

# Effects of Perceived Shoulder Dysfunction on Shoulder Biomechanics during Upper Quarter Y-Balance Test (YBT)

Robin Loiseau<sup>a, b\*</sup>, Yoann Blache<sup>a</sup>, Théo Arnould<sup>a</sup>,  
Méllick Filliard<sup>a</sup>, Isabelle Rogowski<sup>a</sup>

<sup>a</sup> Université Claude Bernard Lyon 1, Laboratoire Interuniversitaire de Biologie de la Motricité- UR 7424, Lyon, France

<sup>b</sup> Université Lyon 1, Graduate Initiative MuSkLE, Lyon, France

\* Corresponding author: robin.loiseau@univ-lyon1.fr

Received date: 14/01/2026

Accepted date: 16/03/2026

Publication date: 02/06/2026

**Keywords:** physical performance testing, Western Ontario shoulder instability questionnaire, upper limb

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Published by Société de Biomécanique

## 1. Introduction

Physical tests are used by clinicians to assess shoulder functions and risk for injury. Especially, YBT is designed to assess joint stability and mobility of the body upper quarter at the limit of stability (Bauer et al., 2023). While frequent physical screening may be time-consuming and fail to detect early injury markers, self-reported functional perception scales emerge as an alternative (Partner et al., 2022). However, it remains to establish whether the athletes with perceived shoulder dysfunction (DYS) present shoulder biomechanical impairments when performing YBT.

This study aimed to assess the effects of **DYS** on the ground reaction forces (GRF), muscle activity and scapular kinematics of the support upper extremity during YBT.

## 2. Methods

### 2.1 Participants

Twelve overhead sport athletes with dominant side **DYS** and twelve non-dysfunctional (**NDYS**) matched-controls (Table 1) participated in this study (Ethical Committee #2024121201). **DYS** was defined by a score above 250 pts for the Western Ontario Shoulder Instability questionnaire (Kirkley et al., 1998).

### 2.2 Testing procedure

Each athlete was equipped with four surface electromyography (EMG) electrodes on dominant Upper (UT), Middle (MT) and Lower Trapezius (LT), and

Serratus Anterior (SA) and with 29 markers placed on the thorax (8), and dominant scapula (5), clavicle (2), arm (7) forearm (3) and hand (4).

After a standardized warm up, four isometric maximal contractions were repeated twice to record the UT, MT, LT and SA maximal activity (2000 Hz; Trigno Avanti Sensor, Delsys, Boston, US). A custom kinematic model with subject-specific ellipsoid, defining the scapulothoracic joint, was used from 5 static poses for which the trigonum spinae and inferior angle markers were relocated after palpation (Lefebvre et al., 2025). The marker trajectories were recorded using 14 cameras (200 Hz; Miquis M3, Qualisys AB, Goeteborg, Sweden).

For YBT, the athlete was in one hand push up position with dominant hand on a force plate (2000 Hz; FP5060-06-PT-2000, Bertec Corporation, Columbus, US) and feet spaced at shoulder width on a second force plate. Then, with the free hand, the athlete was instructed to move a reach indicator as far as possible, in medial, inferolateral and superolateral directions successively. After a familiarization trial, three maximal trials were performed. Maximal distance per direction was normalized by the limb length, i.e. distance between the 7<sup>th</sup> cervical and 3<sup>rd</sup> finger when the nondominant upper limb abducted at 90°, elbow, wrist and fingers fully extended, and thumb pointed upward.

### 2.3 Outcome measures

GRF data were filtered (low-pass 4th-order Butterworth filter, 20-Hz cut-off frequency) and expressed relative

to body mass. For each reach direction, the X-axis of the GRF local reference system was aligned with the direction of motion, the Z-axis, perpendicular to motion ( $GRF_P$ ), and Y-axis with gravitational direction ( $GRF_G$ ). EMG data were filtered (4th-order Butterworth filter, pass-band 15-450 Hz), rectified, smoothed (4th-order Butterworth filter, low-pass 20-Hz), and expressed relative to maximal activity of maximal contractions. Scapular rotations were defined as internal/external, downward/upward rotations and anterior/posterior tilt.

For each YBT direction.  $GRF_M$ ,  $GRF_P$  and  $GRF_G$  for hand and feet and EMG per muscle were averaged between 70% and 100% of the reach distance during both the reach and return phases. Ranges of motion per scapular rotation were computed for the same phase portions. Finally, for  $GRF_G$ , mean hand values were divided by mean feet values ( $GRF_{Prop}$ ).

Independent t-tests were used to compare demographic and dominant-side biomechanical parameters between DYS and NDYS groups, with significant level set at  $p \leq 0.05$ . Hedges' g effect sizes were computed and interpreted as  $g \approx 0.2$  for small,  $g \approx 0.5$  for medium and  $g \approx 0.8$  for large effect.

### 3. Results and discussion

Table 1 shows participants' characteristics and mean outcome measures. Both groups had similar demographic and anthropometric characteristics, and DYS group had WOSI scores 10 times higher than NDYS group, validating the perception of altered shoulder functions. Athletes with perceived shoulder instability achieved similar YBT distances as controls, confirming the limited YBT ability to screen for shoulder injury risk (Bauer et al., 2023).

Perceived shoulder instability of the support upper extremity resulted in no periscapular muscle nor scapular range of motion adaptations when compared to healthy shoulder. For mediolateral reach direction, the perceived shoulder instability led to reduced vertical loading on the hand and a compensatory increase in loading through the feet. These adaptations in GRF distribution would involve changes in reaction force orientation and intensity at the glenohumeral joint and/or changes in force couples of the deep muscles, such as the rotator cuff muscles (Ishikawa et al., 2023). To better understand the underpinning biomechanics, further studies should enroll larger sample size and

integrate musculoskeletal simulations to explore the glenohumeral joint loading related to the perceived shoulder dysfunction.

### 4. Conclusions

Maintaining physical performance despite the perceived shoulder instability did not appear related to adaptations in underlying neuromuscular strategies. These preliminary findings suggest that monitoring athlete's self-reported dysfunction may be relevant for detecting early-stage shoulder pathology.

### Conflict of Interest Statement

None.

### Contributor Roles

RL: Conceptualization, Methodology, Writing original draft, Data collection and treatment; YB: Conceptualization, Methodology, Data treatment, Supervision, Funding acquisition, Writing – review & editing; TA: Methodology, Data collection and treatment; MF: Methodology, Data collection; IR: Conceptualization, Methodology, Writing – review & editing, Supervision, Funding acquisition.

### Funding

This study was supported by the 'Région Auvergne-Rhône-Alpes' (#2101788201).

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**Table 1.** Mean ( $\pm$  standard deviation) anthropometric and demographic characteristics, YBT distances (% limb length), muscle activity (% IMVC) of upper (UT), middle (MT) and lower trapezius (LT) and serratus anterior (SA), ground reaction forces (N.kg<sup>-1</sup>) in moving direction (GRF<sub>M</sub>), perpendicular motion direction (GRF<sub>P</sub>), and vertical direction (GRF<sub>G</sub>), scapular ranges of motion (°) in internal/external (IER), downward/upward (DUR) rotations and anterior/posterior tilt for athletes with (DYS) and without perceived dysfunction (NDYS); effect sizes (g) and p-value.

		DYS	NDYS	g	p	
Age (years)		20.9 $\pm$ 2.3	21.1 $\pm$ 4.3	0.05	0.46	
Sex (M/F)		10/2	10/2			
Height (m)		1.77 $\pm$ 0.06	1.76 $\pm$ 0.10	0.11	0.30	
Weight (kg)		70.2 $\pm$ 4.8	69.3 $\pm$ 10.5	0.22	0.40	
Weekly training (hr)		5 $\pm$ 1	5 $\pm$ 2	0.00	0.50	
WOSI Score		546 $\pm$ 232	45 $\pm$ 57	2.96	<0.001 <sup>a</sup>	
YBT Medio-Lateral	Distance	1.09 $\pm$ 0.09	1.11 $\pm$ 0.04	0.30	0.24	
	LT	0.22 $\pm$ 0.22	0.19 $\pm$ 0.14	0.08	0.35	
	MT	0.05 $\pm$ 0.03	0.07 $\pm$ 0.10	0.29	0.24	
	UT	0.19 $\pm$ 0.14	0.16 $\pm$ 0.11	0.17	0.34	
	SA	0.38 $\pm$ 0.15	0.37 $\pm$ 0.1	0.04	0.46	
	Hand	GRF <sub>M</sub>	0.43 $\pm$ 0.09	0.42 $\pm$ 0.14	0.10	0.41
		GRF <sub>G</sub>	5.79 $\pm$ 0.32	5.98 $\pm$ 0.23	0.66	0.06
		GRF <sub>P</sub>	1.60 $\pm$ 0.35	1.51 $\pm$ 0.33	0.29	0.25
	Feet	GRF <sub>M</sub>	-0.27 $\pm$ 0.39	-0.33 $\pm$ 0.32	0.18	0.34
		GRF <sub>G</sub>	4.21 $\pm$ 0.30	3.99 $\pm$ 0.29	0.76	0.04
		GRF <sub>P</sub>	1.50 $\pm$ 0.33	1.35 $\pm$ 0.36	0.44	0.15
	Hand/feet	GRFG	0.58 $\pm$ 0.03	0.60 $\pm$ 0.02	0.85	0.03
		IER	12.66 $\pm$ 13.74	11.84 $\pm$ 6.99	0.07	0.43
		DUR	14.71 $\pm$ 11.68	16.20 $\pm$ 11.76	0.13	0.38
	YBT Infero-Lateral	APT	4.62 $\pm$ 5.92	3.41 $\pm$ 3.79	0.24	0.28
Distance		0.96 $\pm$ 0.17	0.93 $\pm$ 0.10	0.27	0.26	
EMG		LT	0.07 $\pm$ 0.09	0.06 $\pm$ 0.07	0.17	0.35
		MT	0.06 $\pm$ 0.06	0.03 $\pm$ 0.02	0.63	0.08
		UT	0.28 $\pm$ 0.14	0.24 $\pm$ 0.13	0.28	0.26
		SA	0.47 $\pm$ 0.23	0.50 $\pm$ 0.22	0.15	0.36
Hand		GRF <sub>M</sub>	0.21 $\pm$ 0.14	0.23 $\pm$ 0.07	0.23	0.30
		GRF <sub>G</sub>	5.37 $\pm$ 0.55	5.37 $\pm$ 0.36	0.00	0.50
		GRF <sub>P</sub>	1.28 $\pm$ 0.48	1.49 $\pm$ 0.46	0.44	0.15
Feet		GRF <sub>M</sub>	-0.10 $\pm$ 0.23	-0.15 $\pm$ 0.21	0.22	0.30
		GRF <sub>G</sub>	4.60 $\pm$ 0.49	4.55 $\pm$ 0.38	0.10	0.42
		GRF <sub>P</sub>	1.21 $\pm$ 0.57	1.33 $\pm$ 0.47	0.23	0.29
Hand/feet		GRFG	0.54 $\pm$ 0.05	0.54 $\pm$ 0.04	0.06	0.45
		IER	26.31 $\pm$ 12.81	20.48 $\pm$ 8.77	0.25	0.27
		DUR	30.97 $\pm$ 9.69	26.37 $\pm$ 13.25	0.36	0.20
YBT Supero-Lateral	APT	10.80 $\pm$ 10.76	7.41 $\pm$ 6.02	0.36	0.19	
	Distance	0.81 $\pm$ 0.10	0.82 $\pm$ 0.09	0.10	0.42	
	LT	0.07 $\pm$ 0.05	0.09 $\pm$ 0.05	0.36	0.20	
	MT	0.04 $\pm$ 0.03	0.03 $\pm$ 0.02	0.36	0.20	
	UT	0.24 $\pm$ 0.16	0.17 $\pm$ 0.10	0.48	0.14	
	SA	0.21 $\pm$ 0.09	0.17 $\pm$ 0.08	0.44	0.16	
	Hand	GRF <sub>M</sub>	0.04 $\pm$ 0.14	0.04 $\pm$ 0.14	0.03	0.48
		GRF <sub>G</sub>	6.88 $\pm$ 0.59	7.11 $\pm$ 0.34	0.48	0.13
		GRF <sub>P</sub>	0.46 $\pm$ 0.60	0.32 $\pm$ 0.33	0.27	0.26
	Feet	GRF <sub>M</sub>	-0.01 $\pm$ 0.18	-0.01 $\pm$ 0.10	0.01	0.49
		GRF <sub>G</sub>	3.07 $\pm$ 0.65	2.80 $\pm$ 0.27	0.55	0.10
		GRF <sub>P</sub>	0.32 $\pm$ 0.56	0.14 $\pm$ 0.33	0.40	0.17
	Hand/feet	GRFG	0.69 $\pm$ 0.06	0.72 $\pm$ 0.03	0.53	0.11
		IER	24.45 $\pm$ 13.60	30.37 $\pm$ 13.40	0.33	0.22
		DUR	34.07 $\pm$ 10.49	36.72 $\pm$ 14.77	0.63	0.12
	APT	9.17 $\pm$ 5.05	10.40 $\pm$ 4.66	0.55	0.13	

<sup>a</sup> p was obtained from non-parametrical Mann-Whitney test.

Credit: Loiseau.