PRÄVENTION VON SCHULTERVERLETZUNGEN BEI JUNGEN ATHLETINNEN UND ATHLETEN

2.SPORTORTHODAY WINTERTHUR

ARIANE SCHWANK

29.SEPTEMBER 2023

KSW Kantonsspital Winterthur

Klinik & Forschung

ARIANE SCHWANK, PT, MSc[1-3a] • PAUL BLAZEY, PT[4a] • MARTIN ASKER, PT, PhD[5,6] • MERETE MØLLER, PT, PhD[7,8]
MARTIN HÄGGLUND, PT, PhD[9] • SUZANNE GARD, PT, MSc[10,11] • CHRISTOPHER SKAZALSKI, PT, DPT[8]
STIG HAUGSBØ ANDERSSON, PT, PhD[8] • IAN HORSLEY, PT, PhD[12] • ROD WHITELEY, PT, PhD[13,14] • ANN M. COOLS, PT, PhD[15]
MARIO BIZZINI, PT, PhD[16] • CLARE L. ARDERN, PT, PhD[17-19] • ON BEHALF OF THE ATHLETE SHOULDER CONSENSUS GROUP[b]

2022 Bern Consensus Statement on Shoulder Injury Prevention, Rehabilitation, and Return to Sport for Athletes at All Participation Levels

KSW Kantonsspital Winterthur

RETURN TO SPORT CONTINUUM

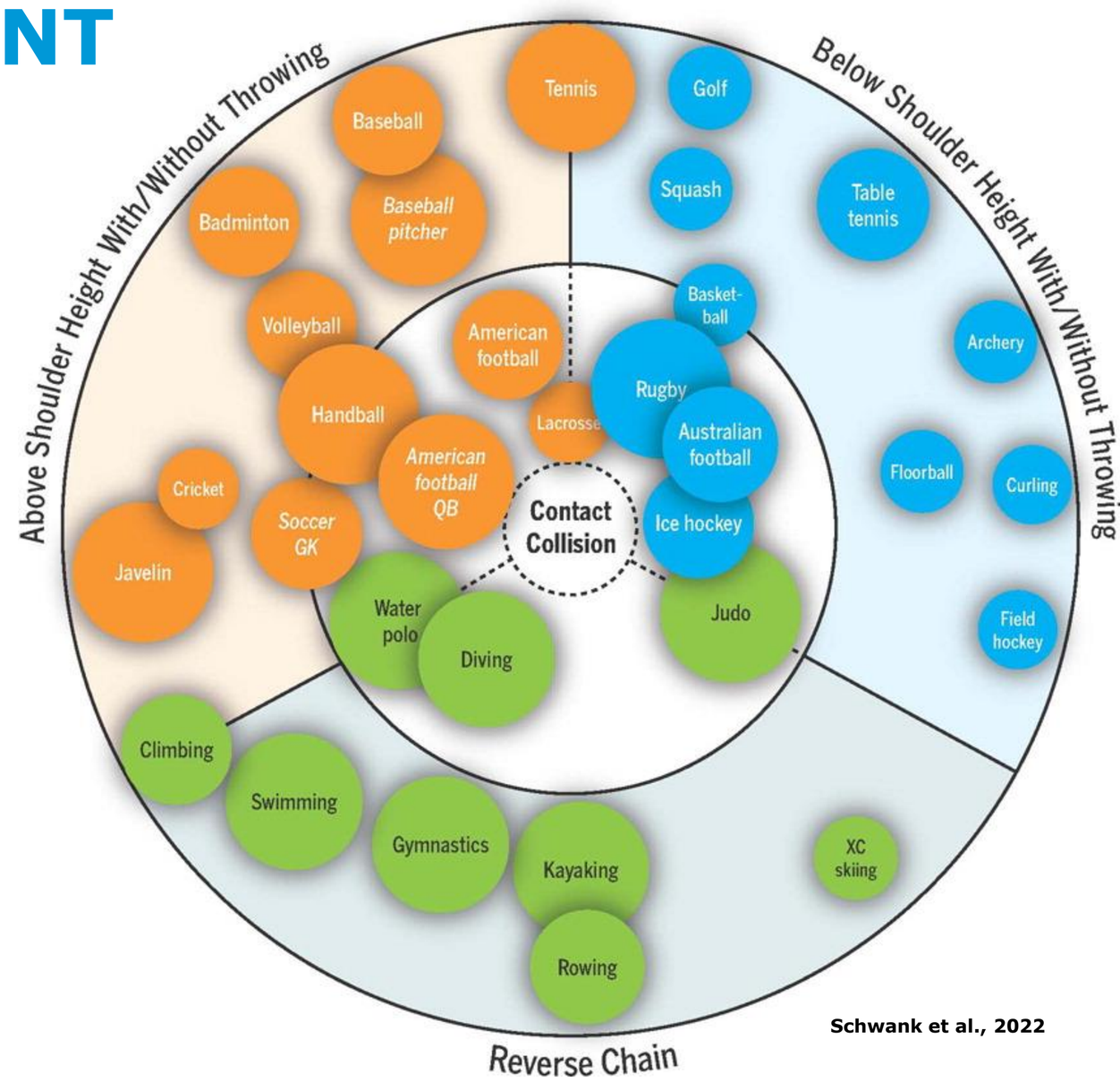
Ardern CL et al. 2016 consensus statement on return to sport from the First World Congress in Sports Physical Therapy, Bern. *Br J Sports Med*.

INJURY RISK MANAGEMENT

- 3 Kategorien:
  - Über Schulter Höhe
  - Unter Schulter Höhe
  - Umgekehrte Kette

- Grösse der Kreise = relative Belastung auf die Schulter im jeweiligen Sport

- *Kursive Schrift = Goalie im Fussball oder QB in AM FB → Positions spezifische erhöhte Belastung*



Schwank et al., 2022

PRÄVENTION IST BESSER ALS REHA

vor allem bei jungen Athletinnen und Athleten

Was bekannt und was unbekannt bezüglich Risikofaktoren für Schuletverletzungen bei Athletinnen und Athleten ist

Screening der athletischen Schulter

Verletzungsrisiko handhaben mittels primären und sekundären Präventionsprogrammen

Implementierung von Übungsprogrammen zur Prävention

RISIKO-FAKTOREN FÜR SCHULTER-VERLETZUNGEN IM SPORT

- ROM Verlust
- Dysbalance der Kraft zwischen Rotationen
- Muskelschwäche[1]
- Veränderungen der Belastung (load)[2, 3]
- Spielerposition
- Sport Niveau
- Geschichte von Schulterschmerz
- Psychosoziale Faktoren

[1]im Vergleich zu baseline Eigenwerten oder normativen Werten

[2]>60% Zunahme der Belastung (load) / Woche, im Vergleich zu den durchschnittlichen vergangenen 4 Wochen

[3]>16h Exposition / Woche von Schulter spezifischer Belastung z.B. Würfe

Asker et al. Risk factors for, and prevention of, shoulder injuries in overhead sports: a systematic review with best-evidence synthesis. 2018
Asker et al., Female adolescent elite handball players are more susceptible to shoulder problems than their male counterparts. 2018
Møller et al. Handball load and shoulder injury rate: a 31-week cohort study of 679 elite youth handball players. 2017
Olds et al. Who will redislocate his/her shoulder? Predicting recurrent instability following a first traumatic anterior shoulder dislocation. 2019

SCREENING VON RISIKOFAKTOREN FÜR EIN "RISKPROFILING"

JA – NEIN – WIE – WANN?

- Fehlende Evidenz und Unklarheit bezüglich Effektivität
- Testergebnisse sind meist schwierig zu interpretieren
- Es gibt keinen Test / Testbatterie, die primäre (vor der ersten Verletzung) oder sekundäre (nach der Verletzung) screening Prozesse unterstüzen würden

- Generisches muskuloskelettales Schulter Screening
- Vor – Mitte – nach Saison
- Unterstützt RTS Entscheidungen

➡ Besser ein regelmässiges Monitoring durchführen, als potenzielle Risikofaktoren zu screenen

GENERISCHES MUSKULOSKELETTALES SCHULTER SCREENING

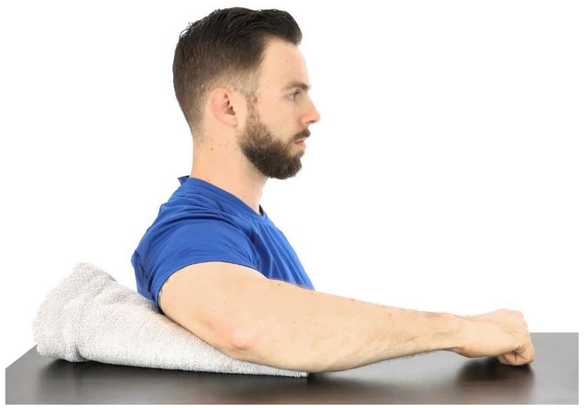
Nicht Verletzungs-spezifisch enthält eine Mischung aus:

- ROM
- Kraft (force), power (rate of force development)
- Sport-spezifischen Ratios für glenohumerale Innenrotation [IR]:Aussenrotation [AR]
- jegliche relevanten Tests für den jeweiligen Sport

IR : AR RATIOS

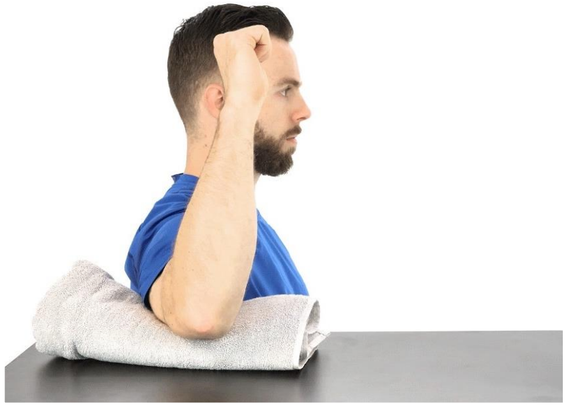
Neutral – Null

RATIO 0.70 to 0.75



90°ABD / neutrale Rot

RATIO 0.90 to 1.00



90° ABD / 90° AR

RATIO 0.60 to 0.85

Cools et al. Reference values for overhead athletes. *Knee Surg Sports Traumatol Arthrosc*. 2016

ÜBUNGSPROGRAMME ZUR PRÄVENTION

Consensus point
Präventionsprogramme mindestens **zweimal wöchentlich** für das gesamte Team einplanen, damit alle die mindeste « Dosis » erhalten

Consensus point
Übungsprogramme zur Prävention von Schulterverletzungen sollten auf allen Niveaus der Professionalität des Sportes hineinpassen

PRIMÄRE UND SEKUNDÄRE PRÄVENTIONS-ROGRAMME

ALLGEMEINE PRINZIPIEN

- Übungen in Sport-spezifischen Positionen
- Übungen integrieren multiple Gelenke → kinetische Kette
- Programme mit minimalem Equipment
- Programme mit kompetitivem Element, idealerweise mit Partner/innen wo Teams sind oder Zweikampf ist
- Programme mindestens 2mal wöchentlich und als Teil der Warm-up Routine
- Programme sollten maximal 10-15 min. dauern, davon 5 min. für Schulter-spezifische Übungen

ZIELBEREICHE DER ÜBUNGEN

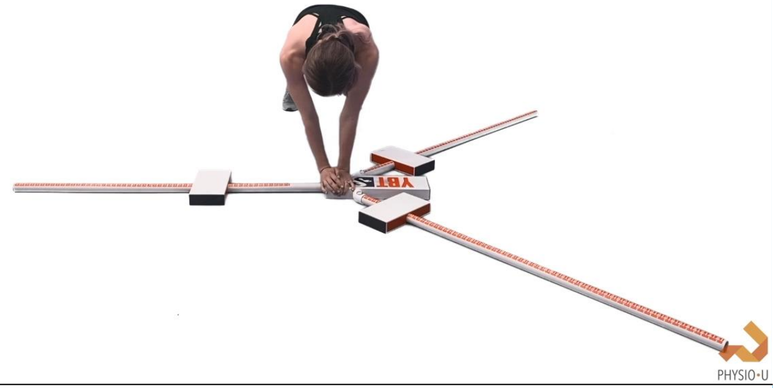
- Rotatorenmanschetten Dysbalancen, mit Fokus auf die Kraft in AR über die gesamte ROM
- Kraft des Schultergürtels über die gesamte ROM
- Dynamische Rumpffunktion / Sport- spezifische Kapazität
- Exzentrische Kontrolle beim Abbremsen → z.B. AR in 90° ABD bei Wurfbewegung

EXPERTEN EMPFEHLUNG FÜR ÜBERKOPF ATHLETINNEN UND ATHLETEN :

KEINE EVIDENZ

PRIMÄR PRÄVENTIONS ÜBUNGEN

Range of motion/motor control	**External rotation through abduction**	**VIDEO 1**



Open/closed kinetic chain	**Y Balance Test exercises or adapted versions**	**VIDEO 3**

Acceleration/ decceleration	**Drop and catch in 90° of shoulder abduction**	**VIDEO 2**

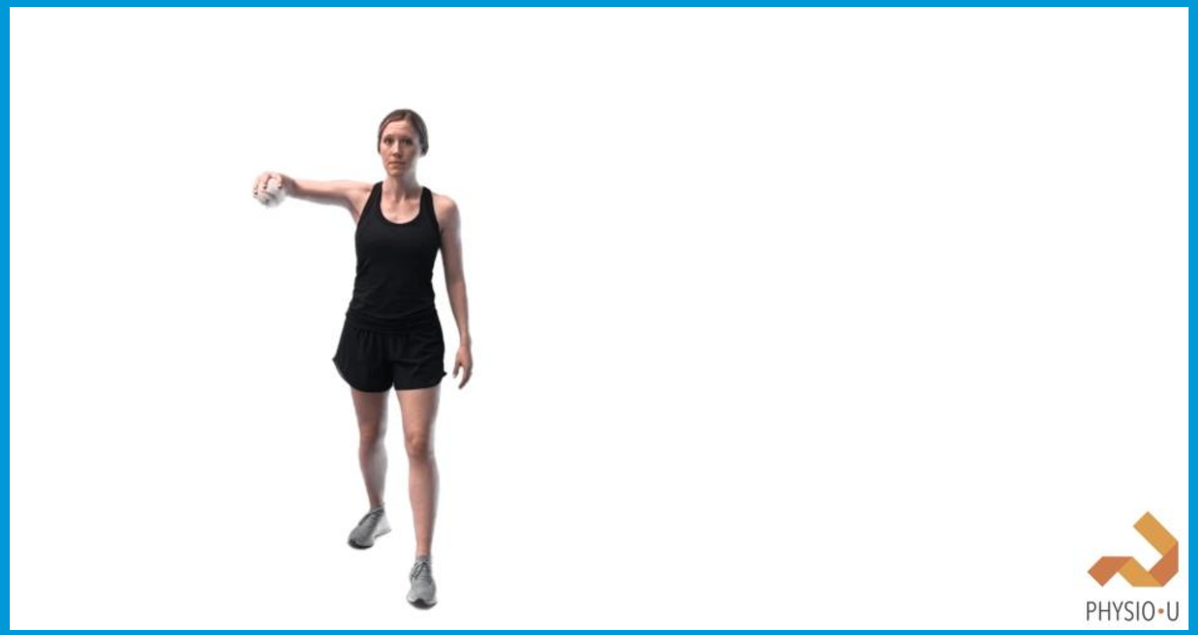
AUSWHAL Übungen: STIG ANDERSSON

Preventing overuse shoulder injuries among throwing athletes: a cluster-randomised controlled trial in 660 elite handball players

Stig Haugsboe Andersson [1], Roald Bahr [1], Benjamin Clarsen [1], Grethe Myklebust [1]

KSW Kantonsspital Winterthur

SEKUNDÄR PRÄVENTIONS ÜBUNG



Z.B. ANSTATT DROP CATCH, SCHNELLE KONZENTRISCHE, LANGSAME EXZENTRISCHE AUSSENROTATION

LOAD MANAGEMENT

Messparameter der Belastung (load)

Monitoring der Belastung (load)

Kapazität (Belastbarkeit) und Belastung

BEISPIELE FÜR MESSPARAMETER VON BELASTUNG

Interne / subjektive Parameter:

- rate of perceived exertion **(RPE)**
- shoulder RPE
- session RPE
- PROMS (z.B.psychological readiness, confidence score)
- fatigue scale
- …

Externe / objektive Parameter:

- Anzahl geschwommene Meter
- Anzahl Service im Tennis
- Anzahl Würfe pro Training
- …

BELASTUNGSMONITORING: PROGRESSION VON JUNGEN ATHLETINNEN UND ATHLETEN HINZU PROFIS

TABLE 3 Measures to Monitor Workload in Different Athlete Populations

Example of Monitoring Workload	Youth Athletes	Adult Athletes[a]	Professional Athletes[b]
Overhead sports	• Shoulder-specific RPE • Pitch counts or serve counts in baseball, softball, cricket, and tennis • Number of laps in swimming/water polo • Number of training sessions and matches (or hours) played	• Session RPE • Shoulder-specific RPE • Strength assessment (eg, endurance and power testing using HHD or other equipment) • Wellness questions or questionnaires (eg, sleep, stress, recovery)	• GPS tracking • Number of strokes in swimming/water polo • Clinical recovery measurements (eg, blood sampling) • Strength assessment (eg, rate of force development analysis) • Pitch/throw velocity
Collision sports	• Shoulder-specific RPE • Number of training sessions and matches (or hours) in team sports • Number of tackles/checks per training in rugby, ice hockey, and lacrosse	• Session RPE • Shoulder-specific soreness NRS • Wellness questions or questionnaires (eg, sleep, stress, recovery)	• GPS tracking • Number of tackles • Clinical recovery measurements (eg, blood sampling) • Strength assessment • Pitch/throw velocity

Abbreviations: GPS, global positioning system; HHD, handheld dynamometry; NRS, numeric rating scale; RPE, rate of perceived exertion.
[a]*In addition to youth athletes.*
[b]*In addition to adult athletes.*

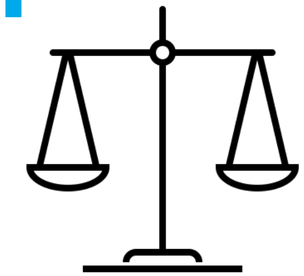
BELASTUNGS MONITORING

RPE SCALE	RATE OF PRECEIVED EXERTION
10	**MAX EFFORT ACTIVITY** Feels almost impossible to keep going. Completely out of breath, unable to talk. Cannot maintain for more than a very short time
9	**VERY HARD ACTIVITY** Very difficult to maintain exercise intensity. Can barely breathe and speak only a few words
7-8	**VIGOROUS ACTIVITY** Borderline uncomfortable. Short of breath, can speak a sentence
4-6	**MODERATE ACTIVITY** Breathing heavily, can hold a short conversation. Still somewhat comfortable, but becoming noticeably more challenging
2-3	**LIGHT ACTIVITY** Feels like you can maintain for hours. Easy to breathe and carry a conversation
1	**VERY LIGHT ACTIVITY** Hardly any exertion, but more than sleeping, watching TV, etc

Abhängig vom Niveau des Sportes, das Monitoring wöchentlich oder täglich durchführen

Die Expertenempfehlung aus dem Consensus Statement war mindestens 1mal pro Woche

GLEICHGEWICHT ZWISCHEN BELASTBARKEIT UND BELASTUNG FINDEN



RPE unterstützt das Kalibrieren von Athletinnen / Athleten und ihrer Wahrnehmung zu Trainingsbelastung und mentaler und physischer Belastbarkeit

Wenn psychophysische Belastbarkeit tief ist (z.B. session RPE 10/10), sollte das Trainingsvolumen entsprechend angepasst /reduziert werden

Coaches sind Schlüsselfiguren wenn es um Belastungsmonitoring geht!

RETURN TO SPORT CONTINUUM

Ardern CL et al. 2016 consensus statement on return to sport from the First World Congress in Sports Physical Therapy, Bern. *Br J Sports Med*.

Zukunft

Wie effektiv sind Präventionsprogramme für junge Athletinnen und Athleten?

Gibt es Sportarten, wo es Sinn macht ein Schulterscreening zu implementieren, weil die Belastung auf die Schulter sehr hoch ist?

TAKE HOME

- RISIKOFAKTOREN FÜR SCHULTERVERLETZUNGEN UNTERSTÜTZEN DIE **EINTSCHEIDUNGSFINDUNG (DECISION-MAKING)** ABER SIND TLW. SCHWIERIG ZU INTERPRETIEREN UND ES FEHLEN STUDIEN DIE IHRE RISIKOPROFILS AUF **MEHRERE MESSPUNKTE** PRO SAISON ABSTÜTZEN→ EVIDENZ ALSO **NICHT AUSREICHEND**
- ANSTATT FÜR RISIKOFAKTOREN ZU SCREENEN WIRD EMPFOHLEN EIN **GENERISCHES SCHULTER MONITORING** DURCHZUFÜHREN, DAS ROM, FORCE & RPE BEINHALTET, DIES MINDESTENS **VOR-MITTE-NACH SAISON**
- **PRÄVENTIONSPROGRAMME** FLÄCHENDECKEND MINDESTENS 2MAL WÖCHENTLICH FÜR 5MIN FÜR DIE SCHULTER EINBAUEN
- BELASTUNG (LOAD) SCHEINT EINE SEHR WICHTIGE ROLLE IN DER PRÄVENTION VOR SCHULTERVERLETZUNGEN ZU SPIELEN, DIES VOR ALLEM BEI **JUNGEN ATHLETINNEN UND ATHLETEN→ BEGINN HEUTE MIT RPE**
- DIE **COACHES** SIND SCHLÜSSELFIGUREN FÜR DAS MONITORING VON LOAD

VIELEN DANK FÜR DIE AUFMERKSAMKEIT

GIBT ES FRAGEN?

ariane.schwank@ksw.ch

@ArianeSchwank

www.paininmotion.be
www.ksw.ch

MORE EXAMPLES OF LOW LOAD PREVENTION EXERCISES

Range of Motion/Strength Training	Plyometrics (?) / Speed	Open / Closed Kinetic Chain
Isometric ER strength	Drop catches/release and catch of ball	Plank with arm movements
Posterior cuff activation in various planes	Anterior cuff activation	Resisted wall slides
Variations of glenohumeral ER • In 45° of abduction/flexion • In 90° of abduction/flexion • Overhead height with an eccentric focus	Elastic bands (fast concentric to slow eccentric) in 90°	Push-up variations (including hands in line with head, push-up back drop, sling, etc) Push-up with a plus
Prone, weighted ER in 90°/90°	Plyometric weighted ER in sidelying	Deep neck flexor exercises (supine and standing)
Integrated upward scapular rotation control, with well-controlled ER	Supine plyometric ER in 90°/90°	Closed kinetic chain exercises (eg, Y Balance Test exercises)
Scaption with low load and a focus on scapular control	Variations of plyometric catch and release with a long lever	(Preactivation) “stick push” partner exercise (both in the ready position)
IR in the abduction-ER position	End-range shoulder flexion with small oscillations (elastic/ball against the wall/manual resistance)	(Preactivation) dynamic trunk rotations, with stable upper extremities

LITERATURE

1Alberta FG, ElAttrache NS, Bissell S, et al. The development and validation of a functional assessment tool for the upper extremity in the overhead athlete. *Am J Sports Med*. 2010;38:903-911. https://doi.org/10.1177/036354650935564 2
2. Andersson SH, Bahr R, Clarsen B, Myklebust G. Preventing overuse shoulder injuries among throwing athletes: a cluster-randomised controlled trial in 660 elite handball players. *Br J Sports Med*. 2017;51:1073-1080. https://doi. org/10.1136/bjsports-2016-096226
3. Andersson SH, Bahr R, Olsen MJ, Myklebust G. Attitudes, beliefs, and behavior toward shoulder injury prevention in elite handball: fertile ground for implementation. *Scand J Med Sci Sports*. 2019;29:1996-2009. https://doi.org/10.1111/ sms.13522
4. Arce G, Bak K, Bain G, et al. Management of disorders of the rotator cuff: proceedings of the ISAKOS Upper Extremity Committee consensus meeting. *Arthroscopy*. 2013;29:1840-1850. https://doi.org/10.1016/j.arthro.2013.07.265
5. Ardern CL, Glasgow P, Schneiders A, et al. 2016 consensus statement on return to sport from the First World Congress in Sports Physical Therapy, Bern. *Br J Sports Med*. 2016;50:853-864. https:// doi.org/10.1136/bjsports-2016-096278

6. Ashworth B, Hogben P, Singh N, Tulloch L, Cohen DD. The Athletic Shoulder (ASH) test: reliability of a novel upper body isometric strength test in elite rugby players. *BMJ Open Sport Exerc Med*. 2018;4:e000365. https://doi.org/10.1136/ bmjsem-2018-000365
7. Asker M, Brooke HL, Waldén M, et al. Risk factors for, and prevention of, shoulder injuries in overhead sports: a systematic review with best-evidence synthesis. *Br J Sports Med*. 2018;52:1312-1319. https://doi.org/10.1136/ bjsports-2017-098254
8. Asker M, Holm LW, Källberg H, Waldén M, Skillgate E. Female adolescent elite handball players are more susceptible to shoulder problems than their male counterparts. *Knee Surg Sports Traumatol Arthrosc*. 2018;26:1892-1900. https://doi.org/10.1007/s00167-018-4857-y
9. Asker M, Waldén M, Källberg H, Holm LW, Skillgate E. Preseason clinical shoulder test results and shoulder injury rate in adolescent elite handball players: a prospective study. *J Orthop Sports Phys Ther*. 2020;50:67-74. https://doi.org/10.2519/ jospt.2020.9044
10. Bahr R. Why screening tests to predict injury do not work—and probably never will...: a critical 26 | january 2022 | volume 52 | number 1 | journal of orthopaedic & sports physical therapy
review. *Br J Sports Med*. 2016;50:776-780. https://doi.org/10.1136/bjsports-2016-096256
11. Bekker S, Clark AM. Bringing complexity to sports injury prevention research: from simplification to explanation. *Br J Sports Med*. 2016;50:1489-1490. https://doi.org/10.1136/ bjsports-2016-096457
12. Black GM, Gabbett TJ, Cole MH, Naughton G. Monitoring workload in throwing-dominant sports: a systematic review. *Sports Med*. 2016;46:1503-1516. https://doi.org/10.1007/ s40279-016-0529-6
13. Blazey P, Crossley KM, Ardern CL, van Middelkoop M, Scott A, Khan KM. It is time for consensus on 'consensus statements'. *Br J Sports Med*. In press. https://doi.org/10.1136/ bjsports-2021-104578
14. Boudreau SA, Farina D, Falla D. The role of motor learning and neuroplasticity in designing rehabilitation approaches for musculoskeletal pain disorders. *Man Ther*. 2010;15:410-414. https:// doi.org/10.1016/j.math.2010.05.008
15. Brzycki M. Strength testing—predicting a one-rep max from reps-to-fatigue. *J Phys Educ Recreat Dance*. 1993;64:88-90. https://doi.org/10.1080/07303084.1993.10606684
16. Buchheit M. The 30-15 Intermittent Fitness Test: accuracy for individualizing interval training of young intermittent sport players. *J Strength Cond Res*. 2008;22:365-374. https://doi.org/10.1519/ JSC.0b013e3181635b2e
17. Bullock GS, Faherty MS, Ledbetter L, Thigpen CA, Sell TC. Shoulder range of motion and baseball arm injuries: a systematic review and meta-analysis. *J Athl Train*. 2018;53:1190-1199. https:// doi.org/10.4085/1062-6050-439-17
18. Burn MB, McCulloch PC, Lintner DM, Liberman SR, Harris JD. Prevalence of scapular dyskinesis in overhead and nonoverhead athletes: a systematic review. *Orthop J Sports Med*. 2016;4:2325967115627608. https://doi. org/10.1177/2325967115627608

19. Chu SK, Jayabalan P, Kibler WB, Press J. The kinetic chain revisited: new concepts on throwing mechanics and injury. *PM R*. 2016;8:S69-S77. https://doi.org/10.1016/j.pmrj.2015.11.015
20. Clarsen B, Bahr R, Andersson SH, Munk R, Myklebust G. Reduced glenohumeral rotation, external rotation weakness and scapular dyskinesis are risk factors for shoulder injuries among elite male handball players: a prospective cohort study. *Br J Sports Med*. 2014;48:1327-1333. https://doi.org/10.1136/bjsports-2014-093702
21. Clarsen B, Myklebust G, Bahr R. Development and validation of a new method for the registration of overuse injuries in sports injury epidemiology: the Oslo Sports Trauma Research Centre (OSTRC) overuse injury questionnaire. *Br J Sports Med*. 2013;47:495-502. https://doi. org/10.1136/bjsports-2012-091524
22. Cools AM, De Wilde L, Van Tongel A, Ceyssens C, Ryckewaert R, Cambier DC. Measuring shoulder external and internal rotation strength and range of motion: comprehensive intra-rater and inter-rater reliability study of several testing protocols. *J Shoulder Elbow Surg*. 2014;23:1454- 1461. https://doi.org/10.1016/j.jse.2014.01.006
23. Cools AM, Maenhout AG, Vanderstukken F, Declève P, Johansson FR, Borms D. The challenge of the sporting shoulder: from injury prevention through sport-specific rehabilitation toward return to play. *Ann Phys Rehabil Med*. 2021;64:101384. https://doi.org/10.1016/j. rehab.2020.03.009
24. Cools AM, Vanderstukken F, Vereecken F, et al. Eccentric and isometric shoulder rotator cuff strength testing using a hand-held dynamometer: reference values for overhead athletes. *Knee Surg Sports Traumatol Arthrosc*. 2016;24:3838- 3847. https://doi.org/10.1007/s00167-015-3755-9
25. Decleve P, Attar T, Benameur T, Gaspar V, Van Cant J, Cools AM. The "upper limb rotation test": reliability and validity study of a new upper extremity physical performance test. *Phys Ther Sport*. 2020;42:118-123. https://doi. org/10.1016/j.ptsp.2020.01.009
26. Declève P, Van Cant J, Attar T, et al. The shoulder endurance test (SET): a reliability and validity and comparison study on healthy overhead athletes and sedentary adults. *Phys Ther Sport*. 2021;47:201-207. https://doi.org/10.1016/j. ptsp.2020.12.005
27. Diamond IR, Grant RC, Feldman BM, et al. Defining consensus: a systematic review recommends methodologic criteria for reporting of Delphi studies. *J Clin Epidemiol*. 2014;67:401-409. https://doi.org/10.1016/j.jclinepi.2013.12.002
28. Dijkstra HP, Pollock N, Chakraverty R, Ardern CL. Return to play in elite sport: a shared decision-making process. *Br J Sports Med*. 2017;51:419-420. https://doi.org/10.1136/ bjsports-2016-096209
29. Edouard P, Frize N, Calmels P, Samozino P, Garet M, Degache F. Influence of rugby practice on shoulder internal and external rotators strength. *Int J Sports Med*. 2009;30:863-867. https://doi. org/10.1055/s-0029-1237391
30. Endo K, Suzuki H, Sawaji Y, et al. Relationship among cervical, thoracic, and lumbopelvic sagittal alignment in healthy adults. *J Orthop Surg (Hong Kong)*. 2016;24:92-96. https://doi. org/10.1177/230949901602400121
31. Eubank BH, Mohtadi NG, Lafave MR, et al. Using the modified Delphi method to establish clinical consensus for the diagnosis and treatment of patients with rotator cuff pathology. *BMC Med Res Methodol*. 2016;16:56. https://doi.org/10.1186/ s12874-016-0165-8
32. Evans NA, Dressler E, Uhl T. An electromyography study of muscular endurance during the Posterior Shoulder Endurance Test. *J Electromyogr Kinesiol*. 2018;41:132-138. https:// doi.org/10.1016/j.jelekin.2018.05.012

33. Evans NA, Konz S, Nitz A, Uhl TL. Reproducibility and discriminant validity of the Posterior Shoulder Endurance Test in healthy and painful populations. *Phys Ther Sport*. 2021;47:66-71. https://doi.org/10.1016/j.ptsp.2020.10.014
34. Fares MY, Fares J, Baydoun H, Fares Y. Prevalence and patterns of shoulder injuries in Major League Baseball. *Phys Sportsmed*. 2020;48:63-67. https://doi.org/10.1080/00913847.2019.1629705
35. Finch C. A new framework for research leading to sports injury prevention. *J Sci Med Sport*. 2006;9:3-9; discussion 10. https://doi.org/10.1016/j.jsams.2006.02.009
36. Fortington LV, Donaldson A, Lathlean T, et al. When 'just doing it' is not enough: assessing the fidelity of player performance of an injury prevention exercise program. *J Sci Med Sport*. 2015;18:272-277. https://doi.org/10.1016/j. jsams.2014.05.001
37. Gerometta A, Klouche S, Herman S, Lefevre N, Bohu Y. The Shoulder Instability-Return to Sport after Injury (SIRSI): a valid and reproducible scale to quantify psychological readiness to return to sport after traumatic shoulder instability. *Knee Surg Sports Traumatol Arthrosc*. 2018;26:203-211. https://doi.org/10.1007/ s00167-017-4645-0
38. Glazer DD. Development and preliminary validation of the Injury-Psychological Readiness to Return to Sport (I-PRRS) scale. *J Athl Train*. 2009;44:185-189. https://doi. org/10.4085/1062-6050-44.2.185
39. Gokeler A, Neuhaus D, Benjaminse A, Grooms DR, Baumeister J. Principles of motor learning to support neuroplasticity after ACL injury: implications for optimizing performance and reducing risk of second ACL injury. *Sports Med*. 2019;49:853-865. https://doi.org/10.1007/ s40279-019-01058-0
40. Gorman PP, Butler RJ, Plisky PJ, Kiesel KB. Upper Quarter Y Balance Test: reliability and performance comparison between genders in active adults. *J Strength Cond Res*. 2012;26:3043-3048. https://doi.org/10.1519/JSC.0b013e3182472fdb
41. Griffin AR, Perriman DM, Neeman TM, Smith PN. Musculoskeletal injury in paddle sport athletes. *Clin J Sport Med*. 2020;30:67-75. https://doi.org/10.1097/JSM.0000000000000565
42. Haller S, Cunningham G, Laedermann A, et al. Shoulder apprehension impacts large-scale functional brain networks. *AJNR Am J Neuroradiol*. 2014;35:691-697. https://doi.org/10.3174/ajnr. A3738
43. Halperin I, Emanuel A. Rating of perceived effort: methodological concerns and future directions. *Sports Med*. 2020;50:679-687. https://doi.org/10.1007/s40279-019-01229-z
44. Headey J, Brooks JH, Kemp SP. The epidemiology of shoulder injuries in English professional rugby union. *Am J Sports Med*. 2007;35:1537-1543. https://doi.org/10.1177/0363546507300691
45. Hellem A, Shirley M, Schilaty N, Dahm D. Review of shoulder range of motion in the throwing athlete: distinguishing normal adaptations from pathologic deficits. *Curr Rev Musculoskelet Med*. 2019:346-355. https://doi.org/10.1007/ s12178-019-09563-5
46. Hickey D, Solvig V, Cavalheri V, Harrold M, Mckenna L. Scapular dyskinesis increases the journal of orthopaedic & sports physical therapy | volume 52 | number 1 | january 2022 | 27
risk of future shoulder pain by 43% in asymptomatic athletes: a systematic review and meta-analysis. *Br J Sports Med*. 2018;52:102-110. https://doi.org/10.1136/bjsports-2017-097559
47. Horsley I. The kinetic chain approach to shoulder evaluation in athletes. *InTouch*. 2019;168:4-9.
48. Kaplan LD, Flanigan DC, Norwig J, Jost P, Bradley J. Prevalence and variance of shoulder injuries in elite collegiate football players. *Am J Sports Med*. 2005;33:1142-1146. https://doi. org/10.1177/0363546505274718
49. Kelly BT, Barnes RP, Powell JW, Warren RF. Shoulder injuries to quarterbacks in the National Football League. *Am J Sports Med*. 2004;32:328- 331. https://doi.org/10.1177/0363546503261737

33. Evans NA, Konz S, Nitz A, Uhl TL. Reproducibility and discriminant validity of the Posterior Shoulder Endurance Test in healthy and painful populations. *Phys Ther Sport*. 2021;47:66-71. https://doi.org/10.1016/j.ptsp.2020.10.014
34. Fares MY, Fares J, Baydoun H, Fares Y. Prevalence and patterns of shoulder injuries in Major League Baseball. *Phys Sportsmed*. 2020;48:63-67. https://doi.org/10.1080/00913847.2019.1629705
35. Finch C. A new framework for research leading to sports injury prevention. *J Sci Med Sport*. 2006;9:3-9; discussion 10. https://doi. org/10.1016/j.jsams.2006.02.009
36. Fortington LV, Donaldson A, Lathlean T, et al. When 'just doing it' is not enough: assessing the fidelity of player performance of an injury prevention exercise program. *J Sci Med Sport*. 2015;18:272-277. https://doi.org/10.1016/j. jsams.2014.05.001
37. Gerometta A, Klouche S, Herman S, Lefevre N, Bohu Y. The Shoulder Instability-Return to Sport after Injury (SIRSI): a valid and reproducible scale to quantify psychological readiness to return to sport after traumatic shoulder instability. *Knee Surg Sports Traumatol Arthrosc*. 2018;26:203-211. https://doi.org/10.1007/ s00167-017-4645-0
38. Glazer DD. Development and preliminary validation of the Injury-Psychological Readiness to Return to Sport (I-PRRS) scale. *J Athl Train*. 2009;44:185-189. https://doi. org/10.4085/1062-6050-44.2.185
39. Gokeler A, Neuhaus D, Benjaminse A, Grooms DR, Baumeister J. Principles of motor learning to support neuroplasticity after ACL injury: implications for optimizing performance and reducing risk of second ACL injury. *Sports Med*. 2019;49:853-865. https://doi.org/10.1007/ s40279-019-01058-0
40. Gorman PP, Butler RJ, Plisky PJ, Kiesel KB. Upper Quarter Y Balance Test: reliability and performance comparison between genders in active adults. *J Strength Cond Res*. 2012;26:3043-3048. https://doi.org/10.1519/JSC.0b013e3182472fdb
41. Griffin AR, Perriman DM, Neeman TM, Smith PN. Musculoskeletal injury in paddle sport athletes. *Clin J Sport Med*. 2020;30:67-75. https://doi. org/10.1097/JSM.0000000000000565
42. Haller S, Cunningham G, Laedermann A, et al. Shoulder apprehension impacts large-scale functional brain networks. *AJNR Am J Neuroradiol*. 2014;35:691-697. https://doi.org/10.3174/ajnr. A3738
43. Halperin I, Emanuel A. Rating of perceived effort: methodological concerns and future directions. *Sports Med*. 2020;50:679-687. https://doi. org/10.1007/s40279-019-01229-z
44. Headey J, Brooks JH, Kemp SP. The epidemiology of shoulder injuries in English professional rugby union. *Am J Sports Med*. 2007;35:1537-1543. https://doi.org/10.1177/0363546507300691
45. Hellem A, Shirley M, Schilaty N, Dahm D. Review of shoulder range of motion in the throwing athlete: distinguishing normal adaptations from pathologic deficits. *Curr Rev Musculoskelet Med*. 2019:346-355. https://doi.org/10.1007/ s12178-019-09563-5
46. Hickey D, Solvig V, Cavalheri V, Harrold M, Mckenna L. Scapular dyskinesis increases the journal of orthopaedic & sports physical therapy | volume 52 | number 1 | january 2022 | 27
risk of future shoulder pain by 43% in asymptomatic athletes: a systematic review and meta-analysis. *Br J Sports Med*. 2018;52:102-110. https://doi.org/10.1136/bjsports-2017-097559
47. Horsley I. The kinetic chain approach to shoulder evaluation in athletes. *InTouch*. 2019;168:4-9.
48. Kaplan LD, Flanigan DC, Norwig J, Jost P, Bradley J. Prevalence and variance of shoulder injuries in elite collegiate football players. *Am J Sports Med*. 2005;33:1142-1146. https://doi. org/10.1177/0363546505274718
49. Kelly BT, Barnes RP, Powell JW, Warren RF. Shoulder injuries to quarterbacks in the National Football League. *Am J Sports Med*. 2004;32:328- 331. https://doi.org/10.1177/0363546503261737

50. Kibler WB, Ludewig PM, McClure PW, Michener LA, Bak K, Sciascia AD. Clinical implications of scapular dyskinesis in shoulder injury: the 2013 consensus statement from the 'Scapular Summit'. *Br J Sports Med*. 2013;47:877-885. https://doi.org/10.1136/bjsports-2013-092425
51. Lee CS, Goldhaber NH, Davis SM, et al. Shoulder MRI in asymptomatic elite volleyball athletes shows extensive pathology. *J ISAKOS Jt Disord Orthop Sports Med*. 2020;5:10-14. https://doi. org/10.1136/jisakos-2019-000304
52. Liaghat B, Bencke J, Zebis MK, et al. Shoulder rotation strength changes from preseason to midseason: a cohort study of 292 youth elite handball players without shoulder problems. *J Orthop Sports Phys Ther*. 2020;50:381-387. https://doi.org/10.2519/jospt.2020.9183
53. Littlewood C, Cools AMJ. Scapular dyskinesis and shoulder pain: the devil is in the detail. *Br J Sports Med*. 2018;52:72-73. https://doi. org/10.1136/bjsports-2017-098233
54. Lynch E, Lombard AJJ, Coopoo Y, Shaw I, Shaw BS. Shoulder injury incidence and severity through identification of risk factors in rugby union players. *Pak J Med Sci*. 2013;29:1400- 1405. https://doi.org/10.12669/pjms.296.3769
55. Matsuura T, Iwame T, Suzue N, Arisawa K, Sairyo K. Risk factors for shoulder and elbow pain in youth baseball players. *Phys Sportsmed*. 2017;45:140-144. https://doi.org/10.1080/009138 47.2017.1300505
56. McClure PW, Michener LA. Staged approach for rehabilitation classification: shoulder disorders (STAR–Shoulder). *Phys Ther*. 2015;95:791-800. https://doi.org/10.2522/ptj.20140156
57. McKay CD, Steffen K, Romiti M, Finch CF, Emery CA. The effect of coach and player injury knowledge, attitudes and beliefs on adherence to the FIFA 11+ programme in female youth soccer. *Br J Sports Med*. 2014;48:1281-1286. https://doi. org/10.1136/bjsports-2014-093543
58. McLaren SJ, Macpherson TW, Coutts AJ, Hurst C, Spears IR, Weston M. The relationships between internal and external measures of training load and intensity in team sports: a meta-analysis. *Sports Med*. 2018;48:641-658. https://doi. org/10.1007/s40279-017-0830-z
59. Michalsik LB, Madsen K, Aagaard P. Technical match characteristics and influence of body anthropometry on playing performance in male elite team handball. *J Strength Cond Res*. 2015;29:416-428. https://doi.org/10.1519/ JSC.0000000000000595
60. Michener LA, Abrams JS, Bliven KCH, et al. National Athletic Trainers' Association position statement: evaluation, management, and outcomes of and return-to-play criteria for overhead athletes with superior labral anterior-posterior injuries. *J Athl Train*. 2018;53:209-229. https:// doi.org/10.4085/1062-6050-59-16
61. Mohseni-Bandpei MA, Keshavarz R, Minoonejhad H, Mohsenifar H, Shakeri H. Shoulder pain in Iranian elite athletes: the prevalence and risk factors. *J Manipulative Physiol Ther*. 2012;35:541- 548. https://doi.org/10.1016/j.jmpt.2012.07.011
62. Møller M, Nielsen RO, Attermann J, et al. Handball load and shoulder injury rate: a 31-week cohort study of 679 elite youth handball players. *Br J Sports Med*. 2017;51:231-237. https://doi. org/10.1136/bjsports-2016-096927
63. Moore SD, Uhl TL, Kibler WB. Improvements in shoulder endurance following a baseball-specific strengthening program in high school baseball players. *Sports Health*. 2013;5:233-238. https:// doi.org/10.1177/1941738113477604
64. Myklebust G, Hasslan L, Bahr R, Steffen K. High prevalence of shoulder pain among elite Norwegian female handball players. *Scand J Med Sci Sports*. 2013;23:288-294. https://doi. org/10.1111/j.1600-0838.2011.01398.x
65. Nair R, Aggarwal R, Khanna D. Methods of formal consensus in classification/diagnostic criteria and guideline development. *Semin Arthritis Rheum*. 2011;41:95-105. https://doi. org/10.1016/j.semarthrit.2010.12.001

66. Nielsen RO, Bertelsen ML, Ramskov D, et al. Time-to-event analysis for sports injury research part 2: time-varying outcomes. *Br J Sports Med*. 2019;53:70-78. https://doi.org/10.1136/ bjsports-2018-100000
67. Olds MK, Ellis R, Parmar P, Kersten P. Who will redislocate his/her shoulder? Predicting recurrent instability following a first traumatic anterior shoulder dislocation. *BMJ Open Sport Exerc Med*. 2019;5:e000447. https://doi.org/10.1136/ bmjsem-2018-000447
68. Owoeye OBA, McKay CD, Verhagen E, Emery CA. Advancing adherence research in sport injury prevention. *Br J Sports Med*. 2018;52:1078-1079. https://doi.org/10.1136/bjsports-2017-098272
69. Paquette MR, Napier C, Willy RW, Stellingwerff T. Moving beyond weekly "distance": optimizing quantification of training load in runners. *J Orthop Sports Phys Ther*. 2020;50:564-569. https://doi.org/10.2519/jospt.2020.9533
70. Perera NKP, Hägglund M. We have the injury prevention exercise programme, but how well do youth follow it? *J Sci Med Sport*. 2020;23:463- 468. https://doi.org/10.1016/j.jsams.2019.11.008
71. Plummer HA, Sum JC, Pozzi F, Varghese R, Michener LA. Observational scapular dyskinesis: known-groups validity in patients with and without shoulder pain. *J Orthop Sports Phys Ther*. 2017;47:530-537. https://doi.org/10.2519/ jospt.2017.7268
72. Pozzi F, Plummer HA, Shanley E, et al. Preseason shoulder range of motion screening and in-season risk of shoulder and elbow injuries in overhead athletes: systematic review and meta-analysis. *Br J Sports Med*. 2020;54:1019-1027. https://doi.org/10.1136/bjsports-2019-100698
73. Prien A, Mountjoy M, Miller J, et al. Injury and illness in aquatic sport: how high is the risk? A comparison of results from three FINA World Championships. *Br J Sports Med*. 2017;51:277-282. https://doi.org/10.1136/ bjsports-2016-096075
74. Putnam CA. Sequential motions of body segments in striking and throwing skills: descriptions and explanations. *J Biomech*. 1993;26 suppl 1:125-135. https://doi.org/10.1016/0021-9290(93)90084-r
75. Richardson E, Lewis JS, Gibson J, et al. Role of the kinetic chain in shoulder rehabilitation: does incorporating the trunk and lower limb into shoulder exercise regimes influence shoulder muscle recruitment patterns? Systematic review of electromyography studies. *BMJ Open Sport Exerc Med*. 2020;6:e000683. https://doi. org/10.1136/bmjsem-2019-000683
76. Rio EK, Mc Auliffe S, Kuipers I, et al. ICON PART-T 2019–International Scientific Tendinopathy Symposium Consensus: recommended standards for reporting participant characteristics in tendinopathy research (PART-T). *Br J Sports Med*. 2020;54:627-630. https://doi.org/10.1136/ bjsports-2019-100957
77. Rizzolatti G, Fabbri-Destro M, Cattaneo L. Mirror neurons and their clinical relevance. *Nat Clin Pract Neurol*. 2009;5:24-34. https://doi. org/10.1038/ncpneuro0990
78. Robinson TW, Corlette J, Collins CL, Comstock RD. Shoulder injuries among US high school athletes, 2005/2006-2011/2012. *Pediatrics*. 2014;133:272-279. https://doi.org/10.1542/ peds.2013-2279
79. Sakata J, Nakamura E, Suzuki T, et al. Throwing injuries in youth baseball players: can a prevention program help? A randomized controlled trial. *Am J Sports Med*. 2019;47:2709-2716. https:// doi.org/10.1177/0363546519861378
80. Sauers EL, Bay RC, Snyder Valier AR, Ellery T, Huxel Bliven KC. The Functional Arm Scale for Throwers (FAST)—part I: the design and development of an upper extremity region-specific and population-specific patient-reported outcome scale for throwing athletes. *Orthop J Sports Med*. 2017;5:2325967117698455. https://doi. org/10.1177/2325967117698455