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ASSESSMENT OF GLENOHUMERAL INTERNAL ROTATION DEFICIT AND SCAPULA UPWARD ROTATION DIFFERENCY WITHIN HUNGARIAN NB2 HANDBALL PLAYERS

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ABSTRACT. The aim of our cross-sectional study was to assess the rotational range of motion of the shoulder joint and the scapula movement of Hungarian NBII handball players, to find out how many athletes may be affected by a rotational range of motion deficit. We also wanted to gain insight into whether players with GIRD report more pain. The study was conducted between September and October 2023. We studied 31 male handball players, all of whom participated in training sessions at least 3 times a week. The survey showed that more than half of the athletes were affected by some level of range of motion deficit. Of those assessed, 29% were affected by Glenohumeral Internal Rotation Deficit (GIRD) and 55% by Total Arc of Motion Deficit (TAMD). Those who had at least 15° of internal rotation deficit during pretesting had significantly less scapula upward rotation in the neutral shoulder, 60° abduction and 90° abduction positions. No significant difference was found in the 120° shoulder abduction position. For the non-dominant upper limb, no significant difference was found between the two groups. Athletes with GIRD reported significantly greater pain on the VAS scale than those without internal rotation deficit.

Keywords: *GIRD, handball players, shoulder joint, scapula up rotation, pain*

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INTRODUCTION

Today the most overhead athletes are affected by Glenohumeral Internal Rotation Deficit (GIRD), in which the internal rotation range of motion (ROM) of the dominant shoulder is reduced compared to the non-dominant side (Aldridge, Stephen Guffey, Whitehead & Head, 2012; Bailey, Thigpen, Hawkins, Beattie & Shanley, 2017; Ohuchi, Kijima, Saito, Sugimura, Yoshikawa & Miyakoshi, 2023). On average, a difference of more than 18-20° is defined as GIRD (Johnson, Fullmer, Nielsen, Johnson, & Moorman, 2018). It is also important to mention the Total Arc of Motion Deficit (TAMD), which represents a 5° decrease in the total rotational range of motion between the dominant and non-dominant shoulder (Amin, Ryan, Fening, Soloff, Schickendantz & Jones, 2015; Guzowski, Stolarczyk, Czyrny, Dębek & Kranc, 2019). These changes are closely related, since, if the internal rotation is reduced, the total rotational range will also change. Most of the research on GIRD tends to focus on baseball players, but handball players are at similar risk, as it is a very explosive overhead contact sport with frequent changes of direction and different throwing techniques (Lubiatowski, et al., 2018). Handball players make at least 48 000 throwing movements in a season in training and matches, with the ball weighing between 425 - 475 grams and leaving their hands at an average speed of 130 km/h after the throw (Almeida, et al., 2013). Bony and articular capsular adaptations are thought to underlie GIRD (Kibler, Ludewig, McClure, Michener, Bak & Sciascia, 2013; Le Gal, Begon, Gillet, & Rogowski, 2018; Tucker & Slone, 2016). These adaptations are thought to be closely associated with repetitive and sometimes extreme throwing stress (Seabra, Van Eck, Sá, & Torres, 2017; Thomas, et al., 2011). During increased humeral retroversion (HR), the humerus exhibits increased adaptive longitudinal torsion compared to its physiological state (Kay, et al., 2018). In capsular changes, thickening of the posterior capsule is usually highlighted (Tooth, Schwartz, Gofflot, Bornheim, Croisier, & Forthomme, 2023). In some sports, such as handball, water polo and baseball, GIRD is an advantage, as the ROM of the external rotation is usually increased. As a result, they can rotate their shoulders backwards more and throw harder, but some research suggests that at a 20° internal rotation deficit, they are 2 times more likely to be injured (Reuther, Sheridan, & Thomas, 2018). Some research shows that the prevalence of shoulder pain among competitive athletes is as high as 30-45% (Hosseinimehr, Anbarian, Norasteh, Fardmal & Khosravi, 2015). It is important to underline that it is not a single disease, but can be associated with a number of pathologies (Kibler, Sciascia & Thomas, 2012), most commonly postero-superior impingement syndrome (PSI), rotator cuff injuries, anterior instability or labral pathologies (Fairall et al., 2017; Thomas et al. 2013). GIRD is associated with altered kinematics of the glenohumeral and scapulothoracic junction due to shortening of the posterior part of the joint capsule, with shrinkage of the soft tissues, abnormal scapular

positioning, increased anterior tilt and protraction, and reduced the upward rotation of the scapula (Guney & Baltaci, 2015). It is important to recognize GIRD as soon as possible to avoid various injuries such as impingement syndrome due to impingement of the supraspinatus tendon, injuries to the posterior superior labrum and anterior inferior capsular structures (Suszter, Nicolas, Mollee & John, 2015).

OBJECTIVE

The aim of our study is to assess the percentage of handball players with a shoulder joint internal rotation deficit and a total rotation deficit. In addition, we want to find out whether those with a greater internal rotation deficit will have less upward rotation of the scapula. Furthermore, we aim to find out whether the presence of GIRD is associated with greater pain. Three hypotheses were formulated, our first hypothesis being that at least 25% of athletes have GIRD and more than 50% have TAMD. Our second hypothesis is that those with an internal rotation deficit greater than 15 degrees will have less scapular upward rotation on the dominant side. Finally, our third hypothesis is that players with rotational deficits will have greater pain in their shoulder during throwing than those without deficits.

METHODS

Before the measurements, we asked the athletes about their demographics, how long they had been playing handball, and assessed their pain level using a VAS scale. During the survey, we examined the athletes' active rotational range of motion. Participants were in a prone position with their shoulders in 90° abduction and elbows in 90° flexion. After stabilizing the scapula, the examiner asked the participant to perform internal- and external rotations with the mobile stem of the goniometer in line with the participant's ulna and the stable stem in a diagonal line with the ground. The range of motion continues until the scapula is in motion. The active total rotation range of motion was calculated from the sum of the active internal- and external rotation (Thomas, Swanik, Swanik & Kelly, 2010). The passive ROM assessment was performed in a similar manner, differing only in that the participants were in supine position (Thomas, Swanik, Swanik & Kelly, 2010). For scapula rotation measurement, the participant stood in a normal, relaxed posture. For the measurement, a helper positioned the upper limb in 60°, 90° and 120° abduction positions, and a goniometer was used to adjust the degrees. The upward rotation of the scapula was then measured at rest, 60°, 90° and 120° abduction positions by positioning the

lateral arm of the inclinometer posterolateral over the acromion and the medial arm at the medial, spina scapulae origin of the scapula margo (Thomas, Swanik, Swanik & Kelly, 2010). To measure the scapula upward rotation in our research, we used Xiaomi Duka LI1 Laser Protractor Digital Inclinometer with an accuracy of ±0.5°. Measurements were performed on both dominant and non-dominant upper limbs.

We included male NBII handball players who had been playing handball at least 3 times a week for at least 5 years for at least one and a half hours for at least 3 times a week and were at least 18 years old. They attended the training sessions during the measurement period. Athletes who had undergone shoulder surgery within one year, shoulder trauma within six months (humerus proximal end fracture, dislocation) were excluded (Guzowski et al., 2019).

For statistical analysis of the study results, data were recorded and analyzed in Microsoft Excel 2021. Descriptive statistics were used to process demographic data and to determine the prevalence of GIRD and TAMD. A two-sample t-test was performed to statistically compare the groups with smaller as well as larger scapula up-rotation. The significance level was set at $p < 0.05$.

RESULTS

The study population consisted of 31 athletes, with a mean age of 19.23±1.34 years and 9.42±1.88 years of handball playing experience. They averaged 181.94±5.89 cm in height and 78.74±6.16 kg in body weight, with a BMI level of 23.79±1.49. At the time of the survey, the athletes reported an average of 2.52±1.12 pain levels.

Table 1. Characteristics of the population

Population (person)	**31**
Age (year)	19.23±1.34
Height (cm)	181.94±5.89
Weight (kg)	78.74±6.16
BMI (kg/m2)	23.79±1.49
Years of playing (year)	9.42±1.88
Pain (VAS)	2.52±1.12

The mean passive internal rotation range of motion in the dominant upper limb of the athletes assessed was 66.77°±9.67°, the mean passive rotational range of motion was 94.84±1.63° and the mean total rotational range of motion was 161.61°±9.26°. For the non-dominant upper limb, the mean passive internal rotation was 76.39°±4.90°, the mean passive external rotation

was 93.23±1.96° and the mean total rotational ROM was 169.58°±5.51°. There were also significant differences in passive internal rotation ($p<0.001$), external rotation ($p<0.001$), and total rotational range of motion ($p<0.001$), as well as active internal rotation ($p<0.001$) and total rotational ROM ($p=0.002$) between dominant and non-dominant upper limbs. No significant difference was found bilaterally in the active rotational ROM ($p=0.476$). Of the athletes assessed, 9 had an internal rotation deficit greater than 18°, i.e. 29% had GIRD and 55% had TAMD, i.e. 17 athletes had a total rotational difference greater than 5°.

Table 2. Comparison of rotational ranges of motion between dominant and non-dominant limbs handball players assessed

	Dominant side (n=31)	**Non dominant side (n=31)**	**p-value**
Active internal rotation	61.23°±9.45°	69.06°±6.65°	<0.001*
Passive internal rotation	66.77°±9.67°	76.39°±4.90°	<0.001*
Active external rotation	89.06°±2.11°	88.52°±3.69°	0.476
Passive external rotation	94.84±1.63°	93.23±1.96°	<0.001*
Active internal rotation	150.29°±9.57°	157.58°±8.27°	0.002*
Passive rotation	161.61°±9.26°	169.58°±5.51°	<0.001*
GIRD rate – 29%		**TAMD rate – 55%**	

The mean scapula upward rotation of the dominant upper limb was found to be significantly lower in the neutral ($p<0.001$), 60° ($p<0.001$) and 90° abduction ($p<0.001$) positions of the shoulder joint in subjects with at least 15° internal rotation deficit. No significant difference was detected in the 120° abduction position of the shoulder joint between the two groups ($p=0.085$). Also, no significant difference was detected in the different positions of the shoulder joint on the non-dominant side.

Table 3. Comparison of the scapula upward rotation of the dominant side in different abduction positions of the shoulder joint in groups greater than 15° internal rotation deficit and less than 15° deficit

glenohumeral joint	**internal rotation deficit <15° (n=17)**	**internal rotation deficit >15° (n=14)**	**p-value**
neutral	6.39°±1.63°	3.59°±1.26°	<0.001*
60° abduction	16.98°±1.24°	14.59°±0.76°	<0.001*
90° abduction	29.48°±1.77°	26.26°±1.08°	<0.001*
120° abduction	37.74°±1.47°	36.79°±1.48°	0.085

Significantly greater pain was reported in the assessments by athletes with GIRD ($p<0.001$). The 9 players with GIRD reported a pain severity of 3.44±0.53 on the VAS scale, compared to those without GIRD who reported a pain severity of 2.05±0.95.

Table 4. Comparison of pain levels between GIRD and non-GIRD groups

GIRD	**nonGIRD**	**p-value**
3.44±0.53	2.05±0.95	<0.001
Whole population	***2.52±1.12***	**-**

DISCUSSION

In addition to assessing the shoulder internal rotation and full rotation range of motion deficits, our research sought to explore whether players with at least a 15° deficit have greater scapula upward rotation than those without such a deficit.

Our first hypothesis that at least 25% of the handball players surveyed would fall within the definition of GIRD was confirmed. Of the 31 athletes surveyed, 9 subjects had a passive internal rotation range of motion of their dominant upper limb at least 18° less than the same value for the non-dominant lateral upper limb. In a study published in 2018, Prateek Srivastav et al. looked at 127 athletes to find out the prevalence of GIRD in athletes and whether it was associated with scapula dyskinesis and rotator cuff muscle strength. Of the athletes they assessed, 37 had an internal rotation deficit, so 29.1% had GIRD (Prateek, Ganesh & Siddharth, 2018). Schlechter J. et al. also examined the prevalence of GIRD in the population they assessed, but they used a higher cut-off point, defining the deficit as a 25° difference. In their survey, 14% of athletes had GIRD. They also mentioned 4 other studies that also investigated the prevalence of internal rotation deficits. Of these, 3 studies used a similar number of elements as ours and averaged similar results around 30%. The fourth study had an order of magnitude higher prevalence of GIRD of 18% out of 288 person (Suszter, et al., 2015). Nakamizo et al. reported similar results, with 10 out of 25 athletes in their study showing a difference of at least 20° when comparing the range of internal rotation motion of the two upper limbs (Nakamizo, et al. 2008). Although they reported a difference of 40%, the athletes they assessed were baseball players, who are at even greater risk due to different throwing techniques than handball players. More than 50% of handball players are affected by TAMD, with 17 of 31 athletes assessed, or 55%, having a passive

total rotational range of motion of their dominant upper limb more than 5° less than the same value for the non-dominant lateral upper limb in the preliminary survey. A 2019 study by Guzowski K. et al. found similar results, with 38 of the 66 athletes they assessed having a difference of more than 5° between their dominant and non-dominant upper limb, representing 57.6% (Guzowski et al., 2019).

Our second hypothesis, that those with an internal rotation deficit greater than 15° will have less upward scapula rotation, was partially correct. There was significantly less scapula upward rotation in the shoulder joint neutral, 60° and 90° abduction positions for those with a 15° internal rotation deficit between the dominant and non-dominant upper limb ($p<0.001$). There was no significant difference between the two groups in the 120° abduction position ($p=0.085$). Similar results were obtained in 2010 by Thomas et al., they conducted their measurements on baseball players. In their study, 43 athletes were divided into two groups, a case group (GIRD >15°), which included 22 players, and a control group (GIRD <15°), which included 21. The results showed that scapula upward rotation was significantly less in the 60° ($p=0.025$), 90° ($p=0.004$) and 120° ($p=0.039$) abduction positions of the shoulder joint in the group with 15° deficit than in the group with less than 15° deficit (Thomas, et al., 2010). Thomas et al. in their study found no significant difference in scapula upward rotation measured in the neutral position of the shoulder joint between the two groups, but there was a significant difference in the 120° abduction position of the shoulder joint, which was not observed in our study. This difference may be explained by the difference in throwing techniques between the two sports, as handball players not only use overhead throwing techniques, but also often throw from the body, unlike baseball players. Laudner et al. compared the scapular position and movements of pitchers with pathological internal impingement of the shoulder to asymptomatic pitchers. Their results showed that in the group of players with significantly greater internal rotation deficits, sternoclavicular elevation and posterior scapular tilt increased during glenohumeral elevation and scapular upward rotation decreased (Laudner, et al., 2006).

Our third hypothesis, which hypothesized that players with rotational deficits would have greater shoulder pain during throwing than those without deficits, proved to be true. Of the 31 athletes we assessed, the 9 athletes who had a rotational deficit had significantly greater pain on the VAS scale than those who did not have a deficit. Almeida et al. divided athletes into a pain group and a non-pain group. Their results showed that the pain group had a significantly smaller range of internal rotation motion than the non-pain group, and the degree of internal rotation deficit was also greater between the two groups (Almeida, et al., 2013). In 2019 Ahmed Mohammed Alqarni et al. investigated the association between pain and rotational deficit. They divided athletes into two groups, a painful case group and a pain-free control group. Their results showed that the case

group had significantly lower internal rotation range of motion than the control group. When testing the correlation between pain level and internal rotation deficit, no significant correlation was found between pain level and shoulder rotational range of motion adaptations (Alqarni, Nuhmani, & Muaidi, 2024).

CONCLUSION

More than a quarter of handball players are affected by GIRD and more than half by TAMD. These phenomena have been observed in several previous studies, mostly focused on baseball players, but it has been shown that the prevalence of these lesions is similar among handball players. Players who had an internal rotation deficit of at least 15° relative to non-dominant sides had significantly lower scapula upward rotation. This type of deformity may be the basis for many injuries as it can lead to disruption of scapulohumeral rhythm. The dynamic stabilizing function of the rotator cuff is reduced, putting the static stabilisers at greater risk of injury. In terms of pain, athletes with GIRD have reported greater pain, which may be a predictor of pathologies such as impingement syndrome.

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