alter the players' serves. Further, there has never been a kinematic comparison of the 3 main types of tennis serves, though there is suggestion some serves are potentially more injurious than others.

Seven NCAA Division I male tennis players performed three successful flat, kick, and slice serves on a tennis court while each serve was recorded using an 8 camera markerless video capture system. Laser scanning was utilized to accurately collect body dimensions and identify joint centers. Joint forces and net joint moments were computed using inverse kinematic methods.

Maximum shoulder external rotation was not significantly different between the flat, kick, and slice serves (89.8 *v* 90.1 *v* 91.5 degrees; $p > 0.67$). Elbow flexion was significantly greater in the slice serve (126.1 *v* 122.1 degrees; $p < 0.01$) compared to the flat serve while shoulder internal rotation angular velocity was greatest in the flat serve as compared with the kick and slice serves (2303, 2018, 1901 degrees/sec; $p < 0.05$). Racquet lateral linear velocity was significantly greater in the kick serve versus the flat and slice (13.4 *v* 8.4 *v* 10.4 m/s; $p < 0.05$) while the flat serve showed the greatest anterior linear velocity versus the kick and slice (25.9 *v* 22.0 *v* 24.6 m/s; $p < 0.05$). The kick serve showed greater total back (2974 *v* 2138 *v* 2568 N; $p < 0.05$) and posterior shoulder force (1370 *v* 809 *v* 741 N, $p < 0.05$) versus the flat and slice while the slice serve demonstrated lower torques at the elbow (71.1 *v* 87.0 *v* 89.3 N-m; $p < 0.05$) and wrist (20.9 *v* 33.5 *v* 27.9 N-m; $p < 0.05$) compared to the flat and kick serves.

Using this novel method of studying joint kinematics, this data suggests that the kick serve may place higher stresses on the back and shoulder while the slice is the least injurious to the elbow and wrist. The findings for the flat serve are in line with what exists in the literature for marker-based systems. This information may be helpful to prevent injury, as well as helping players returning to play from injury or surgery.

Paper # 73: Reliability and Validity of the Boston Biomotion Instrument (BBI) in the Measurement of Upper Extremity Power and a Comparison to the Seated Shot Put Test ***George J. Davies, DPT, PT, ATC, CSCS, USA***
David Lake, PhD, USA
Bryan Riemann, PhD, USA
Josh Campbell, DPT, USA
Joseph Waterman, DPT, USA
Larry Miller, BS, USA · Armstrong Atlantic State University
Savannah, GA, USA

Summary:

Because the BBI demonstrates high reliability and high validity, it provides a method for objective quantification of dynamic muscle performance with 6 degrees of freedom during multiple joint movements in functional patterns.

Abstract:

Background: Only performing functional tests oftentimes misses deficits within the kinematic chain which may be identified with isolated testing. However, traditional isokinetic testing only allows testing in one plane of motion with constrained movement patterns. Therefore, there is a need to perform objective testing of dynamic muscle performance in 6 degrees of freedom with multiple joint kinematics in functional movement patterns.

Objective: To establish the reliability and validity of the Boston Biomotion Instrument (BBI) in the measurement of upper extremity power.

Study Design: Intersession reliability and a correlation to an established power test for determining validity of the movement and the power measurement on the BBI.

Setting: Armstrong Atlantic State University Biodynamics Research Center

Subjects: Twenty (40 arms) physically active healthy subjects (12 females, 8 males; ages 22-31yrs; 1.70 ± .10cm.; 62.3 ± 13.2kg).

Methods and Measures: 20 subjects were tested bilaterally in each of 3 sessions in a random order on the BBI or shot-put test. At least 2 days of rest were allowed between testing sessions. The dominant and non-dominate arms were also tested in a random order. The subjects were seated stabilized with straps and performed the seated shot put using a 2.7kg medicine ball for 3 maximum effort repetitions. The subjects were seated in a similar position and stabilized on the BBI and the resistance was fixed to simulate the mass of a 2.7kg medicine ball. The subjects were instructed to perform a similar shot put motion using 3 maximum effort repetitions.

Main Outcome Measures: The recorded values for power (watts) on the BBI were used for reliability. For validity, the distance of the SSP was compared to the BBI power.

Results: Intraclass correlation coefficients (ICC) were used to establish the reliability of the BBI. The ICC were calculated using a two-way mixed model utilizing the three trial average and a 95 percent confidence interval. ICC for dominant arm and nondominant combined were 0.955-0.969; mean-0.964. Significant Pearson Product Moment correlations (r) revealed the validity of the BBI to SSP to be 0.861-0.929; mean-0.900.

Clinical Application: Because the BBI demonstrates high reliability and high validity, it provides a method for objective quantification of dynamic muscle performance with 6 degrees of freedom during multiple joint movements in functional patterns.

Paper # 74: Reliability, Validity and Responsiveness of a Modified International Knee Documentation Committee Subjective Knee Form (Pedi-Ikdc) in Children with Knee Disorders *ALLEN F. ANDERSON, MD, USA*
MININDER KOCHER, MD, USA · Tennessee Orthopaedic Alliance
Nashville, Tennessee, USA

Summary:
The pedi-IKDC Subjective Knee Form demonstrated overall acceptable psychometric performance for outcome assessment of children and adolescents with various disorders of the knee.

Abstract:
Background: The International Knee Documentation Committee (IKDC) Subjective Knee Form is a knee-specific measure of symptoms, function, and sports activity. A modified IKDC Subjective Knee Form (pedi-IKDC) has been developed for use in children and adolescents. The purpose of this study was to determine the psychometric characteristics of the pedi-IKDC Subjective Knee Form in children and adolescents with knee disorders.
Hypothesis/Purpose: The pedi-IKDC Subjective Knee Form is a reliable, valid, and responsive patient- administered outcome instrument in the pediatric population with knee disorders.
Study Design: Cohort Study.
Methods: Test-retest reliability, content validity, criterion validity, construct validity, and responsiveness to change were determined for the pedi-IKDC Subjective Knee Form in patients aged 10-18 with a variety of knee disorders. Test-retest reliability was measured in a group of 72 patients with a stable knee disorder. Validity was measured in a group of 589 patients, using the Child Health Questionnaire (CHQ) to determine criterion validity. Responsiveness was measured in a group of 98 patients undergoing a variety of knee surgical procedures.
Results: The overall pedi-IKDC Subjective Knee Form had acceptable test-retest reliability (intraclass correlation coefficient = 0.91) and excellent internal consistency (Cronbach alpha = 0.91). The overall pedi- IKDC Subjective Knee Form demonstrated acceptable floor (0%) and ceiling (6%) effects. There was acceptable criterion validity with significant ($p < 0.01$) correlation between the overall pedi-IKDC Subjective Knee Form and nine relevant domains of the CHQ. Construct validity was acceptable with all eleven hypotheses demonstrating significance ($p < 0.0001$). Responsiveness to change was acceptable (effect size, 1.39; standardized response mean, 1.35). 29
Conclusions: The pedi-IKDC Subjective Knee Form demonstrated overall acceptable psychometric performance for outcome assessment of children and adolescents with various disorders of the knee.
Key Terms: validations; IKDC Subjective Knee Form; outcome; children

Paper # 75: Earlier Lower Extremity Neuromuscular Activation Timing, Ground Reaction Force Timing, and Kick Quickness After Progressive Resistance, Whole Body, Long-Axis Rotational Training *JOHN NYLAND, EDD, DPT, USA*
RYAN KRUPP, MD, USA
DAVID N.M. CABORN, MD, USA · University of Louisville
Louisville, KY, USA

Summary:
Progressive resistance, whole body, long-axis rotational training improved lower extremity neuromuscular activation and ground reaction force timing, and kick quickness compared to a matched control group.

Abstract:
Optimized lower extremity neuromuscular activation and peak ground reaction force timing can help improve athletic performance and decrease injury risk. This prospective, randomized, controlled study evaluated the efficacy of short-term progressive resistance, whole body, long-axis rotational exercise training for improving lower extremity neuromuscular activation, peak ground reaction force timing, and kick quickness of healthy subjects. Thirty-six (18 men, 18 women) healthy, recreational athletes (age = 24.1 ± 5 yrs, height = 175.7 ± 10 cm, weight = 72.9 ± 11 kg) participated in this pre-test, post-test design study. Subjects were randomly assigned to groups with an equal number of men and women. The median 2000 IKDC Self-Reported Activity Level was 3 (well-trained and frequently sporting) for both groups. Subjects ranged from level 2 (sporting sometimes) to level 4 (highly competitive). Over a four-week period the training group (Group 1) performed nine, 20 min exercise sessions consisting of seven sets on a Ground Force 360 Device. The control group (Group 2) did not use the test device. Both groups continued regular