PURPOSE: Although the judo is an official Olympic event that played all over the world, serious head injuries, especially acute subdural hematomas (ASDHs) have occasionally occurred during judo competition or practice in Japan. The acceleration at the head impact is considered as one of the major influencing factors in serious head injuries. On the other hand, the break-fall technique called "*ukemi*" has been developed in judo to prevent head collision against the judo-floor (mat) and to minimize its impairments. However, the head acceleration-decreasing effect of *ukemi* on thrown person has not been fully understood. The purpose of this study was to evaluate head injury criterion (HIC) value as a level of head injury risk by the linear head accelerations and to compare it with the values previously obtained from an anthropomorphic test device (ATD) experiment without *ukemi*
METHODS: One male judo expert (thrower) repeatedly threw another male judo expert (faller) for 4 times by judo technique called *Seoi-nage* that has been linked to the occurrence of ASDHs in judo. The faller took *ukemi* adequately without head collision against mat in all trials. The head axial linear acceleration was measured by a tri-axial accelerometer mounted on the forehead of the faller's head in each trial. In order to evaluate the magnitude of faller's impact of the head, we calculated the HIC value from the head linear accelerations. Kinematic data of the faller's head were also recorded during trials using digital video cameras. The HIC values of ATD thrown by the same judo expert were obtained from our previous study (Murayama et al., 2020).
RESULTS: Kinematic data showed that the faller fell forwards without any head collisions against the mat in throwing technique *Seoi-nage*. In all trials, a large acceleration appeared at the body contact phase to the mat. The peak resultant linear acceleration values of faller ranged from 8.36 to 9.30 G and 9.11 to 30.83 G in ATD. The HIC values of faller (2.08 ± 0.22) were significantly lower than those observed in ATD (24.68 ± 21.23, $p<0.05$).
CONCLUSIONS: According to the findings, mastering proper *ukemi* technique could significantly decrease the HIC value of head impact and the likelihood of severe head injuries in judo.

3011

The Influence Of Arm Slot, Stride Length, And Stride Angle On Baseball Throwing Velocity

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Throwing velocity (TV) is influenced by numerous factors. Better understanding of pitching mechanics can aid coaching staff in designing optimal training programs.
PURPOSE: To evaluate the effect of stride length, stride angle, and arm slot on TV across different levels of play.
METHODS: We enrolled 100 baseball pitchers from 3 different populations: high school (n=7), college (n=75), and professional (n=18). Following a standardized warmup, each subject performed 5 pitches that were analyzed using high-speed motion capture cameras (OptiTrack Prime 17W). Stride length, stride angle, and arm slot were exported. Pitch velocity was captured using a Stalker Sport radar system. We estimated differences in play levels using one-way ANOVA. Linear regression measured the effects of kinematic parameters on TV holding confounders constant.
RESULTS: Across the total sample, subjects were 21.4 ± 2.3 years old, 185.3 ± 7.2 cm tall, and weighed 90.7 ± 10.1 kg. Stride length was $83.6 \pm 5.8\%$ of height (70.4 to 99.6%), stride angle was $1.9 \pm 5.9°$ (-9.2 to 13.3°), and arm slot was $42.2 \pm 7.4°$ (14.2 to 59.8°); none of these differed between levels of play (p>0.125). TV was 84.8 ± 4.7 mph (71.3 to 94.0 mph) and was different between play levels (p=0.002): high school (79.6 ± 4.7 mph), college (84.8 ± 4.4 mph), and professional (86.8 ± 4.8 mph). Stride length (p=0.089), stride angle (p=0.065), and arm slot (p<0.001) were associated with TV. Height was related to stride length (p=0.060) and weakly associated with arm slot (p=0.092), but not stride angle (p=0.981). Height (p=0.012) and weight (p=0.014) were correlated with TV. In the regression analysis, high multicollinearity existed between age and play level; age was retained owing to better significance. Weight (β=-0.043; p=0.398) and stride angle (β=-0.091; p=0.208) were insignificant and removed from the model. Holding age (β=0.665; p<0.001) and height (β=15.474; p=0.007) constant, stride length (β=21.190; p=0.003; 95% CI: 7.245, 35.135) and arm slot (β=-0.218; p<0.001; 95% CI:-0.327 -0.110) were significant predictors of TV (r^2=0.332; p<0.001).
CONCLUSION: Among pitchers across various play levels, increased TV was predicted by a lower arm slot and longer stride length. These kinematic variables should be included in a standard assessment by coaches and other sport professionals.

3012

The Influence Of Shoulder Kinematics On Throwing Velocity In Baseball Players

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(No relevant relationships reported)

Baseball pitching involves substantial rotation and velocity within the glenohumeral joint, placing the shoulder at an elevated risk of injury. Better understanding of joint kinematics during throwing may assist in the development of effective training and injury prevention protocols.
PURPOSE: To test the relationship between throwing velocity (TV) and shoulder mechanics in baseball players.
METHODS: We evaluated 100 pitchers (7 high school, 75 college, 18 professional) using an OptiTrack Prime 17W high-speed motion capture system. After a standardized warmup, subjects were analyzed on 5 consecutive pitches. Kinematic parameters were horizontal abduction angle (HAA), external rotation angle (ERA), and internal rotation velocity (IRV). Maximum values (max) and values at foot plant (fp) were recorded separately. TV was assessed using a Stalker Sport radar system. Linear regression measured the effect of all independent variables on TV holding confounders constant.
RESULTS: Subject age was 21.4 ± 2.3 yr, height was 185.3 ± 7.2 cm, HAA_{max} was $48.0 \pm 12.5°$, HAA_{fp} was $41.9 \pm 13.2°$, ERA_{max} was $168.9 \pm 10.1°$, ERA_{fp} was $47.3 = 21.2°$, IRV_{max} was $4,521.8 \pm 300.1°$/s, and TV was 84.8 ± 4.7 mph. Age (r=0.331; p<0.001), height (r=0.250; p=0.012), IRV_{max} (r=0.331; p<0.001), ERA_{max} (r=0.359; p<0.001), HAA_{max} (r=0.384; p<0.001), and HAA_{fp} (r=0.414; p<0.001) were correlated with TV. HAA_{fp} (r=-0.091; p=0.368) and ERA_{fp} (r=-0.035; p=0.729) were unrelated. In the regression analysis, age and level of play were highly correlated (VIF>2.5); age was retained owing to better significance. In the full model, HAA_{max} was insignificant (p=0.787) and was removed. Holding age (p<0.001) and height (p<0.001) constant, significant predictors of TV were IRV_{max} (β=0.005; p<0.001; 95% CI: 0.003, 0.007), ERA_{max} (β=0.088; p=0.024; 95% CI= 0.012, 0.163), HAA_{fp} (β=0.126; p<0.001; 95% CI= 0.063, 0.190), and ERA_{fp} (β=0.042; p=0.028; 95% CI= 0.005, 0.079). The model was significant (r^2=0.500; p<0.001). HAA_{fp} and ERA_{fp} were only significant with confounders controlled; HAA_{max} was only significant without confounders controlled.
CONCLUSIONS: The three most robust predictors of TV were HAA_{fp}, ERA_{max}, and IRV_{max}. Consideration should be given to exercise and injury prevention programs that focus on these parameters.

3013

Effects Of Wrist Pronation Angle, Elbow Flexion Angle, And Elbow Extension Velocity On Fastball Speed

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Baseball pitchers are at risk for developing injuries in the shoulder and elbow, with an increase in ulnar collateral ligament repairs in recent years. Better understanding of pitching kinematics may help coaches and other healthcare professionals design appropriate conditioning and treatment programs.
PURPOSE: To test the influence of wrist pronation angle (WPA), elbow flexion angle (EFA), and elbow extension velocity (EEV) on throwing velocity (TV) in adult baseball pitchers.
METHODS: We used a high-speed video capture system (OptiTrack Prime 17W) to evaluate the throwing mechanics of 100 baseball pitchers (18 professional, 75 college, 7 high school), exporting WPA at foot plant, EFA at foot plant, maximum EFA, and maximum EEV. TV was captured using a Stalker Sport radar system. Following a standardized throwing warm-up, each pitcher performed 5 consecutive throws. Composite values from these throws were calculated. Linear regression tested the effect of arm mechanics on TV holding height and age constant.
RESULTS: Across all play levels, subject age was 21.4 ± 2.3 years, height was 185.3 ± 7.2 cm, and weight was 90.7 ± 10.1 kg. WPA at foot plant was $12.2 \pm 18.0°$, EFA at foot plant $103.1 \pm 16.1°$, maximum EFA was $118.0 \pm 10.0°$, and maximum EEV was $2,464.4 \pm 235.0°/s$. TV was 84.8 ± 4.7 mph, and it differed across play levels (high school: 79.6 mph, college: 84.8 mph, professional: 86.8 mph; p=0.002). Height (r=0.250; p=0.012) and age (r=0.331; p<0.001) were related to TV. Without controlling for confounders, kinematic variables related to TV were WPA at foot plant (r=0.215, p=0.031) and EFA at foot plant (r=-0.183, p<0.001). TV was unrelated to maximum EFA (r=-0.140, p=0.165) or maximum EEV (r=0.088, p=0.385). Holding age and height constant, regression analysis found no significance in any of the four kinematic parameters: EFA at foot plant (β=-0.030; p=0.278), maximum EFA (β=-0.032; p=0.479), maximum EEV (β=0.003; p=0.174), and WPA at foot plant (β=0.040; p=0.109).
CONCLUSION: TV was correlated with WPA and EFA, but these relationships were eliminated by the addition of covariates. Accordingly, training pitchers to use safer arm mechanics might preserve joint and tissue integrity without affecting fastball velocity.

3014

Drop Vertical Jump Biomechanics Differ In Athletes Post-concussion: Implications For Concussion Detection And Rehabilitation

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Athletes recovering from concussions face cognitive impairments predisposing them to higher risk for lower extremity injuries including anterior cruciate ligament (ACL) tears. Current concussion detection methods are limited by observer interpretation and intentional underperforming on baseline testing (sandbagging). Kinematics can aid in objective concussion detection; however, studies investigating changes in jump landing kinematics from pre- to post-concussion are limited.
PURPOSE: To investigate changes in lower extremity and trunk kinematics during a drop vertical jump (DVJ) in collegiate varsity athletes from pre- to post-concussion.
METHODS: 20 collegiate varsity athletes performed 3 DVJs at the preseason assessments directly before and after sustaining a concussion, captured by a Kinect V2 device. Specific DVJ parameters (Table 1), and the standard deviation of each parameter across a participant's 3 jump (inter-jump variability, IJV), were compared between pre- and post-concussion using a paired one-sided *t*-test. Statistical significance was set at $P < .05$.
RESULTS: Peak sagittal angle of left and right knees decreased significantly post-concussion, indicating less knee flexion ($105.66°$ vs $91.74°$, $P = .011$; $105.01°$ vs $91.30°$, $P = .013$). Maximum spine sway in the X axis decreased significantly from $4.37°$ to $3.41°$ ($P = .048$). IJV of peak sagittal angle increased significantly in both knees ($5.81°$ vs $15.71°$, $P < .01$; $4.63°$ vs $15.29°$, $P < .01$). IJV of spine sway variability in the Z axis and maximum ankle distance increased significantly ($0.42°$ vs $0.72°$, $P = .024$; 0.017 m vs 0.029 m, $P = .022$).
CONCLUSIONS: Multiple DVJ parameters change significantly in collegiate varsity athletes post-concussion. Notably, decreased peak sagittal angle has been associated with increased risk for ACL tear. The DVJ is a potentially valuable tool for objective concussion detection and guiding post-concussion rehabilitation to reduce the risk of ACL tears.

Table 1. DVJ Parameter Descriptions

DVJ Parameter	Description
Initial Coronal angle	Coronal knee angle at initial contact
Peak Coronal Angle	Maximum coronal angle of the knee throughout the DVJ
Peak Sagittal Angle	Maximum moment of flexion throughout the DVJ
Max. Spine Sway	Maximum spine sway in X and Z directions throughout the DVJ
Spine Sway Variability	Standard deviation of spine sway values throughout the DVJ in X and Z
Max. Pelvis Tilt	Maximum pelvis tilt angle in Y and Z directions throughout the DVJ
Max. Neck Sway	Maximum neck sway angles in X and Z throughout the DVJ
Max. Ankle Distance	Maximum ankle distance throughout the DVJ
Max TBCM Sway	Maximum TBCM sway value throughout the DVJ
TBCM Sway Deviation	Standard deviation of TBCM sway values throughout the DVJ