Tuck Jump Assessment as an Indicator for Upper Extremity Injury

Authors
Jeff W. Barfield, Gretchen D. Oliver

Affiliation
School of Kinesiology, Auburn University, Auburn, United States

Correspondence
Dr. Gretchen D Oliver
School of Kinesiology
Auburn University
301 Wire Rd
36849 Auburn
United States
Tel.: + 1/334/8441 497, Fax: + 1/334/8441 467
goliver@auburn.edu
www.sportsmedicineandmovement.com

ABSTRACT

The purpose of this study was to determine if tuck jumps can be used as a dynamic movement assessment to ascertain a previous history of upper extremity injury in an overhead throwing sport. Seventy-one youth baseball and softball athletes (28 baseball/43 softball; 12.41 ± 2.22 yrs.; 161.98 ± 13.65 cm; 59.17 ± 14.90 kg) were recruited to participate and were placed in either the previous injury (N = 18) or no previous injury (N = 53) groups. Kinematic data were collected from jumps 4 through 8 during a trial of 10 tuck jumps performed at 100 Hz using an electromagnetic tracking system (trakSTAR™, Ascension Technologies, Inc., Burlington, VT, USA) synced with the MotionMonitor® (Innovative Sports Training, Chicago, IL, USA). A logistic regression showed no significance in trunk flexion or upper leg elevation in the ability to determine upper extremity injury (χ^2 (1, N = 71) = 3.55, p = 0.315). In conclusion, examining only trunk flexion and upper leg elevation during the tuck jump assessment (TJA) is not enough for clinicians to recognize previous upper extremity injury. Even though the body behaves as a kinetic chain, simplifying the dynamic movement assessment while not specifying the type of upper extremity injury is not favorable for the clinician to identify previous injury.

Introduction

Diagnosis of a potential counterintuitive variable observed through a dynamic movement assessment, which directly affects an overhead athlete's upper extremity health, should be of interest to coaches and practitioners alike. Because athletes do not tell the whole story on a medical history questionnaire, it would be to the practitioner's advantage to be able to watch a dynamic movement, see a possible contraindication, and ask the right follow-up questions. Overhead athletes are in danger for a multitude of injuries including partial articular-sided supraspinatus tendon avulsion (PASTA) and superior labrum anteroposterior (SLAP) tears because of the humeral head angulation against the glenoid capsule [4].

However, clinical recognition by sports medicine personnel of movement abnormalities, such as a SICK scapula (scapular malposition, inferior medial border prominence, coracoid pain and malposition, and dyskinesis of scapular movement), can help prevent injury among overhead athletes [1, 4, 15, 19].

Although overhead athletes typically sustain injury to the upper extremity, practitioners are aware that the body behaves as a kinetic chain. Because of the dynamic nature of the overhead throw, the lower extremity generates a substantial amount of force during the throwing motion [6]. Additionally, a relationship found between the trunk flexors, hip extensors and scapular dyskinesis [16] shows the interconnectivity of the human body. These latest find-

ings between the function of the lower extremity and dysfunction of the upper extremity reiterate the importance of the clinical awareness of the pathomechanics within the kinetic chain that can hinder overhead athlete performance and increase their risk of injury [3]. A most recent review of exercise prescription for overhead athletes with shoulder pathologies suggested that rehabilitation address all aspects of injury and recovery including exercises based on local, regional, and global approaches and exercises based on the specific athletic movement [23]. Because rehabilitation programs aim to address local and global stabilizers of the lumbopelvic-hip complex (LPHC), dynamic assessments for overhead athletes should focus on the LPHC.

Because the body behaves as a kinetic chain, any abnormal neuromuscular control could alter the forces in the upper extremity during an overhead movement [1, 3, 8]. However it should be noted that in examining core stability and its impact on upper extremity injury, there is limited support regarding core stability training in injury prevention or performance enhancement [18]. Further examination into the kinetic chain and overhead movements show that low back pain has been reported in 3–15% of active baseball players and results from abnormal motion and extra stresses placed along the spine in the act of either batting or throwing [21]. In an attempt to prevent and properly rehabilitate a lower back injury, clinicians should assess an athlete's LPHC [20]. Additionally, when examining professional baseball pitchers, it was concluded that poor LPHC control was associated with missing significant time due to injury [2]. Subsequently, it was reported that there is a significant association between low back and knee pain with elbow and shoulder pain among youth baseball players [17]. Because of the relationship between weak LPHC and injury [2, 17], clinicians should consider a dynamic assessment that includes kinetic chain efficiency between the lower extremity and LPHC.

When using the tuck jump assessment (TJA) as a dynamic movement assessment, clinicians note movement flaws in order to determine injury potential and provide further training in an attempt to improve movement contraindications. The TJA is known as a dynamic assessment for lower extremity injury [9–12]. Identifying a movement contraindication of knee valgus helps identify the potential for ACL injury [11]. Therefore, in an attempt to determine if the TJA could be used for the upper extremity, it was our purpose to determine if tuck jumps could be used as a dynamic movement assessment to ascertain a previous history of upper extremity injury in an overhead throwing sport. We hypothesized that a more flexed trunk and less elevated upper leg in the peak apex of the tuck jump would correlate with a previous history of upper extremity injury for the overhead athlete.

Materials & Methods

Participants

Seventy-one youth baseball and softball athletes (28 baseball/43 softball; 12.41 ± 2.22 yrs.; 161.98 ± 13.65 cm; 59.17 ± 14.90 kg) were recruited to participate. All participants were in good physical condition and had no injuries within the last six months. A health history form was completed by the participants prior to participa-

tion. If participants indicated that they had any upper extremity injury in the past year, whether acute or chronic, that had kept them from competition, then they were placed in the previous injury group (N = 18). All other participants were placed into the no previous injury group (N = 53). Participants who indicated they had a previous lower extremity injury were excluded from the study. The university's Institutional Review Board approved all testing protocols. Informed written consent was obtained from each participant and the participant's parents before testing [5].

Protocol

Kinematic data were collected at 100 Hz using an electromagnetic tracking system (trakSTAR™, Ascension Technologies, Inc., Burlington, VT, USA) synced with the MotionMonitor® (Innovative Sports Training, Chicago, IL, USA). Fourteen electromagnetic sensors were attached at the following locations: (1) posterior aspect of the torso at the first thoracic vertebrae (T1) spinous process; (2) posterior aspect of the pelvis at the first sacral vertebrae (S1); (3–4) flat, broad portion of the acromion on bilateral scapula; (5–6) lateral aspect of the bilateral upper arm at the deltoid tuberosity; (7–8) posterior aspect of the bilateral distal forearm, centered between the radial and ulnar styloid processes; (9) dorsal aspect of the second metatarsal of the non-dominant foot; (10–11) lateral aspect of the bilateral upper leg, centered between the greater trochanter and the lateral condyle of the knee; (12–13) lateral aspect of bilateral lower leg, centered between the head of the fibula and lateral malleolus [7]; and (14) dorsal aspect of the third metacarpal of the dominant hand. A fifteenth, movable sensor was attached to a plastic stylus used for the digitization of bony landmarks [13, 14, 24, 25]. The error in determining position and orientation of the electromagnetic sensors with the current calibrated world axis system was less than 0.01 m and 3°. For the world axis, the positive y-axis represented the vertical direction, the positive x-axis was anterior to the participant, and the positive z-axis was orthogonal to the x and y axis. Position and orientation of the body segments were obtained using Euler angle sequences that were consistent with the International Society of Biomechanics standards and joint conventions [24, 25]. All pelvis and trunk motions were captured in reference to the world axis. All kinematic data from an appendage were captured in reference to the proximal segmental axis. All raw data were independently filtered along each global axis using a 4th-order Butterworth filter with a cutoff frequency of 13.4 Hz [13, 14, 22]. All data were time-stamped through The MotionMonitor® and passively synchronized using a data acquisition board. Following sensor attachment and digitization, each participant performed 10 tuck jumps [11]. Of the 10 tuck jump trials, only trials 4 through 8 were analyzed.

Statistical analysis

All data were processed by Matlab and analyzed using SPSS version 21 for Windows (SPSS, Chicago, IL, USA). The Shapiro-Wilk test of normality was used with the data to determine normality. After data were determined to be normal, a logistic regression was run to explore if an upper extremity injury could be determined through examining trunk flexion and upper leg elevation during a tuck jump. A priori was set at a level of $p = 0.05$ to determine significance.

Results

A logistic regression showed no significance in trunk flexion or upper leg elevation in the ability to determine upper extremity injury (χ^2 (1, N = 71) = 3.55, p = .315). The model explained 7.2 % of the variance in upper extremity injury and correctly classified 73.2 % of all cases. The logistic regression coefficient, Wald test, and odds ratio for each of the predictor variables can be found in ▸ **Table 1**. Descriptive statistics can be found in ▸ **Table 2**.

Discussion

The purpose of this study was to determine if a previous upper extremity injury in an overhead throwing athlete alters tuck jump movement patterns. We hypothesized that a TJA could determine previous upper extremity injury, however this hypothesis was not supported. The TJA was created by clinicians to identify high-risk landing mechanics and provide direction regarding lower extremity injury [11]. However, upon examination of upper extremity injury, simplifying the TJA variables to those that fall into the proximal body control category does not help identify previous a upper extremity injury for the overhead athlete.

Even though the utilization of the tuck jump as a dynamic movement assessment did not reveal any upper extremity injury relationships, the kinetic chain theory holds true [1, 3, 8]. To be classified as injured in this study, participants only needed to indicate that they missed practice and/or game time due to an upper extremity injury. We did not specify the degree of injury or whether it was the onset was acute or chronic for those in our injured group. Because a link between baseball players exhibiting throwing shoulder and elbow pain with knee and low back pain exists, clinicians should consider examining the trunk and lower extremities in those throwing athletes with an upper extremity injury [17]. However, based on the current findings, further examination into the TJA is warranted.

Although a direct link was not found between the TJA and upper extremity injury, further investigation into injury precursors should be performed. During our TJA, we examined only trunk flexion and upper leg elevation, which are two variables that make up the proximal control factor indicated by Lininger and colleagues [9]. In their exploratory factor analysis, it was concluded that three factors, defined as fatigue, distal landing pattern, and proximal control, should be examined to get the most benefit of the TJA in injury assessments [9]. We simplified their conclusion to look at the one factor that would have the strongest relationship with the upper extremity. Our results agree with their conclusion that a simplified unidimensional construct of the TJA may not be the best way to use this dynamic movement assessment to identify previous upper extremity injury.

Future research should consider examining the relationship between fatigue as determined in the TJA with upper extremity injury. Also, future research should examine the relationship of the TJA with chronic upper extremity injuries. Limitations to this study include using a survey to identify the injured group. Perhaps a test of scapular dyskinesis to separate groups would have been more reliable and shown more of a relationship with TJA variables. Other limitations include a limited injured group sample size and time away from injury. All participants who reported for this study were presumed to be injury-free for the past 6 months. The time away from injury may be enough to correct kinetic chain deficiencies.

In conclusion, the TJA is a complex dynamic movement assessment in which even the unidimensional analysis construct has 10 points of potential deficits for the clinician to assess. Although the TJA is a known assessment for lower extremity injury [10–12], research says little regarding upper extremity injury. Examining only trunk flexion and upper leg elevation during the TJA is not enough for clinicians to recognize a previous upper extremity injury. Even though the body behaves as a kinetic chain, simplifying the dynamic movement assessment while not specifying the type of upper extremity injury is not favorable for the clinician to identify previous injury.

Conflicts of Interest

The authors declare that they have no conflict of interest.

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▸ **Table 1** Logistic regression predicting upper extremity injury from trunk flexion, right upper leg elevation, and left upper leg elevation.

Predictor	β	Wald χ^2	p	Odds Ratio
Trunk Flexion	− 0.02	0.806	0.369	0.98
Right UL Elevation	− 0.01	0.059	0.808	0.99
Left UL Elevation	0.03	0.736	0.391	1.03

▸ **Table 2** Descriptive statistics for trunk flexion, right upper leg elevation, and left upper leg elevation.

Predictor	Injured	Healthy
Trunk Flexion, °	− 24.14 (12.87)	− 18.89 (12.71)
Right UL Elevation, °	73.41 (14.49)	67.47 (16.85)
Left UL Elevation, °	76.27 (13.52)	68.41 (19.04)
Note: Data are presented in table as Mean (SD).		

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