Systematized review: Isokinetic evaluation in the assessment of upper extremity sports

Revisión sistematizada: Evaluación isocinética en la valoración deportiva de extremidad superior.

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», «sports», «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.

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 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).

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>
<thead>
<tr>
<th>Author Year</th>
<th>Sport</th>
<th>N° participant/Gender</th>
<th>Age</th>
<th>Movement evaluated</th>
<th>Joint Limb</th>
<th>Evaluation modality Repetition</th>
<th>Study variables</th>
<th>Quality assessment [Downs &amp; Black score]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ruivo et al. (9) 2012</td>
<td>Judo</td>
<td>44 men</td>
<td>22.6 (± 3.2)</td>
<td>Shoulder IR/ER/ Elbow FLEX/EXT</td>
<td>D limb</td>
<td>CON-CON, 60° s-1 and 180° s-1, 5 rep. max.</td>
<td>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).</td>
<td>14</td>
</tr>
<tr>
<td>Girold et al. (10) 2012</td>
<td>Judo</td>
<td>24 (12 men)</td>
<td>21.8 (± 3.9)</td>
<td>Shoulder EXT</td>
<td>D limb</td>
<td>CON 60° s-1 and 180° s-1</td>
<td>PT CON (Mean and SD), PT ISO (Mean and SD), PT ECC (Mean and SD).</td>
<td>14</td>
</tr>
<tr>
<td>Julienn et al. (12)</td>
<td>2012</td>
<td>Tennis</td>
<td>10 men 22.8 (± 4.6)</td>
<td>Shoulder IR/ER D and ND limb</td>
<td>CON-CON 120° s-1 (IR) and 180° s-1 (ER) 35 rep. max.</td>
<td>PT IR/ER (Mean and SD) Fatigue index</td>
<td>14</td>
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<tr>
<td>Bassan et al. (13)</td>
<td>2012</td>
<td>Paralympic basketball</td>
<td>24 men 28 (± 1.1), 31 (± 3.1)</td>
<td>Not specified 180° s-1 5 Rep. max.</td>
<td>PT IR/ER (Mean and SD) Total power IR/ER (Mean and SD)</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stock et al. (14)</td>
<td>2013</td>
<td>Weightlifting</td>
<td>20 men 23 (± 3)</td>
<td>Elbow FLEX/EXT D limb</td>
<td>CON-CON, 180° s-1, 25 / 50 / 75 / 100 Rep. max.</td>
<td>PT FLEX/EXT (Mean and SD) Fatigue index (Mean and SD)</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Andrade et al. (15)</td>
<td>2013</td>
<td>Handball</td>
<td>32 men 27.7 (± 3.7)</td>
<td>Shoulder IR/ER D and ND limb</td>
<td>CON-CON, 60° s-1 and 180° s-1 5 rep. max.</td>
<td>PT/BW IR/ER CON (Mean and SD) PT/BW IR/ER ECC (Mean and SD) Ratio COM-CON (Mean and SD) Ratio COM-ECC (Mean and SD)</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Hong et al. (16)</td>
<td>2014</td>
<td>Baseball</td>
<td>51 men 20.08 (± 1.64)</td>
<td>Shoulder IR/ER D and ND</td>
<td>CON-CON, 60° s-1 3 rep. max.</td>
<td>PT/BW R1 (Mean and SD) PT/BW RE (Mean and SD) Time to PT IR/ER (Mean and SD)</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Andrade et al. (17)</td>
<td>2014</td>
<td>Handball</td>
<td>27 women 23 (± 3.4)</td>
<td>Shoulder IR/ER D Limb</td>
<td>CON-CON, 60° s-1 and 300° s-1 5 rep max</td>
<td>PT IR/ER CON-CON (Mean and SD) PT IR/ER ECC-CON (Mean and SD) W IR/ER (Mean and SD) Ratio IR/ER CON-CON (Mean and SD) Ratio IR/ER ECC-CON (Mean and SD)</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Follmer et al. (18)</td>
<td>2015</td>
<td>Jiu-Jitsu</td>
<td>15 men 26.5 (± 4.5)</td>
<td>Elbow FLEX/EXT D and ND limb</td>
<td>CON-ECC 60° s-1 2 set of 5 rep. max.</td>
<td>PT/BW FLEX/EXT CON-ECC (Mean and SD) PT/BW FLEX/EXT ISOM 45°, 90 and 120° (Mean and SD)</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Bassan et al. (19)</td>
<td>2015</td>
<td>Swimming</td>
<td>20 men 25 (± 5)</td>
<td>Elbow FLEX/EXT D Limb</td>
<td>ISOM 45°, 90° y 120° 3 set of 5 rep. max.</td>
<td>PT 90° FLEX ISOM (Mean and SD) PT FLEX/EXT CON-CON (Mean AND SD)</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Lin et al. (20)</td>
<td>2015</td>
<td>Baseball</td>
<td>39 men 19.5 (± 0.6)</td>
<td>Shoulder IR/ER D and ND Limb</td>
<td>CON-CON 45°, 75° and 90° 60° s-1, 120° s-1 and 210° s-1 3 rep.</td>
<td>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)</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Authors</td>
<td>Year</td>
<td>Gender</td>
<td>Age Mean ± SD</td>
<td>Sport(s)</td>
<td>Wet Del</td>
<td>Shoulder IR/ER</td>
<td>D and ND limb</td>
<td>PT IR/ER</td>
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<tr>
<td>Vodicka et al.</td>
<td>2016</td>
<td>Men</td>
<td>23.1 ± 2.8</td>
<td>Handball</td>
<td>10 Men</td>
<td>Elite</td>
<td></td>
<td>CON-CON</td>
</tr>
<tr>
<td>Andrade et al.</td>
<td>2016</td>
<td>Men</td>
<td>33.23 ± 7.94</td>
<td>Aikido</td>
<td>13 Men</td>
<td>Recreational</td>
<td></td>
<td>CON-CON</td>
</tr>
<tr>
<td>Borns et al.</td>
<td>2016</td>
<td>Men</td>
<td>21.6 ± 2.5</td>
<td>Different sports (Volleyball, Basketball, Badminton, Handball, Tennis)</td>
<td>29 (14 Men 21.6 ± 2.5)</td>
<td>Athletes of Volleyball (n = 16), Basketball (n = 8), Badminton (n = 1), Handball (n = 1), Tennis (n = 1)</td>
<td>CON-CON</td>
<td></td>
</tr>
<tr>
<td>Akinoglu &amp; Kocahan</td>
<td>2017</td>
<td>Men</td>
<td>28.91 ± 5.0</td>
<td>Paralympic basketball</td>
<td>12 Men</td>
<td>Professionals</td>
<td>Shoulder IR/ER</td>
<td>CON-CON</td>
</tr>
<tr>
<td>Detanico et al.</td>
<td>2017</td>
<td>Men</td>
<td>25.1 ± 4.3</td>
<td>Judo</td>
<td>10 Men</td>
<td>Professionals</td>
<td>Shoulder IR/ER</td>
<td>CON-CON</td>
</tr>
<tr>
<td>Wilson &amp; Greig</td>
<td>2017</td>
<td>Men</td>
<td>23.4 ± 4.1</td>
<td>Handball</td>
<td>26 Men</td>
<td>Elite (n=13), Control Group (n=13)</td>
<td>Shoulder IR/ER</td>
<td>CON-CON</td>
</tr>
<tr>
<td>Geber et al.</td>
<td>2018</td>
<td>Men</td>
<td>29.1 ± 7.3</td>
<td>Surf</td>
<td>16 Men</td>
<td>Professionals</td>
<td>Shoulder IR/ER</td>
<td>CON-CON</td>
</tr>
<tr>
<td>Weissland et al.</td>
<td>2017</td>
<td>Men</td>
<td>46 Men</td>
<td>Handball</td>
<td>46 Men</td>
<td>Shoulder IR/ER</td>
<td>CON-CON</td>
<td>PT IR/ER</td>
</tr>
</tbody>
</table>
**Basketball**

- **2018**
  - Players: 23.4 (± 4.1)
  - Control Group: 23.0 (± 2.7)
  - D and ND limb.
  - 60° s-1 and 180° s-1
  - 3 rep.
  - PT/BW IR/ER ECC-ECC (Mean and SD)
  - Ratio CON-CON (Mean and SD)
  - Ratio ECC-CON (Mean and SD)

**Rugby**

- **2018**
  - Haines (30)
  - 49 men
  - Super League players: 26.6 (± 3.9)
  - Semi-professional: 25.9 (± 3.2)
  - Shoulder IR/ER
  - D and ND limb.
  - ECC-ECC
  - 240° s-1
  - 3 rep.
  - PT IR/ER CON-CON (Mean and SD)
  - 17

**Swimming**

- **2018**
  - Gaudet et al. (31)
  - 24 (11 men)
  - 22.8 (± 4.3)
  - Professionals
  - Shoulder IR/ER
  - D limb.
  - ECC
  - 240° s-1
  - 4 rep.
  - PT IR/ER CON-CON (Mean and SD)
  - 19

**Paralympic basketball**

- **2018**
  - Kulunkoglu et al. (32)
  - 19 women
  - 29.6 (± 4.71)
  - Paralympic 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 IR/ER CON-CON (Mean and SD)
  - 13

**Handball**

- **2019**
  - Erdogan et al. (37)
  - 28 women
  - Players: 22 (± 2)
  - Control group: 22 (± 3)
  - Shoulder EXT/FLEX
  - D and ND limb
  - CON-CON
  - 60° s-1 and 240° s-1
  - 3 rep.
  - PT FLEX/EXT CON-CON (Mean and SD)
  - 19

**Waterpolo**

- **2019**
  - Olivier & Daussin (38)
  - 28 women
  - Players: 22 (± 2)
  - Control group: 22 (± 3)
  - Shoulder IR/ER
  - D and ND limb
  - CON-CON
  - 60° s-1 and 240° s-1
  - 3 rep.
  - PT IR/ER CON-CON (Mean and SD)
  - 12

**Different sports**

- **2019**
  - Wagner et al. (35)
  - 72 men
  - 24.1 (± 5.4)
  - Shoulder IR
  - D Limb
  - Not specified
  - 150° s-1
  - Not specified
  - PT IR (Mean and SD)
  - 19

- **2019**
  - Olivier & Daussin (38)
  - 44 men
  - Athletes of:
    - Hockey: 22.45 (± 2.06)
    - Volleyball: 22.38 (± 1.29)
    - Handball: 22.56 (± 1.60)
    - Badminton: 21.4 (± 1.71)
  - Shoulder EXT/FLEX
  - D and ND limb
  - CON-CON
  - 60° s-1
  - 5 rep.
  - PT FLEX/EXT (Mean and SD)
  - 19

- **2019**
  - Erdogal et al. (37)
  - 28 women
  - Players: 22 (± 2)
  - Control group: 22 (± 3)
  - Shoulder IR/ER
  - D and ND limb
  - CON-CON
  - 60° s-1 and 240° s-1
  - 3 rep. and 12 rep.
  - Ratio CON-CON (Mean and SD)
  - 12
<table>
<thead>
<tr>
<th>Study</th>
<th>Participants</th>
<th>Measure</th>
<th>Protocol Details</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haines et al. (39) 2019</td>
<td>29 men</td>
<td>IR/ER</td>
<td>Shoulder D and ND limb</td>
<td>CON-ECC 240° s-1 4 rep.</td>
</tr>
<tr>
<td>Rugby Professionals</td>
<td>26.8 (± 4.1)</td>
<td></td>
<td></td>
<td>PT IR/ER (Mean and SD)</td>
</tr>
<tr>
<td>Marcondes et al. (40) 2019</td>
<td>20(10 women)</td>
<td>IR/ER</td>
<td>Shoulder FLEX/EXT</td>
<td>CON-CONECC 60° s-1 and 180° s-1 5 rep. and 15 rep.</td>
</tr>
<tr>
<td>Judo Professionals</td>
<td>26 (± 4)</td>
<td></td>
<td></td>
<td>PT/IR/ER CON-CONECC (Mean and SD)</td>
</tr>
<tr>
<td>Moradi et al. (41) 2019</td>
<td>45 men</td>
<td>IR/ER</td>
<td>Shoulder D and ND limb</td>
<td>CON-CONECC 60° s-1,120° s-1 and 180° s-1 5 rep.</td>
</tr>
<tr>
<td>Swimming Athletes trained in</td>
<td>23.2 (± 3.3)</td>
<td></td>
<td></td>
<td>PT/IR/ER CON-CONECC (Mean and SD)</td>
</tr>
<tr>
<td>Open chain: 24.2 (± 4.2)</td>
<td>Control group: 23.4 (± 3.8)</td>
<td>IR/ER</td>
<td>Shoulder D and ND limb</td>
<td>CON-CONECC 60° s-1,130° s-1 and 180° s-1 5 rep.</td>
</tr>
<tr>
<td>J Maryne et al. (42) 2020</td>
<td>22 men</td>
<td>IR/ER</td>
<td>Shoulder D and ND limb</td>
<td>CON-CONECC 60° s-1 3 rep.</td>
</tr>
<tr>
<td>Athletics</td>
<td>23 (± 2.7)</td>
<td></td>
<td></td>
<td>PT/IR/ER CON-CONECC (Mean and SD)</td>
</tr>
<tr>
<td>Ahmadi et al. (43) 2020</td>
<td>13 (6 men)</td>
<td>IR/ER</td>
<td>Shoulder D and ND limb</td>
<td>CON-CONECC 60° s-1 and 180° s-1 5 rep. and 10 rep.</td>
</tr>
<tr>
<td>Volleyball Professionals</td>
<td>32.8 (± 4.1)</td>
<td></td>
<td></td>
<td>PT/IR/ER CON-CONECC (Mean and SD)</td>
</tr>
<tr>
<td>Seco Calvo et al. (44) 2020</td>
<td>28 men</td>
<td>IR/ER</td>
<td>Shoulder D and ND limb</td>
<td>CON-CONECC 60° s-1,120° s-1 and 180° s-1 5 rep.</td>
</tr>
<tr>
<td>Basketball Professionals (n = 12) Control group (n = 16)</td>
<td>Combined movement</td>
<td>Shoulder FLEX/ABD/RE</td>
<td>Not specified 60° s-1 and 180° s-1 Not specified</td>
<td></td>
</tr>
<tr>
<td>Zago et al. (45) 2020</td>
<td>24 men</td>
<td>IR/ER</td>
<td>Shoulder D and ND limb</td>
<td>CON-CONECC 60° s-1 and 180° s-1 5 rep. and 10 rep.</td>
</tr>
<tr>
<td>Overhead sports Athletics</td>
<td>22 (± 2)</td>
<td></td>
<td></td>
<td>PT/IR/ER CON-CONECC (Mean and SD)</td>
</tr>
<tr>
<td>Gurkan &amp; Golunuk (46) 2020</td>
<td>48 men</td>
<td>IR/ER</td>
<td>Forearm SUP/PRO</td>
<td>CON-CONECC 60° s-1,120° s-1 and 180° s-1 5 rep., 10 rep. and 10 rep.</td>
</tr>
<tr>
<td>Different sports</td>
<td>24.5 (± 2,62)</td>
<td></td>
<td></td>
<td>PT/IR/ER CON-CONECC (Mean and SD)</td>
</tr>
<tr>
<td>Maroto Inquierdo et al. (47)</td>
<td>18 men</td>
<td>IR/ER</td>
<td>Shoulder D and ND limb</td>
<td>CON-CONECC 60° s-1, 180° s-1 and 240° s-1 5 rep., 10 rep. and 10 rep.</td>
</tr>
<tr>
<td>2020</td>
<td>23.3 (± 4.1)</td>
<td></td>
<td></td>
<td>PT/IR/ER CON-CONECC (Mean and SD)</td>
</tr>
</tbody>
</table>

**Fatigue index**
Vanderstukken et al. (48) 2020
Paralympic Volleyball
12 (6 men) Men: 32.8 (± 4.1) Shoulder IR/ER 60° s⁻¹ and 180° s⁻¹ 5 rep. and 10 rep. PT IR/ER CON-CONEC (Mean and SD)
Professionals

Vanderstukken et al. (49) 2020
Hockey
50 men Shoulder IR/ER 60° s⁻¹ 5 rep. PT IR/ER CON-CONEC (Mean and SD)
Elite (n = 25) Shoulder IR/ER 60° s⁻¹ and 180° s⁻¹, Not specified . J IR/ER (Mean and SD)
Control group (n = 25) Shoulder IR/ER 60° s⁻¹ and 180° s⁻¹, 10 rep. Ratio IR/ER CON-CONEC (Mean and SD)

Kim et al. (50) 2020
Volleyball
49 men Shoulder IR/ER 60° s⁻¹ and 180° s⁻¹, Not specified . PT/BW IR/ER (Mean and SD)
Professionals Shoulder IR/ER 60° s⁻¹ and 150° s⁻¹, 10 rep. Ratio IR/ER CON-CONEC (Mean and SD)

Villacieros et al. (51) 2020
Paralympic basketball
12 men Shoulder IR/ER Shoulder FLEX/EXT 60° s⁻¹ and 180° s⁻¹, 5 rep. PT IR/ER (Mean and SD)
Elite Shoulder FLEX/EXT 60° s⁻¹ and 180° s⁻¹, 5 rep. PT FLEX/EXT men (Mean and SD)

Dodds et al. (52) 2020
Baseball
18 men Shoulder IR/ER D Limb 180° s⁻¹ and 300° s⁻¹ 5 rep. PT IR/ER CON-CONEC (Mean and SD)
Professionals Shoulder IR/ER D Limb Not specified . PT IR/ER CON-CONEC (Mean and SD)
College athletes Shoulder IR/ER D Limb 180° s⁻¹ and 300° s⁻¹ 5 rep. PT IR/ER CON-CONEC (Mean and SD)

Cobanoglu et al. (53) 2020
Basketball
52 men Shoulder IR/ER Shoulder FLEX/EXT 60° s⁻¹ 5 rep. PT IR/ER CON-CONEC (Mean and SD)
Professionals (n = 18) Shoulder IR/ER Shoulder FLEX/EXT 60° s⁻¹ 5 rep. PT IR/ER ECC-ECC (Mean and SD)
Paralympic athletes (n= 17) Shoulder IR/ER Shoulder FLEX/EXT 60° s⁻¹ 5 rep. PT/BW IR/ER ECC-ECC (Mean and SD)
Control group(n=17) Shoulder IR/ER Shoulder FLEX/EXT 60° s⁻¹ 5 rep. PT/BW IR/ER ECC-ECC (Mean and SD)

Freitas et al. (34) 2021
Paralympic basketball
36 men Shoulder IR/ER D Limb (Mean and SD)
(± 1.6) Shoulder IR/ER D Limb 60° s⁻¹,180° s⁻¹ and 300° s⁻¹ 5 rep,5 rep and 10 rep PT/BW IR/ER (Mean and SD)
Athletes (n =18) Shoulder IR/ER D Limb 120° s⁻¹, 3 sert of 32 rep J R/ER (Mean and SD)
Control group (n = 18) Shoulder IR/ER D Limb 120° s⁻¹, 3 sert of 32 rep J R/ER (Mean and SD)

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Overhead Sport
24 men Shoulder IR/ER D Limb 120° s⁻¹, 3 sert of 32 rep PT IR/ER CON-CONEC (Mean and SD)
Athletes Shoulder IR/ER D Limb 120° s⁻¹, 3 sert of 32 rep PT IR/ER CON-CONEC (Mean and SD)
21,75 (+ 2,23)

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 90° abduction, 70° abduction and 45° abduction. As reported in previous studies (Freitas et al., 2021), shoulder abduction at 45° 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 Girol 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 muscle activity 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 60°/s and 180°/s (9 articles) followed by 60°/s (7 articles), more than three speeds in the same study (9 articles). The maximum speed chosen for an evaluation was 300°/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 60°/s and 300°/s to evaluate maximum force and force resistance, respectively.

On the other hand, Girol 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 (60°/s, 120°/s and 180°/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 Sorensen 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.

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Conflicts of Interest

The authors declare no conflict of interest.

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