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GIRD, TRROM, and humeral torsion-based classification of shoulder risk in throwing athletes are not in agreement and should not be used interchangeably

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## Abstract:

### Objectives

Clinicians commonly interpret the findings of shoulder rotational ranges of motion using various approaches: an apparent reduction in dominant arm internal rotation ("GIRD"), a difference in total rotational range of motion - ie differences in the sum of internal and external rotational range (TRROM), and a combination of rotational ROM and torsional difference ("GIRD-torsion"). We have noticed that these approaches are being considered to provide equivalent estimates of shoulder rotational range. This investigation sought to document the extent of agreement of these three different approaches when classifying athletes' "at-risk" status.

### Design

Observational cohort study

### Methods

162 professional male athletes participating in overhead sports (baseball, handball, and volleyball) had their GIRD, TRROM, and GIRD-torsion calculated, and classified as "at risk" using standard cut-points of 20°, 5°, and 10° respectively.

### Results

25 (15.4%) athletes were classified as "at-risk" using GIRD, 55 (34%) with TRROM, and 30 (18.5%) using GIRD-torsion. Only 3/162 (1.9%) athletes were classified as "at-risk" by all 3 approaches, 4 athletes were concurrently classified as "at-risk" by GIRD and TRROM (Kappa= 0.142, poor agreement), 11 by GIRD and GIRD-torsion (Kappa=0.279, fair agreement), and 11 by TRROM and GIRD-torsion (Kappa=0.025, slight agreement).

## Results

25 (15.4%) athletes were classified as at risk using GIRD, 55 (34%) with TRROM, and 30 (18.5%) using GIRD-torsion. Only 3/162 (1.9%) athletes were classified as at risk by all 3 approaches, 4 athletes were concurrently classified as at risk by GIRD and TRROM (Kappa= 0.142, poor agreement), 11 by GIRD and GIRD-torsion (Kappa=0.279, fair agreement), and 11 by TRROM and GIRD-torsion (Kappa=0.025, slight agreement).

## Conclusions

The three described approaches yield demonstrably different findings, and these approaches cannot be used interchangeably. Examples of clinical reasoning are provided to assist with the interpretation of these different measures.

**Keywords:** Throwing, Baseball, Handball, Volleyball, Sport, Injury

## Introduction

Throwing-related injuries remain a significant burden in baseball and other overhead throwing and striking sports.<sup>1</sup> For some time it has been posited that changes in glenohumeral joint rotational range of motion (ROM), especially reduced internal rotation (IR), are related to shoulder injury in throwing athletes.<sup>2</sup> Clinically there are three distinct interpretations of the relation between rotational ROM and shoulder injury in these athletes.

### Approach 1 - GIRD: "lost" shoulder internal rotation from any origin

A loss of IR ROM in the dominant shoulder compared to the non-dominant shoulder has been termed "GIRD" or Glenohumeral Internal Rotation Deficit.<sup>2</sup> Specifically it is suggested that GIRD, classically attributed to aberrantly tightened soft tissue structures, especially of the posterior shoulder region, is the inciting event that leads to a spectrum of shoulder injury, including type II SLAP lesions and undersurface postero-superior cuff tendinopathy.<sup>3-5</sup> It has been suggested by a number of authorities that a GIRD of 20° is a threshold for clinical concern.<sup>6</sup>

## Approach 2 - TRROM: the whole of shoulder approach

In the late 1960's it was noted that professional throwing athletes routinely demonstrated an increase in shoulder external rotation on their dominant arm associated with a concomitant decrease in internal rotation<sup>7</sup> however it was not until the 1990's that the notion of 'total arc of motion' (ie the sum of internal and external rotational range of motion, or the Total Rotational Range of Motion - TRROM) became more widely reported<sup>8, 9</sup> and considered more relevant in the assessment of shoulder range. Central to this notion is that TRROM provides additional information regarding the throwing athlete which cannot be gleaned from examining IR or ER alone. Relatively recently, it was proposed that TRROM loss, in particular a loss of more than 5°, was of clinical significance.<sup>10</sup>

## Approach 3 - humeral torsion

The amount of twist about the long axis of the humerus is either termed "humeral torsion" or "humeral version." In this paper we will use the term "torsion" as much of the clinical literature on human shoulders using the modifier "-version" refers to the architecture of the glenoid (scapula)<sup>11</sup>. If the distal end of the humerus is twisted toward relative external rotation, this is termed relative "retrotorsion", whereas "antetorsion" refers to the opposite. Greater humeral retrotorsion will effectively "shift" a given individual's rotational ROM toward external rotation; that is their external rotational ROM will be increased by the same amount that their IR ROM is decreased, but there will be no change in their TRROM. In the late 1990's, it was suggested that side-to-side differences in humeral torsion were both caused by throwing and related to throwing pathology.<sup>12</sup> Since that time a number of researchers at different institutions, using differing methodology, have confirmed the relationship between humeral retrotorsion and participation in throwing sports, as well as suggested incorporation of torsional differences in the interpretation of rotational ROM findings.<sup>13, 14</sup>

Examination of published data on athletes from across a range of throwing and striking sports suggest that the dominant arm will on average have about 12° more retrotorsion than the non-dominant arm,<sup>12, 15, 16</sup> so on average the dominant arm should have approximately 12° more passive ER, but also 12° less IR, compared to their non-dominant arm. It should be noted that explicit use of this average difference for clinical purpose can be misguided as the related data are not normally distributed, and in fact the amount of humeral torsion can vary from about 12° of antetorsion to about 46° of retrotorsion.<sup>17</sup> The clinician using the average side-to-side difference in humeral torsion for clinical decision-making will, as a result, be wrong much more often than not.<sup>13</sup>

We have observed that different clinicians are commonly interchangeably employing these 3 differing clinical reasoning strategies in the same category of rotational ROM assessment. We suspect that they should instead be considered distinct approaches likely to vary in their classification findings and clinical reasoning interpretation.

Recently, clinical guidelines have been published attempting to synthesize this information in the assessment of the throwing athlete.<sup>18</sup> However we have noted that in publications as well as in clinical practice the notion of osseous involvement in rotational ROM difference, while readily accepted, is rarely formally incorporated in the clinical assessment. Perhaps part of the reason for this lack of formal attention to the inclusion of torsional measures in assessment of shoulder rotational ROM could be the perception that it is simply unnecessary – assuming that it will have no impact on the clinical finding of GIRD and TRROM differences. Accordingly to understand the implications that variation in humeral torsion can have on classification of GIRD, TRROM, and GIRD-torsion the aim of this paper is to document the agreement between these three approaches in classifying rotational ROM deficits in overhead athletes.

## Methods

We analysed rotational range of motion data from 162 professional adult male overhead athletes, categorizing each as at risk by the 3 described methods. These data were collected during annual pre-season medical assessment (physical screening). Shoulder rotational range of motion was measured with the athlete supine, using inclinometry as is routine practice<sup>19</sup>. Humeral torsion was measured using an ultrasound-assisted method as previously described<sup>13</sup>. Athletes were classified as “at risk” using the previously documented cut-points – GIRD:  $\geq 20^\circ$ , TRROM  $\geq 5^\circ$ , GIRD-torsion:  $10^\circ$ . The  $10^\circ$  figure was derived after considering: the smallest detectable differences of the torsion measure,<sup>13</sup> shoulder rotational ROM,<sup>20-22</sup> clinical reasoning, and clinical experience. The prevalence of each of these classifications as well as the agreement between each of the approaches was calculated individually by simple arithmetic and estimations of agreement for each of the pair-wise comparisons<sup>23</sup>.

Local ethics committee approval and informed consent from the athletes was sought and obtained prior to the investigation, and the study was conducted in accordance with the Declaration of Helsinki.

## Results

25 (15.4%) athletes were classified as at risk using GIRD, 55 (34%) with TRROM, and 30 (18.5%) using GIRD-torsion. Only 3/162 (1.9%) athletes were classified as at risk by all 3 approaches, 4 athletes were concurrently classified as at risk by GIRD and TRROM, 11 by GIRD and GIRD-torsion, and 11 by TRROM and GIRD-torsion (Table1).

<Insert Table 1 about here>

## Discussion

The three described approaches to classifying overhead throwing athletes as at risk were not shown to be in agreement in this cohort of athletes.

The limits of shoulder rotational ROM, both IR and external rotation, are not determined by bony abutment, but rather are largely a function of soft tissue extensibility. In the absence of unilateral alteration or pathology, one arm of a given individual would be expected to have a similar amount of TRROM as the other, but their TRROM will likely be different to the one of someone else. In the athlete, simple measurement of bilateral IR ROM (the GIRD approach), because it does not account for humeral torsion, will only be accurate in identifying the presence of soft tissue restrictions as the cause of the limited IR on the rare occasion that an individual has bilaterally equal humeral torsion. A complementary measurement, and bilateral comparison, of shoulder TRROM that shows a reduction in motion on the dominant side, when done without knowledge of humeral retrotorsion, is also limited in its interpretation. Because variation in torsion can be in either direction (retrotorsion or antetorsion) and of a variable magnitude (up to about  $75^\circ$  between individuals and  $46^\circ$  within an individual<sup>17</sup>), it makes it difficult, based on measurements of TRROM and its individual components, to determine if the restriction of movement due to soft tissue tightness affects IR or ER or both, and consequently which movement should be targeted to restore bilaterally equal TRROM.

To incorporate both soft tissue and bony side-to-side differences in the interpretation of shoulder rotational ROM we suggest that clinicians first measure humeral torsion (to understand in what direction and by what magnitude the dominant arm's rotational ROM is shifted due to side-to-side differences in bony morphology) and then measure rotational ROM to be able to identify rotational ROM targets for this individual athlete. It has been our clinical practice for the last 10 years to use an arbitrary cut point of  $10^\circ$  for the GIRD-torsion difference measure.

To illustrate this point, Table 2 presents data for 3 imaginary yet plausible athletes, each with the same passive shoulder rotational ROMs, the same TRROM's, and an apparent GIRD of  $25^\circ$ . It can be seen that by virtue of variation in humeral torsion difference the clinical implications for each athlete's rotational ROM are quite different. The implications for both the GIRD and

TRROM approaches are the same (but contradictory) whereas the GIRD-torsion approach has three distinct outcomes.

Given the clear differences in clinical implications between these 3 approaches, we propose future research can explicitly use these criteria to more firmly establish which has the greater clinical utility. It has been our practice that the combination of GIRD-torsion allows for simple accurate estimation of rotational ROM targets, however we quickly add that while we feel this approach has a stronger underlying theoretical validity, it currently has no experimental evidence other than association<sup>24</sup> to warrant its adoption. Further we acknowledge that the use of ultrasound and other imaging options for humeral torsion may not be available in all clinical situations.

If it transpires that unilateral alterations in rotational ROM are both associated with, and predictive of subsequent injuries in throwing athletes as seems likely<sup>24, 25</sup>, it is important clinically to accurately assess ROM and humeral torsion as part of the examination of the throwing athlete. Most attention has been directed toward IR ROM, however we suggest that there is likely useful information to be gleaned by examining differences in external rotation ROM as well, particularly when accounting for humeral torsion. Currently, our clinical reasoning approach is to consider both reductions as well as increases in rotational ROM as reflecting potentially pathological changes (stiffening and laxity respectively). We postulate that each of these will require a different therapeutic approach – increasing ROM in the reduced flexibility category, and more attention to active (muscular) control for those with aberrantly increased range, particularly when athletes may be fatigued.

We have provided, online, video description of the ultrasound assisted measure of humeral torsion, along with an Excel spreadsheet which uses a simple formula to document the rotational ROM differences including the 3 categorizations described here for an individual. We have found this useful clinically in setting ROM targets, and particularly when screening athletes

where accurate, rapid, targeted feedback is helpful. The sheet describes GIRD, TRROM difference, as well as torsion adjusted internal and external rotation ROM using the non-throwing arm as a reference. We have set arbitrary cut points for flagging a positive test as 20° for GIRD, 5° for TRROM difference, and 10° for torsion adjusted IR ROM. In all these categories, positive values indicate “lost” range of motion, while negative values indicate relative increased range of motion.

## Conclusion

Current terms and methods to document rotational ROM at the shoulder of throwing athletes (GIRD, TRROM difference, and torsion adjusted IR) while complementary provide distinct information, and therefore these terms, and the clinical implications of these measurements, should not be used interchangeably. We suggest that application of clinical reasoning to setting of rotational ROM targets should include accounting for humeral torsion, and that this should apply for both internal as well as external rotation ROM, and in the case of excessive as well as limited ROM.

## Practical implications

- The terms GIRD, TRROM, and GIRD-torsion cannot be used interchangeably
  - Clinical reasoning should consider the source of rotational range of motion differences (ie: soft tissue, or bony), as well as their magnitude and direction, and infer therapy accordingly
  - Differences in TRROM that are considered clinically meaningful are obtained approximately twice as frequently as those obtained with GIRD or GIRD-torsion.
- However, the conclusions derived from the different tests are not concordant and the different tests appear to measure different underlying physical conditions. TRROM is not simply more sensitive than the other two methods.

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Table 1

Method of classifying	(1) GIRD > 20°	(2) TRROM diff. > 5°	(3) GIRD + torsion diff. > 10°
Total number classified "At Risk"	25/162 (15.4%)	55/162 (34.0%)	30/162 (18.5%)
Agreement: number of athletes concurrently classified as "at risk" using the different approaches			$\kappa$ (95%CI), agreement strength <sup>23</sup> , p
(1) & (2)	GIRD > 20° & TRROM diff. > 5° agree	4	-0.142 (-0.260 to -0.025) <i>Poor</i> , 0.039
(1) & (3)	GIRD > 20° & Torsion + IR > 10° agree	11	0.279 (0.093 to 0.464) <i>Fair</i> , 0.000
(2) & (3)	Torsion + IR > 10° & TRROM diff. > 5° agree	11	0.025 (-0.119 to 0.169) <i>Slight</i> , 0.728
(1), (2), & (3)	All 3 approaches agree	3	

Table 1: Classification and agreement of "At Risk" status for rotational range of motion and torsional data in 162 professional athletes (baseball, volleyball, and handball) using the three described approaches. Only 3/162 individuals were concurrently classified as "At risk" by all 3 approaches. We expressed agreement as  $\kappa$  values between 0 and 1. We interpreted the strength of the agreement according to the recommendations by Landis and Koch<sup>23</sup>, where the strength of agreement for  $\kappa < 0.00$  are considered as poor (less than expected by chance), 0.00-0.20 as 'slight', 0.21-0.40 as 'fair', 0.41-0.60 as 'moderate', 0.61-0.80 as 'substantial' and 0.80-1.0 as 'almost perfect'.

Table 2

Dominant IR	Dominant ER	Non-Dominant IR	Non-Dominant ER	TRROM difference	GIRD	Torsion difference	GIRD-Torsion	Clinical implication incorporating torsional difference
45°	170°	70°	145°	0°	25°	0°	25°	Needs 25° more Dominant arm IR (& 25° less ER)
45°	170°	70°	145°	0°	25°	+25°	0°	Symmetric rotational ROM, no attention to ROM required
45°	170°	70°	145°	0°	25°	+35°	-10°	Has 10° too much Dominant IR (and needs 10° more dominant ER)

Table 2: Example data for 3 athletes with the same rotational ROM, no TRROM difference, GIRD of 25°, but

differences in humeral torsion. Note that 'Torsion difference' represents the torsion value of non-dominant arm minus the dominant arm, and that a positive value indicates that the dominant arm is more retroverted.