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Assessment of Upper Body Physical Tests to Infer Neuromuscular Fatigue in Athletes: A Scoping Review

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Corresponding author:

Inês Arrais

ines.arrais5@gmail.com

Author Affiliation:CIDEFES – Universidade Lusófona &
CIFI2D – Universidade do Porto.Arrais, I; Paulo, A; Rebelo, A; Pires, I; Valente-dos-Santos, J; Lima, L;
Ribeiro, P; Corvelo, R; Pereira, J.**ADMINISTRATIVE INFORMATION****Support** - N/A.**Review Stage at time of this submission** - The review has not yet started.**Conflicts of interest** - None declared.**INPLASY registration number:** INPLASY202570041**Amendments** - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 10 July 2025 and was last updated on 10 July 2025.**INTRODUCTION**

Review question / Objective The aim of the present review was threefold: (i) Identify which upper body physical tests are being used to assess strength/power and therefore infer the neuromuscular fatigue. (ii) Identify the instruments or methodologies (technological or field-based) that are being used in these tests. (iii) To determine which metrics are more precise to infer neuromuscular fatigue.

Background Athletes fatigue is challenging to define (1,2). Neuromuscular fatigue is characterized by a decrease in muscle force or power production (3). Monitor neuromuscular fatigue can be challenging. Direct methods for assessing neuromuscular fatigue can be inaccessible, invasive, and difficult to implement. Therefore, utilizing indirect markers to evaluate

readiness and functional capacities has become valuable for strength and conditioning coaches (4–6). Using performance tests throughout the season allows strength and conditioning coaches to identify fluctuations in results, which can be used to infer fatigue or phases of supercompensation. Research on the subject has, for the most part, focused primarily on the lower body. A possible explanation might be the predominance of skills like running and jumping in various sports disciplines (7,8). The limited evidence regarding upper body neuromuscular fatigue (9), constrains our understanding of fatigue-related performance declines in sports that place significant demands on upper body function. This gap is even more pronounced in research including female elite-level athletes, where studies are notably scarce (10).

Rationale Athletes fatigue is challenging to define (1,2). Neuromuscular fatigue is characterized by a

decrease in muscle force or power production (3). Monitor neuromuscular fatigue can be challenging. Direct methods for assessing neuromuscular fatigue can be inaccessible, invasive, and difficult to implement. Therefore, utilizing indirect markers to evaluate readiness and functional capacities has become valuable for strength and conditioning coaches (4–6). Using performance tests throughout the season allows strength and conditioning coaches to identify fluctuations in results, which can be used to infer fatigue or phases of supercompensation. Research on the subject has, for the most part, focused primarily on the lower body. A possible explanation might be the predominance of skills like running and jumping in various sports disciplines (7,8). The limited evidence regarding upper body neuromuscular fatigue (9), constrains our understanding of fatigue-related performance declines in sports that place significant demands on upper body function. This gap is even more pronounced in research including female elite-level athletes, where studies are notably scarce (10). In response to this, the present research project has three main objectives:

- i. To identify which physical tests are currently used to assess upper body strength and power, which technologies or methodologies are employed (e.g., field-based or laboratory-based), and which neuromuscular performance metrics are collected to infer fatigue.
- ii. To examine potential associations between ITL, upper body ETL, and neuromuscular fatigue during both a mesocycle and the full competitive season.
- iii. To longitudinally track fluctuations in ITL, upper body ETL, and upper body neuromuscular fatigue, and compare them with corresponding fluctuations in lower body ETL and neuromuscular fatigue, to determine whether both regions respond similarly or differently to training demands.
 - a. If similar responses are observed, determine whether these patterns are consistent across all playing roles within the team.
 - b. If divergent responses are found, assess whether these differences vary according to the athlete's roles (e.g., setters, liberos, outside hitters, opposites, and middle blockers).

METHODS

Strategy of data synthesis The data synthesis will be conducted through a narrative and descriptive approach, as no meta-analysis or subgroup analysis is planned. Given the anticipated variability in study designs, test protocols, instruments, and athletic populations, the findings will be summarized in a structured table to allow for comparison across studies. The

extracted data will be organized under the following categories: Study author(s) and year, study design, sample size (N), sport, type of physical test used, instrument or tool employed, outcome variables measured (e.g., strength or power), and test frequency. This tabulated synthesis will allow for the identification of patterns, common methodologies, and gaps in the literature regarding the inference of neuromuscular fatigue in the upper body of athletes.

Eligibility criteria Studies to be included will involve athletes from any sport, of any sex, competitive level, or age group. They must apply physical tests to infer neuromuscular fatigue specifically in the upper body, using either technological or traditional instruments.

Studies to be excluded will be those that assess only lower body fatigue or general fatigue without specific focus on the upper body. In addition, studies not available in full text, not published in peer-reviewed sources, or focused exclusively on recreational sports will not be considered.

Source of evidence screening and selection

The literature search will be conducted using the electronic databases PubMed, SPORTDiscus, Web of Science and Scopus, as they provide broad coverage of relevant literature in sports science fields.

Data management All references retrieved from the database searches will be imported into reference management software to remove duplicates and organize citations. The screening and selection of studies will be conducted through CADIMA which allows for structured and collaborative management of scoping reviews. Data from the studies included will be extracted using standardized forms within the platform and stored securely throughout the process to ensure traceability and consistency.

Language restriction Only studies published in English, Portuguese or Spanish will be considered for inclusion.

Country(ies) involved Portugal.

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Keywords athletic performance, monitoring, fatigue, strength, power, player.

Contributions of each author

Author 1 - Inês Arrais - Drafted the manuscript.

Email: ines.arrais5@gmail.com

Author 2 - Ana Paulo - The author read, provided feedback and approved the final manuscript.

Email: ana.paulo@ulusofona.pt

Author 3 - André Rebelo - The author read, provided feedback and approved the final manuscript.

Email: andre94rebelo@hotmail.com

Author 4 - Inês Pires - The author participated in the screening process and the review of the selected studies.

Email: inesgrijopiresigp@gmail.com

Author 5 - João Valente-dos-Santos - The author read, provided feedback and approved the final manuscript.

Email: joao.valente.santos@ulusofona.pt

Author 6 - Luísa Lima - The author participated in the screening process and the review of the selected studies.

Email: p8210@ulusofona.pt

Author 7 - Pedro Ribeiro - The author participated in the screening process and the review of the selected studies.

Email: pedronetoribeiro@gmail.com

Author 8 - Rui Corvelo - The author participated in the screening process and the review of the selected studies.

Email: ruipenascorvelo@gmail.com

Author 9 - João Pereira - The author read, provided feedback and approved the final manuscript.

Email: p5916@ulusofona.pt