0.12) was more efficient as indicated by a lower Strouhal number ($p=0.001$, $\eta^2=0.71$) than flutter kicking (1.11±0.21). Body position had no effect on any measure of kicking performance ($p>0.05$).
CONCLUSION: For these participants, dolphin kicking was a faster, more efficient form of underwater kicking. However, body position had little effect on the ability of these participants to perform the respective kicking style.

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Higher Vertical Stiffness Is Related To Greater Fifth Metatarsal Bone Mineral Density In Football Players

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(No relevant relationships reported)

Lower-extremity stiffness is suggested to contribute to lower-extremity injury risk. Specifically, lower stiffness is believed to lead to excessive joint motion and contribute to soft tissue injuries. Alternately, higher stiffness is thought to enhance overall joint stability, reduce ligament loading, and potentially increase bone loading. Though beneficial in the short-term, long-term bone loading and the reduced ability to attenuate lower extremity forces may also increase injury risk. Thus, it may be important to elucidate the relationship between stiffness and bone mineral density (BMD).
PURPOSE: To identify differences in BMD between athletes with relatively higher and lower levels of vertical stiffness (K_{Vert}).
METHODS: BMD of the whole body (BMD_{WB}), dominant limb (BMD_{DL}) and second and fifth metatarsals (BMD_{Met2} and BMD_{Met5}, respectively) of the dominant leg, was assessed in 41 male American football players (age: 16.1±1.4 yrs, height: 176.5±6.8 cm, mass: 80.6±18.3 kg) via dual-energy x-ray absorptiometry. Additionally, vertical stiffness (K_{Vert}) of the dominant leg was assessed via a repetitive single-leg vertical hopping task at a set hopping frequency of 2.2 Hz. Participants were divided into tertiles based on their body mass normalized K_{Vert} values. Differences in BMD-related variables between the low- and high-stiffness groups were evaluated using independent t-tests.
RESULTS: Athletes in the high-stiffness group displayed significantly greater K_{Vert} than the low-stiffness group (0.28±0.01 vs. 0.20±0.02 $kN \cdot m^{-1} \cdot kg^{-1}$, $p<0.001$); however, there were no between-group differences identified in terms of age, height, or mass ($p>0.05$). Athletes in the high-stiffness group were found to possess significantly greater BMD_{Met5} compared to the low-stiffness group (0.44±0.11 vs. 0.34±0.11 g/cm^2, $p=0.029$). Similar between-group differences in BMD_{WB}, BMD_{DL}, and BMD_{Met2} were not observed ($p>0.05$).
CONCLUSIONS: Athletes with relatively high K_{Vert} also had greater BMD_{Met5}, indicating that relatively higher stiffness may impose stress on the bone that results in favorable adaptation (increased BMD). Continued work investigating the relationship between K_{Vert}, BMD, and training load may elucidate the risk of bony injury in these athletes is warranted.

1845 Board #106 May 31 3:30 PM - 5:00 PM

The Influence Of Load On Preferred Countermovement Depth During Jump Squats

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(No relevant relationships reported)

The jump squat exercise is used in training to provide increased stress to the countermovement jump. However, it is not clear how load influences preferred countermovement depth during the jump squat.
PURPOSE: Compare preferred countermovement depth (PREF) to full and quarter depths (FULL, QTR) during the jump squat across a range of loads.
METHODS: On day one, participants (Male, n=12; 25.2 ± 3.9 yrs, 1.77 ± 0.7 m, 88.3 ± 15.7 kg) performed a 3 repetition maximum (3 RM) back squat, which was used to estimate the 1 RM back squat (1 RM = 3 RM/0.9). On the second collection 2-10 days later, jump squats were performed with barbell loads of 0%, 15%, 30%, 45%, 60%, and a return to 0% of 1 RM. Three trials at each load were performed with instructions being to jump as high as possible. Order between conditions was counterbalanced. Vertical ground reaction force (vGRF) was measured from a dual force platform setup (fs=1000 Hz). Verbal cues were given for each depth. Acceleration was calculated from vGRF ($\sum F=m*a$), velocity was integrated from acceleration, and position was integrated from velocity. Countermovement depth was calculated as the minimum position during the jump squat. Jump height was calculated as: (takeoff velocity)^2/(2*9.81). 3 (technique) x 5 (load) repeated measures ANOVAs were performed on depth and jump height, followed by planned comparisons (1x5 and 1x3 ANOVAs) if an interaction was present ($\alpha=0.05$). A paired-samples t-test was used to compare first and last 0% loads to assess possible fatigue and/ or potentiation.
RESULTS: Neither depth nor jump height were influenced by an interaction ($p>0.05$). Countermovement depth was influenced by technique ($p<0.05$). Countermovement depth was significantly different among PREF (-0.33 m ± 0.09 m), FULL (-0.44 m ± 0.08), and QTR (-0.24 m ± 0.06) regardless of load ($p<0.05$). Jump height was not influenced by technique ($p>0.05$), but there was a main effect for load ($p<0.05$) with jump height decreasing with load regardless of technique. Jump height was not different between the first and last 0% 1RM jump squat trials ($p>0.05$).
CONCLUSION: Countermovement depth was different among PREF, FULL, and QTR across loads, but jump height was not influenced by PREF, FULL, or QTR. These results demonstrate that verbal cues can elicit three distinct countermovement depths during jump squats.

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The Relationship Between 2D and 3D Biomechanics Data in a Single Leg Hurdle Task

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(No relevant relationships reported)

Three-dimensional (3D) motion analysis has been regarded as the gold standard for measuring landing mechanics. However, motion analysis is limited in clinical settings due to the time and expertise requirements. The amount of knee flexion during a single leg landing task is commonly assessed and has been found to be related to a number of injuries. However, to date there have been few studies investigating the relationship between a simple two dimensional (2D) measure to 3D measurements. Establishing this relationship would be important to provide better tools for clinicians to use.
PURPOSE: To determine if there is there is a relationship between 2 and 3 dimensional knee flexion angle during a single leg hurdle task.
METHODS: 20 Healthy Subjects (11 M, Age 22.4± 3.14, BMI 22.96 ± 3.06). Subjects performed instrumented single leg jumps over a series of 30.5 cm hurdles. The landing over the final hurdle was recorded with both a video camera and motion capture equipment. 2D knee flexion angles were measured using National Institute of Health image J program at the point of initial contact and peak knee flexion. An angle was determined by bisecting the knee along the mid shaft of the femur and tibia for the 2D motion. Peak knee flexion was determined in both the 2D video and 3D motion capture data with the association between the two assessed with a Pearson product moment correlation coefficient.
RESULTS: Mean values for knee flexion in 3D were 24.8±9.0° at initial contact and 59.8±9.2° at peak knee flexion. Mean values for the 2D data were 28.0±6.8° at initial contact and 66.0±8.9° at peak knee flexion. There was a significant correlation at initial contact ($r=0.717$, $p=.001$) as well as for peak knee flexion angle ($r=0.617$, $p=.006$) between the 2D method and 3D motion capture.
CONCLUSION: At both initial contact and peak knee flexion, there was a strong relationship between the 2D and 3D angle values. Both measurements trended similarly but were different in magnitude. This suggests a simple 2D technique may be applicable in the clinical setting providing similar precision but different accuracy to the 3D motion capture data.

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