FUNCTIONAL ADAPTATIONS IN ISOKINETIC PERFORMANCE AND SHOULDER MOBILITY IN ELITE ULTIMATE FRISBEE PLAYERS

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Ultimate frisbee is a team sport where players mainly use their dominant arm for throwing the frisbee. Little is known about possible functional adaptations to this unilateral strain and the purpose of this study was to investigate related shoulder rotation strength and range of motion (ROM) in elite ultimate players. Concentric external (ER) and internal (IR) isokinetic (60°/s) shoulder rotation torque and passive glenohumeral (GH) ROM was tested in 15 male subjects (27.5 ± 5.5 yrs). Work during ER was higher on the dominant side (8.4 ± 8.4 %; p<.01). IR ROM and total ROM was smaller on the dominant side (21 ± 18 %; p<.01 or 5 ± 9 %; p<.05). This indicates similar adaptation patterns of GH mobility compared to other overhead sports, however, differing results regarding shoulder rotation strength.

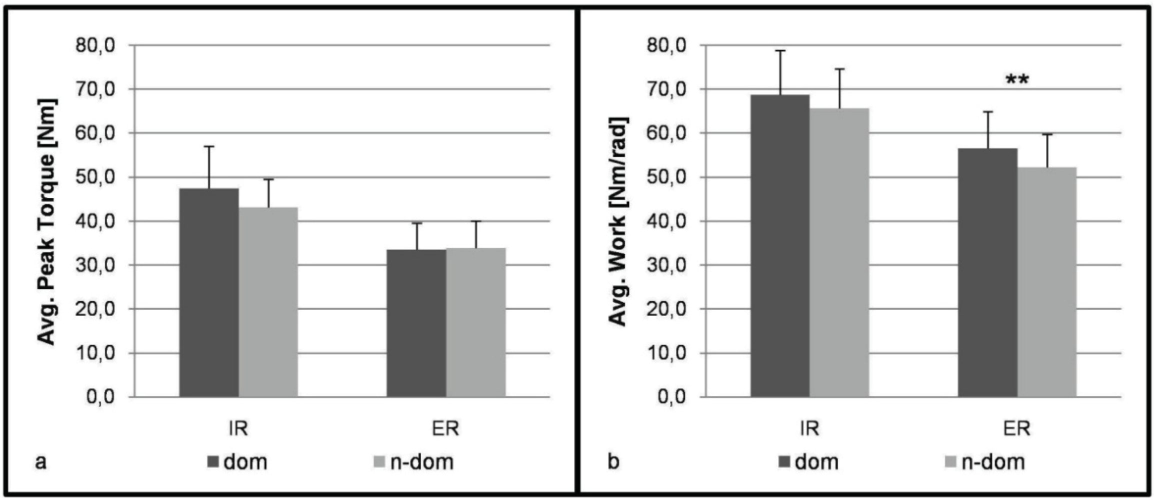
KEY WORDS: injury prevention, muscle imbalances, overhead sports, range of motion

INTRODUCTION: Throwing movements in ultimate place a high load on the dominant shoulder of the players. A kinematic analysis of the forehand throw showed a similar movement pattern compared to overhead throws in baseball or handball (Sasakawa & Sakurai, 2008). Characteristic adaptations of the dominant shoulder in overhead sports are a reduction of the functional ratio between external rotation strength and internal rotation strength, resulting from an increase of internal rotation (IR) strength, or a reduction of external rotation (ER) strength or a combination of both (Kibler, Wilkes, et al., 2013). Another typical adaptation to repetitive overhead throwing is a glenohumeral internal rotation deficit (GIRD) with a concomitant external rotation gain (ERG) (Moreno-Perez et al., 2015). The total range of motion (TROM) of shoulder rotation might remain similar to the non-dominant side, but is shifted towards ER (Wilk et al., 2011). Hummel (2003) and Pesch (1999) published kinematic analyses of the backhand throw that indicate a high ROM of horizontal abduction during the acceleration phase. In combination with the results of Sasakawa und Sakurai (2008), literature suggests that there is a highly asymmetric loading towards the dominant shoulder during throwing. However, there is a lack of data for elite ultimate players and the purpose of this study was to investigate possible functional adaptations in shoulder rotation strength and glenohumeral (GH) range of motion.

METHODS: 15 male elite ultimate players, all currently or formerly members of the German national team, volunteered for this study (age: 27.5 ± 5.5 yrs; height 183.6 ± 5.4 cm; weight 78.8 ± 6.6 kg, duration of sport-specific loading 11.5 ± 5.0 yrs). Maximum torque of shoulder IR and ER was assessed in concentric isokinetic mode at 60°/s using a computer driven dynamometer (Isomed 2000, D&R Ferstl GmbH, GER). The subjects were tested in supine position with the shoulder abducted at 90° and the elbow flexed at 90° (90/90-position) with a total ROM of 100° ranging from 50° ER to 50° IR. 0° referred to the position when the forearm is perpendicular to the body. After a general warmup on an arm crank ergometer and shoulder stretching, 3 submaximal IR and ER repetitions on the dynamometer were performed as a standardized local warmup. Thereafter, the test consisted of 5 maximum voluntary contractions for IR and ER on each side. Each repetition incorporated an IR and ER, separated by 10 seconds of rest in-between. The pause between subsequent repetitions was 30 seconds. The order of the starting arm was chosen randomly. GH mobility was assessed passively in 90/90-position. IR ROM and ER ROM were measured three times in random order using a standard 2D-goniometer with 2 shanks. Average peak torque (Avg. PT), average work (Avg. W) and the angle at which peak torque occurred were analyzed for maximum strength. Functional strength ratios (ER/IR) were calculated for both Avg. PT and Avg. W. The averages of the 2^{nd} to 4^{th} trials were chosen for statistical analysis.

Average ROM values (IR, ER, TROM) as well as side-to-side differences (GIRD, ERG, ΔTROM) were calculated for the mobility assessment. Paired t-tests were used to analyze differences between the dominant (dom) and non-dominant (n-dom) side ($p<.05$) and Pearson correlation coefficient (r) for correlations between parameters.

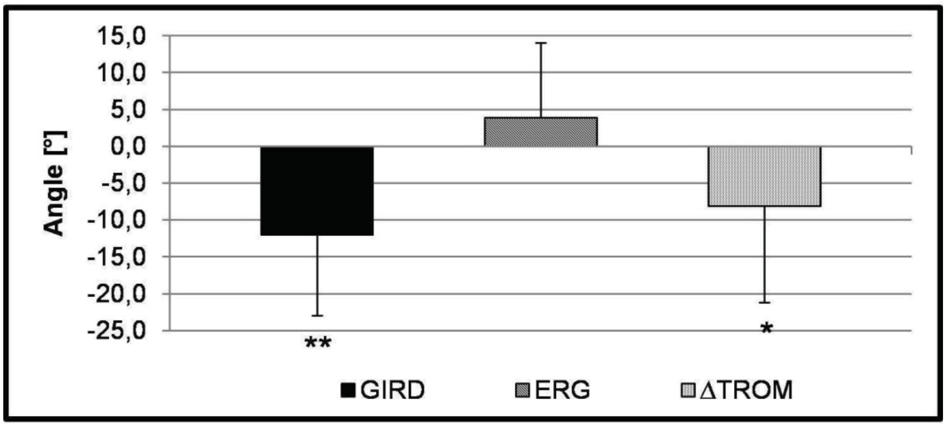
RESULTS: Two subjects were excluded from the analysis due to pain that occurred during the measurements (n=13). We found higher Avg. W in ER (8.4 ± 8.4 %; $p<.01$) for the dominant side. The angle at which PT occurred did not show significant side-to-side differences in IR (dom: 0.3 ± 22.2° of ER; n-dom: 10.7 ± 17.7° of ER) neither in ER (dom: 20.1 ± 14.1° of ER; n-dom: 18.7 ± 14.8° of ER). There were no side-to-side differences between functional ratios (PT and W), however PT-ratios were smaller (dom: 0.73 ± 0.20; n-dom: 0.74 ± 0.12) than work ratios (dom: 0.83 ± 0.10; n-dom: 0.80 ± 0.12).



** p<.01.

Figure 1a/1b: Isokinetic Strength of the Internal and External Shoulder Rotators of Male Elite Ultimate Players at 60°/s (mean ± standard deviation).

On the dominant side, IR ROM was smaller (dom: 41 ± 10°; n-dom: 53 ± 12°; 21 ± 18 %; $p<.01$) as well as TROM (dom: 138 ± 14°; n-dom 146 ± 11°; 5 ± 9 %; $p<.05$). No differences were found in ER ROM. This led to a GIRD of -12 ± 11°, an ERG of 4 ± 10° and a ΔTROM of -8 ± 13°.The duration of sport-specific loading was correlated to the functional ratio of PT n-dom (r=-0.69, $p<.01$).



* p<.05, ** p<.01.

Figure 2: Side-to-Side Differences in Glenohumeral ROM in 90/90-Position (mean ± standard deviation; negative values indicate less ROM on the dominant side).

DISCUSSION: This investigation focused on analyzing the balance of shoulder IR and ER maximum strength and GH mobility regarding laterality in first place. Secondly, possible correlations between strength and mobility were of specific interest. In contrast to other overhead sports, a significantly higher maximum strength was found for ER on the dominant side while there were no significant differences for IR maximum strength. Most investigations on tennis, baseball and volleyball showed a decrease of ER strength or no changes compared to the non-dominant side and a coincident increase of IR strength (Saccol et al., 2010; Stanley et al., 2004; Wang & Cochrane, 2001). In our study, PT-values for IR and ER did not show laterality. Significant side-to-side differences could only be detected by analyzing the work values. This could be interpreted as an adaptation to higher sport-specific loading on the dominant side. During the transition from the wind-up to the acceleration phase and during the follow-through phase a high stress is placed in the IR and ER muscles of the dominant shoulder when throwing a frisbee. Up to now, to the author's knowledge only one single study discussed differences in work parameters in overhead athletes (Ng & Lam, 2002). No laterality could be found in both functional ratios (PT and W), which could be due to a smaller angle of abduction during throwing in comparison to other overhead throwing movements (Ellenbecker & Davies, 2000; Hummel, 2003; Sasakawa & Sakurai, 2008; Wilk et al., 2009). The PT-ratios indicate that elite ultimate players tend to have good (in terms of healthy and preventive) functional ratios, which are recommended to rage between 0.66 and 0.75 (Ellenbecker & Davies, 2000). Higher work ratios were found compared to PT-ratios. To the author's knowledge there is no study that discussed differences between PT-ratios and work ratios. The angles at which PT-IR occurred were found at 0.3 ± 22.2° of ER and of PT-ER at 20.1 ± 14.1° of ER on the dominant side. End-ROM positions are those that put the greatest loading on active and passive structures within the shoulder joint (Ellenbecker & Mattalino, 1997; Ng & Lam, 2002; Saccol et al., 2010; Stanley et al., 2004; Wang & Cochrane, 2001). The angles of PT-IR and PT-ER found in this study are not within the range of these end-ROM positions. In terms of prevention of shoulder injuries and overuse syndromes it might be of interest to evaluate ratios within end-ROM positions, which would be the transition phase from wind-up to acceleration as well as immediately after the release (follow-through phase). This would require calculating angle-specific ratios within the mentioned phases and these ratios should be work-specific at the same time. Work-specific in the transition phase would mean a ratio between eccentric IR and concentric ER, and for the follow through phase a ratio between eccentric ER and concentric IR. The relevance of angle- and work-specific ratios should be evaluated in further studies on injuries related to overhead sports. Adaptations of GH mobility in this study showed similar findings compared to other overhead athletes (Kibler, Kuhn, et al., 2013; Moreno-Perez et al., 2015). The reported GIRD on the dominant side could result from repetitive eccentric-concentric internal rotation overload during the forehand throw (Myklebust et al., 2013; Sasakawa & Sakurai, 2008). The magnitude of these adaptations was smaller compared to other overhead athletes, which could be connected with the lower weight of the disc, the smaller angle of abduction, the number of repetitions performed in competition and training and differing throwing mechanics from striking and pitching in tennis, baseball or volleyball. The combination of these factors could result in smaller distraction forces acting in the GH joint during throwing motions (Escamilla & Andrews, 2009). The relation of the duration of sport-specific loading with the laterality of shoulder strength and GH mobility could play an important role in connection with overuse injuries, as correlations in this study were found with the functional ratio (PT) on the non-dominant side ($p<.05$). The longer the duration of sport-specific loading, the smaller the PT-ratio, which could be associated with reduced ER strength, increased IR strength or both. However, there are limitations of this study. The sample of subjects was heterogeneous with regard to age and duration of sport-specific loading, so these findings should be interpreted with caution. In addition, the assessment of

GH mobility was done by one single investigator and high standard deviations in shoulder rotational strength may indicate insufficient familiarization to isokinetic tests.

CONCLUSION: This study is the first that investigated strength and mobility of the shoulder joint of elite ultimate players. Compared with other overhead athletes, it could be shown that ultimate players have similar functional adaptations regarding mobility. Functional ratios were not affected by sport-specific loading, however there was laterality between dominant and non-dominant side concerning external rotation maximum strength. Regular screenings and diagnostics are suggested to assess possible imbalances in strength and mobility of the shoulder joint. In case of positive findings, rehabilitative and preventive training programs should be introduced to the athletes with focus on strengthening and stretching exercises.

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