2024, Retos, 58, 95-107

Systematized review: Isokinetic evaluation in the assessment of upper extremity sports
Revisión sistematizada: Evaluación isocinética en la valoración deportiva de extremidad superior.

*Matías González, *Belén Montoya, *Aníbal Jiménez, *Martin Salazar, **, ***Esteban Aedo-Muñoz, ***Bianca Miarka, *David Arriagada-Tarifeño

*Universidad de Santiago de Chile (Chile), **Universidad Metropolitana de Ciencias de la Educación (Chile), ***Universidad Federal de Rio de Janeiro (Brasil)

Abstract. Objective: A systematized review was carried out to identify the studies that during the last ten years have used isokinetic equipment in sports in which the upper extremity is the basis of its practice, to provide an updated and detailed view of its use, methodologies and the variables used to express their results. Methods: A systematized search of 10 years of information was carried out, according to the PRISMA process, in the databases: Scopus, Web of Science, Pubmed, CINAHL, using combined terms: «isokinetic» «upper extremity», «upper limb», « sport», «exercises», «upper extremity». Results: 9406 articles were identified in the databases for review, of which only 46 were selected based on inclusion criteria. Among the sports evaluated, 25 articles correspond to sports with overhead throws (basketball, volleyball, baseball, handball, among others), followed by Paralympic sports with six articles (basketball and volleyball). Sports such as swimming, judo, weightlifting, water polo, or combined sports complete the list. The shoulder rotator muscles were the most evaluated and the concentric-concentric modality was the most used. The variable moment is the most reported, but the evaluation methodologies and selected speeds differ significantly between studies. Conclusion: The methodologies used are varied (i.e., selection of speed, type of muscular contraction, positioning, and dominance), and their selection was not always oriented toward the functionality of sports practice. In addition, it was observed that some studies needed to specify the isokinetic modality used, leaving a gap in relevant information within the study methods and affecting their future replicability.
Keywords: Isokinetic evaluation; Isokinetic; upper extremity sports; upper limb.

Resumen. Objetivo: Se realizó una revisión sistematizada para identificar los estudios que durante los últimos diez años han utilizado equipos isocinéticos en deportes donde la extremidad superior es base de su práctica, para brindar una visión actualizada y detallada de su uso, metodologías y variables utilizadas en sus resultados. Métodos: Se realizó una búsqueda sistematizada de 10 años de información, a través de PRISMA, en las bases de datos: Scopus, Web of Science, Pubmed, CINAHL, utilizando términos combinados: «isokinetic», «upper extremity», «upper limb» , «deporte», «ejercicios», «extremidad superior». Resultados: Se identificaron 9406 artículos en las bases de datos para revisión, de los cuales solo 46 fueron seleccionados con base en criterios de inclusión. Entre los deportes evaluados, 25 artículos corresponden a deportes con lanzamientos por encima de la cabeza (baloncesto, voleibol, béisbol, balonmano, entre otros), seguido de los deportes paralímpicos con seis artículos (baloncesto y voleibol). Deportes como la natación, el judo, la halterofilia, el waterpolo o los deportes combinados completan la lista. Los músculos rotadores del hombro fueron los más evaluados y la modalidad concentrico-concentrico fue la más utilizada. La variable de momento o torque es el más reportada, pero las metodologías de evaluación y las velocidades seleccionadas difieren significativamente entre los estudios. Conclusión: Las metodologías utilizadas son variadas (i.e. selección de velocidad, tipo de contracción muscular, posicionamiento y dominancia), y su selección no siempre estuvo orientada a la funcionalidad de la práctica deportiva. Además, se observó que algunos estudios necesitaban especificar la modalidad isocinética utilizada, dejando un vacío en la información relevante dentro de los métodos de estudio y afectando su replicabilidad futura.
Palabras clave: Evaluación isocinética; isocinético; deportes de las extremidades superiores; miembro superior.

Fecha recepción: 26-01-24. Fecha de aceptación: 03-06-24
David Arriagada-Tarifeño
david.arriagada@usach.cl

Introduction

The isokinetic dynamometer is the equipment used both in the field of rehabilitation and in the area of human performance to objectively evaluate muscle parameters that determine the ability to generate force of each subject (Bagordo et al., 2020; (Dvir & Müller, 2020)

Variables such as moment (torque), power and work are the most used to quantify similarities or differences between studies carried out for more than five decades and are considered the gold standard for the evaluation of muscle strength (Dvir & Müller, 2020). This fact is due to the high levels of technical reliability in the implementation of evaluations in the different joints of the human body (Edouard et al., 2013). This evaluation method has significantly impacted sports research, especially in the evaluation of the lower extremity, with the knee joint being one of the most evaluated (Ardern et al., 2016; Saragiotto et al., 2016). However, its use in upper extremity assessments has been less common, although its recording reliability is high (Bagordo et al., 2020). It can provide a large amount of background for decision-making in sports practice. Sports such as volleyball, boxing, basketball, baseball and swimming, among others, use the upper extremity as a pillar of their development, supported by its large number of degrees of freedom and the functionality of its structure, linked to the strength of the minor muscles. size, groups that must be capable of producing actions at high speed (Bragazzi et al., 2020; Lawton et al., 2011). This is where the use of isokinetic evaluation becomes relevant both to determine the sports performance of the upper limb function (Liu et al., 2022; Spratford et al., 2020), asymmetries (Aedo-Muñoz et al., 2023; Carvalho et al., 2019), load control and injury prevention.

The complexity of isokinetic evaluation of the upper extremity lies in its high functionality. This condition can give rise to a wide range of methodologies used for its evaluation (position of the evaluation, speed of the test, modality of

muscle contraction, and others). All of this background is reflected in our research question: "What has been the use of isokinetic equipment in the evaluation of sports that use the upper extremity in the last ten years?"

Therefore, the objective of this study is to analyze the studies carried out in the last ten years, where isokinetic dynamometry was used for evaluations of sports that use the upper limb in their sports practice in order to inform the different methodologies and protocols used regarding of the joints. evaluated, the different isokinetic modalities, the speeds evaluated, and the variables reported in the studies.

Methods

The study was carried out according to the standards of a systematized review following the recommendations declared by Page et al. (2021). For the construction of the database, studies that met the eligibility criteria, published from 2011 to 2022, were analyzed. The following databases were used: PubMed, Cinahl, Web of Science, and Scopus, focusing on the use of isokinetic equipment and its use for EESS evaluations in the practice of different sports. The study has been approved by the institutional research committee and due to its nature, ethical approval was not required for its development. The search was carried out on the same day by four authors independently in the four selected databases, which included the following terms in English: isokinetic; upper extremity; upper limb; exercises; sport. For the use of the keywords, the boolean term [AND] was used through the following combinations: «Isokinetic AND upper extremity», «Isokinetic AND upper limb», «Isokinetic AND exercises», «Isokinetic AND sport». The initial search results using the terms gave the same result for each of the authors (9406 articles). The articles were compiled and analyzed in the Zotero bibliographic organizer. The inclusion criteria of the selected articles were the following: (i) period which includes between the years 2011-2021; (ii) Types of documents: Clinical Trial, Journal Article, Randomized Controlled Trial, Early Access, Article, Proceedings Paper, and Academic Publications; (iii) sports population (iv); English and Spanish language; (v) Age: Adults 19 years of age or older. Subsequently, the authors carried out the step-by-step eligibility process of the 46 selected articles included in this systematized review (Figure 1). The articles were analyzed considering the sport, the participants, movement-evaluated joint limb, modality, and studied variables derived from the isokinetic evaluation. The methodological quality assessment of included articles was determined through the Downs & Black scale, Downs and Black score ranges were given corresponding quality levels as previously reported (Hooper, Jutai, Strong, & Russell-Minda, 2008): excellent (26-28); good (20-25); fair (15-19); and poor (<14).

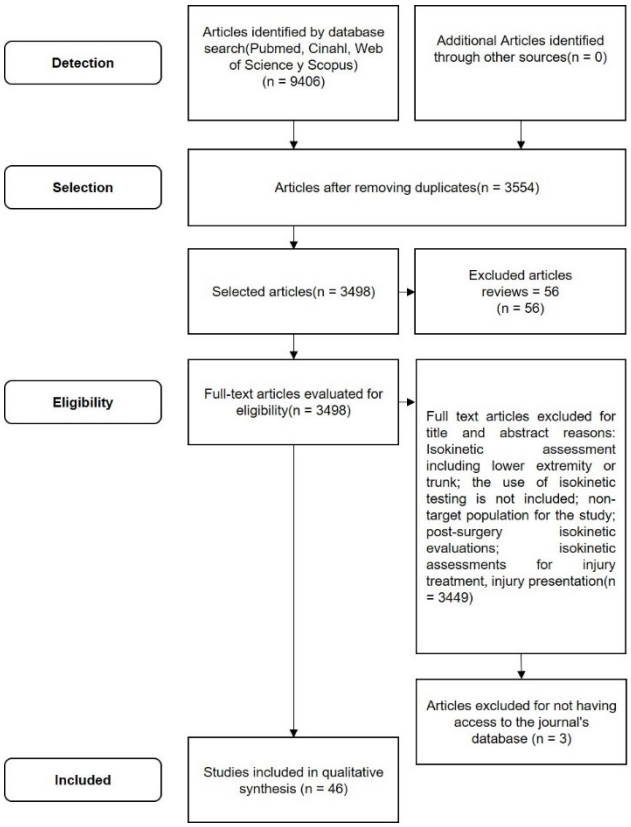

Figure 1. Prisma Flow of studies about isokinetic evaluation in the assessment of upper extremity sports

Results

Table 1. shows the selected studies about isokinetic evaluation in the assessment of upper extremity sports, considering authors, participants, movement-evaluated joint limb, modality, studied variables and methodological quality assessment.

Table 1.
Isokinetic evaluation in the assessment of upper extremity sports, considering authors, participants, movement-evaluated joint limb, modality, and studied variables.

Author Year Sport	N° participant/Gender Age Athlete's condition	Movement evaluated Joint Limb	Evaluation modality Repetition	Study variables	Quality assessment [Downs & Black score]
Ruivo et al.(9) 2012 Judo	44 men 22.6 (± 3.2) Professionals (n = 22) Control group (n = 22)	Shoulder IR/ER Elbow FLEX/EXT D limb	CON-CON. 60° s-1 and 180° s-1, 5 rep. max.	PT IR/ER (Mean and SD). PT FLEX/EXT (Mean and SD). PT/BW IR/ER (Mean and SD). PT/BW FLEX/EXT (Mean and SD). Ratio IR/ER (Mean and SD). Ratio FLEX/EXT (Mean and SD).	14
Girold et al.(10) 2012	24 (12 men) 21.8 (± 3.9)	Shoulder EXT D limb.	CON 60° s-1 and 180° s-1	PT CON (Mean and SD) PT ISOM (Mean and SD) PT ECC (Mean and SD)	14

Swimming	Professionals strength training (n = 8) Professionals' electrical stimulation (n = 8) Control group (n = 8)		ISOM ECC 60° s-1 5 rep. max.		
Laudner et al. (11) 2012 Baseball	30 men 20.2 (± 1.4) Professional pitchers (n = 13) Professionals position players (n = 17)	Wrist PRON/SUP Wrist FLEX/EXT D and ND limb	CON-CON 90° s-1 and 180° s-1 5 rep. max. and 10 rep. max.	PT PRON/SUP (Mean and SD) PT FLEX/EXT (Mean and SD) PT/BW PRON/SUP (mean and SD) PT/BW PRON/SUP (mean and SD)	14
Julienne et al.(12) 2012 Tennis	10 men 22.8 (± 4.6) Élite	Shoulder IR/ER. D and ND limb.	CON-CON 120° s-1 (IR) and 180° s-1 (ER) 35 rep. max	PT IR/ER (Mean and SD) Fatigue index	14
Basar & Ergun(13) 2012 Paralympic basketball	24 men First Group: 28 (± 1.1), Second group: 26 (± 3.1) Athletes trained in frontal plane (n = 12). Athletes trained in the scapular plane (n = 12).	Shoulder IR/ER D limb.	Not specified 180° s-1 5 Rep. max	PT IR/ER (Mean and SD) Total power IR/ER (Mean and SD)	16
Stock et al. (14) 2013 Weightlifting	20 men 23 (± 3) Athletes	Elbow FLEX/EXT. D limb.	CON-CON. 180° s-1. 25 / 50 / 75 / 100 Rep. max.	PT FLEX/EXT (Mean and SD) Fatigue index (Mean and SD)	11
Andrade et al (15) 2013 Handball	32 men 27.7 (± 3.7) Professionals (n = 20) Control group (n = 12)	Shoulder IR/ER D and ND limb.	CON-CON. 60° s-1 and 300 ° s-1 ECC-ECC 300° s-1 5 rep. max.	PT/BW IR/ER CON (Mean and SD) PT/BW IR/ER ECC (Mean and SD) Ratio CON-CON (Mean and SD) Ratio CON-ECC (Mean and SD)	14
Hong et al.(16) 2014 Baseball	51 men 20.08 (± 1.64) Professionals	Shoulder IR/ER D and ND	CON-CON 60° s-1 3 rep max.	PT/BW RI (Mean and SD) PT/BW RE (Mean and SD) Time to PT IR/ER (Mean and SD)	16
Andrade et al.(17) 2014 Handball	27 women 23 (± 3.4) Professionals	Shoulder IR/ER D Limb.	CON-CON 60° s-1 and 300° s-1 5 rep max ECC-ECC 90° s-1 and 300° s-1 5 rep max. .	PT IR/ER CON-CON (Mean and SD) PT IR/ER ECC-ECC (Mean and SD) J IR/ER (Mean and SD) W IR/ER (Mean and SD) Ratio IR/ER CON-CON (Mean and SD) Ratio IR/ER CON-ECC (Mean and SD)	16
Follmer et al.(18) 2015 Jiu-Jitsu	15 men 26.5 (± 4.5) Professionals	Elbow FLEX/EXT D and ND limb Elbow FLEX/EXT D and ND limb	CON-ECC 60° s-1 2 set of 5 rep. max. ISOM 45°, 90° y 120° 3 set of 5 rep. max	PT/BW FLEX/EXT CON-ECC (Mean and SD) PT/BW FLEX/EXT ISOM 45°,90 and 120° (Mean and SD)	16
Bassan et al.(19) 2015 swimming	20 men 25 (± 5) Athletes	Elbow FLEX/EXT D Limb	ISOM 90° FLEX 2 rep. CON-CON 60° s-1 and 180° s-1 5 rep.	PT 90° FLEX ISOM (Mean and SD) PT FLEX/EXT CON-CON (Mean AND SD)	15
Lin et al. (20) 2015 Baseball	39 men Athletes: 19.5 (± 0.6) Control group: 20.6 (± 2.2) College athlete (n = 20), Control group	Shoulder IR/ER D and ND Limb	CON-CON 45°, 75° and 90° 60° s-1, 120° s-1 and 210° s-1 3 rep.	PT 45° CON-CON (Mean and SD) PT 75° CON-CON (Mean and SD) PT 90° CON-CON (Mean and SD) Ratio IR/ER CON-CON (Mean and SD)	14

	(n = 19).				
Andrade et al. (21) 2016 Handball	10 men 23.1 (± 2.8) Élite	Shoulder IR/ER D Limb	CON-CON 60°s-1 and 300° s-1 5 rep. ECC-ECC 90° s-1 and 300° s-1 5 rep.	PT IR/ER CON-CON (Mean and SD) PT IR/ER ECC-ECC (Mean and SD) W RI (Mean and SD) W RE (Mean and SD) J RI (Mean and SD) J RE (Mean and Sd) Ratio IR/ERCON-CON (Mean and SD) Ratio IR/ER ECC-CON (Mean and SD)	20
Vodicka et al.(22) 2016 Aikido	13 men 33.23 (± 7.94) Recreational	Wrist FLEX/EXT D and ND limb.	Not specified 120° s-1,180° s-1 and 240° s-1. Not specified	PT/BW FLEX/EXT (Mean and SD)	16
Borms et al.(23) 2016 Different sports (Volleyball, Basketball, Badminton, Handball, Tennis).	29 (14 men) 21.6 (± 2.5) Athletes of Volleyball (n = 16) Basketball (n = 8) Badminton (n =3), Handball (n =1) Tennis (n =1).	Shoulder IR/ER D and ND limb. Elbow FLEX/EXT D and ND limb.	CON-CON 60° s-1 and 180° s-1 5 rep. and 15 rep CON-ECC 60° s-1 3 rep. CON-CON 60° s-1 and 180° s-1 5 rep and 10 rep. ECC-CON 60° s-1 3 rep.	PT IR/ER CON-CON (Mean and SD) PT IR/ER CON-ECC (Mean and SD) PT FLEX/EXT CON-CON (Mean and SD) PT FLEX/EXT ECC-CON (Mean and SD)	19
Akinoglu & Kocahan(24) 2017 Paralympic basketball	12 men 28.91 (± 5.0) Professionals	Shoulder and wrist FLEX/EXT., D and ND limb. Shoulder an wrist FLEX/EXT D and ND limb.	Not specified 90° s-1 5 rep. submax Not specified 60° s-1 and 240° s-1 5 rep. max and 15 rep max.	PT FLEX/EXT Shoulder (Mean and SD) PT FLEX/EXT Wrist (Mean and SD) PT/BW FLEX/EXT Shoulder (Mean and SD) PT/BW FLEX/EXT Wrist (Mean and SD) Ratio (Mean and SD).	15
Detanico et al.(25) 2017 Judo	10 men 25.1 (± 4.3) Professionals	Shoulder IR/ER D limb.	CON-CON 180° s-1 4 rep.	PT IR/ER CON-CON (Mean and ratio) Ratio CON-CON (Mean and Ratio) Angle of motion to PT CON-CON (Mean and Ratio)	20
Castro et al.(26) 2017 Handball	26 men 23.4 (± 4.1) Elite(n=13) Control Group (n=13)	ShoulderIR/ER D and ND limb .	CON-CON 60° s-1,180° s-1 and 300° s-1 12 set of 5 rep CON-ECC 60° s-1,180° s-1 and 300° s-1 12 set of 5 rep	Ratio CON-CON (Mean and SD) Ratio ECC-CON (Mean and SD)	22
Wilson & Greig(27) 2017 Different sports	25 (15 men) 22 Athletes	Shoulder IR/ER D limb.	Not specified 120° s-1 30 rep.	Angle position (Mean and SD).	18
Geber et al.(28) 2018 Surf	16 men 29.1 (± 7.3) Professionals	Shoulder IR/ER D and ND limb	CON-ECC 60° s-1 and 300° s1 Not specified	PT IR/ER (Mean and SD) J IR/ER (Mean and SD) W IR/ER (Mean and SD)	16
Weissland et al.(29)	46 men	Shoulder IR/ER	CON-CON	PT/BW IR/ER CON-CON (Mean	8

2018 Basketball	Players: 23.4 (± 4.1), Control Group: 23.0 (± 2.7) Elite	D and ND limb.	60° s-1 and 180° s-1 3 rep. ECC-ECC 60° s-1. 3 rep.	and SD) PT/BW IR/ER ECC-ECC (Mean and SD) Ratio CON-CON (Mean and SD) Ratio ECC-CON (Mean and SD)	
Haines (30) 2018 Rugby	49 men Super League players: 26.6 (± 3.9) Semi-professional: 25.9 (± 3.2) (SL) (n= 25), (SP) (n= 24)	Shoulder IR/ER D and ND limb.	ECC-ECC 240° s-1 4 rep. CON-CON 240° s-1 4 rep.	PT IR/ER ECC-ECC (Mean and SD) PT IR/ER CON-CON (Mean and SD)	17
Gaudet et al.(31) 2018 Swimming	24 (11 men) 22.8 (± 4.3) Professionals	Shoulder IR/ER D limb.	CON-CON 240° s-1 50 rep.	PT IR/ER CON-CON (Mean and SD)	19
Kulunkoglu et al.(32) 2018 Paralympic basketball	19 women 29.6 (± 4.71) Paralimpic Athletes (n =10), Person without disabilities (n= 9)	Shoulder FLEX/EXT D and ND limb	Not specified 60° s-1 and 180° s-1 5 rep. and 10 rep.	PT FLEX/EXT CON-CON (Mean and SD)	13
Olivier & Daussin(33) 2018 Waterpolo	15 women 22 (± 2) Professionals	Shoulder IR/ER, D limb Shoulder ER D limb Shoulder EXT D and ND limb	CON-CON 60° s-1 and 240° s-1 3 rep ECC. 60° s-1 3 rep. CON 60° s-1 and 240° s-1 3 rep and 20 rep	PT IR/ER CON-CON (Mean and SD) PT/BW IR/ER CON-CON (Mean and SD) PT RE ECC (Mean and SD) PT/BW RE CON (Mean and SD) PT EXT CON (Mean and SD) PT/BW EXT CON (Mean and SD) Ratio IR/ER (Mean and SD) J EXT (Mean and SD)	18
Vanderstukken et al.(36) 2018 Hockey	50 men Players: 18 – 28 Control group: 19 – 28 Élite (n = 25) Control group (n = 25)	Shoulder IR/ER D and ND limb	CON-CON 60° s-1 and 180° s-1 5 rep. and 15 rep.	PT IR/ER (Mean and SD) Ratio IR/ER (Mean and SD) J IR/ER (Mean and SD)	17
Wagner et al.(35) 2019 Handball	72 men 24.1 (± 5.4) Professionals	Shoulder IR D Limb	Not specified 150° s-1 Not specified	PT IR (Mean and SD)	19
Erdogan et al. (37) 2019 Different sports	44 men Athletes of: Hockey: 22.45 (± 2.06) Volleyball: 22.38 (± 3.29) Handball: 22.56 (± 1.60) Badminton: 21.4 (± 1.73) Hockey (n =16) Volleyball (n = 8) Handball (n = 9) Badminton (n = 11)	Shoulder EXT/FLEX D and ND limb	CON-CON 60° s-1 5 rep.	PT FLEX/EXT (Mean and SD) PT/BW FLEX/EXT (Mean and SD) J FLEX/EXT (Mean and SD) W FLEX/EXT (Mean and SD)	19
Olivier & Daussin(38) 2019 Waterpolo	28 women Players: 22 (± 2) Control group: 22 (± 3) Professionals (n = 18) Control group(n = 10)	Shoulder IR/ER D and ND limb	CON-CON 60° s-1 and 240° s-1 3 rep.and 12 rep. ECC-ECC 60° s-1	PT IR/ER CON-CON (Mean and SD) PT IR/ER ECC-ECC (Mean and SD) Ratio IR/ER CON-CON (Mean and SD) Ratio IR/ER ECC-CON (Mean and	12

			4 rep.	SD) J IR/ER (Mean and SD)	
Haines et al.(39) 2019 Rugby	29 men 26.8 (± 4.1) Professionals	Shoulder IR/ER D and ND limb	CON-ECC 240° s-1 4 rep.	PT IR/ER (Mean and SD) PT/BW IR/ER (Mean and SD) Ratio IR/ER CON-CON (Mean and SD) Ratio IR/ER ECC-CON (Mean and SD)	15
Marcondes et al. (40) 2019 Judo	20(10 women) Men: 26 (± 4) Women: 21 (± 2) Professionals	Shoulder IR/ER Shoulder FLEX/EXT Shoulder ABD/ADD D and ND limb	CON-CON 60° s-1 and 180° s-1 5 rep. and 15 rep.	PT/BW IR/ER CON-CON(Mean and SD) PT/BW FLEX/EXT CON-CON (Mean and SD) PT/BW ABD/ADD CON-CON (Mean and SD) J IR/ER (Mean and SD) J FLEX/EXT (Mean and SD) J ABD/ADD (Mean and SD) Ratio IR/ER CON-CON (Mean and SD)	12
Moradi et al. (41) 2019 Swimming	45 men Athletes trainined in Open chain: 23.2 (± 3.3) Close chain: 24.2 (± 4.2) Control group: 23.4 (± 3.8) Open chain (n = 15) Close chain (n = 15), Control group (n = 15).	Shoulder IR/ER Not specified	CON-CON 60° s-1,120° s-1 and 180° s-1 5 rep. ECC-ECC 60° s-1,120° s-1 and 180° s-1 5 rep.	PT IR/ER CON-CON (Mean and SD) PT IR/ER ECC-ECC (Mean and SD)	16
Maryne et al. (42) 2020 Athletics	22 men 23 (± 2.7) Athletes	Shoulder IR/ER D and ND limb	CON-CON 60° s-1 3 rep. ECC-ECC 60° s-1 3 rep.	PT IR/ER CON-CON (Mean and SD) PT IR/ER ECC-ECC (Mean and SD) Ratio IR/ER CON-CON (Mean and SD) Ratio IR/ER ECC-CON (Mean and SD)	17
Ahmadi et al (43) 2020 Volleyball	13 (6 men) 32.8 (± 4.1) Professionals	Shoulder IR/ER D and ND limb	CON-CON 60° s-1 and 180° s-1 5 rep. and 10 rep.	PT IR/ER CON-CON (Mean and SD)	14
Seco Calvo et al.(44) 2020 Basketball	28 men 27.3 (± 4.4) Professionals (n = 12) Control group (n = 16)	Combined movement Shoulder FLEX/ABD/RE Combined movement Shoulder EXT/ADD/RI D and ND limb	Not specified 60° s-1 and 180° s-1 Not specified	PT FLEX/ABD/RE (Mean and SD) PT EXT/ADD/RI (Mean and SD) PT/BW FLEX/ABD/RE (Mean and SD) PT/BW EXT/ADD/RI (Mean and SD) Ratio CON-CON (Mean and SD)	23
Zago et al. (45) 2020 Overhead sports	24 men 22 (± 2) Athletes	Shoulder IR/ER D limb	Not specified 120° s-1 3 set of 32 rep.	Fatigue index	12
Gurkan & Golunuk(46) 2020 Different sports	48 men 24.5 (± 2,62) Athletes of Table Tennis (n = 12) Badminton (n = 12) Tennis (n = 12) Control group (n = 12)	Forearm SUP/PRO D and ND limb.	Not specified 30° s-1 and 120° s-1 5 set of 5 rep.	PT/BW SUP/PRO (Mean and SD)	10
Maroto Izquierdo et al. (47) 2020	18 men Isoinertial flywheel: 23.3 (± 4.1) Pneumatic resistance: 24.9	Shoulder IR/ER D and ND limb	CON-CON 60° s-1, 180° s-1 and 240° s-1 5 rep.,10 rep. and 10	PT IR/ER CON-CON(Mean and SD) W IR/ER (Mean and SD) PW IR/ER (Mean and SD) Ratio IR/ER CON-CON (Mean and	18

Handball	(± 4.5) Professionals trained in isoinertial flywheel (n = 9) Professionals trainned in pneumatic resistance (n = 9)		rep.	SD)	
Ahmadi et al. (48) 2020 Paralympic Volleyball	12 (6 men) Men: 32.8 (± 4.1) Women: 30 (± 8.9) Professionals	Shoulder IR/ER D and ND limb	CON-CON 60° s-1 and 180° s-1 5 rep. and 10 rep.	PT IR/ER CON-CON(Mean and SD) J IR/ER (Mean and SD)	11
Vanderstukken et al. (49) 2020 Hockey	50 men 18 – 28 Elite (n = 25) Control group (n =25)	Shoulder IR/ER D and ND limb	CON-CON 60° s-1 5 rep.	PT IR/ER CON-CON (Mean and SD) J IR/ER CON-CON (Mean and SD) Ratio IR/ER CON-CON (Mean and SD)	14
Kim et al. (50) 2020 Volleyball	49 men 23.5 (± 3.3) Professionals	Shoulder IR/ER D and ND limb	CON-CON 60° s-1 and 180° s-1. Not specified .	PT/BW IR/ER (Mean and SD) Ratio IR/ER CON-CON (Mean and SD)	15
Villacieros et al. (51) 2020 Paralympic basketball	12 men 29.91 (± 7.27) Elite	Shoulder IR/ER Shoulder FLEX/EXT Elbow FLEX/EXT D and ND limb	CON-CON hombro 60° s-1 and 180° s-1, 5 rep. CON-CON codo 60° s-1 and 150° s-1, 10 rep.	PT IR/ER (Mean and SD) PT FLEX/EXT men (Mean and SD) PT FLEX/EXT codo (Mean and SD)	19
Dodds et al.(52) 2020 Baseball	18 men 20.94 (± 1.21) College athletes	Shoulder IR/ER D Limb	Not specified 180° s-1 and 300° s-1 5 rep.	PT IR/ER CON-CON (Mean and SD)	18
Cobanoglu et al. (53) 2020 Basketball	52 men 22.5 (+-3,9) Professionals (n =18) Paralympic atheletes (n= 17) Control group(n=17)	Shoulder IR/ER D and ND limb	CON-CON 60° s-1 5 rep. ECC-ECC 90° s-1 5 rep.	PT IR/ER CON-CON (Mean and SD) PT IR/ER ECC-ECC (Mean and SD) PT/BW IR/ER CON-CON (Mean and SD) PT/BW IR/ER ECC-ECC (Mean and SD) Ratio IR/ER CON-CON (Mean and SD) Ratio IR/ER ECC-ECC (Mean and SD)	17
Freitas et al. (34) 2021 Paralympic basketball	36 men 35.6 (± 1.6) Athletes (n =18) Control group (n = 18)	Shoulder IR/ER D and ND limb	CON-CON 60° s-1,180° s-1 and 300° s-1 5 rep,5 rep and 10 rep	PT/BW IR/ER (Mean and SD) J IR/ER (Mean and SD) W IR/ER (Mean and SD) Ratio IR/ER (Mean and SD)	19
Klich et al(54) 2021 Overhead Sport	24 men 21,75 (+-2,23) Athletes	Shoulder IR/ER D limb .	CON- CON 120° s-1, 3 sert of 32 rep	PT IR/ER CON-CON (Mean and SD) Ratio IR/ER CON-CON (Mean and SD)	16

IR: internal rotation – ER: external rotation – FLEX: flexion – EXT: extension – PRON: pronation - SUP: supination – ABD: abduction – ADD: adduction - D: dominant – ND: no dominant – CON: concentric – ECC: eccentric – ISOM: isometric - PT: peak torque – W: work – PW: peak work – J: joules - BW: body weight – SD: standard deviation

Discussion

The objective of this systematic review was to analyze the studies carried out in the last ten years, where isokinetic dynamometry was used for evaluations of sports that use the upper limb in their sports practice in order to inform the different methodologies and protocols used regarding the joints. evaluated, the different isokinetic modalities, the

speeds evaluated and the variables reported in the studies.

Among the sports evaluated, 25 articles correspond to sports with overhead throws (basketball, volleyball, baseball, handball, among others), followed by Paralympic sports with six articles (basketball and volleyball). Sports such as swimming, judo, weightlifting, water polo or combined sports complete the list of disciplines evaluated. Professional athletes were the population that presented the most studies compared to elite athletes. This fact may be associated with the high cost of isokinetic equipment and access to evaluations in university biomechanics laboratories, sports clubs and high-performance centers.

The shoulder was the one with the highest number of assessments carried out during the analysis of the studies, reaching 36 articles; followed by the elbow joint with three articles and five articles that included more than one joint. The high percentage of measurements that the shoulder reaches at the level of the upper limb is associated with the fact that this joint presents a wide variability of movements involved in the execution of different technical gestures in these sports (Bakshi & Freehill, 2018). Shoulder rotations are the most evaluated function. This fact is associated with the high rate of injuries reported in the rotator muscles of the shoulder in different studies that evaluated athletes who practice overhead sports (Asker et al., 2018; Lin et al., 2018).

Different positions were used for the evaluation test of the shoulder rotator muscles. In the study by Lin et al. (2015), three different positions were used to evaluate the rotators with 90º abduction, 70º abduction and 45º abduction. As reported in previous studies (Freitas et al., 2021), shoulder abduction at 45º is recommended in the rotator test because the upper limb is positioned in the scapular plane, presenting higher levels of force and more safety in the movements.

The isokinetic muscle evaluation modality selected determines the type of contraction to be evaluated in the test (concentric, eccentric and isometric) and, therefore, the levels of muscle strength that are achieved during the evaluation, given the selection of these variables must be according to the functions performed in each of the Sports. From the analysis of the data it can be deduced that all evaluations were carried out analytically (specifically in a plane of movement). Only the study by Seco Calvo et al. (2020) used the assessment of joint movements (multiple planes of movement). The most used muscle contraction evaluation modality in the selected articles was the concentric-concentric (CON-CON), present in 27 studies. Nine studies used combined assessments with concentric, eccentric and isometric contractions, and only one evaluated isometric contraction (ISOM). Of these, only the study by Girold et al. (2012) evaluated the shoulder extension movement in 3 different contractions, which is rare since it is always preferred to use agonist versus antagonist movements imitating the functionality of sport. It is important to emphasize that 10 of the studies reported in this review do not specify the modality of muscle evaluation performed, a serious methodological error that prevents the consideration of these studies for future work. Considering the above, these ten studies were not included in the discussion on the selection of speeds and variables used.

Although the largest percentage of studies were conducted in throwing sports, few studies used the functional relationship or the concentric-eccentric modality that measures the relationship between agonist/antagonist musculature in the plane of movement. This situation makes us question whether the tests carried out are consistent with the actions carried out by the athletes and whether they reflect the performance of the subjects. Maloney et al. (2019) highlight the importance of defining and differentiating different sports, the required skills and mastery during the execution of a task. This fact is important when designing the protocol used during the evaluations. The sports involved in the selected studies are primarily associated with the use of a limb (e.g., throwing sports); Despite this, the design of their evaluation protocol involved measuring the dominant and non-dominant limb to have a comparison parameter that allows them to accentuate the differences between limbs. There were 15 studies in which only the dominant limb was evaluated; This methodological decision can only be justified in the case of Dodds et al. (2020), who evaluated baseball players who, due to the nature of the sport, tend to throw solely and exclusively with their dominant arm. Only the study by Shahpar et al. (2019) did not specify which limb was evaluated, this being a critical methodological error.

Another essential methodological parameter corresponds to the selection of the evaluation speed. The most used speeds were the modality of 60º/s and 180º/s (9 articles) followed by 60º/s (7 articles), more than three speeds in the same study (9 articles). The maximum speed chosen for an evaluation was 300º/s, corresponding to the evaluation of university baseball players. Of the 46 studies included in this review, only 10 justify the selection of test speed. Laudner et al. (2012), for their part, justify the use of low speed to guide their study with a more clinical than functional approach. Gerber et al. (2018) base their choice on speeds of 60º/s and 300º/s to evaluate maximum force and force resistance, respectively.

On the other hand, Girold et al. (2012) and Lin et al. (2015) created their protocols considering the speeds functionally used in sports gestures. At the same time, some authors (Ahmadi et al., 2020a; M. S. Andrade et al., 2013; Çobanoğlu et al., 2020; Detanico et al., 2017; Klich et al., 2021; Maroto-Izquierdo et al., 2020) selected the evaluation speed based on other previous studies. Speed selection in isokinetic evaluation is a determining factor, considering the mechanical and neuronal adaptations involved in muscle contraction (Lin et al., 2009). Although the isokinetic equipment already has established protocols (60º/s, 120º/s and 180º/s), it is essential that the authors justify the selection of speeds in their evaluation and that these are directly

related to the objective of the research considering their applicability. in sport.

The isokinetic dynamometer is considered the gold standard for measuring strength and provides many evaluation variables (peak moment, peak moment normalized to body weight, work, power), which can be used to obtain other common variables such as ratios. It is common for authors to present more than one variable in their results (37 studies). Despite this, most of the studies included in this review reported results and primarily discussed the changes that occurred in the peak time variable. This fact coincides with the findings of Sørensen et al. (2021) presented in a systematic review of the use of isokinetics in shoulder evaluations. The question about the peak time variable is not current. Morrissey et al. (1987) pointed out that the peak moment, being a point within a curve, does not represent the function of the muscle in an evaluation, but neither does the work (W), which is a minuscule variable used in studies. Amaral et al. (2014) reviewed the relationship between different variables used in isokinetic evaluations. They pointed out that the variables of total work and average work were associated with a greater correspondence with the ability to generate momentum in athletes. In another study, it was found that, when evaluating subjects with shoulder injuries, despite their injury, they maintained the ability to generate a maximum moment similar to that of the uninjured arm. On the other hand, when analyzing the work variable, significant differences were found when comparing the affected limb with the non-injured one, so using the peak moment variable could not represent muscle strength (Lin et al., 2009).

The ratios were also declared variables in the results of several studies. The Ratios are percentage ratios of moment (using the peak moment) depending on the modality evaluated (Functional Ratio and Conventional Ratio). Of the selected studies, 22 used this variable, with the Functional Ratio (CON/CON) being the most common. Thirteen of these studies used conventional and functional relationships (CON/EXC). This variable has been of interest in different studies, both in the clinical and sports fields, to detect muscle imbalances expressed as a percentage. Despite this, its use has been questioned due to its low technical reliability in detecting imbalances with its different methods due to the use of the peak moment variable for its determination (Cozette et al., 2019).

When carrying out an analysis of the different methodologies used to evaluate sports where the use of the upper limb is involved, we believe that it is necessary that in future studies, different tests can be carried out such as a kinematic analysis to define the different speeds to be used in the isokinetic tests, as well as the use of variables such as Work(W) variables, as well as new representation methods are proposed, thus improving the interpretation of the results of muscle function both for sports performance and for the detection of imbalances, so that the information obtained is helpful to Trainers, physical trainers and rehabilitation professionals.

The limitations of the article was; i) the number of databases used for the search, which may leave articles out of this analysis, ii) the methodological limitations carried out in the studies, leaving out key elements such as the evaluation modality and the if the speed is close to the actual practice of the sport, limiting its reproducibility, iii) Isokinetic contraction is not considered physiological, so it does not necessarily reflect the reality of muscle function, but to date it is the gold standard for evaluations of strength of the different body segments.

Conclusions

This systematized review is based on providing updated information from the last ten years on the use of isokinetic assessment in sports that use the upper extremity, highlighting its evaluation protocols and results. The analysis of the 46 selected articles shows that the most effective use is in throwing sports, evaluating the shoulder joint mainly in internal/external rotation movements.

The methodologies used are varied (i.e., selection of speed, type of muscular contraction, positioning, and dominance), and their selection was not always oriented toward the functionality of sports practice. In addition, it was observed that some studies needed to specify the isokinetic modality used, leaving a gap in relevant information within the study methods and affecting their future replicability.

Despite multiple variables selected to report the results, peak moment continues to be the most used to the detriment of the work, which several authors have reported as a variable that is more sensitive to performance in sports activities. Future research addressing isokinetic testing in upper extremity sports should address these considerations.

Acknowledgments

The authors give special thanks to DICYT USACH and project 021991AT_MED for their support in realizing this project.

Conflicts of Interest

The authors declare no conflict of interest.

References

Aedo-Muñoz, E., Brito, C. J., Muñoz, P. M., Nóbrega, O. D. T., Miarka, B., Valenzuela, M. G., & Arriagada-Tarifeño, D. (2023). Do judokas present differences between upper limbs for the concentric strength of the internal and external rotators of the shoulder?. *Isokinetics and Exercise Science, 1-10*. https://doi.org/10.3233/IES-230073

Ahmadi, S., Gutierrez, G. L., & Uchida, M. C. (2020a). Asymmetry in glenohumeral muscle strength of sitting volleyball players: An isokinetic profile of shoulder rotations strength. *The Journal of Sports Medicine and Physical*

Fitness, 60(3), 395-401. https://doi.org/10.23736/S0022-4707.19.10144-2

Ahmadi, S., Gutierrez, G. L., & Uchida, M. C. (2020b). Correlation between handgrip and isokinetic strength of shoulder muscles in elite sitting volleyball players. *Journal of Bodywork & Movement Therapies, 24*, 159-163. https://doi.org/10.1016/j.jbmt.2020.07.015

Akinoğlu, B., & Kocahan, T. (2017). Characteristics of upper extremity's muscle strength in Turkish national wheelchair basketball players team. *Journal of Exercise Rehabilitation, 13*(1), 62-67. https://doi.org/10.12965/jer.1732868.434

Amaral, G. M., Marinho, H. V. R., Ocarino, J. M., Silva, P. L. P., Souza, T. R. de, & Fonseca, S. T. (2014). Muscular performance characterization in athletes: A new perspective on isokinetic variables. *Brazilian Journal of Physical Therapy, 18*(6), 521-529. https://doi.org/10.1590/bjpt-rbf.2014.0047

Andrade, M. D. S., Fachina, R. J. F. G., Cruz, W., Benedito-Silva, A. A., Da Silva, A. C., & De Lira, C. A. B. (2014). Strength field tests performance are correlated with isokinetic strength of shoulder rotator muscles in female handball players. *Journal of Sports Medicine and Physical Fitness, 54*(4), 403- 409. https://www.researchgate.net/publication/264054389_Strength_field_tests_performance_are_correlated_with_isokinetic_strength_of_shoulder_rotator_muscles_in_female_handball_players

Andrade, M. S., De Carvalho Koffes, F., Benedito-Silva, A. A., Da Silva, A. C., & De Lira, C. A. B. (2016). Effect of fatigue caused by a simulated handball game on ball throwing velocity, shoulder muscle strength and balance ratio: A prospective study. *BMC Sports Science, Medicine and Rehabilitation, 8*(1). https://doi.org/10.1186/s13102-016-0038-9

Andrade, M. S., Vancini, R. L., Lira, C. A. B. de, Mascarin, N. C., Fachina, R. J. F. G., & Silva, A. C. da. (2013). Shoulder isokinetic profile of male handball players of the Brazilian National Team. *Brazilian Journal of Physical Therapy, 17*(6), 572-578. https://doi.org/10.1590/S1413-35552012005000125

Ardern, C. L., Glasgow, P., Schneiders, A., Witvrouw, E., Clarsen, B., Cools, A., Gojanovic, B., Griffin, S., Khan, K. M., Moksnes, H., Mutch, S. A., Phillips, N., Reurink, G., Sadler, R., Grävare Silbernagel, K., Thorborg, K., Wangensteen, A., Wilk, K. E., & Bizzini, M. (2016). 2016 Consensus statement on return to sport from the First World Congress in Sports Physical Therapy, Bern. *British Journal of Sports Medicine, 50*(14), 853-864. https://doi.org/10.1136/bjsports-2016-096278

Asker, M., Brooke, H. L., Waldén, M., Tranaeus, U., Johansson, F., Skillgate, E., & Holm, L. W. (2018). Risk factors for, and prevention of, shoulder injuries in overhead sports: A systematic review with best-evidence synthesis. *British Journal of Sports Medicine, 52*(20), 1312-1319. https://doi.org/10.1136/bjsports-2017-098254

Bagordo, A., Ciletti, K., Kemp-Smith, K., Simas, V., Climstein, M., & Furness, J. (2020). Isokinetic Dynamometry as a Tool to Predict Shoulder Injury in an Overhead Athlete Population: A Systematic Review. *Sports, 8*(9), 1-20. https://doi.org/10.3390/sports8090124

Bakshi, N., & Freehill, M. T. (2018). The Overhead Athletes Shoulder. *Sports Medicine and Arthroscopy Review, 26*(3), 88-94. https://doi.org/10.1097/JSA.0000000000000200

Başar, S., & Ergun, N. (2012). Isokinetic Training of the Shoulder Rotator Musculature in Wheelchair Basketball Athletes. *International Journal of Athletic Therapy and Training, 17*(6), 23-26. https://doi.org/10.1123/ijatt.17.6.23

Bassan, N. M., Simões, L. B., Cesar, T. E. A. S., Caritá, R. A. C., Lima, L. C. R. de, Denadai, B. S., & Greco, C. C. (2015). Reprodutibilidade do pico de torque isométrico e isocinético dos músculos flexores e extensores de cotovelo em nadadores treinados. *Revista Brasileira de Cineantropometria e Desempenho Humano, 17*(5), 507. https://doi.org/10.5007/1980-0037.2015v17n5p507

Borms, D., Maenhout, A., & Cools, A. M. (2016). Upper Quadrant Field Tests and Isokinetic Upper Limb Strength in Overhead Athletes. *Journal of Athletic Training, 51*(10), 789-796. https://doi.org/10.4085/1062-6050-51.12.06

Bragazzi, N. L., Rouissi, M., Hermassi, S., & Chamari, K. (2020). Resistance Training and Handball Players' Isokinetic, Isometric and Maximal Strength, Muscle Power and Throwing Ball Velocity: A Systematic Review and Meta-Analysis. International *Journal of Environmental Research and Public Health, 17*(8), 2663. https://doi.org/10.3390/ijerph17082663

Castro, M. P. D., Fonseca, P., Morais, S. T., Borgonovo-Santos, M., Coelho, E. F. C., Ribeiro, D. C., & Vilas-Boas, J. P. (2019). Functional shoulder ratios with high velocities of shoulder internal rotation are most sensitive to determine shoulder rotation torque imbalance: A cross-sectional study with elite handball players and controls. *Sports Biomechanics, 18*(1), 39-50. https://doi.org/10.1080/14763141.2017.1380222

Carvalho, D. D., Soares, S., Zacca, R., Marinho, D. A., Silva, A. J., Pyne, D. B., Vilas-Boas, J. P., & Fernandes, R. J. (2019). In-Water and On-Land Swimmers' Symmetry and Force Production. *International Journal of Environmental Research and Public Health, 16*(24), 5018. https://doi.org/10.3390/ijerph16245018

Çobanoğlu, G., Atalay Güzel, N., Seven, B., Suner KekliK, S., Savaş, S., & Kafa, N. (2020). The Comparison of Flexibility and Isokinetic Shoulder Strength in Wheelchair and Able-bodied Basketball Players. *Turkiye Klinikleri Journal of Sports Sciences, 12*(3), 349-357. https://doi.org/10.5336/sportsci.2020-75591

Cozette, M., Leprêtre, P.-M., Doyle, C., & Weissland, T.

(2019). Isokinetic Strength Ratios: Conventional Methods, Current Limits and Perspectives. *Frontiers in Physiology, 10*, 567. https://doi.org/10.3389/fphys.2019.00567

Detanico, D., Dal Pupo, J., Franchini, E., Fukuda, D. H., & Dos Santos, S. G. (2017). Effects of traditional judo training session on muscle damage symptoms. *Journal of Sports Medicine and Physical Fitness, 57*(6), 872-878. https://doi.org/10.23736/S0022-4707.16.06320-9

Dodds, F. T., Knotts, S.-L. S., Penrod, M. I., Scoggins, W. A., & Conners, R. T. (2020). Shoulder strength and range of motion between collegiate pitchers and position players in baseball. *International Journal of Exercise Science, 13*(6), 123-130. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7039469/pdf/ijes-13-6-123.pdf

Dvir, Z., & Müller, S. (2020). Multiple-Joint Isokinetic Dynamometry: A Critical Review. *Journal of Strength and Conditioning Research, 34*(2), 587-601. https://doi.org/10.1519/JSC.0000000000002982

Edouard, P., Degache, F., Oullion, R., Plessis, J.-Y., Gleizes-Cervera, S., & Calmels, P. (2013). Shoulder strength imbalances as injury risk in handball. International *Journal of Sports Medicine, 34*(7), 654-660. https://doi.org/10.1055/s-0032-1312587

Erdogan, A. T., Umutlu, G., & Acar, N. E. (2019). Evaluation of shoulder strength characteristics in overhead sports and range of motion related changes during isokinetic testing. *Isokinetics and Exercise Science, 27*(2), 153-161. https://doi.org/10.3233/IES-183221

Follmer, B., Dellagrana, R. A., Franchini, E., & Diefenthaeler, F. (2015). Relationship of kimono grip strength tests with isokinetic parameters in jiu-jitsu athletes. *Revista Brasileira de Cineantropometria e Desempenho Humano, 17*(5), 575-582. https://doi.org/10.5007/1980-0037.2015v17n5p575

Freitas, P. S., Santana, T. S., Manoel, L. S., Serenza, F. de S., & Riberto, M. (2021). A comparison of isokinetic rotator cuff performance in wheelchair basketball athletes vs. Non-athletes with spinal cord injury. *The Journal of Spinal Cord Medicine, 44*(4), 557-562. https://doi.org/10.1080/10790268.2019.1603489

Gaudet, S., Tremblay, J., & Dal Maso, F. (2018). Evolution of muscular fatigue in periscapular and rotator cuff muscles during isokinetic shoulder rotations. *Journal of Sports Sciences, 36*(18), 2121-2128. https://doi.org/10.1080/02640414.2018.1440513

Geber, S. O., Cavalcante, B. R., Germano-Soares, A. H., Montes, R. C. C. F., Silva, A. H. O., Veloso, T. S. M., Silva, J. R. L. da C., & Santos, M. A. M. (2018). Relationship between propulsive force of the arm, body composition and isokinetic muscle strength indicators in surfers. *Brazilian Journal of Kinanthropometry and Human Performance, 20*(3), 342-351. https://doi.org/10.5007/1980-0037.2018v20n3p342

Girold, S., Jalab, C., Bernard, O., Carette, P., Kemoun, G., & Dugué, B. (2012). Dry-Land Strength Training vs. Electrical Stimulation in Sprint Swimming Performance. *Journal of Strength and Conditioning Research, 26*(2), 497-505. https://doi.org/10.1519/JSC.0b013e318220e6e4

Gurkan, K., & Golunuk Baspinar, S. (2020). Comparison of elbow joint isokinetic strength and reaction times of racquet players. *Progress in Nutrition, 22*(2-S), e2020016. https://www.mattioli1885journals.com/index.php/progressinnutrition/article/view/10503

Haines, M. R. (2018). Differences in glenohumeral joint rotation and peak power output between Super league and championship rugby league players. *Journal of Strength and Conditioning Research, 32*(6), 1685-1691. https://doi.org/10.1519/JSC.0000000000002029.

Haines, M. R., Fish, M., & O'Sullivan, D. (2019). Seasonal changes in glenohumeral joint isokinetic strength in professional rugby league players. *Physical Therapy in Sport, 39*, 32-37. https://doi.org/10.1016/j.ptsp.2019.06.005

Hong, J., Burfeind, K., Chun, J., & Van Ryssegem, G. (2014). Scapular medial border displacement and its relationships to shoulder internal and external rotator muscle function in division III baseball players. *Isokinetics and Exercise Science, 22*(3), 245–250. https://doi.org/10.3233/IES-140545

Hooper, P., Jutai, J. W., Strong, G., & Russell-Minda, E. (2008). Age-related macular degeneration and low-vision rehabilitation: a systematic review. *Canadian Journal of Ophthalmology, 43*(2), 180–187. https://doi.org/10.3129/i08-001

Julienne, R., Gauthier, A., & Davenne, D. (2012). Fatigue-resistance of the internal rotator muscles in the tennis player's shoulder: Isokinetic and electromyographic analysis. *Physical Therapy in Sport, 13*(1), 22-26. https://doi.org/10.1016/j.ptsp.2011.02.003

Kim, S. E., Choi, Y. C., & Lee, J. Y. (2020). Early rehabilitation after surgical repair of medial and lateral collateral elbow ligaments: A report of three cases. International *Journal of Environmental Research and Public Health, 17*(17), 1-10. https://doi.org/10.3390/ijerph17176133

Klich, S., Kawczyński, A., Pietraszewski, B., Zago, M., Chen, A., Smoter, M., Hassanlouei, H., & Lovecchio, N. (2021). Electromyographic evaluation of the shoulder muscle after an fatiguing isokinetic protocol in recreational overhead athletes. *International Journal of Environmental Research and Public Health, 18*(5), 1-11. https://doi.org/10.3390/ijerph18052516.

Külünkoğlu, B., Akkubak, Y., & Ergun, N. (2018). The profile of upper extremity Muscular strength in female wheelchair basketball players: A pilot study. *Journal of Sports Medicine and Physical Fitness, 58*(5), 606-611. https://doi.org/10.23736/S0022-4707.17.06862-1

Laudner, K. G., Wilson, J. T., & Meister, K. (2012). Elbow isokinetic strength characteristics among collegiate baseball players. *Physical Therapy in Sport, 13*(2), 97–

100. https://doi.org/https://doi.org/10.1016/j.ptsp.2011.06.007

Lawton, T. W., Cronin, J. B., & McGuigan, M. R. (2011). Strength Testing and Training of Rowers: A Review. *Sports Medicine, 41*(5), 413-432. https://doi.org/10.2165/11588540-000000000-00000

Lin, D. J., Wong, T. T., & Kazam, J. K. (2018). Shoulder Injuries in the Overhead-Throwing Athlete: Epidemiology, Mechanisms of Injury, and Imaging Findings. *Radiology, 286*(2), 370-387. https://doi.org/10.1148/radiol.2017170481

Lin, H., Li, J., Lo, S., Shih, Y., Lo, C., & Chen, S. (2009). Isokinetic characteristics of shoulder rotators in patients with adhesive capsulitis. *Journal of Rehabilitation Medicine, 41*(7), 563-568. https://doi.org/10.2340/16501977-0378

Lin, H.-T., Ko, H.-T., Lee, K.-C., Chen, Y.-C., & Wang, D.-C. (2015). The changes in shoulder rotation strength ratio for various shoulder positions and speeds in the scapular plane between baseball players and non-players. *Journal of Physical Therapy Science, 27*(5), 1559-1563. https://doi.org/10.1589/jpts.27.1559

Liu, C., Tian, Y., Zhou, L., Tian, Z., Sun, G., Yin, J., & Zhou, Z. (2022). Upper limb isokinetic muscle strength predicts the performance in cross-country sit-skiing. *Scientific Reports, 12(1)*, 6093. https://doi.org/10.1038/s41598-022-10103-4

Maloney, S. J. (2019). The Relationship Between Asymmetry and Athletic Performance: A Critical Review. *Journal of Strength and Conditioning Research, 33*(9), 2579-2593. https://doi.org/10.1519/JSC.0000000000002608

Marcondes, F. B., Castropil, W., Schor, B., Miana, A., Vasconcelos, R., & Etchebehere, M. (2019). Shoulder isokinetic performance in healthy professional judo athletes: normative data. *Acta Ortopédica Brasileira, 27*(6), 308-312. https://doi.org/10.1590/1413-785220192706223708

Maroto-Izquierdo, S., McBride, J. M., Gonzalez-Diez, N., García-López, D., González-Gallego, J., & de Paz, J. A. (2020). Comparison of Flywheel and Pneumatic Training on Hypertrophy, Strength, and Power in Professional Handball Players. *Research Quarterly for Exercise and Sport, 93*(1), 1-15. https://doi.org/10.1080/02701367.2020.1762836

Maryne, C., Pierre-Marie, L., & Thierry, W. (2020). Angular ranges as a reliable isokinetic method to assess shoulder rotator muscles. *Medical Engineering and Physics, 84*, 16-20. https://doi.org/10.1016/j.medengphy.2020.07.023f Moradi Shahpar, F., Rahnama, N., & Salehi, S. (2019). The Effect of 8 Weeks Open and Closed Kinetic Chain Strength Training on the Torque of the External and Internal Shoulder Rotator Muscles in Elite Swimmers. *Asian Journal of Sports Medicine, 10*(2). https://doi.org/10.5812/asjsm.82158

Morrissey, M. C. (1987). The Relationship Between Peak Torque and Work of the Quadriceps and Hamstrings After Meniscectomy. *Journal Orthopedic Sports Physical Theraphy, 8*(8). https://doi.org/10.2519/jospt.1987.8.8.405

Olivier, N., & Daussin, F. (2019). Isokinetic torque imbalances of shoulder of the french women's national water polo team. *Science & Sports, 34*(2), 82-87. https://doi.org/10.1016/j.scispo.2018.10.003

Olivier, N., & Daussin, F. N. (2018). Relationships Between Isokinetic Shoulder Evaluation and Fitness Characteristics of Elite French Female Water-Polo Players. *Journal of Human Kinetics, 64*(1), 5-11. https://doi.org/10.1515/hukin-2017-0181

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Alonso-Fernández, S. (2021). Declaración PRISMA 2020: Una guía actualizada para la publicación de revisiones sistemáticas. *Revista Española de Cardiología, 74*(9), 790-799. https://doi.org/10.1136/bmj.n71

Ruivo, R., Pezarat-Correia, P., & Carita, A. I. (2012). Elbow and shoulder muscles strength profile in judo athletes. *Isokinetics and Exercise Science, 20*(1), 41-45. https://doi.org/10.3233/IES-2012-0439

Saragiotto, B. T., Yamato, T. P., Cosialls, A. M. H., & Lopes, A. D. (2016). Desequilíbrio muscular dos flexores e extensores do joelho associado ao surgimento de lesão musculoesquelética relacionada à corrida: Um estudo de coorte prospectivo. *Revista Brasileira de Ciências do Esporte, 38*(1), 64-68. https://doi.org/10.1016/j.rbce.2015.12.005

Seco-Calvo, J., Mielgo-Ayuso, J., Calvo-Lobo, C., & Córdova, A. (2020). Cold Water Immersion as a Strategy for Muscle Recovery in Professional Basketball Players During the Competitive Season. *Journal of sport rehabilitation, 29(3)*, 301-309. https://doi.org/10.1123/jsr.2018-0301

Sørensen, L., Oestergaard, L. G., van Tulder, M., & Petersen, A. K. (2021). Measurement Properties of Isokinetic Dynamometry for Assessment of Shoulder Muscle Strength: A Systematic Review. *Archives of Physical Medicine and Rehabilitation, 102*(3), 510-520. https://doi.org/10.1016/j.apmr.2020.06.005

Spratford, W., Elliott, B., Portus, M., Brown, N., & Alderson, J. (2020). The influence of upper-body mechanics, anthropometry and isokinetic strength on performance in wrist-spin cricket bowling. *Journal of Sports Sciences, 38(3)*, 280-287. https://doi.org/10.1080/02640414.2019.1696265}

Stock, M. S., Beck, T. W., DeFreitas, J. M., & Ye, X. (2013). Mechanomyographic Responses for the Biceps Brachii Are Unable to Track the Declines in Peak Torque During 25, 50, 75, and 100 Fatiguing Isokinetic

Muscle Actions. *Journal of Applied Biomechanics, 29*(6), 769-778. https://doi.org/10.1123/jab.29.6.769

Vanderstukken, F., Borms, D., Berckmans, K., Spanhove, V., & Cools, A. M. (2020). Relative scapular-muscle ratios during maximal isokinetic shoulder-girdle strength performance in elite field hockey players. *Journal of Athletic Training, 55*(3), 274-281. https://doi.org/10.4085/1062-6050-499-18

Vanderstukken, F., Jansen, N., Mertens, T., & Cools, A. M. (2018). Elite male field hockey players have symmetric isokinetic glenohumeral strength profiles, but show asymmetry in scapular muscle strength. *Journal of Sports Sciences, 37*(5), 484-491. https://doi.org/10.1080/02640414.2018.1507238

Villacieros, J., Pérez-Tejero, J., Garrido, G., Grams, L., López-Illescas, Á., & Ferro, A. (2020). Relationship between sprint velocity and peak moment at shoulder and elbow in elite wheelchair basketball players. *International Journal of Environmental Research and Public Health, 17*(19), 1-12. https://doi.org/10.3390/ijerph17196989

Vodicka, T., Pieter, W., Reguli, Z., & Zvonar, M. (2016). Isokinetic strength of the wrist in male aikido athletes. *Ido Movement for Culture, 16*(2), 48-54. https://doi.org/10.14589/ido.16.2.6

Wagner, H., Sperl, B., Bell, J. W., & Von Duvillard, S. P. (2019). Testing Specific Physical Performance in Male Team Handball Players and the Relationship to General Tests in Team Sports. *Journal of Strength and Conditioning Research, 33*(4), 1056-1064. https://doi.org/10.1519/JSC.0000000000003026

Weissland, T., Cozette, M., Doyle, C., & Gabrion, A. (2018). Are there bilateral isokinetic shoulder rotator differences in basketball male players? *Journal of Sports Medicine and Physical Fitness, 58*(12), 1768-1773. https://doi.org/10.23736/S0022-4707.18.07973-2

Wilson, L. M., & Greig, M. (2017). The efficacy of functional supports in mediating the effects of exercise on shoulder joint position sense. *Isokinetics and Exercise Science, 25*(2), 127-134. https://doi.org/10.3233/ies-160655

Zago, M., Kawczyński, A., Klich, S., Pietraszewski, B., Galli, M., & Lovecchio, N. (2020). Fatigue-Induced Scapular Dyskinesis in Healthy Overhead Athletes. *Frontiers in Bioengineering and Biotechnology, 8*, 302. https://doi.org/10.3389/fbioe.2020.00302

Datos de los/as autores/as y traductor/a:

Matías González	matias.gonzalez.va@usach.cl	Autor/a
Belén Montoya	belen.montoya@usach.cl	Autor/a
Aníbal Jiménez	anibal.jimenez@usach.cl	Autor/a
Martin Salazar	martin.salazar.g@usach.cl	Autor/a
Esteban Aedo-Muñoz	esteban.aedo@usach.cl	Autor/a
Bianca Miarka	miarkasport@hotmail.com	Autor/a
David Arriagada-Tarifeño	david.arriagada@usach.cl	Autor/a
James Davies	english.review.brazil@gmail.com	Traductor/a